Care Robotics in Aging Japan:
Creating Technical Solutions for the World’s Demographic Problem?

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Abstract

Japan is an ideal country for studying the effects of population aging that cause a wide range of societal issues, ranging from labor shortages and increasing pressure on the welfare state, to growing old age-related poverty and the need for improving productivity to sustain economic prosperity. The research question, which the scientific exploration at hand addresses, is what kind of technologies, generically referred to as robots, may be able to mitigate care problems and generate new solutions, and even further, improve the general health of the Japanese population or serve as a blueprint for other aging societies.

Therefore, the case of Japan can be utilized to describe which strategies decision-makers face, as well as the challenges and opportunities caused by such a demographic transition to cope with the effects. The Japanese government prioritizes the large-scale introduction of robotics in areas of worsening labor shortages and daily life. The New Robot Strategy (NRS), a five-year policy-action plan compiled in 2015, is the new tool to coordinate the support for actors in the robotics industry, to finally leverage the predicted large market potential. Whereas policy-makers are concerned with creating a better infrastructure for the creation of versatile robots (e.g. regulative considerations, channeling of subsidies), the bureaucracy (e.g. METI, MHLW) is supposed to supervise the policy implementation and to link important public and private actors of robotics development (e.g. universities, robot-makers, research institutes). The coordination of this triangle of three stakeholder groups will be vital for the success of large-scale implementation of robotics to lessen the burden on caregivers, improve average health and wellbeing and exploit the economic potential of the silver market.

Rapidly aging societies are a worldwide demographic phenomenon. Whatever feasible technical solution for care Japan invents for its own society is likely to have an impact elsewhere in the world. If the development of care robots works in Japan, it will likely be of fundamental relevance to other aging societies and may incidentally come to be one of the next export successes for Japan. It might be a chance for the government to kill two birds with one stone: taking care of Japan’s elderly and the Japanese economy at the same time. Whether there is a realistic chance this unique technical-driven approach to solving social problems to work out will be at the heart of this academic inquiry.

Keywords: care robotics, demographic change, Japan

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List of Abbreviations

Artificial Intelligence	AI
Chief Executive Officer	CEO
Defense Advanced Research Projects Agency	DARPA
International Safety Standard	ISO
Interview Number	INR
Interview Partner	IP
Interview Question	IQ
Japan Agency for Medical Research and Development	AMED
Ministry of Economy, Trade and Industry	METI
Ministry of Health, Labour and Welfare	MHLW
Ministry of Internal Affairs and Communications	MIC
Ministry of Land, Infrastructure, Transport and Tourism	MLIT
National Institute of Advanced Industrial Science and Technology	AIST
National Institute of Information and Communications Technology	NICT
New Energy and Industrial Technology Development Organization	NEDO
New Robot Strategy	NRS
Research and Development	R&D
Rikagaku Kenkyūjo	RIKEN
Science and Technology Studies	STS
Science Fiction	SF
Small and Medium Enterprise	SME
Social Construction of Technology	SCOT

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Author's Note

All translations from Japanese to English or German to English are mine as long as not otherwise stated.

In addition to this, the main text of this thesis is addressed to a reader, who is not familiar with the Japanese language. For this reason, and for the sake of consistency, the following rules and linguistical specifications apply for this study:

- The Japanese original, its explanations and quotations are in the foot notes.
- Japanese names are written in the order of family name prior to the given name.
- The main text is mostly in English. Japanese words are written in the spelling of the Merriam Webster Dictionary, if an entry is available. The remaining cases refer to the revised Hepburn transcription.
- The names of the companies and their robots are written, as far as they are available, in the official transcription or spelled in official documents, such as the official homepage or publications.

In addition, the following papers have partly been used, with the kind approval of the authors, for this study:

Rabe, B. and M. Rathmann. 2016. *Ready for the "Robot Revolution? Japan's Attempts to Solve Societal Issues by the Implementation of Advanced Robotics*. Paper presented at the 3rd International Conference on Universal Village, 6-8 October 2016, Nagoya University, Nagoya.

Rathmann, Martin. 2015. *Care Robots for an Over-Aging Society: A Technical Solution for Japan's Demographic Problem?.* Proceedings of the 8th Next Generation Global Workshop, 1-3 August 2015, Kyoto University, Kyoto. http://www.kuasu.cpier.kyoto-u.ac.jp/wp-content/uploads/2015/10/Care-Robots-for-an-Over-Aging-Society.pdf

1 Introduction

This study is a quest. A quest for understanding technology development. A quest for understanding exactly those people's mindsets, who are directly involved in the process of technology development. These engineers are positioned in a field of tension between the ideas of the government and user demand, and are a relevant, if not the most relevant, actor for the outcome of the development process. Technology never happens in a vacuum and it depends on the interaction and negotiation of various actors. The current developments in Japan within care robotics as an emerging field serve as a showcase to not only understand how technology emerges, but also to what extent technology, through the example of care robotics, can contribute to overcoming social challenges, such as demographic change.

The following chapter provides an overview of this quest. The starting point is the explanation of the research interest, design and objective (see Chapter 1.1) and the hypotheses (see Chapter 1.2). In the following I am outlining the structure of this study (see Chapter 1.3), which serves as the roadmap for the thesis at hand.

1.1 The Research Interest, Design and Objective

Japan has the world's longest life expectancy and highest proportion of older people in its population. As a result, the delivery of old-age care is becoming an urgent and high priority issue for the Japanese government. There is a high demand for care within a society whose population is constantly aging, and within this discrepancy, we have to somehow find a balance. Since the fertility and immigration rates are too low to compensate for labor shortage, other solutions have to be found for providing care and for sustaining economic power. The implication from this rapid demographic transition will be an extensive shrinking labor force, which will not only be an issue for Japan to sustain its global economic power, but also for providing care for its constantly aging society. There already is a labor shortage in the care sector and it will be even greater in the future. The Japanese government has to work out remedial measures to counteract these burdens on the welfare system.

Moreover, after a quarter of a century of lackluster economic performance, partly due to the erosion of its demographic advantages, Japan is now in search of new fundamental hit export products according to its changed capabilities. Japan's main industrial promotion agency has been METI, which had its greatest success in the postwar high-growth area (cp. Johnson 1982). METI is now again trying to jump-start another growth area and has identified robotics as one of the key industries for economic promotion (METI 2004b) with a projection of a strong market growth from 1.8 trillion yen in 2010 to 6.2 trillion yen by 2025 (METI 2004b; JETRO 2006). Its Robot Policy Research Council (2005) recommended future areas of application to realize a 'neo mechatronics society'. One of the outcomes has been to establish the robot business network project 'Roboness' with four robot business promotion hubs in Kawasaki, Gifu, Kansai and Fukuoka. Since 2014 the METI Committee for the Implementation of the Robot Revolution aims at bringing together government and well-known businesses such as AIST and Mitsubishi Electrics to a round table. Among other METI initiatives, there is the so-called initiative to carry out 'robot olympics' simultaneous to the Tokyo Olympics in 2020 (RRRC 2015; DeWit 2015) as a way to add public visibility to robot research and development promotion programs.

Against this background, it is not surprising that robots are discussed as a technical solution to lower Japan's demographic burden, especially the provision of care and the balancing of the shrinking economic labor force (Nakayama 2006; NEDO 2009). In addition, it would be interesting to see if there has been a change within the R&D landscape of robotics over the years, away from media effective, but difficult to sell, robot projects like Honda's ASIMO, onto a user-demand centered development approach, which would also meet market demand.

To understand how technology might contribute to solving social challenges, it is necessary to understand how technology emerges and how technological change takes place. There is an inseparability of innovation on the one hand and a concrete invention, such as a robot, on the other (cp. Rogers 2003). Thereby innovation is, according to social constructivists, a process which is capable of being influenced by several actors (Grunwald 2012; Wiebe E. Bijker 1987). The vision concept from Dierkes, Hoffmann, and Marz (1992, 1996) extends this assumption into a theoretical framework of catching the complexity of the process of evolving innovations and helps evaluate the feasibility of up-and-coming technologies at the development stage, but this can also be expanded to capture a wider range of relevant actors. Visions follow the desire of realization by various actors, which depends on the technical state of the art. In the case of Japan, there is an interesting linkage of ministries, engineers and end-users. This forms the base for the realization of care robots on a wider scale.

The theoretical framework consists of the combination of the SCOT terminology (Wiebe E. Bijker 1987), the vision concept (Dierkes, Hoffmann, and Marz 1996) and a model for the diffusion of innovations (Rogers 2003). To a certain degree, the intersection for all theoretical theories is a consensus, because even the most groundbreaking vision disappears without people who are convinced by and support it. The SCOT approach provides the general terminology for being able to name the processes of technological development. Dierkes, Hoffmann, and Marz (1996) provide the structure to analyze impacts and processes during the genesis of innovation until it materializes, and Rogers (2003) goes one step further, when he explains what is necessary for diffusion within society and how certain actors are able to promote or jeopardize this process.

The current state of the implementation of care robots outside the laboratory and diffusion within society, as well as research obstacles, are still mostly unknown. Through analyzing the key connectors within this process on the base of a theoretical framework, the status quo can be revealed. The key connectors are the engineers, because they are influenced by the government and users' needs. Thereby engineers can directly influence the emerging care robot market with their inventions, which gives them a key position for the study at hand.

Research questions and theses will be verified through a bottom-up based analysis of the robot development process. Due to the fact that even in Japanese there are only official proposals or technical publications available, and no proper secondary sources on the actual development process of care technology within society: it is therefore necessary to perform primary data research through interviews with directly-involved actors in Japan. Care robots as inventions are developed by engineers and can be seen as the intersection point of feasibility and the desire of various actors. Moreover, the analysis of several robot projects will lay open the current state of the art, trends in development and common visions, and also existing systematic, institutional and practical challenges in general.

Nevertheless, inventions have to be implemented into care facilities and private homes. A comparison of the engineers' visions with the private and professional sector is indispensable. For this reason, the methodological approach for investigation will be a verification performed through bottom-up based qualitative research with the involved actors. In this context, semi-structured interviews (Wengraf 2001) with Japanese engineers, the robot developers, and a subsequent survey of nursing staff in care facilities are an essential method to not only give structure to covering all relevant contents, but also to receive data for a comparison.

Interviews with developers make it possible to reveal methodical and institutional obstacles, and through extending the study onto the user side, practical problems during the implementation process will become clear. The abstract research questions will be answered by analyzing the two aforementioned surveys. The developers' interview guideline will be sectioned into various categories. The interviews will be systematically analyzed by establishing a thematical and theoretical codification, a typification and an interpretation (Flick 2007; Mayring 2010).

Overall, I will discuss the critical aspects of technology development mainly from the engineers' perspective and outline how it is possible that their ideas and technical solutions for care lead to an outcome that often forgets about caregivers' and the elderly's needs. Technology development can serve as the basis for cost-efficient and user-centered product development and can be expected to gain further importance, especially in the above-mentioned way; it can help to open up important new market segments. The empirical findings are derived from an extensive fieldwork, which includes the developers' side and also keeps the users' side in mind through collecting additional information.

On one hand, I provide further empirical evidence about the relevance of robot technologies for care. On the other, I uncover additional insights that can be overlooked easily or at least side-tracked in the literature, and thus I contribute to adding new knowledge to the state of the field. Further, I extend the perspective of just looking at the technical-versed engineers by taking the demand-orientated implementation perspective into account. In other words, I collect information from the implementation side (e.g. ministries, local promotion centers) and the user side, the care practitioners (care facilities and hospitals), who are the key point to understanding the needs for a successful adoption and diffusion within the social system.

Several forecasts predict an immense potential with an enormous multiplication. The Yano Research Institute (2014) expects a market growth from 2.3 billion Yen in 2015 to 34.9 billion Yen by 2020. However, only little is told about how this ambitious objective can be reached, because so far, the field of care robots is an emerging one, with a still manageable number of available care robots and a low diffusion rate within care facilities.

This in return leads to the problem of less reliable data on the positive or negative impacts of robots being available, which is necessary for a qualitative evaluation on the true status of the market, its demands and its problems. This explorative study provides qualitative data gained through interviews, which will make it possible to catch the current state of the art and to deduce tendencies for further successful technology development and an effective market realization. In addition, I am aware of the limitations that come along with qualitative empirical research, but nevertheless, I am confident that my findings show tendencies which similarly exist in most other aging societies, because the needs and demands within the field of care in Japan might have their cultural specifics (e.g. bath culture), but are not substantially different from other countries.

Taking a closer look at the care market and the current developments in robotics in Japan, it is apparent that, compared to most foreign countries, there are different approaches for the use of robots; for example, in home usage, health care provision and old-age care. Especially as technology is expected to support care, self-dependence and communication, robots are answering the demands of aging consumers (cp. METI 2013b; RRRC 2015). Despite rapid technological changes, there still appears to be a gap between technical feasibility and desired usages, and this is manifested in official statements, where robots are proclaimed as not merely supportive tools, but also as autonomous solutions for ensuring elderly care. In essence, this is a long-term vision where robots replace humans as primary caretakers of elderly humans. The major stakeholders, who contribute to this vision, are the government, the bureaucracy, represented especially by METI and MHLW, and also private actors (e.g. robot developers, universities, research institutions).

Japan is said to be the robot nation, due to its prevalence in manufacturing since the seventies (Schodt 1988). As a nation that invested heavily in manufacturing, it compensated its labor shortage during years of economic growth better than other industrial nations, mostly through the incorporation of industrial robots into the production process. In the course of this robotization of production, Japan's main industrial promotion agency has been MITI, which had its greatest success in the postwar high growth area (Johnson 1982) and was succeeded by the newly created METI in 2001. METI is promoting robotics not only as a standard part of the industrial production process, but in collaboration with MHLW, as a possible means for alleviating the labor shortage of care-giving for an over-aging society.

Since the bursting of the economy bubble in the nineties, Japan is in search of an economic upturn for its flagging economy. In this context, METI has identified robotics as one of seven key industries for economic promotion (METI 2004c) with a projection of strong market growth. The other six key promotion fields are fuel cells, digital consumer electronics, content, health and welfare devices and services, environment and energy devices and services, and business support services (METI 2004a, 7, 2004b, 9). The government is calling for the development of robot-based care equipment as part of its Japan Revitalization Strategy (Prime Minister's Office 2014). Ultimately, this can be interpreted as an attempt to robotize care.

The aim of this research is bringing together relevant information about the state of the art of care robots in Japan, including a wide range of publications from discourse within Japanese studies, technical papers and government documents, as well as publications on the state and trends within the field of care. This information processing does not purport to be complete, because I consider it more important to work out current developments, areas of focus and existing or possible connections between individual aspects (e.g. pop culture and technical affinity). Consequently, I will derive the central research question and the related hypotheses.

1.2 The Central Research Question and Working Hypotheses

Against the background of the research interest and the research objective, I formulate the following research questions: What kind of robots may be able to mitigate care problems and generate new solutions and further improve the general health of the Japanese population, and even serve as a blueprint for other aging societies?

Moreover, to answer the central research question, the following working hypotheses are set up:

1. There is much information about industrial robots, in particular Japanese robots available, but only little or even incorrect information is known about the state of the art in care robotics. The questions that are related to this are: What is the state of the art, and what are the general development trends within care robotics in Japan? What, for instance, is the market potential or the acceptance towards care robots within society?

2. The wide-scale introduction of robots within the field of care is a unique Japanese approach to countermeasure care issues, because care robots intend to replace human labor and furthermore, it is argued in Japan that they are easier to integrate into the relatively homogenous Japanese society. The following questions are relevant: What are the fields of application that arise out of technological progress? Will there be autonomously-acting robots or caregivers supported by robot technology in the future? What are the reasons for believing that there is a high acceptance towards robots in Japan?
3. For the successful development of an invention, the institutional and cultural environment, which the first are embedded in, is more important than having a groundbreaking or convincing vision. Therefore, an answer to the following questions is needed: What does the process look like from the first vague vision to a marketable product? What are the factors influencing the innovation process? What is necessary for a successful diffusion within society? Can both of these processes be influenced from outside and if so, how?

The first hypothesis is addressing the lack of information about care robotics in Japan (below: Lack of information thesis). Care robotics is an emerging field with only a few studies so far, which have several limitations. The first and foremost limitation is the timeliness of information, because most studies were published years before and mostly are not up-to-date. Another is that the completeness of the information on Japanese care robots is, in particular in the media coverage, a problem, whereby the information is partially or totally incorrect. One example is that the ROBEAR, a nursing care robot that can lift people, is still mentioned as the future of care robotics (e.g. Dredge, February 27, 2015), whereas this robot is not covered positively by Japanese media (cp. *kaigo pado*, May 15, 2015). The second is Softbank's robot Pepper, usually simplified as Softbank's invention (e.g. Martin, August 16, 2017) but is in fact a development that was provided by the former French robotics company Aldebaran, which was adopted by the Softbank group in 2012 (cp. Palmer, March 11, 2012).

The second thesis focuses on care robotics as a feasible solution within the field of care (below: Labor replacement thesis). If we think this through to the end, it may cause robotization of care, comparable to the robotization of production introduced in the seventies. Thereby three assumptions play a major role. One, the technical possibilities are limiting the range of applications. It is likely that a wide range of challenges might be in connection to the technical state of the art. These issues can be high market entry barriers that have to be overcome before being able to exploit the field of care. This includes safety issues arising from man-robot interaction, as well as the limited scale of application, and also practical issues such as the navigation of a robot within a continuously changing environment like a care facility. Second, I assume that in practice the question, if robots will replace human labor, will be answered by a more or less simple cost-benefit consideration. Even if it would technically be possible to replace human labor, overly high production or running costs entail that a replacement is economically not profitable or socially not a reasonable alternative. Finally, yet most important, Japan is frequently mentioned as a homogeneous and technically enthusiastic nation. But do the developers and the users really prefer care robots to foreign labor? Which arguments are given for and against this statement?

The third thesis covers important theoretical points about the innovation process in general, and thus serves as a framework for catching the structure and processes behind a single invention (below: Relevance of environment thesis). Of course, it is obvious that technology development is influenced by certain factors and that the environment matters. Through a theoretical framework it is possible to locate the relevant factors within the process of technological change. A closer look has to be taken of the factors and environment that makes it possible for a vision or promising idea to materialize into an artefact, and then to widely and deeply diffuse within society. An innovation process is embedded in an institutional framework and cultural environment, whose impact is significant for its successful outcome. I assume that in the case of Japan the public discourse on care robots is one that is influenced and instrumentalized by various actors (e.g. the government and communication media), who try to control the outcome. Hence, special interest has to be given to the question of if the success regarding the outcome can be influenced or even instrumentalized, and what is in fact supporting or hindering the implementation of care robots.

1.3 The Structure of this Study

On the base of the research design and objective described in the first chapter (see Chapter 1.1.) and the formulated working hypotheses (see Chapter 1.2.), the second chapter provides the theoretical framework for this study. This framework comes along with the necessary vocabulary, which makes it possible to name the complex processes during technology development. At the beginning of this process there is the fundamental question of how the term 'innovation' itself can be defined (see Chapter 2.1). The understanding of the term 'innovation' has changed significantly (see Chapter 2.2), away from a linear perspective with evolutionary biology as an explanatory model towards the understanding of innovation as something whose outcome is influenced by society. This change of perspective with society in its focus (see Chapter 2.3) comes along with its very own terminology that can explain the relationship of innovation and society. The strength of the SCOT approach, with its vocabulary, is a whole-in view, but leaves the interpersonal processes behind technology's development process open. For this reason, the SCOT terminology is extended by the vision concept (see Chapter 2.4.). Visions conceptualize the interpersonal factors that are relevant for the successful materialization of an idea into an invention (see Chapter 2.5), as well as a model to understand the course of development (see Chapter 2.6). However, even the best theoretical model has its weaknesses and thus I want to point out the limitations of this theoretical model (see Chapter 2.7). At the end of this chapter (see Chapter 2.8), the last piece within the puzzle of the process of technological change is highlighted: diffusion within society. The SCOT approach and the vision concept make it possible to explain how an idea materializes, but remains unclear about what comes after it. Technological change is the journey of an idea, materializing through an invention and finally spreading within society.

The third chapter is an introduction into robotics in general, especially in Japan. The initial problem is to get an idea about what is understood by the term 'robot' (see Chapter 3.1). For this study it is essential to have a proper working definition to be able to analyze robotics. This includes collecting information about the different types of robots (see Chapter 3.1.1) and a framework that classifies care robotics especially. At this point, I borrow a framework from the Japanese government about the priority areas for the promotion of care robotics (see Chapter 3.1.2). The combination of a working definition, the understanding of the various robot types and priority areas, makes it possible to talk about care robotics while avoiding misunderstandings. Misunderstandings arise easily. The coverage of robotics within the media easily leads to wrong impressions about what technology can do (see Chapter 3.2.1). This becomes clear when comparing the media coverage with the current research on robotics within academia (see Chapter 3.2.2). Moreover, the information about current developments and trends within robotics in Japan has to be collected (see Chapter 3.3), which includes the demographic transition (see Chapter 3.3.1), the activities of the government (see Chapter 3.3.2), the implementation of robotics as a technical solution for a social issue through the ministries (see Chapter 3.3.3) as well as Japan's self-perception as a robot nation (see Chapter 3.3.4), and some approaches of robots within the field of care (see Chapter 3.3.5).

The fourth chapter builds up a methodological approach. The central research question and the working hypotheses can only be answered when finding a way to access information. At the beginning of creating a proper tool for analysis, it is necessary to get a basic understanding about empirical research (see Chapter 4.1). The next step is to build up a proper research design (see Chapter 4.2) and the interview guideline (see Chapter 4.3). Thereby the theoretical findings and the state of the art are transferred into the categories of the interview guideline (see Chapter 4.3.1- 4.3.9).

The fifth chapter is about fieldwork. It is the documentation of fieldwork from 2016, but also goes deeper into challenges during it (see Chapter 5.1). Even if it is only the description of one year, the course of fieldwork also gives insights about the diffusion of care robots in Japan. Since this study is about robots, it is necessary to give care robotics a face and to get it out of namelessness. Already the description of the interviewees and their robot projects (see Chapter 5.2) clearly shows what care robotics can do and what care robots might look like in the future.

The sixth chapter is the heart of this study, because it sets up the state of the art in relation to engineers' reality. To understand the engineer mindset means to read between the lines, because it gives necessary information which cannot be gained through reading publications only. In doing so, the collected data of all 27 engineers is discussed against the background of the previously created research framework. It covers a broad spectrum of personal background (see Chapter 6.1), development framework (see Chapter 6.2), the robot project (see Chapter 6.3), usability tests (see Chapter 6.4), the vision behind the robot (see Chapter 6.5), development problems (see Chapter 6.6), expected market potential (see Chapter 6.7), general expectations of robots in Japan (see Chapter 6.8), as well as the possible contribution of robotics to an aging society (see Chapter 6.9).

Finally, the seventh chapter brings everything together. In doing so, the theses raised at the beginning of this study are verified (see Chapter 7.1) and the essential findings of this study are shown. This is followed by recommendations for further actions (see Chapter 7.2) for the diffusion of care robots. I know that to formulate recommendations for action is a thin line, because it goes beyond scientific analysis and is to some extent based on personal evaluation, never a neutral assessment. However, on the basis of my extended fieldwork and consultation with various experts and actors, I want to make suggestions on how existing challenges could be overcome. The study at hand discloses the engineer mindset and its relevance for the development of care robotics in Japan. At the same time, this study leaves various relevant topics untouched. Some of these research gaps were known before starting this project, and the decision within science to dive deeper into a certain topic is always means a decision against certain aspects related to a topic. Some of these research gaps appeared during the project and the closing remarks of this study are a call for further research on care robotics (see Chapter 7.3), because the relationship of an aging society and technology will undoubtedly remain of high relevance.

2 Theoretical Framework

The aim of this study is a technology assessment of care robotics and robot technologies in Japan. The basis for this are the previously formulated hypotheses (see Chapter 1.2), namely the lack of information thesis, the labor thesis and the relevance of the environment thesis. There is a need for a theoretical structure in order to be able to verify the theses. The theoretical framework is the foundation for creation of the semi-structured interview guideline (see Chapter 3), which in turn is the core of the fieldwork with robot developers and representatives within the care field. It is an appropriate tool for this study for three reasons:

1. It makes it possible to capture current developments, trends and problems in care robotics (thesis 1).
2. It ensures evaluating social and potential cultural barriers or facilitators, which might become notable factors for technology transfer into other countries (thesis 2).
3. It allows detecting general patterns and the structure of technology[1] development, which also has to cover the potential diffusion of inventions in the future (thesis 3).

Against this background, the first step has to be to understand the transformation of an idea into a more or less tangible artifact, the so-called innovation process. Thereby I will rely on theories from science and technology studies (STS), which provide the theoretical vocabulary to understand this complex process in general. STS and, in particular, the descriptive social construction of technology (SCOT) approach offer a wide spectrum of suggestions for catching the relationship between the developer, the user and technology itself. This applies especially in the context of discourse about impact factors on technology genesis, when having a closer look at how technology crosses over with society, politics and culture. SCOT provides the terminology to name technology development but remains vague about the process of implementation of a certain artifact.

For that reason, I connect the SCOT terminology with another theoretical concept, the concept of vision (see Chapter 2.4). Thereby, I especially make use of the concept of visions by Dierkes, Hoffmann, and Marz (1996), which is an essential analytical tool to grasp the complex relationships, because it continues and applies the thoughts of SCOT.

[1] Science and technology are closely interconnected. In order to avoid confusion, the difference between science and technology is explained. Whereas science deals with abstract matters such as theories, principles or laws of nature and new insights about it, technology is the subsequent transformation of science. In other words, technology deals with more or less physical and tangible artifacts, process and design.

I see the strength of the concept in its attempt to reveal how and why one innovation spreads and another fails. Visions have the potential to motivate and stabilize the individual, but also to achieve enough consensus for diffusion within society. The concepts offer an explanation of the relevant impact factors within the development process of an artifact and at the same time, they attempt to provide tools in order to influence the course of innovation towards a positive outcome.

The second step (see Chapter 2.8) is to understand how inventions diffuse within society, or in other words, how to comprehend the subsequent diffusion process of innovations. The vision concept offers an explanatory model on the potential of a single artifact and its future success within society. Its explanatory power ends with one vision or uncovered technology. However, this study attempts to answer a question about the future of care robotics in Japan. In this context, innovation studies, especially the theory about the diffusion of innovations from Everett Rogers (2003), offer a theoretical model to capture the overall process of the emerging field of care robotics. Several individual uncovered visions may lead to a great societal vision. After revealing several visions, innovation studies make it possible to continue SCOT's approach and the findings created from the vision concept. Nevertheless, care robotics in Japan is a currently emerging field. Therefore, rather than making it possible to make reliable statements, this study attempts to give tendencies about the future of their diffusion, or possible care robotic futures. Innovation studies precisely address this point, because they make it possible to capture the current state of diffusion and make a first forecast about the intensity of diffusion within society.

2.1 The Comparison of the Innovation Process to Darwin's Evolution Theory

To understand why one technology is successful and another fails, it is important to deal with terminology, theoretical approaches and relevant viewpoints on technology. This theoretical knowledge is important for understanding how an idea materializes and to grasp the potential of its dissemination within society. Especially for an emerging field such as care robotics, it helps to understand the ongoing process. Additionally, it might offer opportunities to influence the future field in the desired direction. For this study, an extensive knowledge of the theoretical field is essential for subsequent analysis (see Chapter 6) of several care robot projects. In the course of this, the focus lies in particular on the initial idea, development process and implementation.

Charles Darwin defined evolution from a biological perspective as the development and adaptation of a species to their natural environment. For several decades in technology studies, Darwinian beliefs also prevailed in understanding the success of inventions (see Figure 2-1). At first glance, technological development and innovation seem to be subject to a linear evolution-like process, because they seem to be simple adaptations of technical possibilities and user demands. A century after Darwin, Mokyr (1990, 273–74) points out: *"the analogy [of biological evolution] is useful for understanding the dynamic aspects of technological progress. In particular, it can be used to answer the question whether or not technological progress took place in small incremental steps or large leaps."* By making use of this analogy, technological change is understood as a rather continuous process that builds more on temporal logic than an abrupt process with shortcuts. It makes sense to rely on biological evolution terminology because it helps to get a better basic understanding of the complexity of technology. For this reason, many scholars used and still use the biological term 'evolution' as a metaphor or tool to illustrate technology development (Braun-Thürmann 2005, 42). In other words, the term biological evolution sheds a first light on the multi-faceted transition of a first vague idea into a finished commercialized invention. This simplification applies to care robots as well, with an engineer's idea at the beginning which has to be transformed into an artifact.

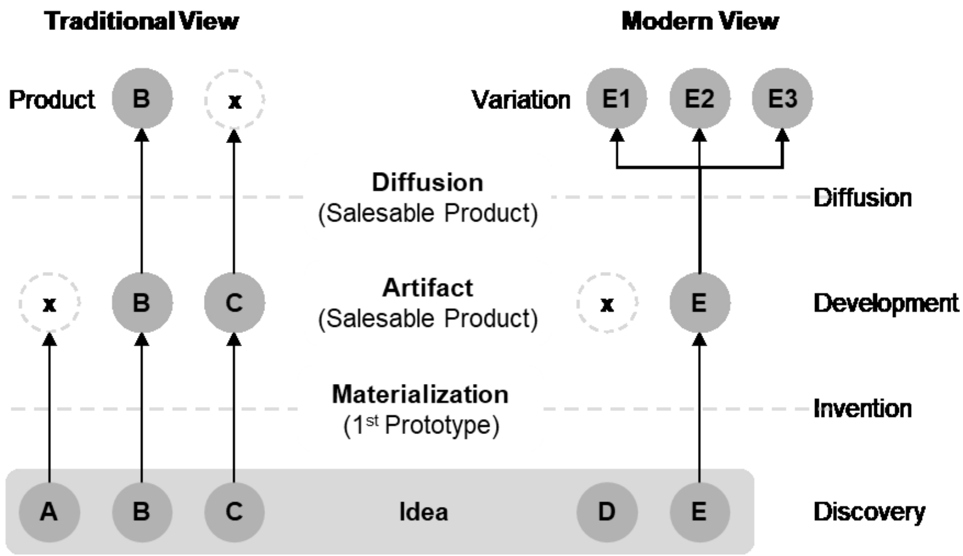

Figure 2-1 The Traditional and Modern View on the Production of Technical Knowledge

The invention[2] of a new artifact, product or other kind of technical knowledge can be divided into four simple stages (see Figure 2-1): Discovery, invention, development and diffusion (Braun-Thürmann 2005, 36–37). First, a promising idea is picked (stage of discovery) out of a pool of various ideas and basic research is initiated. Second, selective application-oriented research is pursued (stage of invention), which often ends with the registration of a patent. Third, in the transfer stage of development, an idea is designed into a commercial product. Finally, the invention is available on the market (stage of diffusion) and context of use is developed within society, which means the users decide about adoption or rejection.

However, the main weakness of evolutionary (see Figure 2-1) approaches has been substantially critiqued by Dierkes, Hoffmann, and Marz (1996, 34), who argue that "*the 'best' technical solutions survive and the 'poor' ones do not. Conventionally, the history of technology is therefore presented as a chronicle of 'technological victors'*". Similar to Darwin's evolution theory, technology also becomes a survival of the fittest, which quickly forgets the losers. However, there is the risk of imagining innovation as an "*evolutionary mechanism of technological inception*" (Dierkes, Hoffmann, and Marz 1996, 33). Ferguson (1974, 19) states that "*the whole history of technological development had followed an ordered or rational path, as though today's world was the precise goal toward which all decisions, made since the beginning of history, were consciously directed"*. In the end, this means that a linear evolutionary approach can only highlight successful and finished technologies.

Wiebe E. Bijker, Hughes, and Trevor J. Pinch (1987, 406) take this a step further, when they criticize the evolutionary approaches, because *"[they] rely on the manifest success of the artifact as evidence that there is no further explanatory work to be done."* Not implemented and unsuccessful technologies remain forgotten. Even more, successful inventions are not the only possible ones. In many cases, there are alternatives to the prevailing inventions. One example is the QWERTY keyboard (Braun-Thürmann 2005, 51), which is the dominant keyboard, even if more user-friendly alternatives exist, but never prevailed in the end.

In this context, another relevant limitation of the evolutionary perspective on technology becomes clear: Technology is often understood as a neutral, not moral, instrument. The utilization of the instrument makes a positive or negative invention out of it. In doing so,

[2] The terms artifact, invention, innovation, technological knowledge or product are regarded as interchangeable.

the responsibility for any technology assessment is pushed onto its utilization (Gleitsmann-Topp, Kunze, and Oetzel 2009, 35). The advantage of such a viewpoint lies in its simplicity to make the untransparent process of technology development accessible. According to this viewpoint, which is rather associated with technological determinism, technology development is seen as independent from society, which leaves the influence of the user on technology unconsidered. For instance, one may use a knife as a kitchen tool for cooking or as a tool to injure people. Technological determinism pushes the responsibility for the consequences of technology onto the society which is utilizing it.

Dierkes, Hoffmann, and Marz (1996, 33) argue that "*the history behind the emergence of these artifacts […], however, [is often] forgotten in the finished products*." Adequately, theoretical concepts have to offer analytic solutions (see Chapter 3) able to include alternative unsuccessful inventions as well. Otherwise, it is not possible to structurally capture current emerging fields, such as care robotics, with a theoretical framework. One of the characteristics of emerging fields is that the prevailing state of the art develops out of a process, with many unsuccessful inventions or ideas which never make it to the prototype stage. This process is dominated by trial and error. In other words, there is a danger that technology studies limit themselves to success and its reconstruction. It is not important to explain the success; it is important to explain the process.

For this reason, theoretical studies on technology have to address the relevant and critical impact factors of the process on technology development, which is fundamental for capturing the process of innovation in its full complexity. This study fulfils this responsibility through a two-step approach. First, a vocabulary from the STS is built up in order to capture the process of technology development and second, this vocabulary is interlaced into a theory, namely the concept of vision, to get an analytic tool to work with.

2.2 The Paradigm Shift to a Participatory Understanding of Technology Development

Already in the fifties, anthropologist Arnold Gehlen (1957, 9) mentioned the dependence of technology on human beings: *"The world of technology is, so to speak, the <great human>: Ingenious and tricky, life-supportive and life-disrupting like himself, with the* *same broken relationship to nature. It is, like humans, <nature artificielle>."*[3] Every technology is not only artificial by itself, but also depends on human beings, because without humans there would be no technology. Having said this, there has not been enough consideration to the circumstance that technology does not develop by itself. Mokyr (1990, 151) also argues that a technology-centered perspective provides an inaccurate approach to the reality of the emergence of technology, because *"the 'demand' for technology is a derived demand, that is, it depends ultimately on the demand for the goods and services that technology helps produce; there is little or no demand for technology for its own sake."* In other words, new technologies are embedded into a complex social setting rather than emerging in a vacuum. This can be summarized with Braun-Thürmann's (2005, 6) definition of innovation. According to this, *"innovations can be described as material or symbolic artifacts, that observers perceive as new and experienced as an improvement to the existing."*[4] This means that innovations are interactive objects produced artificially through social interaction and also, once emerged, become utilized through a specific social adaption. Thereby the needs of society are the major impact factor for the successful development of technology and its overall use within society. When having a closer look at various care robot projects (see Chapter 6), I presume that the ones which were developed according to the user's needs are the ones which will prevail in the long-term.

At this point, I want to recapitulate the contrary viewpoints of technological determinism and social constructionism[5] to avoid misconceptions about development. Both have in common that they are dealing with technology and its genesis, progress and impact and break down the life cycle of technology, but each end in its own way. A major difference is that the former, technology determinism, indicates an understanding of technology *"according to that technology determines, through its consequences, the social, while it is itself not determined by the social, but follows an intrinsic logic outside of social factors."* [6] (Grunwald 2012, 55–56) Thereby technology is understood as something with a high

[3] „Die Welt der Technik ist also sozusagen der <große Mensch>: geistreich und trickreich, lebenfördernd und lebenzerstörend wie er selbst, mit demselben gebrochenen Verhältnis zur urwüchsigen Natur. Sie ist, wie der Mensch, <nature artificielle>. " (Gehlen 1957, 9)

[4] „Als Innovation werden materielle oder symbolische Artefakte bezeichnet, welche Beobachterinnen und Beobachter als neuartig wahrnehmen und als Verbesserung gegenüber dem Bestehenden erleben." (Braun-Thürmann 2005, 6)

[5] I want to make a short remark on the difference between social constructionism and social constructivism, because the familiarity of both terms can be confusing. The former understands artifacts as the result of social interactions. The latter focuses on the process resulting from the interaction of a single or multiple actors, giving no specific importance to the artifact.

[6] „[…] danach determiniert die Technik durch ihre Folgen das Soziale, während sie selbst nicht durch das Soziale determiniert wird, sondern einer außerhalb gesellschaftlicher Einflussfaktoren liegenden Eigenlogik folgt." (Grunwald 2012, 55–56)

momentum, forcing society to adjust to it rather than being able to influence it. The latter sees technology development as a process, which is influenced by various actors and which sees technology as socially constructed. When focusing on emerging technologies, a social constructionist understanding of technology, according to which the innovation and its outcome is influenceable, fits better than technological determinism with innovation being an unchangeable process. This applies to care robots with their various representations as well, because they are an emerging field that is embedded in its target field of care, which in turn is strongly influenced by society and its needs.

Among the large number of theoretical approaches that deal with technology, the field of science and technology studies has especially to be mentioned, and it was established in the seventies. STS is not a single, but rather an interdisciplinary field, which is influenced by a variety of disciplines, in particular anthropology, psychology, and the political and social sciences (Niewöhner, Sörensen, and Beck 2012, 16). Within STS, many studies focus on the relationship of technology and society, and related questions. In many cases, the above-mentioned technological determinism is questioned by having a closer look at the framework of technology development. STS theories can be subdivided into theoretical and active approaches (Sismondo 2008, 19–20). The former focus on the essence of technology, its definition and structure, its genesis and change as well as its connection to society. The main questions discussed are to which degree technology is dependent and how it affects society.

My study relies on terminology from the social construction of technology. SCOT deals with technology genesis as a social process. Thereby the critical factors for successful technology development are social factors, such as the consensus within a group or the construction of a common sense about the utilization of technology within society. In this context, the key concepts are the relevant social group and interpretative flexibility, which I will go into in detail later in this chapter (see Chapter 2.3).

However, for a better understanding of social constructionist perspectives on technology development, I give an overview of the main approaches, which is at the same time a short history of STS. Thereby the following, namely laboratory studies, actor-network theory and feministic STS approaches are set in relation to my study.

Laboratory studies, which emerged in the seventies, made scientific knowledge and technology approachable for analysis. Coming from a social constructionist perspective, laboratory studies focused on the micro-level within the generation process of new knowledge – the laboratory. In deviation from previous studies on technology, *“what was* *new was that they [laboratory studies] observed natural science in practice and described and analyzed the local modalities and forms of the production of natural science and knowledge in the laboratory in detail"*[7] (Amelang 2012, 145). In doing so, laboratory studies opened natural science and laboratories for the field of STS. and STS for natural science by making use of ethnographic methods. The so-called 'black box' (Latour and Woolgar 1986, 242) as the knowledge thinking process within the natural sciences had been seen and could be accessed by empirical research. The main question now was how scientists achieved their data and obtained their results, rather than questioning the validity of results. Such research has a lasting effect on the contemporary view of natural science as a specific knowledge culture.

Two publications particularly shaped laboratory studies with their ethno-methodological approach of observing social reality created through daily actions of scientists. First, Lynch (1985), with his publication 'art and artifact in laboratory science', makes clear that science is the result of an ongoing interactional process influenced by certain socially located practices. His insights were deduced from fieldwork within a neuroscience's laboratory using participating observation. Second, Latour and Woolgar (1986) with their work 'laboratory life', in which they give a fundamental introduction about how to observe scientific work, including the complex embedding of research in an organizational and social network, form a basis for further research.

The contribution of laboratory studies to the field of science and technology studies is significant, because it opened laboratories as a research area for the first time. However, the microscale focus on mostly scientific and abstract methods for the creation of knowledge makes it difficult to apply it to this study. On the one hand, a major difference is given by the focus of analysis. Whereas science is the result of discoveries gained by experiments, technology is the result of design and a concrete production process. Put more simply, technology is the practical transformation of science, which usually materializes as invention. Since care robots are inventions, the focus automatically shifts to the process and interaction between involved actors, which laboratory studies cannot capture adequately.

Latour (1996), Law (1986) and Callon (1986) are considered as the primary developers of the actor-network theory. The actor-network theory gives a theoretical framework for uncovering the interactions of actors and networks accessible for analyzation. According

[7] „Neu war, dass sie Naturwissenschaften in der Praxis beobachteten und die lokalen Modalitäten und Praxisformen naturwissenschaftlicher Natur- und Wissensproduktion im Labor detailliert beschrieben und analysierten." (Amelang 2012, 145)

to this theory, knowledge structures emerge within networks. Laboratory studies, and especially Latour and Woolgar, inspired later research and studies on the actor-network theory. The actor-network theory assumes a strong heterogeneity within networks, which includes humans and non-human beings as actors. Strictly speaking, everything, including materialized objects as well as abstract things such as institutions, can become a network. Both are equal and active actors, and consequently they have to be treated and analyzed equally. It postulates that "*this general symmetry in the analysis makes it possible to uncover that knowledge and technologies are not only defined by social phenomena such as hierarchies, interests and values, but also by the contribution of apparatus, instruments and other things*" [8] (Mathar 2012, 173). In doing so, actor-network theory not only attributes the capacity of action to physical objects, but also criticizes SCOT theories through giving material and immaterial objects the possibility of becoming actors. According to SCOT, humans make technology, but in turn technology influences human action, too. Central for the actor-network theory is that human and non-human actors are equal and organized in networks, where they figuratively work towards a common goal.

In doing so, actor-network theory makes it possible to unveil the relational links within a network, rather than being able to explain why and how a network is constituted as it is. What is important is the interrelation of several actors within the network. The theory remains very abstract and makes it difficult to build up a theoretical framework for a structured analysis of technology. Nevertheless, actor-network theory sensitizes that it is important to not only take human actors and the emerging invention into account. The outcome is not necessarily in focus, which makes it difficult to apply the theory for analysis onto a specific invention, in this case care robots, as the outcome of a complex process.

At its beginning, feministic STS' focus was a heterogeneous spectrum covering the interrelation between the creation of gender and the development of science. The history of science has mainly been influenced by male researchers and inventors, and left only limited space for women to be mentioned. For this reason, the themes of feministic STS include, for example, the exclusion of women from the history of science, or the problematization of theories, which include social beliefs on gender. Feministic STS experienced an upturn in the eighties through the emerging SCOT approach. Early feminists, in particular Harding (1993), urged for a strong objectivism, because scientific objectivity

[8] „Diese generelle Symmetrie in der Analyse ermöglicht es sichtbar zu machen, dass Wissen und Technologien nicht nur von sozialen Phänomenen, wie Hierarchien, Interessen und Werten definiert werden, sondern auch durch die Beiträge von Apparaten, Instrumenten und anderen Dingen." (Mathar 2012, 173)

and the development of knowledge are subject to social beliefs. Science and technology are the result and manifestation of patriarchal power relations, which can only be overcome by readjusting the specifications of scientific objectivity. In the following years, the progress of biological and medical science questioned the gender- and sex-specific perception of the body, and lead to a redefinition of the human as a more or less open and free construct, especially in contrast to a traditional religious understanding. Feministic STS picked up a new understanding of gender, which shifted from its formerly material-orientated focus to paying more attention to the intangible. Feministic STS research and the localized concept of technoscience, which questioned the existing scientific and common practices, are complementary. Donna Haraway (1988, 583) argues that

> *"The moral is simply: only partial perspective promises objective vision. All Western cultural narratives about objectivity are allegories of the ideologies governing the relations of what we call mind and body, distance and responsibility. Feminist objectivity is about limited location and situated knowledge, not about transcendence and splitting of subject and object."*

The major issue is that science and technology are inseparable research subjects and objects of influence at the same time. In other words, for STS feminists, the focus has to be on how to create neutral knowledge and to what extent concepts of neutrality itself are the result of gender specific selection. Technoscience is not limited to laboratories, but can also include popular culture such as video games and SF literature.

In recent years, feministic STS scholars discussed and contributed to current topics, such as genetics or automatization that emerged out of the newest developments in science and technology. One is Sarah Franklin with her research on reproductive technologies in the context of embryos (Franklin 2006) and the cloned sheep Dolly (Franklin 2007), where she goes into the social and cultural implications resulting of genetic engineering. Suchman with her research on the human-machine interaction (Suchman 2009) and AI. Both scholars use the term 'cyborg'[9], which had already been mentioned by Donna J. Haraway (1991) in her publication 'Cyborg Manifesto'. Furthermore, Robertson (2007, 2010, 2014, 2018), with her work, transfers the feministic STS on robots in Japan and related gender perceptions.

For this study, feministic STS, with its emphasis on the gender aspect of technology and its development, provides something to think about since the majority of robot developers and engineers are male, and they bring their concept of gender and role models. This means, in general, that male engineers develop their technical solutions for a majority of

[9] The term 'cyborg' is understood as a hybrid creature of living being and a machine.

female users. Against this background, feministic STS contributes to the development of a research framework that can uncover gender presumptions and their impacts, also for the study at hand.

2.3 The Birth of the Social Construction of Technology

The more participatory understanding[10] of technology development is the starting point for SCOT, in which the social dimension and the user play a key role (Trevor J. Pinch and Wiebe E. Bijker 1987; Oudshoorn and Trevor J. Pinch 2003b). For Pinch and Bijker, the spiritual fathers of the SCOT approach, the social dimension provides the *“explanations for the genesis, acceptance and rejection of knowledge-claims [what] are sought in the domain of the Social World rather than in the Natural World”* (Trevor J. Pinch and Wiebe E. Bijker 1984, 401). Having said this, SCOT is not a single approach, but rather a theoretical framework with various open suggestions that inspired many scholars. The basic assumption of SCOT is that every development of technology is a social process. Trevor J. Pinch and Wiebe E. Bijker (1984) segment this social process into three stages, namely the utilization potential of a technology, its stabilization and subsequent integration into the broader socio-cultural context. That is to say, rather than technical factors (e.g. durability or use of latest technologies), social processes (e.g. consensus or meaningfulness) are critical for the development of a certain technology and its success. SCOT attempts to practically explain how and why technology is used within society.

Pinch and Bijker are not the only ones who recognized the impact of society and culture on technology development. Already, before the eighties and SCOT, Carroll (1971, 647) emphasized the influence of society on technology development, when pointing out *“that participation in the public development, use, and regulation of technology is one way in which individuals and groups can increase their understanding of technological processes and develop opportunities to influence such processes in appropriate cases.”* This early understanding of the relevance of social participation prepared the ground for an active and critical technology assessment. According to that, society has not only passively responded to new technologies and their aftermath, but can use the chances which arise out of participating in technology development. There has been research on the impact of non-engineers and their mindset about how to solve social problems with

[10] According to a participatory technology development, single or multiple actors can actively influence the process, shape the outcome of technology development and weigh their thoughts.

technology, too. In his paper about the implications of technology assessment for politics, Wynne (1975, 135) points out:

> *"At least in contemporary society, however, technology is a good deal […]. It mediates man's understanding of his social situation, […] which help to constitute his definition of social reality. It serves, in fact, important symbolic roles in society, e.g. as the agent and mediator of status, progress, destiny, and so on."*

The shift from society as an object of technology to a subject was the essential basis for later social constructionism. Hereinafter, society, and thus various interest groups, could actively exert their influence on technology development. In Japan, to give one example, government as one interest group in particular promotes the use of care robots before the background of demographic change and expected shortage of labor within the field of care.

Social groups and needs form the determinant for the construction and shapes of knowledge and technology. The metaphor of Darwinian evolution makes the course of technology development easy to understand. However, a closer look reveals that technology follows no biological-evolutionary law. It does not emerge for its own sake, and seemingly better inventions successfully diffuse. Technology does not determine use, but rather the demands and needs determine technological change and its diffusion. In this context, the evolution and terminology of SCOT described as *"the development process of a technological artifact […] as an alternation of variation and selection"* (Trevor J. Pinch and Wiebe E. Bijker 1984, 411) have, to a certain extent, similarities. This variation and selection of development processes and paths within care robotics pave the way for future products and their usage.

However, relevant social groups, which see an emerging technology as a solution for a specific problem, exert the major influence on an invention. The importance and problems vary for each of the involved groups. Consequently, various groups have different understanding of emerging technology and assign different meanings to it. Trevor J. Pinch and Wiebe E. Bijker (1984, 423) emphasize this when saying that *"different social groups have radically different interpretations of one technological artifact."* This group-specific connotation becomes essential when evaluating for whom and whether a developed invention is useful or useless. Even more, the user and technology are not separated; they are two sides of the same coin (Oudshoorn and Trevor J. Pinch 2003a, 2–3). This also applies to care robots and their use within society. The invention, namely the robot itself, and society are interconnected. There is no successful development of a certain robot without taking the needs of society into account. In conclusion, SCOT is typically very empirical, because it focuses on how technology is used.

In this context, this understanding suggests that the approach is too narrow, because it limits influence on the technological decision to immediate needs, interests, problems and their solutions of selected social groups. Winner (1993, 370) criticizes that*, "[SCOT] disregards the possibility that there may be dynamics evident in technological change beyond those revealed by studying the immediate needs, interests, problems, and solutions of specific groups and social actors."* Social interactions between social groups are not only determined on a level of individual or narrow needs, they are influenced by a complex social and cultural framework as well. I will pick this point up later, when talking about the connection of culture and robotics (see Chapter 3).

The social group of engineers is particularly interesting, because as it is closest to the process of technology development, it influences care robotics more than any other relevant social group, such as the ministerial bureaucrats or caregivers. The individual approach to care issues and its automation capacity reveals much about problems and solutions not only limited to the field of care, but also within society. Robotic toilet aids are one example, where technology intends to solve a private and very delicate issue. The approach of a certain engineer to the care task of going to the toilet reveals a lot about the relevance of care from an engineer's perspective. Also Trevor Pinch and Wiebe Bijker (1986, 351) stress the significance of focusing on the developer or engineer *"[important] is not to turn to macro-sociological theory, or to speculate about possible alternative technologies, but to carry out micro-studies of how engineers and technologists actually go about deciding whether or not a technology works and how it is to be tested."* Their statement is a reaction to Russell (1986, 338), who criticized their approach as too much focused on the artifact and too little on the macro-sociological relations. The advantages of a micro-study for Trevor Pinch and Wiebe Bijker (1986, 354) are that *"by studying the activities of engineers in laboratories it is possible to understand how society is transformed in the laboratory."* In the end, how the laboratory interprets society is reflected in their contribution on how to solve social issues through technology. For the case of Japan, the developers function as the tool of society for how society wants to face its demographic challenges.

The first stage of Trevor J. Pinch and Wiebe E. Bijker's (1984, 421) SCOT approach is the reconstruction of alternative interpretations on technology. Then the exploration of problems, which have to be solved by a certain technological artifact, follows. Various relevant social groups, which are involved in the development process, attach varying importance to certain developments. This varying perception of a desired invention, its function and meaning depending on the relevant group, leads us to question the view of inventions in general. To some extent, this leads to a loose understanding of the process of technology genesis and its use, as well as a pluralism of divergent interests. That is why social constructivists prefer to speak of a pluralism of artifacts or interests, because one artifact looks different in every context. Pluralism is possible through an overall ambiguity of an artifact, precisely why it is not only possible to interpret it, but rather necessary to do so. Trevor J. Pinch and Wiebe E. Bijker (1984, 421) were apparently the first to use this under the term of interpretative flexibility, whereby *"[…], not only that there is flexibility in how people think of, or interpret, artifacts, but also that there is flexibility in how artifacts are designed. There is not just one possible way, or one best way of designing an artifact."* This flexibility allows taking non-technical influencing factors (e.g. cultural specifics, religious rituals, philosophical traditions) into account. The development process and shifting interpretation patterns are like a trial-and-error search for the final working solution. Winner (1993, 366) describes the relationship of the relevant social group and interpretative flexibility, as well as its relevance for research as follows:

> *"What social analysts do in this new focus is to study the 'interpretative flexibility' of technical artifacts and their uses. […] People may use the same kind of artifact and its uses can vary widely as well. […] They [social analysts] must pay attention to the variety of interpretations of what a particular technological entity in a process of development means and how people act in different ways to achieve their purposes within that process."*

This also applies to the study at hand as well, when the responsible engineers and their robot projects are analyzed, which includes the examination of their intended concepts of use. A prevailing meaning of care robots, and a habitual use of a robotic invention is not developed before a technology stabilizes, and the interpretative flexibility and issues with the technical artifact are solved. Furthermore, each relevant social group decides for itself which problems with an artifact they want to solve. Trevor J. Pinch and Wiebe E. Bijker (1984, 414) note that:

> *"In deciding which problems are relevant, a crucial role is played by the social groups concerned with the artifact, and by the meanings which those groups give to the artifact: a problem is Clayton (2002, 353) only a defined as such, when there is a social group for which it constitutes a 'problem'."*

They (Trevor J. Pinch and Wiebe E. Bijker 1984, 415) argue moreover that:

> *"A detailed description of the relevant social groups is needed in order better to define the functioning of the artifact with respect to each group. […] Having*

> *identified the relevant social groups for a certain artifact we are especially interested in the problems each group has with respect to that artifact. Around each problem, several variants of solutions can be identified."*

The second stage of Trevor J. Pinch and Wiebe E. Bijker's (1984, 424) SCOT focuses on how to solve a problem and thus to stabilize an artifact. This refers to the manifestation of a technology, in particular a specific artifact, and the collapse of interpretative flexibility among several relevant social groups. It is the progress of reaching a consensus on the use of a certain technology. According to SCOT, technology development is a form of social negotiation between several relevant groups. In the course of this, the interpretative flexibility and coexisting interpretations of the involved groups compete for predominance. The more interpretative flexibility is shrinking, the more the invention takes shape and through a process of variation and selection, gains clarity. Finally, the ambiguity disappears, the discourse about its interpretation is closed and what is left is the developed artifact. Trevor J. Pinch and Wiebe E. Bijker (1984, 426–27) point out that:

> *"To close a technological 'controversy', the problem need not to solved in the common sense of that word. The key point is whether the relevant social groups see the problem as being solved. In technology advertising can play an important role in shaping the meaning that a social group gives to an artifact."*

It is not about the question of technical rationality or the best solution to a problem, but rather how relevant groups evaluate a solution to their problem. The disappearance of a problem through an artifact, i.e. its stabilization, is called rhetorical closure by Trevor J. Pinch and Wiebe E. Bijker (1984, 428). Moreover, the fact that stabilization can be supported through advertising, promotion and by organizations close to the government or by government itself will be shown as a significant impact factor when investigating the emergence and diffusion of care robotics in Japan.

Another way to close the discourse is the redefinition of a problem. Trevor J. Pinch and Wiebe E. Bijker (1984, 428) go further into this, when talking about the air tire. The original intent was to solve the public problem of bicycle vibration in terms of racing bicycles' speed, when air-tired proved superior to traditional airless-tired bicycles. *"And thus, by redefining the key problem with respect to which the artifact should have the meaning of a solution, closure was reached for two of the relevant social groups. How the third group, the engineers, came to accept the air tyre [sic] is another story"* (Trevor J. Pinch and Wiebe E. Bijker 1984, 428). It becomes clear that the rhetorical closure. as well as the redefinition of the problem, has a separate logic, which can be irrational and even exclude the developers when their technology is used in a different context.

One remark has to be made on the often cited case of the bicycle; although this example makes it easy to understand the SCOT approach and terms, there are historical findings that take issue with the clarity of the illustration. Clayton (2002, 358) mentions that from the beginning, Dunlop designed the pneumatic tires not only for comfort, but also as an acceleration device as already mentioned in their patent.

I will illustrate this abstract approach by referring to the application example of the invention of the bicycle given by Trevor J. Pinch and Wiebe E. Bijker (1984). Besides there are other examples used to illustrate the SCOT approach, e.g. bakelite and fluorescent lightning (Wiebe E. Bijker 1987, Wiebe E. Bijker 1992), the radio (Douglas 1999), telephone (Fischer 1992), the manufacturing of steel (Misa 1992) and the internet (Abbate 1999). The original utilization concept of the bicycle was one of an antivibration device, which intended to improve the driving comfort. However, the target group, venturesome young men, did not accept this because for them and their cultural context, namely sport, speed was central. This did not change until pneumatic tires successfully asserted at races. Comfortable tires transformed into an essential tuning part, which in turn made it possible for their interpretative flexibility to disappear.

Silverstone (1993, 227) made changes to the concept of interpretative flexibility which, regarding his understanding, is more likely the process of utilization. Thus, he prefers to use the term ‘domestication’, which he defines as *“a process of domestication because what is involved is quite literally a taming of the wild and a cultivation of the tame.”* This is was concretized by Oudshoorn and Trevor J. Pinch (2003a, 14), when pointing out that emerging technologies have to make the transition from unfamiliar, interesting and promising things *“into familiar objects embedded in the culture of society and the practices and routines of everyday life.”* In other words, where Trevor J. Pinch and Wiebe E. Bijker focused on the process of problem solving, Silverstone (1993, 232) emphasizes the utilization and consequent diffusion as a *”negotiated and underdetermined process of technological and social change”.*

However, both have in common that it is a question of power as to which relevant group asserts itself in the end. This is a critical factor for acceptance and consequently the diffusion of not only a single care robot, but also of care robots as a whole in general. Technology has to be culturally accepted to successfully diffuse (Oudshoorn and Trevor J. Pinch 2003a, 12). The key for diffusion is integration into everyday life, which can only be successful through understanding its socio-cultural framework. For care robots, this means that already at the beginning, the development process has to include the social needs of the very special and demand-driven field of care, because with felt improvement on care, the development will end at the stage of a prototype at the latest.

However, before being able to pay attention to a specific socio-cultural framework, it is necessary to leave the conceptual design process and reveal the demands of daily life. When thinking about care tasks, such as lifting people from a bed into a wheelchair, which care robots can carry out, it is obvious that they are not limited to Japan. On the downside, cultural specificities might develop, such as bathing aids or transfer aids for small or light persons, which may not be easy to integrate into the everyday life of other countries. The consequence is that, as a general rule, Japanese care robots are worth considering for other countries as well. At this stage of diffusion, it is more important to understand the general state of development and benefit for society than to consider cultural specificities. Due to that the field of care robotics is currently emerging, the majority of care robotics currently are in development or still on the level of prototypes or a testing-phase. Only a limited number of robots are ready for the market, or ready to use and can thus start their process of domestication with all the involved actors and groups.

This brings us to the third stage of Trevor J. Pinch and Wiebe E. Bijker's (1984, 428) SCOT approach to set a technological artifact into a broader setting. Trevor J. Pinch and Wiebe E. Bijker (1984, 428) summed it up when they said, *"obviously, the sociocultural and political situation of a social group shapes its norms and values, which in turn influence the meaning given to an artifact."* They call this broader setting the wider context, but rather than to expand this concept, their approach ends and remains unclear without making use of the explanatory potential of their approach. The discourse about how to solve a common or social problem, and the acceptance within a wider framework, are two essential points when talking about the diffusion of care robots within society (see Chapter 6.9), because both might involve probable opposing interests of relevant social groups. For this reason, it is necessary to solve this theoretical gap with other concepts in order to analyze the interrelation between the original artifact and its related broader setting, which includes its utilization by society.

The SCOT approach offers an understandable and accessible overall approach on technology development. However, SCOT and especially the undeveloped thoughts of the 'wider context' have been reviewed critically. One main limitation of the SCOT approach is its lack of technology assessment. The approach describes how technologies emerge, but overlooks the impact and consequences of technology afterwards. Winner (1993, 368) argues that *"the most obvious lack in social constructionist writing is an almost total* *disregard for the social consequences of technical choice."* According to his understanding, technologies become describable, but stay descriptive. SCOT offers no answer on how to deal with the consequences of technology or how they matter in this 'wider context'. Winner (1993) criticized the SCOT approach for not taking a moral position on the advantages or disadvantages of a technology. Winner (1993, 372–73) argues that:

> *"The frequency with which technology looms as a crucial issue for commitment in modern society makes this posture [of the interpretative flexibility] an extremely vain and unhelpful one. Sometimes it matters what a thing is, what name it has, and how people judge its properties. […] But noticing the diversity and flexibility of interpretations in such cases is of little help."*

It makes sense to urge for informative value for implications on society. However, it is the claim for an almost impossible balancing act between being an analytic tool to understand technology development, and at the same time being an assessment tool to evaluate a technology and its future impact within society.

Since the publication of the SCOT approach in the eighties, it was amended and criticized by several scholars, e.g. the actor-network theory for its limited agency. The below-mentioned scholars represent some examples within a large number of interpretations and adjustments of the SCOT approach, which tried to meet recent developments in science and technology.

One major extension of the SCOT approach was formulated by Wiebe E. Bijker (1987) with the concept of the 'technological frame'. According to their definition, *"a technological frame is composed of, to start with, the concepts and techniques employed by a community in its problem solving"* (Wiebe E. Bijker 1987, 168). Technological frames are located not within a single actor, but between them. Here one can see parallels to actor-network-theory and Callon's (1986) understanding of networks, which also emphasize the interaction between actors as crucial. A technological framework links a variety of determinants such as tacit knowledge, technical expertise or cultural understanding. According to Orlikowski and Gash (1994, 179) technological frames have to be extended on formative elements, such as the concept of design and application, as well as the artifact of the robot itself.

It is the framework for application possibilities and, at the same time, a problem perception and a problem-solving approach, whereby the latter creates stability in thinking and interaction patterns.

In the end, what is more important than an engineer with a revolutionary concept for a care robot is if this concept connects to a network and involves the network in the course of development. Wiebe E. Bijker (2007, 122) makes this clearer by pointing out that *"people with a high degree of inclusion in a technological frame will find it difficult to imagine other ways of dealing with the world, of using these things radically differently or even not using them at all."* The technological frame does not mandatorily determine the outcome. Rather it influences the interaction between actors and consequently the objectification of an artifact. The degree of inclusion into a technological frame is concurrently the degree of influence of an actor within a social group. It is the theoretical and functional consensus between various actors about the artifact, which is essential for successful development. To put it in a nutshell*, "[a technological frame] must be applicable to social groups of non-engineers also"* (Wiebe E. Bijker 1987, 171). Even the best care robot will not objectify if its concept does not make it possible to get a social group behind it. This includes not only the classical consensus of participatory decision-making, but also the transfer process of engineers' technical concept of the care robot communicated clearly to a non-technical audience. Otherwise, consensus and success-critical involvement in development will not take place. As a consequence, Orlikowski and Gash (1994, 175) argue that:

> *"An understanding of people's interpretations of a technology is critical to understanding their interaction with it. To interact with technology, people have to make sense of it; and in this sense-making process, they develop particular assumptions, expectations, and knowledge of technology, which then serve to shape subsequent actions toward it."*

These sense-making processes are of critical importance, because they can reveal how not just a single actor, but also the associated organization of the actor, think and take action towards an invention in the development stage. Consequently, to disclose these processes helps to understand the influence of an actor and its organization on the objectification, implementation and transformation of technology.

A shared technological frame within several actors increases the chances of success. However, developer and user might have different views on and knowledge about a certain technology. Orlikowski and Gash (1994, 203) call this coexistence of various perceptions 'frame incongruence'. This may lead to a lock-in situation. This means in turn that, as soon as an artifact has developed or, to speak in SCOT terminology, the discourse on the interpretation is closed, change and modifications might become difficult. According to Orlikowski and Gash (1994, 177) *"[technological] frames can create 'psychic prisons' that inhibit learning"* and ultimately the established concept *"may even stand* *in the way of innovation"* (Wiebe E. Bijker 2007, 122). The robot wakamaru[11] is one example that illustrates the problem of frame incongruence and its impact on successful technology development. After a longer process of decision-making, Mitsubishi Heavy Industries committed to the concept of wakamaru as a communication robot partner for everyday life (Mitsubishi Public Affairs Committe 2006). However, in the following years, the communication robot served more as a receptionist for companies' entrance areas or exhibition halls than it was used in homes. The originally intended home use could not prevail. In the end, Mitsubishi was not able to recalibrate a new business-oriented concept effectively. Mitsubishi did not succeed in replacing its old concept and the underlying technological frame within relevant social groups. A first rental service was launched, but the wakamaru itself never advanced beyond the first prototype.

Rather than only focusing on the developer side, scholars focused on users and non-users of new technologies. Cowan (1987) stressed the importance of user inclusion, which she identified as the 'consumption junction'. Technology development does not start and end with the engineer. According to Cowan (1987, 262), the user, or in her terminology 'consumer', is *"a person embedded in a network of social relations that limits and controls the technological choices that she or he is capable of making"* and thus can be seen as the key actor between the developer and later diffusion. This is an important point for emerging fields such as care robots. When the user accepts a certain care robot even or especially in the development stage, this dramatically increases the chances of its diffusion within society. Already, in an earlier publication, Cowan (1983, 143) advanced to the heart of this issue when pointing out that *"the machine that was 'best' from the point of view of the producer was not necessarily 'best' from the point of view of the consumer."* Particularly in retrospect, a user-side analysis allows better understanding of why one invention was successful and another failed. For widespread diffusion of a single, or multiple, care robot within society, it is not about the implementation of engineers' presumed best technical solution for a problem. It is about how the user evaluates and interprets their technical suggestions, and further, how the user is able to modify engineers' technical suggestions for a certain issue to their very specific needs, which is critical.

[11] Wakamaru was made by Mitsubishi Heavy Industries in 2005. The measurements of the robot with two arms are 100 cm tall and 30kg heavy. The height of the yellow humanoid robot makes the design remind of a unisex child.

Oudshoorn and Trevor J. Pinch (2003b, 25) give something to think about by approaching this from the opposite angle, whereby *"the non-users and people who resist technologies can be identified as important actors in shaping technological development."* The non-use of an artifact directly influences its (dis-)appearance, because no matter how advanced an invention might be, without users, its influence remains insignificant. Wyatt (2003, 78) further postulates the benefit of *"the importance of incorporating users […] as way of avoiding the traps associated with following only the powerful actors. Another way […] is to take non-users and former users seriously as relevant social groups, as actors who might influence the shape of the world."* Powerful actors can be ministries (e.g. MHLW, METI) and large companies (e.g. Mitsubishi Heavy Industries, Panasonic or Sony). They can create and foster a conducive climate for the development of care robots, but can fully ensure a successful outcome. The examples of METI and Sony illustrate the issue of user(s). On the one hand, METI was not able to create a sustainable demand for care robots within society with large financial subsidies, and on the other, Sony, even with its large financial and organizational capacities, was not able to place their robot-dog AIBO profitably on the market. Sony started to sell AIBO in 1999, but announced its discontinuation[12] in 2006.

The non-use(r) of technology makes it possible to overcome basic issues of technology studies with its tendency to highlight successful, and easier to study, technologies. In this context, one major problem of SCOT becomes obvious: the identification of all relevant social groups. Winner (1993, 367) calls this the problem of 'irrelevant social groups'. Winner (1993, 369) raises the questions *"who says what are relevant social groups and social interests? What about groups that have no voice but that, nevertheless, will be affected by the results of technological change?"* In reality, this leads to two issues. First, it is unavoidable that even within the involved social groups there is some kind of power structure between more and less influential groups. The higher-ranked groups can decide the solutions for all. The social groups, which raise their voices, are not heard, even though a certain technology affects them. Second, irrelevant groups are in principle difficult, if not impossible, to detect. Winner (1993, 369) summarizes that *"by noticing which issues are never (or seldom) articulated or legitimized, observing which groups are consistently excluded from power, one begins to understand the enduring social structure upon which more obvious kinds of political behavior rest."* For this study, the group of the

[12] This discontinuation of AIBO (ERS-110 Series to ERS-7M3 Series) was only temporary. Sony announced a restart of AIBO (ERS-1000), now in small letters 'aibo', after twelve years in 2017 (Sony 2017).

end-user might be such an irrelevant group, which includes caregivers, and even more importantly, the elderly as the recipients of care.

Cowan and Wyatt have in common that their approaches to technology focus on users, or non-users. Both question the traditional view on technology, whereby technology development is an evolutionary process without mentioning unsuccessful alternatives. Cowan (1983, 128) urges that *"in order to find out why a particular test model was never manufactured, one must learn about the technical problems involved, the decision-making procedures within the company that developed the test model, the state of the general economy, the availability of resources, and so forth."* Furthermore, Trevor Pinch and Wiebe Bijker (1986, 353) comment on the importance of tracing alternative solutions within the development process, because *"if a technological artifact can be shown to have more than one developmental path, and if radical departures are possible, then this argues against the view that there is a necessary immanent logic of technical development."* Even though the importance is emphasized, it remains difficult to take non-users of technology into account, because usually they are much more difficult to access. The same applies to unsuccessful technologies. The SCOT approach provides insufficient response to the question of why alternative unsuccessful care robots are not considered, even if they might have been the better solution for a future problem.

When taking a closer look on the potential and diffusion of care robotics in Japan, a conclusive analysis must include the user side, because otherwise it only touches the surface of the topic. What one engineer thinks might be revolutionary for the field of care might be useless for care workers, because of its limited value to improve their actual everyday life. For this reason, the study at hand is not only limited to the developer side, but also extended to care-related facilities and thus pays attention to the user-side and the non-use aspect. Additionally, two unsuccessful inventions (wakamaru and ROBEAR), which went beyond the prototype stage but never gained wide use, could be made accessible through interviews with the responsible developer (see Appendix).

In conclusion, the initially introduced term of evolution seems to make sense for explaining technology development on the surface, because technology development undergoes an evolutionary process. However, the concept of evolution leaves out the influencing factors of technology development almost completely.

The science historian Layton (1977, 198) pointed out *"what is needed is an understanding of technology from the inside, both as a body of knowledge and as a social system."* In the light of this, the process of how an artifact or a technology is shaped can easily be understood with the SCOT approach. It provides terminology to identify the important steps from a first vague idea to a finished invention. Even if Trevor J. Pinch and Wiebe E. Bijker (1984, 406) offer no solution to locate unsuccessful artifacts, they are right when they mention that *“the success of an artifact is precisely what needs to be explained.”* Thereby, recent developments and tendencies within the field of care robotics, as will be shown below (see Chapter 3), can be, at least partly, explained by making use of the terminology of social constructionism. Social constructionism, in which technology development is socially situated and inventions are constructed through interaction with various actors and groups, makes technology accessible as a research object. The process of technology development and its outcome, the artifacts, are influenceable. The quest of analysis is to find these influencing factors, and the relevant actors and groups behind it.

Moreover, when having a closer look at specific robot projects within the field of care robotics (e.g. mobility aids), what Trevor J. Pinch and Wiebe E. Bijker found when analyzing the development history of the bicycle applies even in the present *“In the view of the actors of those days, these variants were at the same time very different from each other and equally were serious rivals”* (Trevor J. Pinch and Wiebe E. Bijker 1984, 411). Expressed in other words, for deep analysis of current development trends and the future of an emerging field, such as care robotics, it is invaluable to deal with the parallelly existing technology alternatives which express different visions and concepts. Only through showing alternatives and the concepts behind various robots is it possible to detect similarities or fundamental differences. This builds the basis for evaluation of the process of technical and social maturity of care robotics in general. In more simple terms, if society develops an understanding on how to utilize technology for its purpose, or in SCOT terms, to solve its problems, it gives insights about how society currently accepts care robots and diffusion in general might be progressed. Furthermore, what obstacles have to be solved for a successful diffusion of an invention?

For the case of robot pioneer Japan, one issue remains: Why does the acceptance of care robots remain low, even if the number of available robots increases? Instead of adhering to taken for granted work practices, it makes sense to reduce the physical burden of caregivers by superseding physical tasks with already developed and tested robotic devices. However, reality is different. Trevor J. Pinch and Wiebe E. Bijker (1984, 416) explain this upholding of traditional patterns when talking about the history of the bicycle*: “As a result of the stabilization of the artifact [namely the bicycle] after 1898, one* *did not need to specify these details: they were taken for granted as the essential 'ingre-dients' of the safety bicycle."* This non-acknowledgment of a certain new technology is applicable to the change of work practices, in the case of using care robots. New tech-nologies challenge long-established work practices of providing care by hand. Mokyr (1990, 12) gets to the heart of this by remarking that "*in every society, there are stabiliz-ing forces that protect the status quo. Some of these forces protect entrenched vested interests that might incur losses if innovations were introduced, others are simply don't-rock-the-boat kind of forces. Technological creativity needs to overcome these forces.*" The mentioned technological creativity must include offers to ensure that new ways of providing care will be accepted, such as technologically driven care from caregivers, instead of physically demanding manual labor.

So far, the SCOT approach offers the terminology to explain technology development, especially in the retrospective. However, its limitations, such as the problem of finding irrelevant social groups addressed by Winner (1993), makes it a non-standalone kind of analyzation model. For this reason, the elaborated terminology of SCOT (see Chapter 2.3) serves as a vocabulary. The SCOT terminology unfolds its explanatory power when it is combined with a theoretical framework. Especially for emerging technologies at a very early stage of the development process, such as the case for care robotics in Japan, this combination of terminology and theoretical concept helps to grasp the complexity.

2.4 The Concept of Visions by Dierkes, Hoffmann and Marz

In my study, I adapt the theoretical concept of vision and interlink it with the terminology of SCOT. SCOT possesses a differentiated vocabulary to easily describe technology development but provides only a vague theoretical framework to structure the process of materialization from an idea to a finished artifact. By contrast, the framework of vision structures the process genesis of technology very well, but its terminology remains vague. Where SCOT and the vision concept have weaknesses, they are completed by each other.

This integrative approach is above all especially well equipped for empirical study and technology assessment, which takes sociocultural factors into account. Rammert (1993, 49) points out that it is indispensable for technology assessment to take a closer look at organizational and institutional environments to become meaningful.

> *"Who wants to competently assess the consequences of new technologies of today, cannot address this without a precise knowledge of the social conditions of the generation and the design of technical products. Because in the organized processes of technology development, namely in research institutes and industrial laboratories, the preliminary decisions on the design and the use of new products and therewith also partly for the consequences are taken. The rest of the consequences are caused by the institutional conditions and cultural patterns of acquisition and the handling of things in their respective social sphere."*[13]

Technology assessment has to be given attention even beyond artifacts. An artifact is the result of organizational and institutional interactions within a specific cultural environment. For this reason, it is necessary to discover the overall framework behind an artifact and its relevance on the process of innovation, as well as the interconnections between several actors. The theoretical approach of Dierkes, Hoffmann, and Marz (1992, 1996)[14] is centered on visions and offers a tool to analyze the process of turning a first vague idea into a marketable product. Thereby the approach especially pays attention to impacts and obstacles, such as organizational and institutional environments that directly influence the outcome of technology development. According to their understanding, a vision follows the desire of various actors to achieve realization through gradually increasing technical feasibility. There is a strong interlink between a vision and the following innovation; simply said, there is an inseparability of the idea behind a concrete invention.

In what follows, the concept of vision as theorized by Dierkes, Hoffmann, and Marz (1996) will be presented by an examination of their publication 'Visions of Technology', supplemented by the terminology of SCOT. The subject of their is the genesis of innovation and the process of how an imprecise thought develops into a successful invention. The essential role of visions is seen as stemming from their formative function (1992, 31). The focus of the vision concept[15] therefore is to identify and to concretize functions that have

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[13] "Wer gegenwärtig kompetent die Folgen neuer Techniken abschätzen will, kann dies nicht ohne genauere Kenntnis über die Sozialen Bedingungen der Erzeugung und Gestaltung technischer Produkte angehen. Denn in den organisierten Prozeßen der Technikentwicklung, in den Forschungsinstituten und Industrielabors, fallen schon die Vorentscheidungen über Gestalt und Verwendung neuer Produkte und damit auch für einen Teil der Folgen. Der restliche Teil der Folgen wird durch die institutionellen Bedingungen und kulturellen Muster der Aneignung und des Umgangs mit den Dingen in den jeweiligen gesellschaftlichen Bereichen hervorgerufen." (Rammert 1993, 49)

[14] Dierkes, Hoffmann, and Marz first published their vision concept in German in 1992 under the title "Leitbild und Technik: Zur Entstehung und Steuerung technischer Innovationen" an edited and extended version in English in 1996 in under the title "Visions of Technology: Social and Institutional Factors Shaping the Development of New Technologies". In this study, I will mostly refer to the English version from 1996.

[15] In the original publication in German, the authors (see Dierkes, Hoffmann, and Marz 1996, 17–18) use the term 'Leitbild'. 'Leitbild' is the composition of the verb 'leiten' (to lead) and 'Bild' (picture, image or conception. For them the English equivalent is the term 'vision'. On reason for this is that other possible concepts such as 'paradigm' or 'trajectory' already linked to other specific theoretical concepts. The Oxford Dictionary defines a vision as "the ability to think about or plan the future with imagination or wisdom". However, thereby

an impact on certain visions and thus constitute a model to explain the origin and development of innovation itself.

The term 'knowledge cultures' plays a central role in '*Visions of Technology*'. Both general and specific knowledge exist in different cultures. The term knowledge cultures not only addresses various scientific disciplines but also other sectors of society. From these disciplines and sectors new knowledge can emerge, because of the interaction of various actors of these groups. Knowledge cultures are furthermore defined *"as spheres of social actions that have specific levels of production and representation"* (Dierkes, Hoffmann, and Marz 1996, 34–35). The terminology of knowledge cultures is comparable to the technological framework of certain social groups with their own subject-related interpretation of reality.

One limitation is that the term knowledge cultures applies exclusively to scientific disciplines and social actors. Rammert (2001, 5) points out that *"the cultural shaping of technology plays a significant role in the design of artefacts, in the direction of technological development and in the diversity of engineering traditions, user cultures and innovation regimes."* However, the link to culture itself is only mentioned in passing and not further elaborated. Therefore, the vision concept has difficulties taking cultural specifications into account. In the case of Japan, one organizational specificity is the personnel shuffle[16] within many organizations. The shuffle of personnel within the Japanese business culture presents a challenge for technology development, because there is the risk that acquired knowledge and established networks gets lost within the shuffle.

In addition to this specific business culture, there are further factors that can influence the innovation process, which in turn needs to be integrated into our understanding of knowledge cultures. Japan is a good example in this relation, through the highlighting of three cultural characteristics, namely history of technology, religion and pop culture. First, from a historical perspective, karakuri puppets[17] are noteworthy and were developed during the Edo period (1603-1868). The development of karakuri puppets is a form of the

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the immanent two-parted character of 'Leitbild' with its abstract and concrete dimensions gets lost. For this reasons, they the reader is advised to remember the original German connotation, when reading the term 'vision'.

[16] In Japanese the personnel shuffle is called jinji idō seido 人事異動制度. It is the organizational exchange of the staff on certain positions within time intervals. The basic idea behind this system, which still exists in a wide majority of instituations and companies, is that the the staff become all-rounder and are easier to deploy within the orginaization.

[17] In Japanese: karakuri ningyō からくり人形

making of things, monozukuri[18], because it denotes the Japanese adaptation of European watchmaking. Monozukuri means the process of making or creating things, especially in the manufacturing sector. Second, the dualistic systems of Shintoism and Buddhism are often repeated to have an effect on the culture's relationship to technology, especially in research (cp. Wagner 2009) and the process of development. Unlike the Christian worldview, in which innovation is traditionally seen with suspicion and as a human interference in the divine order, in Buddhism there seems to be less objection to such innovative research and development. Third, in particular, the research and development of robotics in Japanese pop culture, with the popularity of manga and anime even among adults, has a high value. Images of robots can also be transported through pop culture, and it can be assumed that this is also reflected in the early conceptions of their inventors. Rammert (2001, 4) concludes that culture is a framework for "*how things are viewed differently, how things are done differently, and how these activities are institutionally arranged differently."* For this reason, the term of knowledge cultures includes not only those with scientific knowledge and its terminology, but also social and cultural environments and their specifics.

The production and reproduction of knowledge within a knowledge culture takes place by means of the combination of object, actor and self-reference. Neither can human actions be reduced to just one of these references, nor can any of these factors be viewed in isolation. Since actions have their starting point within an individual, only the ratio of the three references can vary (Dierkes, Hoffmann, and Marz 1996, 35). The representation of knowledge takes place in the discourse of a specific knowledge culture and in its outward communication. The reality of a certain knowledge culture is reflected through a culture's own typical system of concepts, patterns and codes. This communication of different fields is easier to understand with the SCOT terminology which describes the interaction of various relevant social groups and their technological framework.

New knowledge is not developed and spread into one single field, but rather formed through the merging and sharing of different fields (Dierkes, Hoffmann, and Marz 1996, 34). More precisely, knowledge is not materialized within a single knowledge culture, but is the result of intercultural overlapping. Due to this interference, an absolute new technology comes about not only quantitatively but also qualitatively. Here interference should not be understood as a process on a systematic level, but rather through people with their social and personal characteristics (Dierkes, Hoffmann, and Marz 1996, 36).

[18] In Japanese: monozukuri ものづくり

The interference between different cultures of knowledge is furthermore not solved by their own actors. The interference of various knowledge cultures takes place by means of outer communication and an inner individual level in humans, which includes various actors (in SCOT terms the relevant social groups and their interpretation of the emerging technology.)

Communication between actors from different knowledge cultures is a large, if not the largest, challenge in the creation of knowledge. Within the concept of visions, communication does not differentiate only between transmitter and receiver, but rather more specifically entails the mutual coordination of behavior. *"What is important is not necessarily what 'A' says or what 'B' understands, but whether B changes in the way that A expects*" (Dierkes, Hoffmann, and Marz 1996, 38). In other words, the communication and cooperation of different knowledge cultures have to work in the context of various paradigms. The reason for this is simple: A might see a different thing in an invention than B, and thus talk at cross purposes. Furthermore, constant reproduction and coordination between cooperative actors from different traditions of knowledge is necessary.

In this context, individuation means a process which takes place within an actor and is key for a successful process of technological adaptation. For successful communication, the representatives of different knowledge cultures have to attune to each of the various patterns of thoughts and expression. This adaptation and internalization also has to be repeated and controlled (Dierkes, Hoffmann, and Marz 1996, 39). It is easier to understand with what SCOT calls the gradual closure of interpretative flexibility and the emerging of a common sense about a technological framework.

The basic assumption of the vision concept states that new technological knowledge is produced by the interference of different knowledge cultures, which depend upon reproductive and synchronizing communication and individuation processes (Dierkes, Hoffmann, and Marz 1996, 39). For successful cultural interference, it is necessary that this outer communication between several groups and inner individuation processes is produced, reproduced and synchronized. As each representative of a single knowledge culture has his or her own internalized mindset, the continuous adaptation and repetition of all representative cultures is essential. In the case of care robotics, this means that the engineers must prepare for the mindset of the caregiver, their needs and business cultural reality.

This specific cultural knowledge, communication and individually-based synchronization performance must be provided for the successful interference of knowledge cultures, which is called the problem of the triple synchronization by Dierkes, Hoffmann, and Marz (1996, 40). The triple synchronization performance can be carried out by a single individual or by a crossed knowledge-culture. An illustrative example of such a single individual is the proactive inventor, who is driven by his vision and the desire to realize it. Nevertheless, the problem of triple synchronization exists and has to be solved to generate new knowledge.

Therefore, there is a need for a 'something' (Dierkes, Hoffmann, and Marz 1996, 41) to be present, just as there is a need for a coordination-performing structural mechanism which can solve the problem of the aforementioned triple synchronization. This 'something' must fulfil the following conditions: It must exist closely to synchronization, be evident and knowledge culture (un-)specific, it must cause interference impulses, be interference-orientating, interference-stabilizing and interference-correcting[19] (Dierkes, Hoffmann, and Marz 1992, 39–40). A vision must meet the above-formulated criteria in order to solve the triple synchronization problem. With reference to Dierkes, Hoffmann, and Marz (1992), all of these performances are provided by and through visions. In the following section, the structure of visions and their functions will accordingly be analyzed.

2.5 The Guiding- and Image-Functions of Visions

A vision consists of three guiding- and image-functions (see Table 2-1). The three guiding-functions are collective projection, synchronous preadaptation and functional equivalent. These act as a common orientation and provide the framework for the development of technology. In addition, the three image-functions are the cognitive activator, the individual mobilizer and the interpersonal stabilizer, all of which are motivating and stabilizing elements.

[19] „Dieses 'Etwas' muß – dort, wo die Synchronisation stattfindet existieren, also zugleich auf der 'äußeren', der Kommunikationsebene, der 'inneren' der Individuationsebene und zwischen diesen beiden Ebenen auszumachen sein." (Dierkes, Hoffmann, and Marz 1992, 39–40)

Table 2-1 Guiding- and Image-Functions

Guiding-Function	Image-Function
Collective Projection	Cognitive Activator
Synchronous Preadaptation	Individual Mobilizer
Functional Equivalent	Interpersonal Stabilizer

The first function, the collective projection, is a projection which forms the interface between reality and desire. Dierkes, Hoffmann, and Marz (1996, 43) describe this projection as, "*Visions bring together people's intuitions and empirical as well as other types of knowledge about what appears feasible and desirable to them*." As in a triangle, there are points on the baseline, the feasibility and desire of which are in conflict with each other (see Figure 2-2). Based on these points, there are two projection lines, those of feasibility and desirability, which meet in an intersection, i.e. the vision (Dierkes, Hoffmann, and Marz 1996, 43–44). This vision interlinks the present (feasibility) with the future (desire) of the innovation.

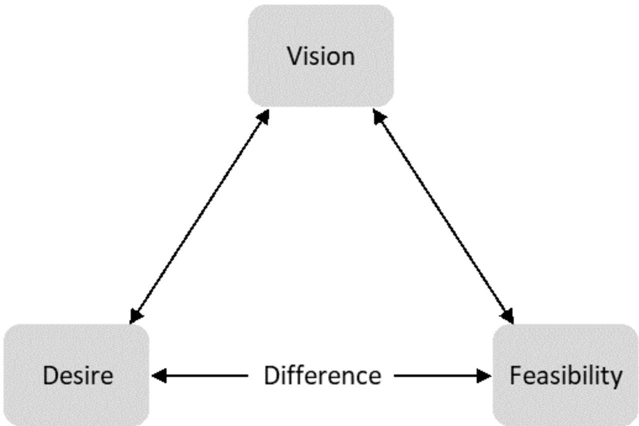

Figure 2-2 Collective Projection

The collective projection ensures that all actors, even if they come from different cultures of knowledge, have the same collective aim in mind. In the words of Wiebe E. Bijker, Hughes, and Trevor J. Pinch (1987, 414) *"the key requirement is that all members of a certain social group share the same set of meanings, attached to a specific artifact."* The major questions here are who the relevant social groups are, and if the artifact has any significance for them. Ideally, already at an early stage, the artifact is accepted by the group of the consumer, or user. This function ensures a basic consensus on the vision.

Through variance comparison of actual and future status, a common objective is set and hence its reproduction. The main difference here between an ideal and a vision is that vision requires an anchor in the real world. In the course of development, feasibility and desirability converge until the process ends with an idea's actual realization. In the terminology of SCOT, this is the closure of interpretative flexibility. Dierkes, Hoffmann, and Marz (1992, 44) describe the need for a relation to reality, because *"in the desert of everyday work, it is not enough to be continually chasing after the source of visions like a fata morgana; one must again and again – even if it is only drop by drop – refresh oneself for it."*[20] Thus, there is the risk that a vision, when the balance between desire and current feasibility is missing, rapidly changes into a utopian ideal, which never will reach realization. Collective projection might be the most influential function of a vision for the success of emerging technologies. In the case of care robotics, the point of looking in the same direction is important in a narrow sense for a successful cooperation between robot developers and caregivers, and also in a wider sense for the negotiation process about the future use of robots within society.

In the beginning, there is a visionary idea that intends to change an existing situation. Braun-Thürmann (2005, 34) explains this further: "*Radical innovations [are] the starting point for a wide spectrum of possible applications, which increase the probability that out of the pool of possible uses one will meet the demand of the consumers and become successful. This is often related to a utilization concept, which was not intended by the inventor himself."*[21] This means that the technical principle behind an invention can motivate, or might even push, relevant social actors into a certain direction and thus ultimately lead to an originally not considered utilization.

Synchronic preadaptation is the second function of a vision and ensures that the communication and individuation processes will be reproduced and synchronized in the future. This is achieved by the different interrelations of various actors' perceptions, which are adjusted into the same direction by visions. Within the vision concept, the synchronous pre-adaptation cannot be overestimated, because, through a common framework, there is less friction and fewer problems arise later in the development process (Dierkes, Hoffmann, and Marz 1996, 47). The more precise this preadaptation is, the smaller the

[20] „In den Wüsten der alltäglichen Arbeit genügt es nicht, dem Leitbildquell ewig wie einer Fata Morgana hinterherzulaufen, man muß sich immer wieder - und sei es auch nur tröpfchenweise - an ihm laben können." (Dierkes, Hoffmann, and Marz 1992, 44)

[21] „Radikale Innovationen [sind] der Ausgangspunkt für ein ganzes Spektrum von Anwendungsmöglichkeiten, was die Wahrscheinlichkeit ungemein erhöht, dass aus dem Pool von Nutzungsofferten eine einzige auf die Nachfrage von Konsumenten stoßen und somit zum Erfolg wird. Häufig ist damit solch ein Nutzungskonzept verbunden, das vom Erfinder selbst nicht intendiert wurde." (Braun-Thürmann 2005, 34)

common direction field on which each diverse individual and collective evaluation path moves. A comprehensive preadaption connects to a more loss-free, smooth and effortless process of future communication and individuation.

Successful preadaptation is no guarantee for the success of this frictionless development. It merely ensures that the representatives of various knowledge cultures come together and do not immediately break up when a problem occurs. This partial function merely ensures that representatives of different knowledge cultures find themselves together in the same boat again and again, and if they go overboard, they do not drift in every direction but rather instinctively move back into the same boat.

The final guiding-function is the functional equivalent. Even if collective projection and synchronous preadaptation guide, the problem of triple synchronization still exists. Usually there is a system of rules within every culture of knowledge which all participants follow and which makes the process of inner communication possible, reproducible and able to be coordinated. For a better understanding, the functional equivalent, in the words of SCOT, is covered with a flexible interpretation when the relevant social groups define their idea for use in technology. The culture of knowledge is equal to the technological framework.

However, actors from different disciplines interact with others to develop new technological knowledge. As a consequence, interference from different knowledge cultures appear, because a common set of rules and expressions is still missing. According to Dierkes, Hoffmann, and Marz (1996, 48) there is an ever-present risk of a ‘discursive collapse’. The only exception to this risk is technology, which has already established itself as a prevailing state-of-the-art design. Here, the current state of the art has taken over the role of the functional equivalent as a common rule and expression system. Atan early stage in technological creation, artifacts are in their conceptual development stage and remain blurry. Their visions serve as functional equivalents to replace the missing current state of the art appliance with a non-existent rule and expression system. This equvivalent is required for the interaction of different cultures of knowledge which thereby prevents a discursive collapse. The formation of a functional equivalent is what SCOT calls the need to eventually close the discourse on flexible interpretations of an invention

Dierkes, Hoffmann, and Marz (1996, 50) raise two questions, which visions have to answer. First, is a vision in its guiding functions strong enough that it exerts sufficient attraction on the representatives of different knowledge cultures? Second, is it able to extract them from their knowledge-specific circulation of dialogical and logical self-constraints? If so, then the triple synchronization problem is solved. In this context, the synchronous preadaptation focuses on the communication and individuation of participating actors on a common objective. This means that even different knowledge cultures look the same without seeing any other alternatives. In addition, the functional equivalent works as a focal point for all actors, which, if strong enough, ensures permanent communication because it is all about the same objective, the intersection between feasibility and desire.

The first image-function is the cognitive activator. A vision replaces the paradigm of different knowledge cultures with a new set of structures and languages. Dierkes, Hoffmann, and Marz (1996, 51) emphasize that due to a new image, thinking is given direction. That is, if the image as a catalyst is strong and stable enough, this image will become a new mindset (Dierkes, Hoffmann, and Marz 1996, 52). It functions as an attractive coordinator, which helps to solve problems relating to the process of the production of technological knowledge, which is better than simple traditional ways of thinking and term paradigm within each interfering knowledge. An appropriate and meaningful vision serves as a representative of different knowledge cultures in order to make new knowledge come into existence. In summary, the cognitive activator coordinates and organizes thoughts, and so has an important function within the development process.

The individual mobilizer points out that knowledge indeed arises in different cultures of knowledge, but ultimately comes about through real people (Dierkes, Hoffmann, and Marz 1996, 52). Therefore, the degree of personal involvement is a key factor for the long-term and successful creation of knowledge, because visions "*reside in both the minds of people and their hearts (Dierkes, Hoffmann, and Marz 1996, 52).*"

The last image-function is the interpersonal stabilizer (Dierkes, Hoffmann, and Marz 1996, 52–54). For the production of knowledge, successful cooperation between different cultures of knowledge is required. However, since each involved actor has a different background, and this can sometimes include very contrary mindsets, a steady cooperation is only possible if friction is limited between them. Visions keep the producers of technological knowledge together, despite all personal and subject-related difficulties again and again. It stabilizes permanent self-constraint into cooperation and internalization. The SCOT approach touches this function with the term of the relevant social group, which steadily negotiates the outcome of development. The interpersonal stabilizer forces actors to cooperate and work together again and again. Further visions are stabilizing problems between different traditions of thought and motivational problems in this sustainable partnership. The assumption goes so far that even visions can be both social and personal constraints.

> *"Visions unite people who may otherwise have nothing in common. These people may belong to different social milieus and different knowledge cultures. Under certain circumstances their perceptions, thinking, and behavior may therefore follow diverging, even diametrically opposed, orientations. The people involved might not be bound to one another by external social pressure nor drawn together by mutual sympathy." (Dierkes, Hoffmann and Marz 1996, 54)*

In this sense, visions liberate inner constraints as well as traditional social constraints, such as realization of gains and maintenance of relations with other organizations, because of their image-function which is self-strengthening, and which brings together actors from different knowledge cultures and ultimately different social groups.

At this point the vision concept, in particular the term interpersonal stabilizator, goes much deeper into interpersonal processes that are relevant for successful technology development. The SCOT approach, with its blurry concept of the relevant social group leaves out the interpersonal process during the development process.

Dierkes, Hoffmann, and Marz (1996, 55-70,92-99) apply their concept with a detailed reconstruction of six historical case studies, namely the diesel engine, typewriter, mobile phone, data networks, biotechnology and AI. Thereby the focus lies upon a test of plausibility, as the latter illustrates the stringency of their vision concept. The logic behind this is that these plausibility tests illustrate the explanatory power of the theoretical framework that is relevant for the analysis and comparison of several studies. In doing so, they confirm some assumptions on technology development to show the advantages of their concept of visions compared to other theories within STS.

First, traditional models within STS are limited and soon reach an 'analytical dead-end of unidimensional reductionism' (Dierkes, Hoffmann, and Marz 1996, 74). Dierkes, Hoffmann's, and Marz' (1996, 72–74), criticism is that most models are not able to capture the full complexity and fast pace of technological development. Furthermore, there is also a risk that only successful developments, as in the case of linear evolutionary-oriented models, are considered.

Second, new technological knowledge does not arise, as it is often assumed, in one knowledge discipline. It is about the interaction and interlink between different knowledge cultures (Dierkes, Hoffmann, and Marz 1996, 75–76) or social groups. For this reason, STS has, right at the beginning, to cover the complex networks between different thinking traditions. New innovations emerge out of the interaction of several disciplines, not within a single one.

Third, the interference of knowledge cultures, communication services, such as the creation, maintenance and organization of long-term stable cooperation and individual performance (e.g. in the internalization of different ways of thinking), are essential for a successful course of development (Dierkes, Hoffmann, and Marz 1996, 77–81). Communication is not limited to external individuation, the classical communication between individuals; it also includes internal individuation, the processes within human-beings.

Fourth, there is a need for a unifying and stabilizing factor to overcome the resulting threefold synchronization problem of interference during the production of new knowledge (Dierkes, Hoffmann, and Marz 1996, 41,82), which is not taken into account in the majority of terminological concepts. According to the vision of Dierkes, Hoffmann, and Marz (1996, 81–87), unlike other existing terms such as idea and goals, the vision concept provides these required functions.

Fifth, visions with their guide and image functions are not only perceptual patterns (Dierkes, Hoffmann, and Marz 1996, 100-105,). The vision's guide and image-functions provide us with appropriate characteristics for the successful production of knowledge. Through the guiding-function, a collective orientation and direction framework with the image-function, the motivating and stabilizing elements are understood.

However, the historical case studies are, according to Dierkes, Hoffmann, and Marz (1996, 55) *"that [the plausibility test of the vision concept] we do not mean a stringent empirical examination, but rather an attempt to illustrate the key categorical and argumentative assumptions of the approach on the basis of actual historical processes of generating technology*". Their plausibility tests serve as a point of reference, whereby each development follows its own origins, specific situations and conditions. All case studies have in common that they are tools to illustrate the explanatory power of their concept.

2.6 Carrier of Visions

With regard to the concept of vision, the latter constitutes a solution for the triple synchronization problem in the process of technical knowledge. For this reason, the guiding-and image-functions (Dierkes, Hoffmann, and Marz 1996, 43–54) are needed, which have been illustrated within the plausibility tests (Dierkes, Hoffmann, and Marz 1996, 55–99). This section focuses on the second part of the vision concept: The structure and process of visions.

> *"If they [visions] are not seized upon by others and these are not gripped by them, if they are not manifested in the daily patterns of perception, thought, behavior, and decisions of the actors operating in networks of technology-generating process; in short, if there is no moderately broad consensus on them and if only a few rather than many individuals or small groups are behind them, then these ideas are not visions." (Dierkes, Hoffmann, and Marz 1996, 101)*

In other words, without consensus on a vision as an innovative idea, a vision is nothing more than an idea without the potential for successful development into new knowledge. To develop an idea into a vision and establish it, a certain minimal consensus, which varies based on the research area, is needed. Thereby, Dierkes, Hoffmann, and Marz (1996, 102) clarify that *"Great or small, the group of those active in a technology-generating field is never homogeneous. Not only do the individual members of the group have specific relations to objects, actors, and meaning, but they also differ in power, knowledge, experience, and authority",* which means they attach a specific value to development. Thus, group numbers and specific values of actors are relevant for spreading a vision. As Dierkes, Hoffmann, and Marz (1992, 109) point out further *"How is it that some ideas which are viewed as technically, feasibly and socially desirable at a certain point, meet with a broad resonance within a particular genetic engineering field, […] while other ideas have been denied this support?"*[22] In other words, consensus alone is not enough to ensure the success of a vision. The influential actors or relevant social groups must be convinced by it.

Furthermore, the career of visions seems to depend not only on the number and relevance of supporting actors, but also on other structural factors of impact that take effect on the successful development and process of visions. In the following section, these are explained from both a process-oriented and a structural perspective.

The process-oriented perspective deals with how the development of an idea or vision takes place. There are two possible careers of vision: Success, in which an idea is able to change into a vision, or failure, in which an idea is not able to collect enough actors

[22] "Wie kommt es eigentlich, daß einige Ideen über das als technisch machbar und gesellschaftlich wünschbar Angesehene zu gewissen Zeitpunkten in einem bestimmten technikgenetischen Feld auf eine breite Resonanz stoßen, […] während anderen Vorstellungen eine solche Unterstützung versagt bleibt?" (Dierkes, Hoffmann, and Marz 1992, 109)

around it in order to establish as a vision. The latter is often not analyzed in science and is forgotten, but this is of course the more frequent variant of technological development. The idealized career of a vision possesses the following appearance (cp. Dierkes, Hoffmann, and Marz 1996, 104):

1. Stage: The creation of an idea with the potential to develop into a vision
2. Stage: Forming of potential and consensus
3. Stage: Stabilization and maturation
4. Stage: Consolidation, reorientation and end

The first stage is the creation of an idea with the potential to develop a specific vision in the beginning. The idea may have existed before but was not recognized. It is also possible that the crisis of a widespread vision is the activator of a fundamental shift. Apart from that, realization of another vision can lead to the production of new knowledge. In any case, the idea must be available to a certain group of people.

It is possible that visionary ideas emerge totally out of the blue. One source for this is SF literature as a resource for new research and development. Dierkes, Hoffmann, and Marz (1992, 112) call attention to the influence of other resources that initiate technology development *“very deep, very indirect and with a long range affecting sources for ideas with vision potential can be seen, for example, in science fiction literature.”*[23] The role of science fiction and comic books, with their illustrative and metaphorical terminology, should not be underestimated in this context. There is mutual exchange and influence between technology and SF (Gaßner 1992; Stableford 1992; Steinmüller 1992; Hoffmann and Marz 1992). On the one hand, technology influences SF as it provides the fundamental framework on which SF literature bases its visionary and futuristic stories. On the other, SF literature, with its foresight of the future, inspires developers and the current development of technology. This applies particularly to Japan, where anime and manga are very popular. There is an influence from anime and manga, with SF and the future as a topic, on society, which will be covered in detail in interviews with robot developers (see Chapter 6).

The second stage of the vision career is about the forming of vision potential and enlargement of the consensus. In order to spread the vision potential, there needs to be a recognizable process of the vision and the finished artifact (Dierkes, Hoffmann, and Marz

[23] „Ganz tiefliegende, äußerst indirekt und langfristig wirkende Quellen für Ideen mit Leitbildpotential könnten zum Beispiel auch in der Science-Fiction-Literatur gesehen werden.“ (Dierkes, Hoffmann, and Marz 1992, 112)

1996, 106). Besides the connection of artifact and vision, an anchoring in other areas of society is also necessary. If the artifact has a wide distribution and visions about utilization within other areas of society, it is likely that it will reach the level of public interest.

According to Dierkes, Hoffmann, and Marz (1996, 106) a vision is influenced by *“representatives of the media, the decision-making community, business and unions, religious institutions, and social movements will adopt them, propagate or resist them, and correct or otherwise modify them.”*. This creates an area of tension between various interest groups, or in SCOT terminology, relevant social groups. The negotiation process arising from this cause, according to Dierkes, Hoffmann, and Marz (1996, 106) is that *“the vision is forged in the fire of these complexly intertwined processes, the visionary potential of an idea develops, and consensus becomes broader and more deeply anchored.”* This means that the negotiation processes shape the vision, and if the vision has great potential, it will lead to a broad consensus, which in turn will lead to successful development. The question here is if a single powerful actor, such as the Japanese government, can plant a vision, such as robotics for care, on the level of society and if this vision is able to gain enough consensus. This process becomes clearer when illustrating it with the SCOT terminology; a certain powerful, relevant social group promotes a certain idea, which in turn is discussed within other social groups, the society. The negotiation process on the use of technology is the discourse on interpretative flexibility, and at the successful end of this negotiation, there is diffusion of the technology including a specific concept of its usage.

With its stabilization and maturation, a vision reaches the third stage of its career of creation. At this stage, the original idea has already been established and has developed specific organizational forms, each with its own symbols and rituals. Through the establishment of the vision, the original innovative force is replaced with a stabilizing effect. The vision dominates for a certain time, especially if it is very successful, and it influences one or more larger parts of the technical field, it is actors and organizations (Dierkes, Hoffmann, and Marz 1996, 106–7). It is well established and has achieved its innovative trend-setting function. The third stage is the closure of discourse about the usage of the vision.

In the last stage, the vision has finally lost its innovative force and acts only in a technologically legitimizing way. The artifact is developed and has become established. For the vision there is now only the opportunity of reorientation or its replacement by a new vision. It is obvious that only a few visions have enough potential to go through these four stages.

From the idea to the established vision, there are very different ways to fail, which highlights the fragility of this process. For care robotics in Japan, the course of development and the negotiation process about usage of robotics within the field of care is still in progress.

On the other hand, there are also structural perspectives that focus upon factors influencing vision development, namely plausibility, the representation within various knowledge cultures, the linkage between different technology fields and processes. For Dierkes, Hoffmann, and Marz (1996, 108–12) there are at least four of these factors, in which the structure of visions make up the first. Basically, almost every new idea has the potential to become a vision. The successful career progression up to the point of a vision's establishment is essentially dependent on the structure of the idea, and whether it is able to bind different cultures of knowledge and their representatives to itself. Within the vision concept, plausibility of an idea is a major factor, because especially in technical innovation, there are often very complex ideas that do not automatically have to make sense to other knowledge cultures. For that reason, Dierkes, Hoffmann, and Marz (1996, 108) summarize that *"What is plausible, indeed positively elementary to the representatives of one knowledge culture […] can be totally beyond the members of another knowledge culture."* The plausibility of the successful development of care robots in Japan is highly relevant and will be discussed in detail further on (see Chapter 6). To what extent the concepts of different robots are plausible for non-developers, so that a vision can successfully spread, is only of marginal significance in the empirical study because the focus lies on the direct development process.

The representatives of knowledge cultures, the second structural factor, as well as their internal and external social networks, are especially influencing factors at the beginning for the later career of visions (Dierkes, Hoffmann, and Marz 1996, 109). This point is important for successful development and forms the second structural factor. Particularly at the beginning, when a new idea is not widely in use, the authority of individuals and their personal networks is significant for a vision's development.

> *"The better the initiator group is already organized for other purposes, the more it can draw on highly influential existing networks to propagate a visionary idea. The quicker the establishment of an existing field of technology can be won over to the idea, the more likely it is that the idea will successfully pass through the other stages of becoming a vision." (Dierkes, Hoffmann, and Marz 1996, 117)*

Single influential actors and their available networks give a new idea, which as yet has no legitimacy and no authority, developmental acceleration. This makes it possible to attract more actors for this new idea, as well as get other knowledge cultures involved in development and make it possible to further develop and to spread within society.

The linkage between different technology fields is the third structure factor. This means the connection of each different technical field with its respective sector and connection to society. Due to the qualitative difference in the coupling of several technical fields or sectors, different interdependencies occur with their respective impacts on the vision's potential. The field coupling affects the vision's horizon of expectation, and thus directly affects the possible spreading spectrum of a specific vision. Especially unforeseen events and changes, such as wars or crises, can lead to a reorientation and can suddenly blaze a trail for a previously unknown idea (Dierkes, Hoffmann, and Marz 1996, 111). In Japan, the demographic change, with its rapidly aging society, is a possible activator, which leads to a reorientation towards the application of technology (see Chapter 6).

The last factor of the structure perspective is the linkage between different processes. Crucial to the success of an idea with vision potential is success itself. Insofar as the involved actors are aware of their success, it is likely that this will impact positively on their future action and thus the process of development. Success has a self-reinforcing element. Thereby the increasing connection to the reality of the artifact has a strengthening effect, because with the increasing realization, the involved actors become aware of success and are encouraged to further promote it. Nevertheless, success can also have a negative impact on stability if it is too fast, and too many actors are involved in development. It is therefore possible that integration, communication and especially the establishment of a consensus between the actors involved leads to a collapse of the discourse.

2.7 Criticism: Technology Assessment through the Visions-Concept

Dierkes, Hoffmann and Marz see visions with their genesis as guiding, and image functions and careers as an approach for technology assessment since SCOT studies and general technology studies alone are inadequate to explain and influence emerging technologies. In doing so, the vision concept claims to be able to not only analyze innovation, but at the same time, also forecast the outcome of technologies in development. It is questionable whether the concept can fulfill this double aspiration, to both analyse and assess technology.

Traditional technology assessment tries to primarily solve occurring problems of the development process through regulations. Thus, it tries to directly control technology. According to Dierkes, Hoffmann, and Marz (1992, 122), strict adjustments and regulations achieve a high degree of influence on the development process, which affects the scope of action and thus the further development. For this reason, Dierkes, Hoffmann, and Marz (1992, 124) with their 'vision leaded technology assessment' offer a softer and more experimental approach to influence technological development. In their words (Dierkes, Hoffmann, and Marz 1992, 161)[24], *"Actually, the idea of a vision leaded technology assessment, that is, the attempt, to make technological developments designable through a transformation of their underlying visions, is not as spectacular as it might seem at first glance."* Here they are leaning on the process perspective and careers of visions (see Chapter 2.6). There are three possible fields for a vision-leaded technology assessment that results from their concept.

At the beginning, there is the creation and promotion of certain ideas (Dierkes, Hoffmann, and Marz 1992, 154). This is more or less a focused generation and selection of visions. Thereby the concept becomes paradox, because according to the argumentation of the vision concept it is not possible to artificially create vision. An artificial vision is not able to gain enough consensuses.

Then, there is the support of the interference of knowledge cultures through the organization of a systematic exchange of different knowledge cultures. Thus, the problem of artificial generation remains. The organization becomes the tool to indirectly affect the interference of knowledge cultures. What seemed to be only possible through the individual being in the leading position is now extended onto the organization.

Finally, there is the implementation of a public discussion forum (Dierkes, Hoffmann, and Marz 1992, 157), wherein expectations towards visions and their related impacts on society, can be discussed. It is possible to foster a broad consensus on a specific vision already at a very early stage of the vision career through the inclusion of the public, society and other social spheres, which lay an essential foundation for the successful career of a vision. However, the authors remain blurry about how this is possible in detail.

[24] „Eigentlich ist der Gedanke einer leitbildorientierten Techniksteuerung, also der Versuch, technische Entwicklungen über eine Transformation der ihnen zugrunde liegenden Leitbilder gestalten zu wollen, auch gar nicht so spektakulär, wie es auf den ersten Blick den Anschein hat.“ (Dierkes, Hoffmann, and Marz 1992, 161)

The vision concept is overreaching itself and is not able to meet its claim to analyze and forecast. Nevertheless, the suggestions about the leading and guiding functions of visions convince and provide a solid framework for taking a closer look at the processes of innovation. Thereby the vocabulary of the vision concept remains on an abstract level, such as when it illustrates the interference of knowledge cultures. The terminology provides only an insufficient access to the complexity of innovation. At this point, it makes sense to integrate the SCOT terminology into the vision concept to complete the concept and enable it to function as a proper analysis tool. And yet to take the previous example further, the interference of knowledge cultures becomes easier to understand, when using the SCOT terminology. It is simply the negotiation of the interpretative flexibility within several technological frameworks to close the discourse about how a specific technology should be used in the future. The vocabulary of SCOT makes it easier to access the solid framework behind the vision concept. Thatfore this study complements both approaches to make it possible to access the emerging topic of care robotics in Japan.

2.8 The next Step: The Diffusion of Technology within Society

The interpretive approach of visions basically ends with the realization of an idea, when the interface of the desire and feasibility finally met. The next step after the materialization of an idea is how this idea can diffuse within society and cause technological change. There are a variety of theories and models in economics, social science and other fields, which are better in explaining the diffusion of technologies. Also the SCOT approach with its term of the wider context remains blurry about the diffusion process. There is the need to find an additional model for the final stage of technological change, the process of diffusion.

For this reason, I want to introduce Everett M. Rogers' (2003) theory about the diffusion of innovation. Like in other diffusion and lifecycle models (cp. Fagerberg, Mowery, and Nelson 2011, Utterback 2006) the life course of inventions is divided into four logical stages: The introduction of an artefact and furthermore the growth and stabilization as well as the saturation and decline of the invention. According to Rogers (2003, 11) the decision to accept or reject an innovation is not spontaneous, but rather a social process performed during a certain period by specific actors. According to the model from "Diffusion of Innovation" (Rogers 2003, 168–69) the adoption process develops in five stages:

The first stage is about the awareness about a new invention. The concept uses the term of innovation for the artifact and inventions such as robots. An individual finds out about a certain innovation, but misses further information about the innovation. At this stage, the individual is neither interested, nor disinterested in the innovation. It is literally only about the discovery of the innovation. In other words, it is the pure awareness of an innovation.

The second stage is about persuasion. Now the innovation attracts interest. The individual starts to proactively collect information for a later decision about the acceptance or rejection of the innovation. In this stage, the communication with other social groups plays an important role, because it directly influences the decision.

The third stage is about the decision. The individual considers the advantages and disadvantages of an innovation and its use. In other words, whether the individual will adopt or reject the innovation and the concept behind it as well as the connected consequences. Thereby one way to eliminate uncertainties regarding an innovation is simply to test the innovation, which increases the chance of a successful diffusion. This test run can be made representatively by one key actor of a social group. Another way is the demonstration of the innovation, e.g. in the media, which can likewise empower the adoption of the innovation.

The fourth stage is about the implementation. Often an innovation is not implemented exactly one-to-one, but rather partially modified according to the individual needs. This is what SCOT calls the discourse about the interpretative flexibility. The implementation phase may take some time. This stage ends, when the innovation becomes an integral part of society. It becomes common and loses its innovative strength.

The last stage is about the confirmation. It is about the decision whether to continuously use the invention or to withdraw from it. The individuals, and in a wider sense society, want to confirm their decision of the adoption of the innovation. In doing so, false expectations and incorrect use of the innovation might lead to disappointment.

At all stages of the diffusion process it is about reducing existing uncertainties. This is done, e.g. through collecting information, testing the innovation or a discussion about the innovation on a social level. The stage of implementation is only reached if the features of an innovation can convince in comparison to already existing other innovations. Features that lead to an adoption and ultimately a successful diffusion are low complexity, high compatibility, high availability for test runs and a high degree of presence within society in comparison to other innovations.

3 Robots in Japan

This chapter brings together relevant information about the relationship between robots and Japan in three steps. The first step is to clarify, what a robot is and if there are different understandings in regard to robots in Japan and other countries. The clarification and the definition of the term robot is an essential element of this study, because without a working definition, the analysis risks becoming blurred and this may lead to misconceptions. The second step is an introduction of coverage of Japanese robots within the media and academia. This primarily serves the function of a literary review, but also intends to give an impression about how robots are picked up by the media especially. At a later point of this study (see Chapter 6.8) there is a comparison of information within the media and the technical reality, whereby I assume that an information gap exists. The final step is to discover the state of the art within the field of care robotics in Japan. For this reason, the argumentational logic behind the idea to instrumentalize robots as the solution for the challenges of Japan's steadily aging society is outlined. There will also be a closer look on demographic change in Japan and its impact on the care system, as well as political countermeasures for an aging population and decreasing work force.

3.1 The Origins of Robots and the Quest for a Definition

The origin of the term robot, as it is used today, comes from the play R.U.R. by Karel Čapek, a Czech author, written in 1920. He derived it from the Czech word for forced labor 'robota'. In his play, humans create machines that can do their work and this enables them to be free from work. At some point, the machines start to develop emotions and to revolt against their creators (Čapek and Wyllie 2012).

Originally, robots were something we would mainly associate with science fiction literature, but since the nineteen seventies, they have become part of reality. However, with the progress of automation and, thereby, the development of industrial robots, a great number of autonomously acting machines have found their way into production. Joseph Engelberg and George Devol are said to be the inventors of the first industrial robot, Unimate. Devol recognized early that a large number of tasks in fabric production consisted of simple mechanical actions and that these tasks could easily be automated (Schodt 1988, 30–35). Due to industrial robotics, extensive mass production without a compromise in quality became possible and led to considerable economic growth in the industrial nations.

Robots not only played an important role in Japan's economic growth but also play a special role in modern pop culture with their representatives: manga and anime. There is a positive view of robots in Japan, where robots are often portrayed as friends or seen as helping humans. A few examples are Doraemon, Mobile Suit Gundam and Astro Boy. All examples have in common that their design is mostly humanoid. Positive icons of pop culture are leading to spin-off effects, not only in fostering the acceptance of robot development, but also robot developments based on pop cultural archetypes. One example is the robot Neon created in 2003 by the robot creator Takahashi Tomotaka, for the fictional year of Astro Boy's birth (Inōe Takeo 2006). Broad presence within daily life and the economical importance of industry influences the acceptance of not only robots but also technology.

History, in particular the early 20th century with its economical development after the Second World War, made it possible for the term 'robot' to spread widely and to build up a positive connotation of the term. Nevertheless, as already explained, it is important to agree on a specific definition. For this reason, the first useful tool is having a closer look at already existing definitions.

The International Organization for Standardization defines robots through the ISO 8373 (ISO 2012) as *"a device that automatically performs complicated, often repetitive tasks (as in an industrial assembly line)",* but also as *"a machine that resembles a living creature in being capable of moving independently (as by walking or rolling on wheels) and performing complex actions (such as grasping and moving objects)".* In doing so, the focus already shifts from the automatization of certain tasks to the imitation of the actions of living creatures. However, the digital version of the Japanese Daijisen (Dejitaru daijisen n.d.) goes even further: "*A puppet that operates similar to a human by an electric or magnetic powered advanced mechanical system. An artificial human.*"[25] This makes it clear that what is understood as a robot is already difficult, because there is a reference to humanoid design. At this point, there is a difference from the English definitions because the Japanese includes the term "artificial human." This more extensive cultural concept is often explained with two specifics of Japanese culture: Religion and pop culture.

To come to the point, first there might be a definition of the term robot, but there is no generally accepted definition for the term care robot. It is impossible to give an answer

25 The original Japanese in the digital version of the Daijisen: 電気・磁気などを動力源とし、精巧な機械装置によって人間に似た動作をする人形。人造人間。

to the question of what the required functions or applicable tasks necessary to declare something as a care robot are. However, and against the background of a missing definition, it is even more important to collect various information, statements and issues to be able to come up with an applicable definition, which will work for this study and possibly for further research.

Japan is called the 'robot kingdom' (Schodt 1988) and has a long tradition with robots. The latter are expected to reduce the burden within the field of care and support the self-dependence of the elderly in a steadily aging society. For this reason, it is surprising that care robots remain almost unknown.

In August 2013, the Cabinet Office conducted a special opinion poll on care robots with a questionnaire about the perception of care robots (CAO 2013; Martin, August 16, 2017). According to the opinions in this survey, 42% of the respondents had only little knowledge about care robots and 26% answered that they had no knowledge about care robots (CAO 2013, 3). In sum, this means that the respondents of these two groups make a bit less than 70% of the total, who are unfamiliar with care robots. Nevertheless, what is more important is that care robots are still little noticed in the public's perception, which is a great contrast to the government, which expects care robots to reduce the care burden and support the independence of care recipients.

Against the background of a steady technological progress, and thus an increasing presence of robots within society, it is important to keep in mind that the majority are rather machine-like than humanoid. For this reason, it is essential to deal with the term care robot in detail. There are several robot definitions, but according to the Robot Policy Research Council of METI, a robot has to meet the following three technical requirements (Robot Policy Research Council 2005, ii): Being able to process information (sensor system), to judge (intelligence and control system) and to operate (drive system).

On this basis, METI uses the term robotic devices for nursing care[26] as a synonym for care robots in its official publications and statements, such as the Project to Promote the Development and Introduction of Robotic Devices for Nursing Care (AMED 2015b). In the latter, care robots are defined as "*devices based on robot technology to be leveraged in all life situations with care recipients and caregivers as main users*"[27] (Japan Research

[26] In Japanese: robotto kaigo kiki ロボット介護機器

[27] The Japanese original: 「要介護・要支援」「虚弱」な者（以下、「要介護者等」とする）とその介護・介助者を主な利用者とする、すべての生活場面（分野）で活用するロボット技術を用いた機器。

Institute 2014, 15). That also means that care robots need to meet these technical elements of a sensor system, intelligence, a control system and a drive system.
MHLW categorizes care robots under the term 'welfare equipment with the use of robot technology'[28] in its Guidelines for Developing Welfare Equipment and Care Robots (MHLW 2013a, 6). According to the mentioned guidelines, care robots are treated as welfare equipment, which also applies for wheelchairs or nursing beds. Nevertheless, MHLW is aware that "*service robots including care robots are still in an embryonic stage on a technological and product level and currently no clear definition of a robot itself exists.*[29] (MHLW 2013a, 7) and develops this thought further by assuming that "*due to the connection between technology and the consumer and the care field, it is likely that devices which will take new approaches will emerge in the future*"[30] (MHLW 2013a, 7). In other words, along with a changing care environment and improving robot technology, it is likely that the perception of care robots is subject to change. The important point here is that the definition of the term care robot is equal to the definition of the term welfare equipment.

For this reason, it makes sense to have a closer look at welfare equipment. Welfare equipment is defined precisely in the Act on Promotion of Research and Development and Promotion of Welfare Equipment[31] and Long-Term Care Insurance Act[32]. According to the former (MHLW 1993), welfare equipment are "*tools for daily life convenient for people experiencing disability or elderly people and tools or equipment for the functional training of these persons"*[33]. The latter (MHLW 1997) defines welfare equipment as "*devices intending to support the independence of daily life of i.e. care recipients"*[34]. As a conclusion, it can be said that welfare equipment targets tools that help people who receive nursing care or need help for everyday life.

Against the background of this wide definition of the scope of application, it is easy to mix the term care robot with robots for health care, in particular in the medical sector.

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28 In Japanese: robotto gijutsu o katsuyō shita fukushi yōgu ロボット技術を活用した福祉用具
29 The Japanese original: 介護ロボットを含むサービスロボットは[…]萌芽段階の技術・製品であり、現在のところ明確な定義は存在しない。ロボットの定義自体定説といえるものはなく。
30 The Japanese original: 介護現場や生活者のニーズと技術との結びつきによって、今後も新たなアプローチを行う機器が登場することが考えられる。
31 In Japanese: fukushi yōgu no kenkyū kaihatsu oyobi fukyū no sokushin nikansuru hōritsu 福祉用具の研究開発及び普及の促進に関する法律
32 In Japanese: kaigo hokenhō 介護保険法
33 The Japanese original: 第一章（定義）第二条「この法律において「福祉用具」とは、心身の機能が低下し日常生活を営むのに支障のある老人（以下単に「老人」という。）又は心身障害者の日常生活上の便宜を図るための用具及びこれらの者の機能訓練のための用具並びに補装具をいう。」
34 The Japanese original: 第一章第八条 「この法律において「福祉用具貸与」とは […]要介護者等の日常生活の自立を助けるためのものをいう […]。」

That is why it is necessary to differentiate both terms and understand different connotations behind the terminology (see Table 3-1). The term medical or also health care robot is mostly used for robots that are used in a medical environment, such as in hospitals or rehabilitation centers. In doings so, it embraces robots that are intended to affect the structure of the body (health care) or to treat or cure diseases (medical). This includes, for example, robotic devices that are attached to the upper body or limbs, and are used to restore the function of the body in order to achieve symptomatic improvement or to hold down progress. A common example for this field of application is the exoskeleton HAL, which is used also for rehabilitation. The main difference between medical and care robots is that medical robots fall under the category of medical devices. For the latter, permission and approval of the Pharmaceutical Affairs Law[35] (MHLW 1960) is required.

Table 3-1 Difference between Medical Robots and Care Robots

	Medical Robots	Care Robots
Definition	Robots affecting the structure of the body or to treat or cure diseases	Robots to be used in the care sector
Scope of Application	(1) Used to restore the function of the body and/or to achieve symptomatic improvement or to hold down progress (2) Attached to restore motor functions (rehabilitation) or used to diagnose or cure diseases (medical)	(1) Support of movement (wheelchair)/ transfer (bed-wheelchair) (2) Attached or used to assist motor functions (3) Support of daily life (toilet, bathing, eating etc.) or work (transfer, monitoring etc.)
Permission and Authorization	Yes, for devices corresponding as medical devices Approval by the Pharmaceutical Affairs Law required	No permission for production and distribution required

According to this understanding, a specific robot could theoretically be used within a medical and a care environment. The major difference here is that for use within a medical environment, certification according to the Pharmaceutical Affairs Law is necessary. This in turn is likely to increase the development costs of a robot, because more test runs and evidence about its benefits and risks have to be collected.

Against this background, it is easy to understand why companies with no experience within the health and care sector prefer the latter, as the financial risk is lower and thus

[35] In Japanese: iyakuhin, iryō kikitō no hinshitsu, yūkōsei oyobi anzensei no kakuhotō nikansuru hōritsu 医薬品、医療機器等の品質、有効性及び安全性の確保等に関する法律

it is easy to obtain profits. This also has implications for the diffusion of robots. The hurdle for use within hospitals might be high, but it remains relatively low for care facilities. A possible approach for diffusion within society could be to first gain experience and data within care facilities, and from that point enter the medical sector and the private market.

There is no single definition. In fact, robotics is a relatively new field and thus things that can be referred to remain low, which even more applies for care robots. Even the two ministries which are in charge of the diffusion of robot technologies do not agree on a single term and list care robots under two different names. It is not surprising that other organizations have other, even wider understandings of care robots. For example, the Kanagawa Welfare Service Association[36] puts care robots under the generic term of advanced devices that support care services[37] (Seto 12.11.2015, 5). Although there are convenient definitions for development, introduction and utilization, there is also the possibility that the range of interpretation will widen as technology develops. In either case, the answer to the question 'why are care robots required?' undoubtedly leads to a better understanding of care robots themselves. It can be agreed that rather than terminology, the field of application makes a robot a care robot. This applies especially because the word robot itself is undefined and interpreted differently by people, and its terminology changes among the field of application. For this reason, I want to illustrate this change of terminology through the field of application in explaining three types of robots: Service, health care, welfare and care robots.

First, service robots are robots or robot technologies that interact with humans and often fulfill communication tasks like guidance in museums (e.g. Reborg-Q within the Otsuka Museum of Art 2009-2015). The current state of technology makes simple communication and entertainment with limited interaction options possible. For this reason, the delegation of complex tasks will remain unreachable in the near future.

Second, health care robots are covering the wide field of medical support, especially in hospitals. The wide spectrum ranges from automatic laundry transport systems to human-controlled surgical robotics systems (e.g. Da-Vinci, an American robotic surgical system).

Finally, welfare and care robots are embedding robot technologies for the wide field of institutional and individual support, where support is understood under the prospect of improving the quality of life including for individuals such as elderly, disabled or invalid

[36] In Japanese: kanagawa fukushi sābisu shinkōkai かながわ福祉サービス振興会
[37] In Japanese: 介護ロボット=「介護サービスを支援する先端機器・システム」の総称

persons, as well as caregivers. The difference between a care robot and a welfare robot is based on the user. Care robots address the care support of elderly, whereas welfare robots address daily life support for disabled people.

After comparing and contrasting various concepts, I define care robots flexibly and in a wider sense as welfare equipment including robot technology. The background behind this is the concept of interpretive flexibility (see Chapter 2.3), according to which a definition emerges through the negotiation process within society. Also van Wynsberghe (2016, 61) sees the need for a working definition that is based on the intended scope of application. In other words, a specific robot to lower the physical workload (e.g. the exoskeleton HAL) may be categorized as a care robot when it is used by the caregiver, but may also be classified as an industrial robot when used by workers.

Furthermore, it is necessary to distinguish the term robot from robot technology. Metaphorically speaking, this relationship is comparable to the one of IT technology and computers. A computer is the sum of various elements such as processor, memory and hard disk built into a machine, whereas IT technology refers to the entire applied system, which incorporates various information processing functions. The same applies for the relationship between robots and robot technology. A robot is the sum of three key technologies (sensor, drive, and intelligence and control system) from the entire applied system. Thereby robot technologies include a wide spectrum of machinery such as transportation, manufacturing, construction, medical and welfare equipment (JERI 2011, 21).

Therefore I will use my working definition of care robots as robot technologies that contribute to the field of care. It is an application-driven definition and in the future, it might slightly change after the negotiation process when the interpretation of the term closes. Until this point, there is a need for flexibility.

3.1.1 The Different Types of Care Robots

In Japan, each ministry, namely METI and MHLW, has a different understanding about how to categorize robot technologies. Referring to the interim report of METI's robot policy research group, the wide range of mechanical systems that consists of the three technology components of robot technology (sensor, drive as well as intelligent and control system) can be called a robot (Robot Policy Research Council 2005, 2). For this reason, so far, the devices that have been suggested as care robots are widely varying concerning their functions, usage and in particular, the degree of human-robot interaction. In MHLW's handbook for the development of welfare equipment and care robots, robot technologies are categorized into five categories from high to low contact with people: Prosthetic fittings, rehabilitation support, transfer and mobility support, daily life support, communication and monitoring devices (MHLW 2013a, 7). Robot technology for care should depend on its connection of technology, the needs of the care sector and consumer rather than being limited to these categories. This includes assistive technologies and adaptive equipment that can be applied by subjects who benefit from long-term insurance. Coverage through insurance is an important mechanism for an effective diffusion of new robot technologies, because it can reduce a significant obstacle for the diffusion: The economic costs of robotics.

Since 2010, the Kanagawa Nursing Care Robot Promotion Project (n.d.) supposes three main fields of application (see Figure 3-1) regarding care robots (Seto 12.11.2015, 6), namely care support, support of independence and communication and security. This threefold division is more a rough classification than a precise one. It gives a better understanding of which fields robot technologies can be used in.

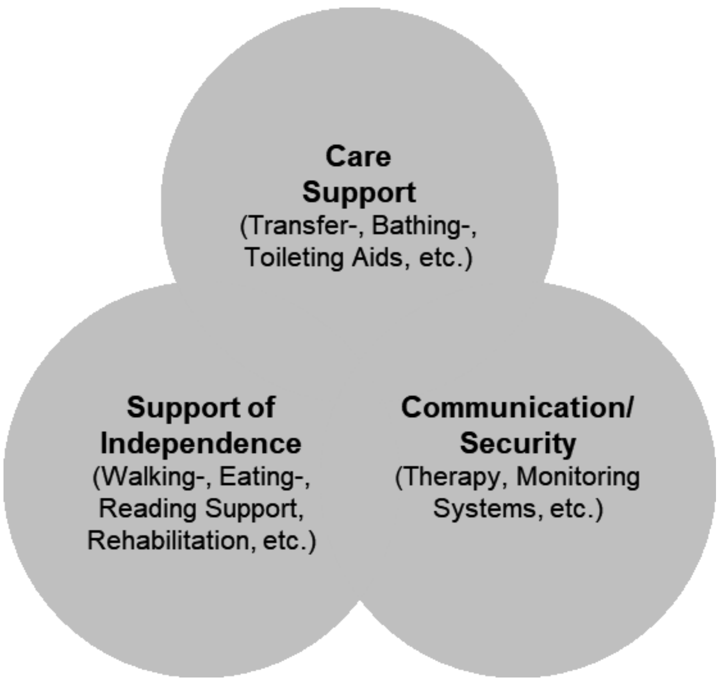

Figure 3-1: Care Robots‘ Fields of Application
(Seto 12.11.2015, 6)

The first field, robots for care support, such as lifting aids, bathing and toilet aids are mainly robots for supporting care with regard to care activities. The existing issues are that lifting and transferring of care recipients is often done by hand, which leads to physical health issues on side of the caregiver. Against this background, the introduction of care robots is expected to reduce the burden on care staff and to increase work efficiency at the same time. The thought is that with the introduction of robots, the current caregiver recipient-ratio of one caregiver for every three care recipients could increase to one caregiver and one robot for four elderly (Ogata 2016). This clearly illustrates that it is an important thought of how to match the increasing shortage of qualified care workers and the accelerating demand for professional care, while simultaneously trying to set incentives for the use of care robots.

There are two advantages associated with the introduction of care robots. First, for the caregiver, the advantage of reducing the care burden itself. In particular care tasks, such as lifting care recipients, physically stress the body constantly to an extreme degree and lead to consequences like hip pain, which in turn leads to an inability to work in the long-term. It is an existing problem for female or older care staff to lift or transfer heavy people, which could be solved with robot technology. Second, there is the advantage of improvement of care quality for the care recipient. Elderly persons may be afraid when being lifted or transferred by caregivers, because of the risk of human failure, such as being dropped. The risk of being dropped applies particularly for those elderly with dementia, who can become aggressive by just being touched. By using a care robot, receiving care at ease can be accomplished.

The second field, robots for supporting independence or self-dependence, are largely robots that support the autonomy of elderly persons, such as robots that support walking, eating or reading, and also rehabilitation. In contrast to robots for care support, they not only address care facilities, but also target private homes. The expected result is an increasing scope of activities without being reliant on others. This in turn leads to a noticeable reduction of the psychological burden for the elderly. One example is the possibility of eating independently through robot technology that assists certain movements of the body. Thereby, not only the ability to live self-reliantly, because the user gains confidence, but also the motivation to live an independent life increase.

For those who receive nursing care, moving their body to the instruction of the caregiver, when receiving help, can be a problem. Particularly with regard to personal requests such as going to the toilet, this can create psychological stress, because of a conflict between an urgent need and shame. In this case, toilet aids with automatic washing and wiping functions can offer a solution to people who have problems with getting up, sitting or who are embarrassed. At the same time, caregivers will be relieved, because the accumulation of small tasks, such as assisting with going to the toilet, might cease. These are small, but in sum very time-consuming tasks, and there is the potential of partly or totally delegating them to robotic devices.

In addition, there are also rehabilitation robots, which can for instance be worn on the upper or lower limbs to assist the motor function. Clinical studies (e.g. Kukaino et al. 2017; Saitoh et al. 2016; Hasegawa and Sankai 2014) evidence that not only the speed, but also the quality of rehabilitation increases by using robotic devices for rehabilitation. For several reasons this is an important finding, because elderly can live independently for a longer time and postpone, or avoid, a stay in a care facility. A drawback of this robot type is the still high price per unit, which forms an obstacle with respect to the introduction of care robots into private homes.

The motivation of the government to promote care robots for supporting the independence of the elderly is not only to reduce the burden on the nursing staff, but to ease the situation in institutional care. Healthy elderly, who are longer able to live self-reliantly, will presumably enter care facilities at a later point. This obviously directly reduces the rush for care facilities, which needless to say lowers the workload for the care staff and even more importantly, it finally alleviates the situation for an already overburdened welfare state.

Robots for mental care or monitoring system which interact with human users can be summarized as communication robots. Thereby communication is not limited to a narrow linguistic sense, but rather understood in a broader sense as interaction through for instance music, gymnastics or recreation to support the mental care of the user.

In addition, recent research by AIST makes it clear that communication robots are not only there for communication, but also have a positive impact on self-care (Ōkawa 2017).

The third field, communication and security robots are a monitoring support based on robot technologies that are installed in care facilities or private homes used for professional or home care. The care recipient does not necessarily need to have to push a button to call for help; the care staff is automatically informed by the monitoring system through EG sensors, which guarantee continuous monitoring. The characteristic of security robots and in particular communication robots is that they are equipped with AI and due to that, are able to interact with humans.

There are great expectations on security robots to find wandering elderly with dementia (e.g. Yamaguchi and Fujimoto 2017; Tokunaga et al., 2016). In care facilities, caregivers spend much time primarily during night shifts searching for wandering dementia patients. For relatives, the increasing number of wandering elderlies with dementia is an even more urgent issue. According to the Nikkei Shimbun, the number of people with dementia disappearing has increased for the fourth year in a row (*Nikkei Shimbun*, June 15, 2017). Therefore, it is not surprising that in recent years, the interest in and the number of security-related robots in care facilities or assisted living apartments for elderly increased.

On the downside of this, especially when using monitoring devices with in-built cameras, all activities of the elderly and caregivers are automatically recorded. This invasion of privacy has unpredictably an impact on the mental well-being of the caregiver and the elderly. For this reason it is necessary to carefully weigh the benefits and risks of technology, not only on the developer's side, but also within society in general.

As a conclusion for the definition of how a robot can be defined, it can be said that this mainly depends on the purpose and the field of application. This adaptability bases on the interpretative flexibility of emerging technologies (see Chapter 2.3) about which a common consensus has to be found, and who thus still have to find their place within society. Therefore, a robot can be classified as a care robot, but the precise field of application is still open. Many care robots that are introduced into the market fit into any of the three mentioned categories (care-support, independence and communication or security robot), because most care robots often have many functions and are adaptable. One example for this is the toilet aid Dreamer, which can be classified as a care-support robot, when used within a care facility or as self-support robot, when used within private homes. The same applies, for instance, to the transfer aid aijō-kun, which can be classified as a care-support robot, when used as a transfer aid within a care facility or as a self-support robot, when used at home for living self-reliantly.

In addition, the term robot itself is more than a physical humanoid technical invention. For this study, a robot is understood as a device with robot technologies or in other words, the term robot includes robot technologies as well. This definition pays attention to the current technical state of the art, according to which most robots are inconspicuous and only hardly can be defined as a robot with regard to design. What is still more important are the function and inner components that make even an inconspicuous device a robotic device. Robots are devices that are based on robot technology in a wider sense.

3.1.2 The Priority Areas for Robot Technologies within the Field of Care

After setting up the three possible fields of application for care robots, MHLW and METI (03.02.2014) announced the 'Priority Areas to which Robot Technology is to be Introduced in Nursing Care of the Elderly'[38] in 2012. The priority areas were revised by MHLW and METI in 2014 (MHLW and METI 2014) and 2017. The definition of areas to be prioritized for future development of care robots is the attempt to summarize forecasted needs within the care sector, as well as to more efficiently promote the development of care robots. It is no exaggeration to say that the definition of the priority areas is a milestone within the promotion of care robotics in Japan, because it specifies the expected field of application and tries to contribute to solving the issue of interpretative flexibility. Furthermore, the revision of the priority areas shows that the government tries to pay attention to the implications of demographic change and to meet current developments.

At the beginning in 2012 (MHLW and METI 03.02.2014), METI and MHLW consisted of four areas (transfer aids[39], mobility aids[40], toilet aids[41] and monitoring systems[42]) with five items (wearable[43] and non-wearable transfer aids[44], outdoor mobility aids[45], toilet aids[46] and monitoring systems for people with senile dementia at facilities[47]).

Later, in 2014, the definition of the areas and items was diversified further. The areas expanded from four to five, adding bathing aids[48] as a new area and the items specified from five to eight with adding indoor mobility aids[49], monitoring systems for people with dementia at home[50] and bathing aids. This revision was influenced by the newly launched care robot council'[51] (Kaigo Lab 2016), which with its many years of experience and competence from the field ensured that the previously formulated areas could diversify on the basis of the demand of the field.

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[38] In Japanese: robotto gijutsu no kaigo riyō niokeru jūten bunya ロボット技術の介護利用における重点分野
[39] In Japanese: ijō kaijo kiki 移乗介助機器
[40] In Japanese: idō shien kiki 移動支援機器
[41] In Japanese: haisetsu shien kiki 排泄支援機器
[42] In Japanese: mimamori shien kiki 見守り支援機器
[43] In Japanese: ijō kaijo kiki （sōchaku gata）移乗介助機器（装着型）
[44] In Japanese: ijō kaijo kiki （hi sōchaku gata）移乗介助機器（非装着型）
[45] In Japanese: idō shien kiki （okugai gata）移動支援機器（屋外型）
[46] In Japanese: haisetsu shien kiki 排泄支援機器
[47] In Japanese: mimamori shien kiki （kaigo shisetsu gata）見守り支援機器（介護施設型）
[48] In Japanese: nyūyoku shien kiki 入浴支援機器
[49] In Japanese: idō shien kiki （okunaigata）移動支援機器（屋内型）
[50] In Japanese: mimamori shien kiki （zaitaku kaigo gata）見守り支援機器（在宅介護型）
[51] In Japanese: kaigo robotto kyōgikai 介護ロボット協議会

In 2017 there was a second revision of the priority areas. The major important change was the rewording of monitoring systems into monitoring systems and communication robots and the creation of the area care business support. The former pays attention to the R&D activities of companies, but also to the high demand for reducing the psychological burden of caregivers and the stress of the elderly. The latter tries to take the technological progress within IT and the arising possibilities for IT within the field of care, such as synchronizing the data within a care facility, and saving time into account. In total there are six areas with a total of 13 items now (see Table 3-2). The new area is care business support[52] and the new items are wearable mobility aids[53], predictive toileting[54], toiled-sided aids[55], and monitoring systems for people with dementia (communication robots) [56] and care business support.

[52] In Japanese: kaigo gyōmu shien 介護業務支援
[53] In Japanese: sōchaku gata idō shien kiki 装着型移動支援機器
[54] In Japanese: haisetsu shien kiki (haisetsu yosoku kiki) 排泄支援機器(排泄予測機器)
[55] In Japanese: haisetsu shien kiki (toirenai de no shien kiki) 排泄支援機器(トイレ内での支援機器)
[56] In Japanese: ninchishō no hō no mimamori (komyunikēshon robotto) 認知症の方の見守り(コミュニケーションロボット)

Table 3-2: Priority Areas for Robot Technologies within Nursing Care (3rd Revision of 2017)

Area	Item		
Transfer Aids	Wearable	Non-wearable	
			
Mobility Aids	Outdoors	Indoor	Wearable
			
Toilet Aids	Toilet Aids	Predictive Toileting	Toilet-Sided Support Device
			
Monitor-ing Sys-tems	At Facilities	At Home	Communication Robot
			
Bathing Aids	Bathing Aids		
			
Care Busi-ness Support	Care Business Support		
			
(AMED n.d.b, 1–13) https://www.amed.go.jp/content/000036548.pdf			

The priority areas for robot technologies within the field of care address the three basic categories for the application of robots, namely care support, support of independence and communication or security. This wide scope of application covered by priority areas goes from the support of transfer, mobility, toileting, monitoring and bathing to functional training (e.g. exercises, rehabilitation), medication, dementia therapy, nutrition, oral care, and health care service (e.g. cleaning, laundry, cooking). In doing so, the advantage of addressing care instead of health care is that the robotic devices do not have to conform to the Pharmaceutical Affairs Law. For this reason, the hurdle for the government to win over companies to provide robotic devices is much lower than for a clinical environment, and thus it is easier to influence the future development of the field.

In doing so, there are primarily two major fields for care robots: The implementation within institutional care or home care. Having an eye on the situation of both fields makes it possible to balance the burden on the welfare system, because a running system does not only work with institutional care. In comparison the costs for home care are much lower than for institutional care. This means that especially the financial burden on the welfare state can be controlled to a certain extent through providing a good environment for home care. Robotic devices are intended to make a contribution to this. However, the current Japanese approach for development and diffusion is to focus on care robots for institutional care first and then extend onto the domestic market. On this point, it has to be kept in mind that the demands for institutional and home care are slightly different, and thus there might be the need to adjust technology, especially to the user's budget. It is likely that consumers will only buy robots if they see a clear balance within the cost-performance ratio.

Already at this point it becomes clear that care robots cannot be treated as an extension of industrial robotics, because of their different focus and objective (Nature Interface 2001). Care robotics is centered around humanity, whereas industrial robotics is centered on automation of the production process (Udo 2005, 59). Care robots have to be safe and fulfil two purposes: To support the independence of the elderly and disabled and to reduce the burden of caregiving.

At the same time, the idea of using robots within the field of care seems to be widely accepted in Japan already. From an economic perspective, the government and many companies have invested huge amounts of money into robotics research. However, the reason behind this initiative might rather be a way to distract from the challenges of government to countermeasure the consequences of demographic change. Moreover, the market for industrial robots is saturated, which brought up the idea of creating a new care robot market for additional economic growth. The first step was to add authority to establishing a new market by proclaiming robotics as a key industry for economic promotion (METI 2004b). METI measured the key performance indicator for the domestic care robotics market scale on 1 billion yen in 2012; they set the very ambitious objective of 50 billion yen for 2020 and 260 billion yen for 2030 (METI 2014d). For reaching the 2020 objective, an annual increase by 6 billion yen would be necessary and it remains unclear how to realize such an optimistic goal.

The government acts on the assumption that there is wide acceptance towards using care robotics. The CAO (2013) released the results of its special public opinion survey of around 1800 people. The result is that 25% of the caregivers would use care robots, 35% might, 6% do not know and 34% do not want to use robots for care. On the side of the care recipients, the acceptance of care robots is slightly higher with 35% of the care recipients considering and only 30% refusing them, when making use of care services care robots. This means that 25% of the caregivers and 35% of the care recipients could imagine using robots for care, which is still not a high number yet.

In addition, it has to be mentioned that 60% of the 1800 respondents had no experience with home care. Moreover, only 30% of the caregivers had some knowledge about specific care robots, 40% had heard about care robots or had no knowledge. This means that not only care experience is missing by the majority of the respondents, but also specific knowledge about what care robots can do. The latter might be caused by the fact that the number of currently available care robots is limited. For the reason of a high percentage of people being unfamiliar with care and care robots, it is difficult to generalize the survey.

Also from an everyday perspective, families are looking for ways to facilitate the care of their aging relatives. It is often claimed that the whole of Japanese society is very robot-friendly. Intercultural studies (cp. MacDorman, Vasudevan, and Ho 2009; Broadbent, R. Stafford, and MacDonald 2009; Trovato et al. 2013; Bartneck et al. 2006) indicate that the attitude towards robots in Japan might be more complex than assumed and possibly does not differ significantly to other countries. For example, Bartneck et al. (2006), shows that in many areas the acceptance of technology in comparison to other robot technology countries, such as China, the Netherlands and Germany, is not very different. In all measured categories Japan had an acceptance towards robots comparable to Germany. If young persons, who are more open towards technology are almost equal to other countries, then it can be assumed that the results for empirical data collection with elderly will probably lay open a more cautious view on the acceptance of care robots. Additionally, it needs to be considered that the sample group was made up of young students who might be more curious and attracted by new technologies than elderly persons. Hence, it could be assumed that similar surveys conducted with seniors would lay open a more reliable view on acceptance, especially in terms of robotic products targeting high-aged persons in need, workers and institutions in the care sector.

3.2 The Coverage of Japanese Robots within the Media and Academia

After getting a basic understanding of robotics and distinguishing industrial robots from care robots and other kinds of robots, it becomes clear that what basically makes a robot a care robot is only the field of application. In the end, it remains difficult to find a generally accepted definition for care robots. Against this background, it is interesting to take a closer look on the coverage of robotics within the media and academia. The former, the media, has a significant impact on how average people, who do not design and develop robots, think, because for them this might be their only connection to robots. The latter, academia, shows how robots are picked up by researchers and what the relevant issues are. This is interesting especially for research that is going on outside engineering, such as social and cultural studies, which think more about the non-technical features of robots, the implementation of technology.

3.2.1 The International Media Coverage on Japan's Robot Technology

Foreign media are following the unresisted introduction of robots in Japan with great interest. Especially, when media set robotics in relation to the steadily aging Japanese society and the existing challenges of this population development, the headlines are usually about 'robots care Japanese elderly' (cp. Di Nuovo, December 06, 2018; Hurst, February 06, 2018; *The Economist*, November 23, 2017; *The Times*, December 16, 2018). With a birthrate that has been declining for decades, in combination with a steadily aging society, labor shortage poses a serious problem for Japan to maintain its status as a leading economy. In the course of this, the government is urging the introduction of robots in a variety of industries and it seems that they are preferred in order to balance labor, especially care, deficits instead of rethinking immigration. In contrast, in Europe and the United States, immigration is able to compensate for labor shortages to some extent. Against this background, foreign media coverage on Japan tends to highlight technology-driven approaches as the way of Japan, the robot kingdom[57]. In doing so, the media coverage includes the following phenomenons: Robot funeral, robot hotel, robot farmer or robot nurse.

The robot funeral is the introduction of Softbank's humanoid robot Pepper. The concept is that Softbank offers a robot priest service for funerals (Gibbs, August 23, 2017; Martin, August 16, 2016). The 'robot funeral' includes the option of a live stream for relatives, who live far away and thus have difficulties in participating, but is 80% cheaper in comparison to a traditional funeral with human priests. Softbank not only tries to access new business areas, but also offers reasonable services within the highly competitive funeral market, targeting especially secular-minded persons. When thinking about robots involved in funerals, it is only consequent to think this to an end and to highlight a robot funeral for robots (*The Times*, June 10, 2017; Walker, March 08, 2015; Soble, June 18, 2018). This type of robot funeral aims at outdated robots, in particular Sony's AIBO, which cannot be repaired. The concept is to give the owners of AIBO an opportunity to saying goodbye to their beloved robot pets.

The robot hotel, which is often picked up as 'strange hotel'[58] , is located in Nagasaki Prefecture (*CBS News*, July 28, 2017). The concept was to be able to run a hotel with only seven employees due to the the large-scale introduction of robots. For a hotel of this size, usually 35 employees necessary and thus hotel owners all over the world are apparently paying attention to the outcome of this new business approach. On the hotel's website (Huis Ten Bosch n.d.a), the various robotic employees are introduced, i.e. front desk robots that can communicate in multiple languages to welcome guests, window wiping robots and lawn mower robots. The hotel seems to gain a high reputation with its unique accommodation experience (Huis Ten Bosch n.d.b). However, the concept does not seem to work well, because half of the robotic employees have been fired recently (*Spiegel Online*, January 16, 2019; Hertzfeld, January 31, 2019).

The robot farmer, in particular driverless tractors, are supposed to balance the labor shortage within the agricultural sector (Lewis, August 20, 2017; *Japan Times*, April 23, 2016). Thereby Japanese engineers have to deal with the difficulty of developing robots for muddy and relatively small paddy fields. In Europe and the United States, their large and even landscapes make it relatively easy to develop robots for the agricultural sector.

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[57] In Japanese: robotto taikoku nippon ロボット大国日本, robotto ōkoku nippon ロボット王国日本
[58] In Japanese: henna hoteru 変なホテル

However, Japan's alleged disadvantage might turn out as a competitive advantage with regard to exporting Japanese robotic technology as agricultural solutions to geographically homogenous Asia.

Undoubtedly, there are robots in a wide range of applications such as funeral, hotel and agriculture in Japan, which are attracting attention abroad. Against the background of a declining birthrate and a growing proportion of elderly people causing a rapid increase in demand within the care sector, one question is often raised: To what extent can robots solve Japan's demographic issues (e.g. Arillo, December 04, 2019)? The consideration of robots for the field of care can be seen as the consideration of the robot nurse.

In doing so, foreign media emphazies the Japaneseness of this approach as somewhat uncanny and creepy (cp. Dickinson, June 14, 2019; Goldman, March 18, 2019). Thereby the argument is that the broad acceptance of robots in Japan backs up a sense of technology affinity (see Chapter 3.3.4), influenced by pop culture such as the manga Astro Boy. Moss (August 22, 2017) writes in her article for Bloomberg that*, "cultural affection for the anime character [Astro Boy] has made it easier for people to feel more relaxed about robots and technology in their lives."* The link of design and technology in the form of a character seems to be one important factor, which can be better understood through the care robot ROBEAR[59] developed by RIKEN and featured in various media (e.g. Emont, March 01, 2017; Byford, April 28, 2015). It could be assumed that elderly people would feel scared or uncomfortable when several care robots are introduced in a certain care facility. However, in Japan, the elderly show interest and are better motivated for health care activities such as exercises or rehabilitation (Blair, August 07, 2017). The use of robots for motivation might be transferable onto various other activities within care facilities and make a contribution to ensure healthy daily life for the elderly and a high quality of care on the caregiver side.

This optimistic evaluation of technology, excluding other possible solutions to ensure a properly running care system, may lie in a reversal of the resistance against a revision of the immigration policy. Prime Minister Abe got to the heart of this issue, when having been asked at the U.N. General Assembly in 2015, if Japan would be accepting refugees from Syria, by pointing out *"I would say that before accepting immigrants or refugees, we need to have more activities by women, elderly people and we must raise our birth rate.*

[59] ROBEAR is a transfer aid, which is intended to transfer people, e.g. from the bed into the wheelchair and back. The robot looks like a polar bear with a soft skin, weighs around 140kg and is equipped with several tactile sensors

There are many things that we should do before accepting immigrants." (*Reuters*, September 30, 2015). This short statement fairly accurately summarizes Japan's long-standing resistance towards accepting foreigners.

The current situation for migrants in Japan is not easy. Emont (March 01, 2017) observes that in American care facilities, immigrants are mostly serving as caregivers, whereas in Japanese care facilities, the number of foreign caregivers remains insignificant. There is a case study of a care facility in rural Japan, where twelve Indonesian caregivers are working. However, the reality of working in Japan is difficult, because caregivers are forced to return home unless they pass the Japanese Language Proficiency Test (JLPT) N1, the same exam that Japanese nurses and caretakers have to pass, of course in Japanese. As Efendi et al. (2013) found out, between 2008 and 2010 only 51 out of a total 316 Indonesian nurses, who came with the Indonesia Japan Economic Partnership Agreement, passed the exam, which is only around 16%. This illustrates that the language barrier, or in other words, receiving professional training while having to attain a high proficiency level in Japanese, is limiting the chances of entering the care sector. Even if there are governmental programs to attract foreign workers, there is still resistance to accept them as regular employees in the near future (Hoenig and Ujikane, August 21, 2017). One expectation on the utilization of robots is the hope that this will lead to a rise in human wages and higher productivity.

Media suggests a wide field of opportunities for robotics within the field of care. And indeed, the focus on what technology can already do is important. However, this can end up in misconceptions about the actual state of the art and thus lead to a too optimistic evaluation of technology.

3.2.2 Research on Japanese Robotics and Japanese Robot Researchers

English publication on the rise of Japanese industrial robots and their role within Japanese society in the West comes from technology writer and translator Frederik L.Schodt (1988) with his book "Inside the Robot Kingdom". For his publication, Schodt uses a large number of Japanese sources, interviews representatives from industry and politics as well as visits robot manufacturers. He moreover analyses the competition within this industrial sector and its attempts for first international cooperation, and he also evaluates future-oriented government programs. Schodt interprets the rise of industrial robots and the role of pop culture in acceptance of robots in Japan. As the subtitle of his publication suggests, for Schodt, the ‘coming robotopia’ is no pure reverie. Even though his publication is from a late eighties economic expansion phase, it remains a reference for understanding the state of Japanese robotics before 1990.

In the new millennium, Timothy Hornyak (2006) published his book “Loving the Machine”, which tries to tie into Schodt’s findings. In contrast to Schodt’s focus on industrial robots, Hornyak is especially highlighting the history and current state of the art of Japanese humanoid robots. For this purpose, Hornyak conducted interviews with the developers of several humanoid robots on their popularity, expectations and vision of the future for robots in Japan. A limitation of his publication is that his broad empirical data collection and the update on the current state of robotics is not based in scientific grounding and evaluation.

Schodt’s and Hornyak’s publications are representative for Western research on robots in Japan. More than the industrial robot, the focus is mostly on the relationship of human and humanoid robot. Even though up to now the research on humanoid robots was still in the stage of development, their technical capabilities are very limited and there is no significant practical value or specific fields of applications. They are preferred to industrial robots, which revolutionized production in the seventies, and provided the basis for current developments in robotics. This means that current Western research focuses on media attention to the spectacular phenomenon of humanoid robots.

Miriam J.S. Leis’ (2006) publication with the promising title “Robots – Our Future Partners” (Leis 2006) examines the role, perceptions and acceptance of robots as future partners for humans by contrasting Germany and Japan. The publication gains interesting interpretation and evaluation patterns through several excurses, i.e. phenomenons, like the AIBO fan club. The publication is written from the perspective of somebody who might sympathize with AIBO, and it would have been interesting to see her findings more in relation to academic discussion.

The publication of Cosima Wagner (2013) “Robotopia Nipponica” explains the social acceptance and cultural popularity of robots in Japan. Her work considers a broad spectrum of Japanese sources and interviews with Japanese robot experts. Robots are evaluated as a metaphor for the complex use of the creation and implementation of technological artefacts, which are influenced by the interdependency of culture and history, expectations of the Japanese government and economy, and the challenges of sociocultural change caused by a rapidly aging society. Wagner critically shows that the often-mentioned arguments for the cultural robot-affinity of the Japanese, such as a long technical tradition with robots, the religious perception toward inanimate objects and positive illustrations in pop culture, is mostly a matter of 'invented traditions' (Wagner 2009).

Apart from these main studies in English literature, there is a wide range of Japanese sources about robotics. This includes scientific and also popular publications, such as robot construction instructions for scientifically interested young people (e.g. Luo 2009). There are also publications that explain robotics, with the example of Doraemon (e.g. Fujiko 2014) or Astro Boy (e.g. Fukuda 2003) This also goes over to engineers (e.g. Yoshifuji 2017; Furuta 2010) who use the narrative of their own story to show that robots can change lives and society for the better. In addition to these rather technical and scientific publications, there is an increasing number of publications on service and domestic robots, which demonstrates the interest in their social use. Regardless of the publication genre, a common point is that the publications are rather non-critical.

Comprehensive surveys on the historical development of robots for the entire 20th century are rare. Covering the first half of the 20th century, Haruki Inoue (1993) traces the introduction and diffusion of the term robot in Japan and in his subsequent publication "History of Robots in Japan during the War 1939-1945"[60] (Haruki Inoue (2007). He illustrates the genesis and adoption of the image of robots as human helpers and servants.

For the second half of the 20th century, Hirochika Inoue et al. (2004) published with "Robotics Creation"[61] the first volume of the seven-volume series of the Iwanami Series. The first volume focuses on robotics and their history. It starts with a chronical description of robot ideas and concepts after the Second World War, but also includes the emergence of modern robotics up to today.

Besides, there are several Japanese pioneers in robotic research with a special approach, who have an impact on current development within the field of robotics, as well as influence the discussion on the use of robots within society. The following two engineers are exemplary for this group of robot pioneers.

The bionic engineer Hirose Shigeo, Professor at the Tokyo Institute of Technology, is working on various movement types of robots, including for example walking, crawling and swimming robots. Moreover, he is actively engaged in the research and development of mine exploration and disaster response robots, and also contributed to an un-

[60] In Japanese: nihon robotto sensōki 1939-1945 日本ロボット戦争記 1939 - 1945
[61] In Japanese: robottogaku sōsei ロボット学創成

derwater exploration robot for the investigation of the Fukushima-Daiichi Nuclear Reactor after the Tōhoku earthquake in March 2011 (Hirose 2013). He published about copying movement types of certain animals into robots, such as snakes (Hirose 1987b), but also published two general introductions on robotics "Robotics－Vector Analysis of Mechanical System"[62] (Hirose 1987a) and "Introduction to Robotics "[63] (Hirose 2011). His research is based on bionic engineering and aims at a technology transfer from nature into robotics with a utilizable research outcome. Against this background, Hirose (1998) is questioning the usefulness of humanoid robots.

The android researcher Ishiguro Hiroshi is a Professor at Osaka University and director of the Hiroshi Ishiguro Laboratories at the Institute for Advanced Telecommunication Research; he receives a lot of attention by the media (cp. Adina 2017; Fehr and Macho Andreas, December 02, 2018; Omura) for his research on androids and their interaction with humans. Androids are intended to be realistic humanoid robots that look and act like their human originals. His research is dedicated to the idea of making a robot that is indistinguishable from a real human being, even if it is only for a short moment (Ishiguro 2007, 2012). This idea is not only limited to publications on the related philosophical issues, such as the essence of a robot (Ishiguro 2009) and human being (Ishiguro 2011), but also the technical realization of his highly realistic robots through advanced robot systems. For him the advantage of a humanoid appearance is that the robot needs no special adjustment to a human environment, and thus is easily integrated into daily life.

Android research is trying to overcome the uncanny valley and current research seems to prove some success towards the development of realistic human copies under certain circumstances. An important difference to Mori's theory (cp. Mori 1970) is that in contrast to the seventies, when the uncanny valley theory was published, technological progress today makes it possible to verify the impact of design and movement on the robot's acceptance.

3.3 The Current Developments and Trends of Robotics in Japan

Japan is not only a leading country in the high-tech sector, especially in robotics, but also has a proactive approach to technology, which is creating a conducive environment for

[62] In Japanese: robotto kōgaku - kikai shisutemu no bekutoru kaiseki ロボット工学 - 機械システムのベクトル解析
[63] In Japanese: robotto sōzōgaku nyūmon ロボット創造学入門

the development of care robots. It is worth investigating, if after the robotization of production during the seventies, the next step will be the robotization of care or to what extent technology will diffuse into society.

3.3.1 Japan`s Aging Society - Challenges and Opportunities

The Japanese population peaked at around 128 million in 2016 (MIC 2016), but according to projections this number will decrease to 90-100 million inhabitants by 2050 (Atoh 2008; Coulmas 2010). The reasons for this rapid demographic transition are manifold. A constantly low and further decreasing fertility rate since the early seventies, accompanied by a steadily rising life expectancy induces the aging and shrinking of the population. Until the mid-seventies, the total fertility rate settled down around replacement level for industrialized societies of 2.1, but dropped from 1975 until 1990 below 1.5 children per woman. The lowest statistical record has been in 2005 with a total fertility rate of 1.26, however, recently it recovered slightly to a level of 1.42 in 2014 (MHLW 2015c). At the beginning of the twentieth century, life expectancy was around 44.8 years for females and 44.0 for males. In 2005, the average life expectancy was 82.3 years with 85.6 for women and 78.5 for men (Coulmas 2010), which is an astonishing increase of almost 35 years for men and 40 years for women. The percentage of the population over 65 years will shift from 20% in 2005 to 40% in 2050, which means the average age will shift from 43 to 57 over the same period (Atoh 2008).

Some of the implications resulting from this rapid demographic transition are a decrease of the available labor force and a growing share of seniors in the population, which could become a growing burden for the Japanese social welfare system. On the one hand, it will get increasingly difficult to satisfy demands for professional care for the increasing number of elderly, especially as the area of nursing care is severely affected by a shrinking workforce. The MHLW assumes that by 2025, the sector will face a labor shortage of around 380,000 caregivers (MHLW 2015a). On the other hand, the currently 32 million seniors aged above 65 years living in Japan (25.1% of population (RRRC 2015, 1) are one of the factors responsible for growing social security costs (state expenditures for pension, medical care, welfare, nursing care, etc.) to a record high of approximately 122 trillion Yen in 2015 (MOF 2012, 6).

Japan's immigration level is one of the lowest among developed nations because of language barriers and strict immigration laws. As a result, in 2014 only 1.6% of the population held a foreign passport (MOJ 2015). A strong division between decision makers seeing a threat to national security and cultural homogeneity by increased immigration, and supporters for opening the country to foreign labor to tackle worsening shortages, lead to significant policy inconsistencies. Examples are the various international 'trainee programs', which should enable foreign workers to get limited residence and work permission in selected sectors of the economy (e.g. construction, agricultural production). The bilateral Economic Partnership Agreements with the Philippines, Indonesia and Vietnam, in combination with Japan-sponsored setting-up of training programs and facilities in these Southeast Asian countries, were supposed to enhance a constant inflow of adequately trained care workers to Japan (Rabe and Kohlbacher 2015). However, concerns about a decrease of the average wage level, diminishing of care quality (Osaki, April 19, 2015) and high requirements for potential immigrants, such as final exams in Japanese for receiving long-term visas, hinder programs and lead to the exodus of a majority of workers after their visa expires (Lam 2009). The diverse political views on migration are hindering a steady supply of foreign human resources and facilitate considerations to find alternative solutions, especially in the highly pressurized area of care service provision.

Additionally, recent shrinking of the number of citizens at an employable age to 79 million (RRRC 2015, 1) has, furthermore, contributed to the extraordinarily low unemployment rate of 3.4% (MIC 2015), which together with the rising quantity of unfilled jobs (two-decades high) (Fensom 2015) is another indicator of a general labor shortage in Japan and an expanding need for automation and increasing productivity (Pradyumna P. Karan, Gilbreath, and Pradyumna P. P. Karan 2010, 164).

3.3.2 The New Robot Strategy from 2015 – Incentives for the New, Comprehensive Policy Action Plan

To coordinate efforts addressing the challenges caused by demographic transition and to revitalize the Japanese economy, the Robot Revolution Realization Initiative[64] promoted by Prime Minister Abe developed the 'New Robot Strategy'[65] (NRS), which was launched in 2015 – a five year plan to build a diverse industry for robotics producing

[64] In Japanese: robotto kakumei inishiatibu kyōgikai ロボット革命イニシアティブ協議会
[65] In Japanese: robotto shin senryaku ロボット新戦略

adequate solutions for challenges- is composed to answer a variety of social issues, but solving the labor shortage by releasing workers to the labor market due to improved productivity and stopping the increase of social costs are prioritized targets (RRRC 2015, 2). The strategy identifies the aged Japanese society as a fruitful background for the upraising of a new robotics industry, as it bears not entirely utilized economic potentials, being targets for innovative technologies in various areas (health, care, human support, etc.). The introduction of robot technology in the way defined by the NRS may, additionally, contribute to lowering the pressure on the welfare state by supporting the self-dependence of Japanese elderly, and improving the situation for workers in the care sector through reducing physical and mental burdens by the use of technology.

Basically, there were five main clusters of incentives which have led to the establishment of the new support strategy for robotics: (1), the demographic situation as described in chapter 3.3.1, (2) the economic market potential of robotics, (3) growing global competition challenging the country's status as ‘robotic superpower’, (4) the Olympic games in Tokyo in 2020 as a platform for show-casing based on world-wide attention for the event, and (5) the chance to use the accentuation of rules and arrangements hindering the breakthrough of many robotic products as a means to continue and legitimize deregulation.

The METI has realized the diverse market potentials of the robotics industry in its estimations of the possible size of certain market segments. The segmentation into four submarkets for robotics used in the case of METI's market prediction was slightly extended to five target sections in the NRS (manufacturing, service, nursing/ medical care, infrastructure maintenance/ disaster response/ construction, food refinement) emphasizing the labor-intensive health care and infrastructure sectors as important targets for robotic innovations (RRRC 2015, i).

In 2013 METI (2013b) data combines the results of a survey conducted among the Japanese robotics industry and world robot-trading figures, enormous growth is predicted for the introduction of robotics in all of these sectors, leading to an expansion of more than ten times of the total market value. The NRS adds the advancement of the market for nursing-care robots to 50 billion Yen as an aim (RRRC 2015, 89). Additionally, in 2013, the Yano Research Institute forecasted less enormous, but still significant, growth of the market volume in the case of care robots from 2.3 billion Yen in 2015 to 34.9 billion yen in 2020 (Yano Research Institute 2014). For reaching this predicted market size in 2020, annual growth of around 6.5 billion yen is necessary. These positive evaluations of market potentials allow two conclusions: Leading political actors have realized the economic potential of robotics and a large percentage of the market is not yet adequately realized. The predicted growth of partial markets for robotic products is not the only important economic factor making coordinated support of the robotics industry attractive for decision-makers. Japan has acquired a competitive advantage in robot production due to the growth of its high-tech industries. Supplies essential for the construction of robots like sensors, high-capacity processors, various kinds of servo-electronics and other fine-mechanics, can be produced in high quality and quantity at relatively low prices by experienced domestic companies. This enhances affordability for robotic solutions and enables the development of attractive high-tech products.

The third incentive for the NRS is growing competition in the robot business, leading to fear that Japan might lose its status as a ‘robotic superpower’ and the world's forerunner of robot innovation (RRRC 2015, 1).

Additionally, the NRS does not only see growing motivation of reference economies to invest in robotics as a threat. Increased basic research inducing knowledge exchange and cooperative projects leading to an opening of the Japanese scientific community to foreign input, added to the chance of evaluating other countries' approaches to fostering robotics, could become fruitful factors for the overall progress of the Robotic Revolution (RRRC 2015, 5). In that sense, expanding experiences and a raise in general affinity for robots based on successful trials in other countries could also turn them into target markets for Japanese products, especially as most advanced industries have gathered experiences with the import and quality of Japan's industrial robots.

The fourth incentive, which led to the compilation of the new robot strategy, was the selection of Tokyo as the host city for the summer Olympics scheduled for 2020. This event will attract visitors from all over the world and focus the media's attention on Japan. Such an international event is an opportunity to present the country and its robotic inventions to the world. Hence, the NRS includes a plan to use the attention to showcase the outcome of the Robot Revolution to the world in a competition between the world's most advanced robotics in the form of a ‘robot olympic’ tournament (RRRC 2015, 48). In addition, foreign visitors are supposed to experience the penetration in Japanese society by robotics on the base of daily interaction, and return to their home countries with a positive impression advertising Japan as an innovative country with outstanding achievements in robotics. In this sense, the Olympic Games will be the benchmark for the NRS, showing the progress or potential shortcomings of the strategy. This explains further why many parts of the plan are composed in a detailed five-year-schedule, aiming at the acceleration of research for the on-time achievement of progress until the Games.

The last, but, as there is no hierarchy of importance between points, not least significant incentive for the NRS is the chance for the Abe government to promote deregulation in various sectors. Even though the cutting-edge domestic research of well-known institutes turned into a promising business model, it was nearly impossible to obtain funding. The establishment of a culture of venture investment and, in this sense, the liberalization of the financial market, is one of the central aims of Prime Minister Abe. For that purpose, the prime minister also initiated an exchange program to send around 200 Japanese business actors to Silicon Valley in the next few years to learn the culture of entrepreneurship and investment in the high-tech sector (Shigeru Sato and Yui 2015). The importance of adequate capital sources for SME and start-ups is explicitly highlighted in the NRS as well (RRRC 2015, 15).

The opening of the capital market is, nevertheless, just one part of the deregulation strategies concerning robotics. The NRS recognizes the need for initiation of far-reaching reforms encouraging the advanced utilization of robots by institutions under close cooperation with the Regulatory Reform Council (RRRC 2015, 15), tackling various areas of society such as the establishment of 'internationally harmonized regulations'[66] (RRRC 2015, 27) according to safety and approval procedures, to enable standardization and to build the foundation for export. Moreover, trials conducted in special robot testing zones, following the example of the Fukuoka site, are supposed to be beneficial for recognition of the need for regulatory reforms. Accidents occurring through the course of testing leading to damages of not yet defined responsibility, for example in case of an incorrect individually-made decision by an AI, could be one way to identify necessary regulatory adjustments (Weng 2015).

A first success stemming from the Japanese trial system was the acceptance of ISO13482 as the new international standard for the interaction of humans and robots (ISO 2014). The application of this new norm is supposed to be the first step in the direction of development of a regulative framework adjusted to the needs of new robots and facilitating the development of technological innovations.

[66] In Japanese: kokusai teki ni chōwa shita kisei 国際的に調和した規制

3.3.3 Technical Solutions for Social Problems – Care Robots from an Administrative Point of View

In Japan, coordination for the promotion of care robots and robot technologies touches the responsibility of several ministries. The following chapter will present an overview of the main bureaucratic efforts. METI as a central actor, being in charge of the coordination of efforts and subsidies in the manufacturing sector and, therefore, a vital part of the robotics industry, has an outstanding responsibility in the area of technology promotion and in driving the implementation of innovations. METI first attempt to support robotics focused on industrial robots, but recently a shift towards service robots, including care robotics and also disaster response and logistic systems, can be recognized. This alteration of the agenda is, among others, motivated by labor shortages caused by demographic developments (METI 2013b; NEDO 2011).

METI launched several support projects up to 2009 under the term 'Life Support Robots'[67]. Since 2009, medical use of the promoted robots is highlighted and illustrated by the new project name: Robotic Devices for Nursing Care[68] (see also chapter 3.1).

Between the years 2009 and 2013 NEDO, a think tank and research organization associated with METI, was responsible for the Project for Practical Applications of Service Robots[69]. The aim of this project was to establish methods for the safety assessment of new service robots (NEDO 2011). The outcome after the end of the project in 2013 was the Robot Safety Center[70] (NEDO 2014), as well as the first internationally accepted safety certification including robots, namely the ISO13482 (METI 17.02.2014).

In November 2012, METI and MHLW defined the 'Priority Areas to which Robot Technology is to be Introduced in Nursing Care of the Elderly'[71] (see also chapter 3.1.2) in cooperation, targeting better coordination of the promotion of robotic devices in the area of nursing care. Four areas and five items were, in the first step, declared as priority areas (lifting aids, mobility aids, toilets, and monitoring systems for people with dementia) for R&D support. Based on this specification, METI selected 31 in 2013 (METI 2014c) and in 2014 20 (METI 2014b) domestic companies as targets for subsidies, of which approximately two thirds can be categorized as SME. In February 2014, the areas were reviewed and extended to five by the inclusion of bathing aids. Additionally, eight robotic

[67] In Japanese: seikatsu shien robotto 生活支援ロボット
[68] In Japanese: robotto kaigo kiki ロボット介護機器
[69] In Japanese: seikatsu shien robotto jitsuyō ka purojekuto 生活支援ロボット実用化プロジェクト
[70] In Japanese: seikatsu shien robotto anzen jōhō sentā 生活支援ロボット安全情報センター
[71] In Japanese: robotto gijutsu no kaigo riyō niokeru jūten bunya ロボット技術の介護利用における重点分野

items within the five areas were designated as targets for further promotion, and the list of companies being awarded special funding was increased to 51, among which a budget of 1.82 billion Yen was shared (METI 26.05.2014) On top of that, both ministries promised to provide an infrastructure for the testing and presentation of 1,500 robot case studies (METI 2014e).

The aim of the selection of prioritized items and companies of differing sizes and high economic and innovation potential in the area of robotics was to match development within the sector with the political agenda. Moreover, especially SME faced problems to access proper funding sources for risky technology R&D projects in Japan. Therefore, the subsidies were supposed to alleviate negative effects resulting from the difficult search for capital. The ministries hoped that the products stemming from these coordinated efforts could enable some elderly persons to sustain independent lives in their homes, lowering the pressure on the market for professional care provision and on families providing home care for elderly generations. Furthermore, another integral part of the program was the exploration of concrete needs in relation to care robotics, enabling the successful exploitation of the markets' potential (METI 2013b).

Between the years 2012 and 2014, METI and NEDO additionally launched the Robotic Devices for Nursing Care Project[72], which centered on two points - a Public Private Partnership for the development of robotic devices for nursing care and the establishment of a website as a platform for upcoming activities and information. The concept of the Public Private Partnership is the identification of demand in the sector, the reduction of (public and private) costs and the organization of further financial support. Moreover, the partnership was supposed to help companies getting access to information from the administrative side, utilizing data collected during conducted surveys for a deeper understanding of users' needs (NEDO 2013, 13). The supplementary website 'Care Robot Portal Site'[73] was, furthermore, launched in August 2013 (AMED n.d.a).

Besides the continuation of the previously outlined initiatives, an additional budget for robot promotion related projects is provided in the form of subsidies by MHLW-related Association for Technical Aids since 2014 (ATA n.d.). The achievements of the subsidy program to the present day were summarized in the Practical Support for Welfare Devices and Care Robot[74] report (MHLW 2015b). Based on its content, it can be deduced

[72] In Japanese: robotto kaigo kiki kaihatsu dōnyū sokushin jigyō ロボット介護機器開発・導入促進事業
[73] In Japanese: kaigo robottopōtarusaito 介護ロボットポータルサイト
[74] In Japanese: fukushi yōgu kaigo robotto jitsuyō ka shien 福祉用具・介護ロボット 実用化支援

that MHLW is pursuing a similar support strategy like METI, but uses a different terminology. Whereas METI is promoting robot technology for care under the slogan of 'Robotic Devices for Nursing Care', MHLW is specifically referring to care robots. The effects of this duplication of efforts could either be of a negative (e.g. contradicting agendas, easy access to funding leading to the waste of public funds) or a positive nature (e.g. supplementation of each other spreading capital to more actors of need) and has to be evaluated.

In the context of the NRS, the CAO established the Japan Agency for Medical Research and Development (AMED) in April 2015 as a cross-ministerial institution for setting up a promotion system to lead results of basic research in the health and care sectors to commercialization (AMED 2015a). It seems that care robot development finally took shape thanks to the coordination efforts of the AMED.

In 2015, AMED adopted and continued the Robotic Devices for Nursing Care Project until 2017 (AMED 2015b). It is also interesting to look at the summary of the project budget between the years 2013 and 2016, which were published by METI. In 2013, 2014 and 2015, the annual budget volume was 25.5 billion yen, with a supplementary budget of 20.5 billion yen in 2013 and the objective of reaching a market size of 260 billion yen by 2030 (METI 2013a, 2014a, 2015). However, two points are noteworthy when the new budget for 2016 is regarded. Firstly, the annual budget decreased to 20 billion Yen and secondly, the budget has been limited to only two of the five priority areas, namely mobility and bathing aids (METI 2016). The practice of focusing support on selected areas, instead of channeling money into all five sectors, was newly established in 2014. Since then, different items were on the agenda each year; for example, in 2014, monitoring systems for nursing care homes and outdoor mobility aids were favored, whereas in 2015 monitoring systems for private homes, toileting aids, and wearable as well as non-wearable transfer aids took precedence. This could have created dissatisfaction and might come as a shock for companies which decided to invest in the other three areas (AMED 2016).

3.3.4 Japan's Constructed Image of Being a Robot-Loving Country

Under consideration of the introduced political attempts to promote the robotics industry, it is noteworthy that various authors address how the Japanese government, academia, and industry are presenting robots as an indigenous part of domestic culture to stimulate acceptance of policies related to the implementation of robotics in daily life (Sabanovic 2014, 343; Rathmann 2015).

The higher connection of the Japanese to animate objects results in the ability to form deep relationships with (social) robots based on the Shinto belief that everything can incorporate a spiritual life, the so-called Shintoism (Schodt 1988, 198; Ito 2003, 2; Krebs 2006, 64; Robertson 2007, 377; Wagner 2009, 511; Robertson 2014, 576). The presentation of karakuri puppets as the origin and proof of a long tradition of sophisticated Japanese robots (mechanical toy puppets developed in the Edo period (Schodt 1988; Hornyak 2006; MacDorman, Vasudevan, and Ho 2009; Wagner 2009; Wagner 2009 i.e.), and the enormous popularity and success of Japanese pop-cultural artefacts conveying a positive image of robots cohabiting or co-operating with humanity, e.g. Astro Boy (Ito 2003, 14) or Doraemon as examples for a peaceful cohabitation with humans, (Wagner 2013, 94) are the three main streams forming this argumentation.

Nevertheless, all three have been challenged in their status of being indicators for an extraordinary affinity for robots, or a special 'national character of machine loving', in Japan (Wagner 2009). Differing forms of animism also exist in other cultures, and recently gain importance due to the expansion of the internet and advances in AI development, which are turning technology into something more autonomous, less controllable, and irrational (Wagner 2009). Moreover, not many Japanese admit to believing in animism (MacDorman, Vasudevan, and Ho 2009, 493).

Karakuri puppets or mechanical dolls came to Japan from China during the seventh century and were refined in the sixteenth century by technology imported from Portugal (cogwheel-mechanism). The production and further development of karakuri puppets was forced by the prohibition of research on new technologies due to an edict of the Tokugawa Shogunate in 1649. The latter feared the violent uprising of a technologically more sophisticated domestic rival. Thus, the toy and entertainment business were the only sectors in which refinement was allowed. This is the reason for the focus on karakuri puppets, which were an important source of entertainment for the masses by their use in popular karakuri theatres (Wagner 2013). Nevertheless, the fact that the mechanical dolls were forgotten by the 1960s, and that similar toys existed in Europe during the same time as well, makes it difficult to define karakuri puppets as an indigenously Japanese phenomenon (Ito 2003, 15).

The famous Astro Boy manga and anime series is mentioned by many contemporary roboticists as the main source of inspiration and a core reason why they started to become interested in robots (Sabanovic 2014, 352). 30% of Japanese households have watched episodes based on viewership ratings (Masuda 2013). As the popularity of this series was related to its fit into the atmosphere of an economically catching-up post-war Japan, it is arguable that contemporary pop-culture has similar robot-promoting effects on Japanese people, especially as new series often draw a darker picture of robots and as the dystopian visions of Western cinema (e.g. Matrix, Terminator, I,Robot) are increasingly penetrating Japan.

Nevertheless, against this background of promoting the image of a special cultural affinity for robots in Japan as part of the debate around the increase of automation, it is not surprising that robots are discussed as a technical solution to demographic challenges, especially, in terms of care provision and regarding the shrinking labor force (Kishi 2011; METI 2013b; Nakayama 2006; NEDO 2009).

Various stakeholders in favor of robotics are acting on the assumption that (based on the outlined cultural affinity discourse) there has to be a wide acceptance of utilization of robots in elderly care (see also chapter 3.1.2). However, as shown by the example of the study by MacDorman, Vasudevan, and Ho (2009), and in terms of the argumentation against a special cultural affinity and 'national character of machine loving' (Wagner 2009) persisting in Japan, the academic debate often does not support claims that Japanese society is extraordinary robot-friendly or extraordinarily attracted to technologies.

3.3.5 The Use of Robots in the Field of Care and Therapy

Taking a closer look at the care market in Japan shows different concepts for home usage, health care provision and elderly care. Technologies for care assistance aim at reducing the burden on nursing staff and at improving the quality of care through transfer systems like the polar bear robot ROBEAR or a RoboBed. Aside from this, in the field of entertainment, robots can be used for playing (e.g. AIBO, RoboCup), for communication (e.g. NAO, Papero, KOBIAN-R) or for fostering creativity (e.g. Lego Mindstorms). This illustrates that the transition between care and entertainment can be smooth. Technologies for medical purposes like rehabilitation and therapy are another very promising development field. Through the utilization of robots for therapy or rehabilitation by using, for example, the robot seal Paro or the robo-skeleton HAL, psychical and physical conditions can be improved. Also other technologies, such as Nintendo's Wii (Watanabe

2013; Nishiwaki et al. 2012), that are not directly associated with robotics, seem to be very promising for care. However, the main problems for the wide expansion of robots are their high costs and battery limitations.

In the study and development of assistive robotic technology, Japan has already been doing research for many years. An example is the research of Prof. Toshimitsu Hamada and Prof. Mitsuru Naganuma, who analyze the effects and benefits of robot-assisted therapy. In their experiments, they use AIBO and Paro in nursing homes to examine their effect on the elderly (Hamada, Okubo, and Onari 2006; Hamada 2013). AIBO is a dog-like robot that is able to interact with its owner and can be programmed through a remote control. Paro is a seal-like robot that can communicate through sound and is used for therapy. On a similar basis as animal-assisted therapy, it seems that by using *Paro*, it can help relieve stress and discomfort in the elderly (Shibata 2006). One advantage of robots in the field of health care is that there is no problem with hygiene regulations and the running costs, compared to an animal therapy dog, are much lower.

Another Japanese robot that enjoys great media attention is the humanoid robot ROBEAR. Already ROBEAR's predecessors RIMAN and RIBA were equipped with visual, olfactory, auditory and tactile sensors (Mukai, Hirano, and Hosoe 2009) and were able to lift and carry people. RIBA was expected to be used in hospitals and nursing homes in the near future. The robot should have relieved the physical burden on nursing staff by moving people out of bed and into wheelchairs, and vice versa (Susumu Sato et al. 2012). The project was a collaboration between RIKEN and Tokai Rubber Industries, which together established the RIKEN-TRI Collaboration Center for Human-Interactive Robot Research. The most noticeable difference to its predecessor is that its design was not inspired by a human, but by a polar bear.

In Japanese society, the idea of using robots within the field of elderly care seems to be highly fixed. From an economic perspective, the government and many companies have invested huge amounts of money into robotic research. From an everyday perspective, families are looking for ways to facilitate care for their aging relatives, which easily explains the high expectations behind the development and the future fields of implementations for care robots. There seems to be a positive association of technology that is creating a conducive environment for research and development of service and care robots in Japan. Within this context, to some extent robots can be construed as a connection between society and technology. Thereby, robot images within pop culture can lead to positive spin-off effects fostering consensus for robot development, but at the same time might hinder their successful diffusion within society through their specific and advanced robot characters.

The current state of implementation outside the laboratory and diffusion within society, as well as research obstacles, are mostly ignored. Current research on Japanese robotics in Japan is either focused on discourse about culture (e.g. Wagner 2013; Robertson 2018), the technical parameter (e.g. Hirose 2013) or is limited to several projects (e.g. Ishiguro's Geminoid, Honda's Asimo). Conversely, the Japanese government and responsible ministries are rather vague and imprecise about details on how to realize the use of robot technology after the end of specific projects (see Chapter 3.3.2). A possible reason for this impreciseness could be a missing umbrella organization, comparable to for instance DARPA in the United States, to concentrate robot development in general. Additionally, the end of a project period often marks the end of a robot, because the inventions are neither supervised nor monitored by the ministries. They are developed on the basis of a specific budget. and not on the basis of market demands, which might be crystallized in the mismatch between the four actors (government, engineers, caregiver and care recipient).

4 Methodological Framework

After understanding how innovation emerges and taking a closer look at the state of the art within robotics in Japan, it becomes clear that this study needs to rely on empirical data. Sismondo (2008, 23) gets to the heart of this necessity when he underlines that *"STS has shown […] that the solution to scientific and technical controversies rests on judgment by experts and judgments of the location of expertise rather than on any formal scientific method; science and technology are activities performed by humans, not machines."* Against this background, the key element of this study is its empirical field research with the essential elements of empirical survey, data processing and analysis of data. Thereby, qualitative methods have their very own methodology. For this reason, I provide a general introduction into empirical research (see Chapter 4.1.). On this basis I work out research design with its structure (see Chapter 4.2.) and consequently develop an interview guideline (see Chapter 4.3), which includes some notes about the procedures of documentation. The interview guideline is attached in the appendix (see Appendix).

4.1 An Introduction into Empirical Research and the Selection of the Research Design

Lüders (2017) critically contrasts empirical research studies with common literature-based research because the latter is a citation catalog and remains only an academic matter and misses, among other things, a certain pragmatism. Gläser and Laudel (2010, 14–15) indicates that the ability to *"[…] learn strategies for [exclusive] knowledge acquisition and being able to successfully apply them [becomes generally more important]"*[75] in an era in which knowledge is of increasing relevance within society, going hand in hand with a prevalent overload of information at the same time. At this point, the exclusive access to specific knowledge can become key for involved actors in order to obtain relevant information and being able to make a valid forecast about a certain topic. This might even influence the development of emerging technologies. In particular, in the forefield, when the decision to develop a new technology, its subsequent conversion and future incremental improvement, are still in progress. Qualitative methods are a tool for this, even though their time-consuming and demanding character might oppose acceptance of their use. For this reason, it is easy to understand that *"qualitative methods*

[75] "[...] Strategien der [exklusiven] Wissensbeschaffung zu erlernen und erfolgreich anwenden zu können [wird im Allgemeinen immer wichtiger]." (Gläser and Laudel 2010, 14–15)

of empirical social studies become more important for complex and new problems […] in academic as well as commercial market and marketing research"[76] (Auer-Srnka 2009, 161), even outside the original field of social studies such as in applied economics.

At the same time, there is, as Gläser and Laudel (2010, 24-45,28-29) mention, a dominant polarization of qualitative and quantitative paradigms within empirical social studies, and their current mutual exclusion leads to a drop-out of a common methodology. In doing so, according to Lamnek (2010, 25), the label of qualitativeness sticks to a large number of different basic theoretical positions and methods, which can sometimes lead to inconsistency in qualitative social studies.

According to Flick (2007, 39–54), primary research divides into qualitative and quantitative methods. Thereby the choice of a suitable approach of research depends on the research project and object of investigation. If representative and generalizable results are intended, a quantitative approach, where data is statistically evaluable, makes the most sense. The disadvantage here is that data has to be collected from large samples in order to obtain meaningful and generalizable results. One approach is especially recommendable, that which is based on qualitative methods. Even for quantitative research, with its difficulty to quantitatively measure certain characteristics, reliable and specific results can be achieved through a focus on of the behavioral or thought patterns of a particular group.

This study (see Figure 4-1) relies on a mix of primary and secondary sources. Before the fieldwork period, there was a literature review based on secondary and also primary Japanese sources. The review of the state of research within care robotics in Japan provides fundamental information about the topic and all further qualitative data collection. However, the thesis (see Chapter 1.2) cannot be verified with literature only, because the literature does not touch on important technology developments, the engineers' mindset and other relevant groups. The mindset of relevant social groups of technology development must be revealed in the order to answer the theses.

[76] […] bei komplexen und neuartigen Problemstellungen unzureichend sind. Dementsprechend gewinnen in der akademischen wie auch der kommerziellen Markt- und Marketingforschung qualitative Methoden an Bedeutung." (Auer-Srnka 2009, 161)

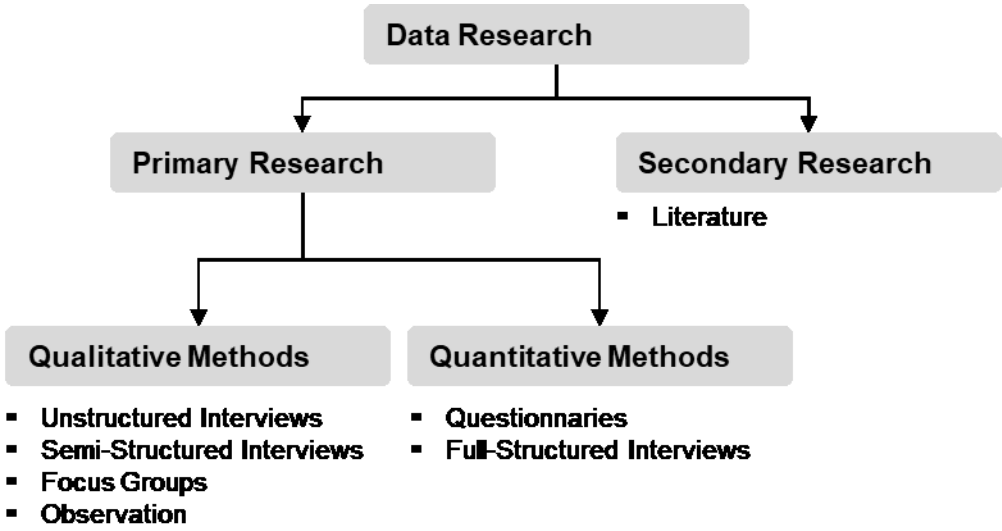


Figure 4-1 Research Design of this Study

There are different types of interviews. In the following, I introduce some qualitative and quantitative methods of primary research with focus on the research instruments of the interview. Thereby interviews can serve both quantitative and qualitative research purposes. The different types of interviews are unstructured, semi-structured and structured interviews (Flick 2007: 194-226) within the field of empirical research, whereby special attention is on the mentioned three interview types.

At the beginning, there are unstructured interviews. As expected, these types of interviews, can do without a solid structure. Empirical data is collected through a free interview between interviewer and interviewee. This interview type can be done in small numbers but is not suitable to compare a larger quantity of data. For this reason, because the goal of this study is to compare a larger group of engineers and draw conclusions from the data, this interview type is unsuitable.

In contrast, structured interviews have a fixed format, which usually gives only limited response options to the interviewee. It is possible to combine semi-structured interviews with quantitative methods in order to give significance to collected data (Kelle and Erzberger 2017). Compared with a survey, data is collected and easily compared through standardized questions. Therefore, it is possible to analyze larger sample groups with this interview type. The main difference to a traditional survey is, however, that the interviewer can explain the questions further, if required. Due to the given response options through the given structure of the interviews, the informative value of this interview type with its fixed structure remains low for this study, because the topic of care robotics in Japan is an explorative one with a not yet known outcome.

According to Hopf (2017), semi-structured interviews are a symbiosis of structured and unstructured interviews, and are one of the most common survey methods in the field of qualitative research. Through this type of interview, issues that are even more complex can be captured. The essential component hereby is an interview guideline. Through an interview guideline, it is possible to give structure to an interview without limiting the interviewee's response options. It can also make the interview situation itself flexible, because questions can be optionally added or left out. In addition, an interview guideline comes along with the advantage that it is possible to use the guideline for several interviews, and thus be able to compare collected data of small and larger sample groups with relative ease. This advantage is also a disadvantage, because open answers cause more work. Especially if the sample group is large, analysis requires a relatively long time which makes a researcher reach his limits rather fast.

A precondition for a successful semi-structured interview is a certain practice of the interviewer towards interview procedure. According to Flick (2007, 203–4) an interview guideline ensures that all relevant information can be collected through the course of the interview. The guideline ensures success of the interview and furthermore supports the interviewer. For this reason, it is important that the guideline is logically structured and easy to understand. It must be possible to quickly grasp the questions and read them to the interviewee during the interview. The guideline helps concentration during the interview, even if the interviewee gives long explanations. Moreover, the interviewer can guide the conversation back to the question or explain an unclear question if necessary. The guideline can be extended with notes to make sure that the interviewer does not miss any important information, too. Therefore, it is necessary to pay special attention to the structure of the semi-structured interviews and develop them on the base of a guideline or handbook.

Aside from the interview situation and format itself, the formulation of the interview questions is important for successful semi-structured interviews (Flick 2007, 195–96). A logical order and clear word choice for questions supports the interview and allows the interviewee to respond freely. For this reason and for a better understanding, double negatives or lengthy questions have to be avoided. In addition, there should be some easily answerable or open questions, to make it possible for both sides to get familiar with the interview situation at the beginning of every interview. In doing so, open questions have the advantage that they allow the interviewee to answer freely and give more information. Subsequent questions can be answered in advance. However, open questions might connect to an excessive response. In combination with closed questions this ensures receiving the information necessary, but also leaves the interviewee liberty to answer in detail.

During the course of the interview, closed questions serve as an anchor to make it possible to follow the structure and not end in an unstructured interview. At all times, questions can be deepened or clarification can be obtained through further questions. This can also be used when the interviewee's answer is too short or if the original question was not understood.

It is important to check the guideline before and after every interview. This revision helps identify potential issues, such as the need to rewrite questions for better understanding or reacting to interesting and newly upcoming content. For this reason, it makes sense to take notes during the interview. Furthermore, if possible, all interviews should be recorded, because it is a great help for subsequent analysis of the interview data.

4.2 The Research Design and the Structural Framework for the Interviews

The method of choice is the semi-structured interview. Thereby the literature review (see Chapter 3) serves as the basis for the interview, for a better understanding and classification of collected data. The research objective is to uncover the Japanese engineer's mindset, including thoughts on how to contribute to Japan's demographic challenges through technology.

This study focuses on engineers or developers as experts in their discipline and key actors for technology development. Since a meaningful sample of experts is only realizable with great difficulties, it should be clear at this point that representative data collection is not feasible. For this reason, the collected data does not intend to stand for all Japanese engineers. The data collected through the interviews attempts to give the tendency of the matter.

Thereby, the SCOT and vision concept provide essential elements with their understanding of interpersonal and external communication processes that are necessary within the process of the emergence of knowledge. Visions (see Chapter 2.5) take possession of the participating actors and make the interference of knowledge cultures, and thus innovation, possible. These theoretical assumptions about the role of the individual and society serve as a framework, which makes it possible to structure the complex process of emerging technologies.

Moreover, even if the group of the engineers is a very narrow group, reliable and relevant data can be collected because open questions lead to a wide range of information and comprehension problems, which can be further explained and compared with other sources, such as literature. For this reason, the argumentation for semi-structured interviews with engineers is their direct involvement in the innovation process. Although there are several publications which generally (cp. Giesel 2007, 178–82) or scientifically deal with the vision-concept or robots, these publications are usually limited to the evaluation of literature. So far there exists no empirical survey which analyzes Japanese engineers' mindset on the base of socio-scientific theories.

It is also possible to combine semi-structured interviews with quantitative methods in order to give significance to the collected data (Kelle and Erzberger 2017). However, for this study, the working conditions with only one researcher set limits. Rather than to claim representative insight for the whole robot industry in Japan, this study attempts to give first insights and tendencies of the Japanese robot developer's way of thinking. It paves the way for further future research.

Before I go deeper into the interview structure, I'd like to clarify a few things about the research language. The complete correspondence, interviews and data processing is in Japanese. The main reason for this decision is that the research objects are Japanese robot developers, respectively their ideas about robots. Here the choice of the mother tongue of the interviewees has several advantages. First, there is no language barrier for answering interview questions, so that there is no difference between what is thought and what is meant. Here, language has the function of not just being a medium of communication, which would have been possible in English as well, but rather it is understood in this study in the sense that language is influencing thought. The choice of language ensures that the content nuances and specifics are preserved for analysis without using language as a simple medium for communication. Another very pragmatic reason is that the probability of agreement for an interview increases with choosing the mother tongue of the conversation partner. The concern that the complex subject of research is not explainable within an interview can be omitted. The decision for use of the Japanese language is a strategic one.

A disadvantage of this approach is, however, that through complex interviews the effort for subsequent analysis increases and it becomes even more important to carefully prepare the interviews. The interview must be clearly structured and possible language difficulties have to be kept in mind. For this reason, all collected data has been recorded with a digital recording device in order to simplify analysis. However, since interview data contains over 37 hours material, there is no full transcription but a selective transcription of the interview material. I am aware of the fact that preselection of material is never totally neutral. However, for reasons of proportionality of the documentation and its additional value for this study with regard to the available human resources, selective transcripts have been created for each interview.

The agreement for recording and the use of data has been obtained, before, during and right after each interview with the option to withdraw cooperation at any time. For a matter of data protection, all names have been anonymized through numbers. The selective transcripts are in Japanese, created on the basis of recordings. The use of Hepburn romanization has been deliberately omitted, as in the main text only English translations appear and the original Japanese can be found in the footnotes.

In the following I explain everything related to the interview and its structure. This includes the research purpose and development of research categories, which form the basis for the interview guideline. To develop a meaningful interview guideline, a clear overview of the thematic field and the deduction of theory-driven research issues are necessary. Helpful for this process is a methodical structure and organization according to certain criteria. Thereby the structure of the interview guideline is inspired by 'Qualitative Research Interviewing' by Wengraf (2001). The hierarchy is built on the research purpose (RP), which is converted into the central research question (CRQ). Out of it, categories (C) are built and in the end, turn into the interview questions (IQ). Additionally, another advantage of its structuring function is that the theory-driven questions form the basis for later analysis (see Chapter 6). In the following figure (see Figure 4-2), the methodology approach for this study is illustrated.

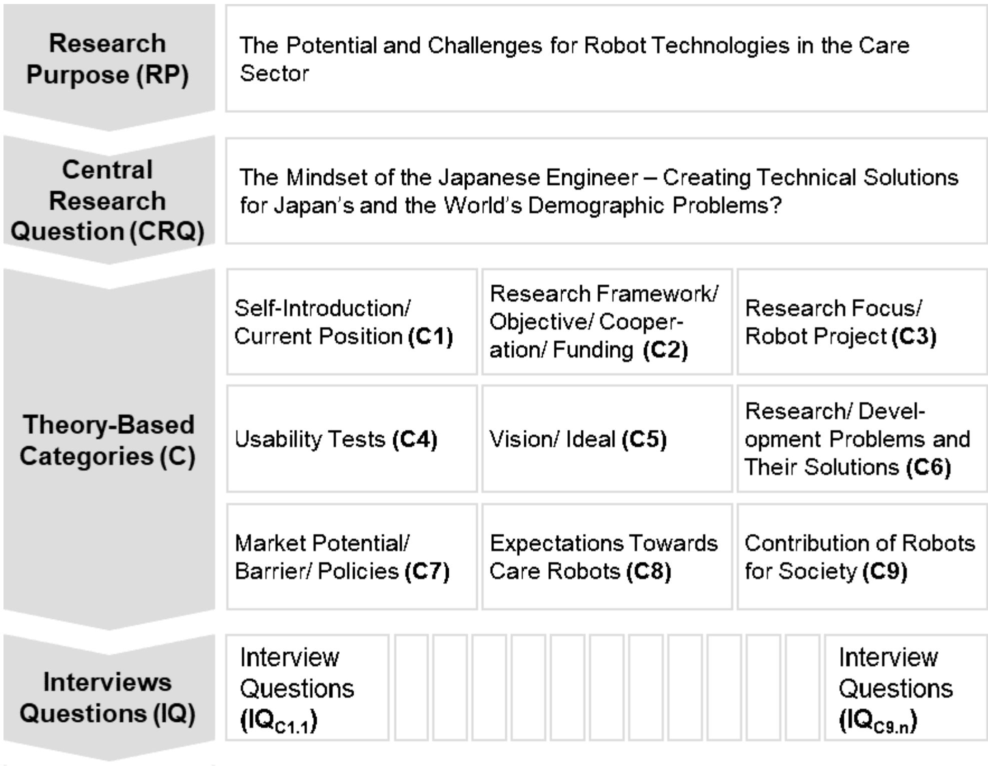


Figure 4-2 Structure of the Research Project

The research purpose of this study is to discover the potential and challenges of robot technologies for the field of care. This abstract topic must be transferred into a concrete central research question in order to being able to make the topic accessible for further analysis (see Chapter 6). The central research question is: Do the technical inventions of Japanese engineers offer feasible technical solutions for Japan's and the world's de-mographic problems? In other words: What kind of robots may be able to mitigate care problems? The next step is to break the central research question down into workable pieces, namely the nine categories, which are briefly introduced in the following.

The first of the nine research categories (C1) deals with motivation towards choosing a job that has to do with robots. This makes it possible to question the importance of the individual against the background of the vision-concept, according to which motivation is central to developmental success (see Chapter 2.4).

The second research category (C2) focuses on the internal structures of the organization. Regarding theory, (see Chapter 2.5) the problem of triple synchronization has to be solved for the creation of new technological knowledge. Therefore, it will be checked in how far the organization and especially the interorganizational information processes influence the widening and coordination outcome of development.

The third research category (C3) highlights the robot project itself. In doing so, the category centers on the specifics of the robot, the current state of technology and further development plans. It is the overview of the past, present and future of the robot.

The fourth category (C4) sets robot development and the thoughts of engineers in relation to the field of care. Questions about usability and field tests give insight into how far the robot is anchored in reality. Even the best idea will disappear if it doesn't experience a realization in the real world. Moreover, this topic shows how the engineers deal with feedback and to what extent their technical solution for care issues is seen by the caregivers themselves.

The fifth category (C5) is paying attention to long-term vision and development goals. There the existence of an explicit or implicit vision, as well as its shaping and purpose, will be discussed. Here the role of collective projection (see Chapter 2.5) is of particular interest, since this is crucial for the realization of a vision. In connection to the second category (C2), it is possible to have a closer view on the impact of organization on development and on expectations.

The sixth category (C6) covers challenges and setbacks within the course of development. From a theoretical perspective, (see Chapter 2.6), the solution to occurring problems shows the strength of the concept behind a robot as well as its acceptance within other relevant social groups.

The seventh category (C7) picks up the potential and at the same time the experienced issues of care robotics. The question is whether or not engineers agree to optimistic market forecasts.

The eighth category (C8) discusses possible cultural characteristics and environment. The vision concept deals primarily with the innovation process, which is caused through knowledge cultures and pays only a little attention to the role of culture within the developmental process.

The last research category (C9) closes with the application of robots in the context of demographic change. The Japanese government and media are often discussing robots as a possible solution to the problems that are associated with an aging society (see Chapter 3). It is interesting to see how the Japanese developers think about the potential of robotics as a technical solution for social issues.

4.3 The Interview Guideline and its Content

The next step after defining the research interest and research categories is to design the interview guideline with its interview questions. Because of their abstract nature, the theory-based categories cannot be converted directly into interview questions in the above described form, but rather have to be converted into categorical interview questions for a questionnaire and then be used to structure the interview course. In addition, the use of terminology can lead to problems in understanding and therefore impede answering the questions. The direct transfer and translation of research questions can have a confusing or limiting effect on the interviewee, so that fewer opportunities for wide statements occur. For a smooth interview course and better understanding, the theory-based categories are split into interview questions. According to Mayring (2002, 69–70) standard questions ensure a certain degree of comparability in the collected data within semi-structured interviews. However, the number of standard questions has to be limited in order to not affect flexibility too much. Before covering the categories in detail, I want to make general comments and notes on the interview structure, interview questions and codification.

The codification system, or in other words the formulation, fulfills the function that the interviewer can find needed information for the current interview quickly and directly (Flick 2007, 402–7). Therefore, the codification has to be simple and clear coding was used within the interview guideline. The interview questions are formulated indirectly to create an overall picture instead of simply covering a specific aspect, therefore broader results will be realized. The term ‘indirect’ means that interviewees are, for example, not directly asked for certain expectations, but rather a reference is created by a question about robots. Thus, the importance of visions and ideas on the individual and the organization can be understood in total.

Before actual empirical data collection, the necessary duration of an interview must be considered. For an efficient interview, it is important to keep the overall length in mind, in order to estimate the right amount of time for each interview category. This allows efficient use of the available time. It will also prevent the interview from suddenly ending without collecting all relevant information needed for analysis. The structure of the interview guide is based on an estimated available time of maximal one hour for each interview. The estimated time should not exceed one hour or concentration on both sides will decrease. Moreover, a time limit has a positive influence on the interview, because it increases the need for an understanding of the questions before the interview and a focus on the interviewee.

The nine interview categories provide a better overview and a fast track to relevant questions. By grouping questions into categories, various aspects of a particular field can be collectively highlighted. It will also help avoid the repetition of questions, which in turn saves time. On the other hand, questions can be asked again, to ensure that all required data is collected. The categories consist of specific and wide questions, which can be clarified by further questioning or commenting. Further questions remind the interviewer to deepen the question and to get more information if the interviewee is not adequately responding. Furthermore, a question can be made more accessible by further questioning, in case the interviewee does not understand it originally. The transition from deepening to explanation by asking is partially blurred.

Along the categories, the answered questions are marked, in order to avoid single questions being asked twice or that others are accidentally forgotten. The categories and markings make it easier for the interviewer to check the relation to the interview questions without losing track even during longer explanations by the interviewees. Thus, it is easier to focus on the interview and respond flexibly to the interview situation by optionally asking further questions, or leading a wandering interviewee back to the interview.

When creating the interview questions, it must be ensured that these questions are put in a logical order and that all related aspects will be discussed together. Some interview questions can also give information about more than one research question. The interview guideline is a red thread, which starts with the individual, highlights the robot and its development framework, as well as the situation, and tries to get insight on the overall social discourse. Against this background, I explain the interview categories with their interview questions in detail below.

4.3.1 Category 1: Self-Introduction and Current Position

At the beginning of each interview there was a self-introduction of the interviewer, including the research purpose to give the interviewee an impression of the interview course and its relevance to the research. The use of a voice recorder was pointed out and it was confirmed that interview data would be used within the context of this study. Nevertheless, the names of the interviewees have been anonymized in order to avoid possible misunderstandings.

Before starting with actual interview questions (see Table 4-1), I opened the interview with the points' age (IQ 1.2), educational and personal background (IQ 1.3) and the motivation for developing robots (IQ 1.4). Dierkes, Hoffmann, and Marz (1996) assume that precise visions serve as an anchor to overcome difficulties that arise during the course of development. Consequently, passionate developers are supposed to be more successful from a development perspective and likely to directly influence the current robot project. In addition, to ask about names, positions, birthdates and marital status helps to make the interviews more comparable and to make the interviewee feel more comfortable. The first category is about personal motivation.

Table 4-1 Category 1: Self-Introduction and Current Position

IQ#	Question
IQ 1.2	May I ask for your birth year?
IQ 1.3	Can you please tell me at the beginning something about yourself, your career and current job?
IQ 1.3.1	Could you please explain the contents of your current job/ position?
IQ 1.4	Since when have you been interested in robots? Have you always wanted to become a robot developer?
IQ 1.4.1	*[If yes] What kind of efforts arose from it?*

4.3.2 Category 2: Research and Development Framework

Aside from personal motivation and background, the structure of the institution (IQ 2.1) in which the robot development takes places has a significant influence on the outcome of development. This also includes the internal or external cooperation networks associated with the institution. In addition to institutional structure, the way in which information is exchanged (IQ 2.2) affects the course of development. This includes, for example, weekly or monthly meetings with all or only the leading members. These meetings include, for example, cooperation partners (IQ 2.3). On the one hand, through the negotiation process on intended use, the interpretive flexibility among the related social groups steadily reduces. On the other hand, this broadens the consensus, which is necessary for the materialization of an idea into an artifact. Consequently, the results of the interview are divided into the development background (IQ 2.1), institutional structure (IQ 2.2, e.g. size of division and communication habits) as well as cooperation partners and special or joined development projects (IQ 2.3) (see Table 4-2).

Table 4-2 Category 2: Research and Development Framework

IQ#	Question
IQ 2.1	Can you explain the organizational framework and structure for robot development in a few words? Who is involved in the development and how is it structured?
IQ 2.1.1	*How many persons are directly involved in the development?*
IQ 2.2	How are research or development related information exchanged? Is there a rule (e.g. weekly/ monthly meetings) or is it more informal exchange?
IQ 2.3	Are there national or international organizations (e.g. care facilities, companies, governmental or research institutions) with whom you are cooperating or doing collaboration projects (e.g. national, prefectural or municipal promotion projects)?
IQ 2.3.1	*[If yes] Specifically, which project(s)?*
IQ 2.3.2	*[If yes] What are the advantages and disadvantages of this cooperation for your research?*
IQ 2.3.3	*[If yes] Are there certain requirements to meet for receiving support (e.g. interim reports etc.)?*
IQ 2.3.4	*[If no] Why? What are the reasons for this?*

4.3.3 Category 3: The Robot Project

At the beginning, the focus lies on the trigger for the robot project, (IQ 3.1) precisely when and why a company started the development of a specific robot. As a result, the answer to the question, if the starting point of the development bases on an idea of a single developer or if there was an external incentive (IQ 3.1.1), receives special attention. The response gives insights about the timeline and the motivation behind the development. Especially from a theoretical perspective, (see Chapter 2.4) the origin of the development matters because internal motivation in particular provides a strong foundation, and has a high probability to gather enough consensus for successful development with an invention at its end. The next step is the evaluation of a robot's potential for innovation and a distinction between other already existing products in this field (IQ 3.1.2). In other words, to what extent do the developers believe what they are doing is unique and innovative?

In the following the focus shifts to the current state of development (IQ 3.2). In the words of Dierkes, Hoffmann, and Marz (1996), is there a collective projection (see Chapter 2.5) which stabilizes the tension between the desirable and the feasible? Visions are characterized by their grounding in the present and their perceptible realization. The process of perceptible realization takes shape through further development plans (IQ 3.2.1) or thoughts on future application or business opportunities (IQ 3.2.3). The more the vision translates into reality, the weaker its visionary potential becomes. In SCOT (see Chapter 2.3) terminology, this is the decreasing interpretative flexibility.

Having said this, at the end of the development process, there is the invention of a specific robot and its diffusion within society or onto the market. The market maturity (IQ 3.2.4.1) or the objective for market maturity (IQ 3.2.4.2) bundles the effort of the involved actors or, as SCOT says, the relevant social groups. One way to evaluate if there is a social consensus about a specific robot or its acceptance within society is the indicator of mass production (IQ 3.3). The next step is to reveal if there is a broader consensus about this new technology, and if it has the potential and plan to transfer it to other countries (IQ 3.3.1) (see Table 4-3). This makes it possible to create an overall picture for the robot project, its origins, its progression and its objective as well.

Table 4-3 Category 3: The Robot Project

IQ#	Question
IQ 3.1	What can you tell me about the development of your robot?
IQ 3.1.1	*Was the robot development decided internally or was it induced by an external incentive (e.g. governmental or ministerial request)?*
IQ 3.1.2	*What are its (robot) characteristics? What is the novelty of it (e.g. special design, function)?*
IQ 3.1.3	*Could you briefly explain the function/ features of the robot?*
IQ 3.2	In what phase of development is the robot?
IQ 3.2.1	*What will be the further development/ research?*
IQ 3.2.2	*[Production stage] If there is, could you please tell me the produced or sold robot units?*
IQ 3.2.3	*[Production stage] What kind of business model (so called regular sales, rental etc.) will you rely on? Why did you choose this business model?*
IQ 3.4.1	*[Past] When will it have marketability? When will you enter the market?*
IQ 3.4.2	*[Future] When will you reach the stage, where it goes on sales in the market?*
IQ 3.3	Is a series production planned?
IQ 3.3.1	*For what market (domestic or international) are you developing your robot? Why?*

4.3.4 Category 4: Usability Tests

The key question (IQ 4.1) is if the potential target group, such as caregivers or elderly people, could test the robot within their daily environment. The first step is whether the developers were able to find cooperation partners (IQ 4.1.1), who agreed to have a closer look at the care robots or a first prototype. The resulting human-robot-interaction from this cooperation is very valuable to understand the specific needs of the field of care. It enables developing a robot that meets demand and to get a mutual understanding about possible areas of application. On the one hand, this includes that the field recognizes the limits of what is technically feasible and, on the other hand, that the developers receive an impression of what the work routine or daily life within a care facility of the future target group (IQ 4.1.2) looks like.

The follow-up question is how the developers incorporated user feedback (IQ 4.1.3), if they have been able to perform practical trials. Based on this, there follows a critical review and rethinking of development (IQ 4.1.4), or the rejection of feedback (IQ 4.1.5) for specific reasons (see Table 4-4). Development considering the potential target group and its view on technology is more likely to lead to success, because the participation of the target group, or in STS terminology (see Chapter 2) a relevant social group, helps to close the discourse about interpretative flexibility faster and without friction.

Table 4-4 Category 4: Usability Tests

IQ#	Question
IQ 4.1	Have you tested your robot in interaction with humans?
IQ 4.1.1	*[If yes] Are you cooperating with companies, care facilities or/ and consumers? Why?*
IQ 4.1.2	*With which groups of persons have you tested your robot?*
IQ 4.1.3	*How was the feedback or response to the interaction test?*
IQ 4.1.4	*Has something been optimized afterwards? (Design etc.)*
IQ 4.1.5	*Why? What are the reasons for this?*
IQ 4.1.6	*Is your robot currently used somewhere?*

4.3.5 Category 5: Vision and Ideal

The first question refers to the goal or motivation (IQ 5.1) behind the development. This topic area overlaps with the previously mentioned subchapters (see Chapter 6.2 and

Chapter 6.3) and thus already mentioned content is unavoidable, but kept as short as possible. This time there is a new aspect, the aspect of an additional value through the robot (IQ 5.1.1). This aims at the developer's external perception and to what extent they might understand the field of care.

Nevertheless, since the previous subchapters touched on the structure and origins behind development, and how value might be measurable in its course, there is a need for taking a closer look at design (IQ 5.2) and on who finally decides what the robot will look like (IQ 5.2.1). The design is the direct transfer of the robot concept or more illustrative, the materialized idea, and thus gives insights on the vision of development. The same applies for the origins of the name of the robot (IQ 5.3).

The last section deals with the existence of a concrete vision (IQ 5.4) and if so, if it is written down (IQ 5.4.1) or not (IQ 5.4.2) (see Table 4-5). Especially from a theoretical perspective, this is relevant because, according to the theory, developments with a vision are more likely to be realized. For this reason, information on whether there is something written down or not explains the order or structure of the robot. Furthermore, how is the robot evaluated technically and socially?

Table 4-5 Category 5: Vision and Ideal

IQ#	Question
IQ 5.1	Could you tell me more about your motivation for your robot development/ research on robots?
IQ 5.1.1	*What is the purpose of your development/ work?*
IQ 5.1.2	*How do you think the usefulness/ value can be measured (in numbers/ data)?*
IQ 5.2	Has the robot design been selected due to certain factors? Why?
IQ 5.2.1	*Who selected the design of the robot?*
IQ 5.3	Could you please tell me the origin of the robot's name?
IQ 5.4	How do other involved actors in the project see the development? Is there a shared concept or vision?
IQ 5.4.1	*[If yes] Is this vision written down somewhere?*
IQ 5.4.2	*[If no] Is there an informal understanding regarding the future development?*

4.3.6 Category 6: Development Problems and their Solution

When developing something new, unforeseeable problems or other obstacles occur. Above all, what was the obstacle with the strongest impact on a robot project (IQ6.1)?

The answer to this major question shows if a problem is an internal one, such as the current state of technology, or an external one, such as the lack of understanding of the invention on the user side, to give only two examples. Thereby the responses disclose a complex relationship of interwoven problems. This becomes clear when one analyzes the given examples with respect to the problems (IQ 6.2). Finally, questions about the problem-solving strategies (IQ 6.2.1) give insights into the expectation towards development and the organizational structure to respond to occurring problems (see Table 4-6).

Table 4-6 Category 6: Development Problems and their Solution

IQ#	Question
IQ 6.1	What are the current problems for the robots' development/ your research (e.g. financial, technical, legal regulation)?
IQ 6.2	Have there been any specific failures during the development? Can you give one example?
IQ 6.2.1	*[If yes] Which? How have they have been solved?*

4.3.7 Category 7: Market Potential and Barriers

At the beginning, there is an evaluation of the market potential of care robots (IQ7.1). Thereby, the assumption is that, in general, demographic change leads to the optimistic assessment of future market potential and size that might even supplant important issues. For this reason, a two-step approach first highlights (IQ7.2) whether there are any problems for broad diffusion within society or not, and second (IQ7.2.1) if so, what the current barriers for care robots are. The difference to the previous subchapter is that developers are detached from their own development project and its related problems. It is about the expected issues that occur or might occur in the future. After that, how the current and future situation can improve are discussed (IQ7.2.2), so that care robots can enter a large number of care facilities and finally become a part of the work routine within the field of care. At this point, it is interesting to see how developers evaluate the government with its attempts and approaches to support care robotics (IQ7.2.3). Since the developers are the focus of analysis, METI with its promotion of the economy plays an important role. At the end, the subchapter closes with developers' views on responsibility in the case of a human-robot-accident (IQ7.3). Even the best technology can cause an accident. This is only a question of time and besides a relevant issue, which not only the developers, but also all relevant social groups or in other words, the whole of society, has to discuss.

Table 4-7 Category 7: Market Potential and Barriers

IQ#	Question
IQ 7.1	How do you estimate the national and international market for service and especially care robots? Why?
IQ 7.2	Do you think there are any obstacles that are limiting the diffusion of service and especially care robots?
IQ 7.2.1	*[If yes] What kind of issues (e.g. technical, social, political, legal issues)?*
IQ 7.2.2	*Are there any environmental changes necessary for improving the development and diffusion of robots (e.g. safety standards, technical capabilities, and care insurance system)?*
IQ 7.2.3	*In this connection, how do you evaluate the role and activities of the government especially the ministries in charge of service robot development and diffusion (METI, MHLW, MIC)?*
IQ 7.3	What do you think about the legal liability for accidents arising from the interaction between a person/ user and a robot? The robot, the user or the developer?

4.3.8 Category 8: Expectations towards Care Robots

The opening question, which introduces the first topic, is about the general perception of robot development and robot-related activities in other countries (IQ8.1). This gives the developer a first opportunity to create awareness of differences in development structure, or if there is another approach to robotics in other countries (IQ8.1.1). It is about if the developers see any characteristics of robot development in Japan. For example, it creates perspective by putting the American development approach dominated by DARPA, in relation to the METI and MHLW-driven development approach of Japan. The next step is to deepen the topic and to evaluate Japan's international competitiveness not only within the field of industry, but also within service robotics, including care robotics (IQ8.1.2). This happens against the background that the size of the domestic market is limited and, in some foreseeable future, it will become saturated. The result is that foreign markets are attractive for Japanese companies and that, in the long-term, they cannot ignore them as a business market. Furthermore, it is theoretically possible that foreign makers could also enter the Japanese market, when they fulfil regulations.

The second topic of the eight categories intends to consider the existence of any specific characteristics of Japanese robots (IQ8.2). Thereby, the follow-up question picks up the often-mentioned aspects of pop culture, religion and traditional crafts (IQ8.2.1). What is more important than if the developers believe in the existence of such cultural impacts is if they think that such characteristics have a positive or negative impact on their work (IQ8.2.2). There might be differences between official statements by the government, society and developers, who carry out development on the basis of these tangible and intangible impact factors. For example, the government might instrumentalize cultural factors to legitimize the use of robots within care and try to increase the acceptance of robots with this presumed logical cultural-based argumentation.

The third section deals with various aspects of expectations. This applies especially for the government and society, if they have specific expectations towards care robots (IQ8.3) and what these expectations look like (IQ8.3.1). In this context, it is of special interest if there is a gap about the desired robot or not, because the field might think differently about the intentions of the government in order to make care more efficient. Different perspectives and desires cause friction which have to be overcome, and notwithstanding, the above question remains if the current state of the art can respond to these desires (IQ8.3.2). At the end of the third section, there is a backup question (IQ8.3.3) in order to ensure getting an answer to the impact factors on the developers' work (see Table 4-8).

Table 4-8 Category 8: Expectations towards Care Robots

IQ#	Question
IQ 8.1	How do you see development in other countries?
IQ 8.1.1	*Are there any differences regarding the robot development worldwide (especially Europe and the United States) and in Japan?*
IQ 8.1.2	*How do you see Japan's competitiveness within the field of industrial robots and service/ care robots?*
IQ 8.2	Can you tell me what the features of Japanese robots are?
IQ 8.2.1	*It is often said that robots in Japan enjoy wide popularity due to Shintoism, modern pop culture (e.g. anime and manga) and karakuri puppets. What do you personally think about it?*
IQ 8.2.2	*Do you think that (pop) culture is increasing the expectations or pressure on your work?*
IQ 8.3	Do you think there are external expectations towards (e.g. public, governmental, media) service, especially care robots?
IQ 8.3.1	*[If yes] What kind of expectations?*
IQ 8.3.2	*[If yes] When you think about the use of robots within the field of care, do you think it is technologically feasible?*

IQ 8.3.3	*[If yes] Are they (cultural/ social expectations) influencing/ putting pressure on your work? To what extent?*

4.3.9 Category 9: Contribution of Robots to Society

At the beginning, the last category provides a general clarification about whether care robots can make a contribution to overcoming the challenges that emerge from demographic change or not (IQ9.1). Official documents (e.g. METI 2013b) and the media (e.g. *CBS News*, July 28, 2017) often present robotics as the solution for balancing the labor shortage and improving the care environment, and it is interesting what the engineers with their technical knowledge think about this approach.

In doing so, insight intends to go deeper as only on the general level, because the further question (IQ9.2) deals with how robotics will change and improve the care industry and care workflows in detail. In this context, it is of high relevance to ask about the chances and risks of this new field of technology (IQ9.2.1). Thereupon the theoretical discourse on the general and concrete contributions to the over-aging society in Japan is closed.

The focus then switches to the evaluation of the acceptance of robots within society (IQ9.3). Many developers represent their company and robot projects at trade shows or present them to a public audience on other occasions. This gives developers valuable insights and a feeling of how average people think about robotics, if there is already a positive attitude towards making use of care robots. In the second step it is outlined how developers assess the future of care robots in Japan (IQ9.4); will it come to wide-scale introduction within the service, and especially the care, sector and what other options (IQ9.4.1, IQ9.4.2) might exist for robots? The latter topic especially targets possible incentives to improving the labor population and environment, as well as the comparison of technology against of foreign labor (e.g. Moss, August 22, 2017; *Canvas8*, March 07, 2017).

The final and only remaining topic is whether engineers can imagine suggesting a robot for the care of their relatives (IQ9.5) or not. In addition, how they would think about using a robot when they need to eventually receive care, or have to rely on further equipment to master their everyday life (IQ9.6). The last question complements the topic about the contribution of care robots to a steadily aging society, and the power of persuasion as a technical instrument to countermeasure social challenges (see Table 4-9).

Table 4-9 Category 9: Contribution of Robots to Society

IQ#	Question
IQ 9.1	It is often said that robots are a possible solution for the occurring problems of demographic change. What do you personally think about it? Why and to what extent?
IQ 9.2	How do you think care robots will improve the workflow within the field of care?
IQ 9.2.1	*How should care robots be used? What opportunities or risks do you see?*
IQ 9.3	Do you think there is a broad consensus about the use of robots in care within society? What are the reasons for/ against it? (e.g. ethical, social problems)
IQ 9.4	Do you think there will be widespread implementation of care robots?
IQ 9.4.1	*[If yes] Why? Is this unavoidable?*
IQ 9.4.2	*[If no] Why? Are there alternatives?*
IQ 9.5	Would you recommend a care robot for the care of your own family and relatives?
IQ 9.5.1	*[If no] Please tell me the reason for no recommendation?*
IQ 9.6	Could you imagine using robots yourself?

5 The Fieldwork, the Interviewees and their Robots

In the following, I will explain how I proceeded with the implementation of the interviews during the fieldwork period. I carried out the fieldwork between December 2015 and December 2016 and during the whole time, I stayed under the supervision of Prof. Wako Asato at the Graduate School of Letters at Kyoto University. The fieldwork was only viable through a generous research fellowship provided by the Japan Foundation, which I would like to express my gratitude for.

5.1 The Fieldwork

In total, 39 interviews were carried out (see Figure 5-1), of which there were 22 main interviews and 17 additional, with over 37 hours of audio data[77]. Moreover, most interviews took place in the Kansai and Kanto regions of Japan (see Figure 5-2). The main interviews are the ones with the engineers and developers of companies active within the field of care robotics. The additional 17 interviews were carried out with people from various fields related to the diffusion of care robots, including a wide spectrum of research institutions (e.g. universities), promotions (e.g. ministries, promotion centers), the care industry (e.g. hospitals, facilities) and discontinued projects.

Moreover, I attended various events, such as six conferences, seminars or working groups, and five exhibitions related to robotics in order to get more insights into the topic, and to get access to the field and potential interviewees. For the analysis of empirical data (see Chapter 6) I use the main interviews with robot developers. However, additional interviews (see Appendix) and attended events serve as additional knowledge, which lead to a deeper understanding of the topic and therefore a more comprehensive view on the main data.

[77] For the recording of the interviews, I used an Olympus Voice-Trek V-821 voice recorder.

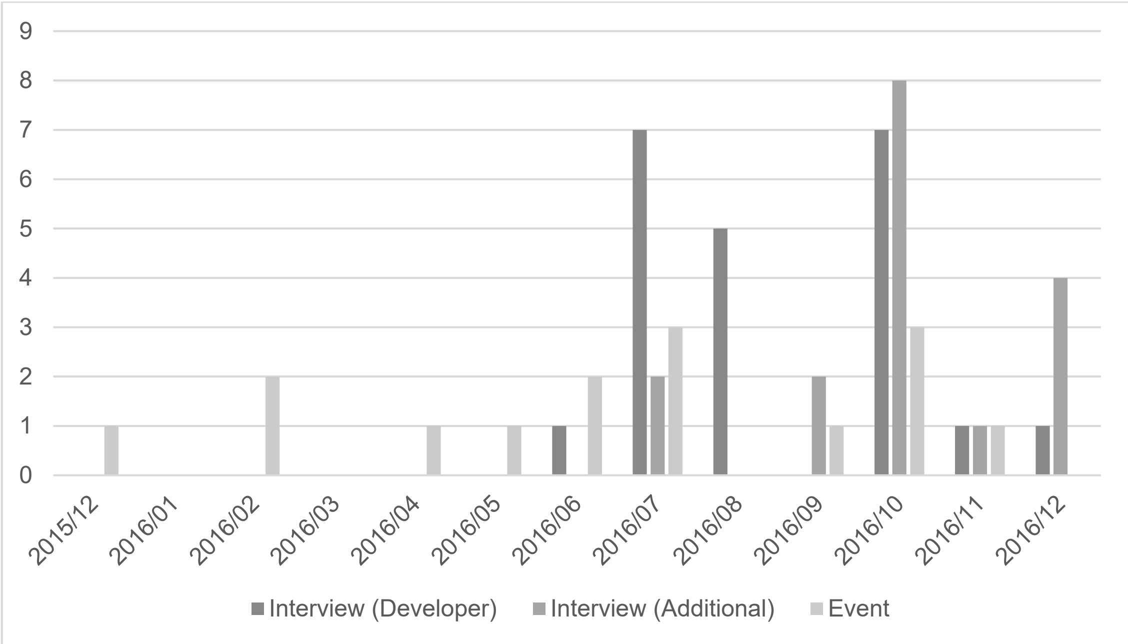


Figure 5-1 Chronological Order of the Fieldwork

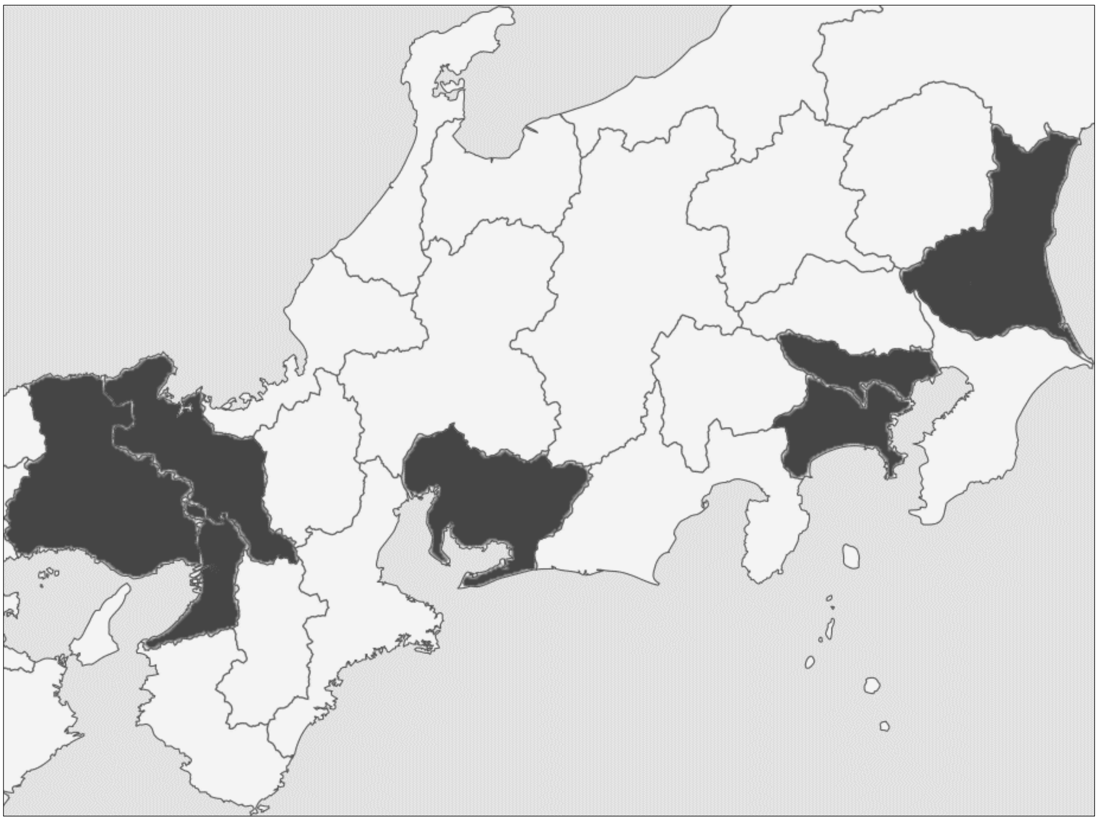


Figure 5-2 Geographical Distribution of the Fieldwork

In the following I would like to describe the methodological approach to fieldwork further. The finalization of the information search and the creation of the interview guideline serve as the basis for the fieldwork with its interviews. After arriving in Japan in December 2015, I closed my literature research in February 2016 and started to create a list with all relevant researchers and companies active in the field of robotics. This was done at the same time as the creation of a list with potential interviewees.

Consequently, from March to May 2016, I started content preparation for performing my interviews. On the basis of the literature review, I adjusted the research outline and worked out the design for my interview questionnaire. The design process of the interview guideline was to transfer my research interest into categories and write out interview questions in the next step (see Chapter 4.3).

In addition to literature research, I started to attend events related to robots and health care i.e. public symposiums, working groups or exhibitions to establish a better network within the field. Unlike the literature research, which I ended in February 2016, I continued looking for and participating in events throughout the whole fieldwork period until December 2016. The participation in events had several advantages, such as being able to develop broader knowledge and deeper understanding of the topic.

Apart from this, participation in events came along with other benefits. It enabled me to be up to date with current developments, newest trends and challenges within the field. This is difficult to obtain by just reading documents and publications that are always a bit behind the times. Furthermore, through listening to presentations and directly interacting with presenters such as policymakers or engineers, I could get a feeling for whether the considered research questions depicted the reality of the field. It helped to confirm the relevance of the research. However, all events that were mentioned above are a good framework for establishing first contacts within the field and its major players, and for making first contacts by exchanging business cards. This was a strategic approach adjusted to the business culture of Japan (cp. Alston 1989; Brislin, Worthley, and Macnab 2016; Pornpitakpan 1999) with the goal to directly raise the chance for participation in interviews. This made it much easier to contact the developers of relevant robot projects in the following and increase the response rate, because a contact had been established through meeting before.

There was a processing of each event that consisted of adding relevant actors to the list of potential interviewees and contacting them by e-mail. The medium of e-mail had several advantages for qualitative research (cp. Derks and Bakker 2010; Dimmick, Kline, and L. Stafford 2016; McCoyd and Kerson 2016; Meho 2006). First, it was possible to not only present the research project, but also to give an explanation on the use of data. Second, the textualization of the interview request functioned as something that could be shown to superiors. This is relevant within the Japanese business context, because the way decisions are made varies (cp. Martinsons and Davison 2007) and often are not decided by any single individual. The employees rather have to confirm with their superiors, or even a whole division. This also means that textualization serves as a fast-track procedure for the decision process. Another advantage of textualization is that both sides, the interviewer and interviewee, are equipped with something they can keep and eventually refer to in the case that an issue occurs. Third, e-mail can help prevent misunderstandings, such as expectations towards the interview. A clear definition of research objectives, interview specifications (such as the use of a voice recorder and the handling of personal data) help create trust through being transparent about the interview in general. Finally, it is easier to coordinate the schedules of the interviewer and interviewee, because several suggestions for an appointment can be made. For the interviewee, the advantage is that he can confirm in comfort with his own schedule. For the interviewer, it increases efficiency because, through contacting several potential interviewees at the same time, it is possible to arrange interviews into regional blocks.

It was useful, especially during the later stage of fieldwork, to attend certain events. Then after the event, I contacted the persons I met via e-mail and tried to coordinate and optimize the interview schedule with regards to place and time, so that I would be able to build regional blocks and hence get synergistic effects. For this reason, additionally other institutes, companies or other possible relevant organizations in one specific region were located and contacted to lower transaction costs. Every interview was conducted at the interviewee's workplace, which means either their company, the venue of a seminar or booth to make it as convenient as possible.

In general, an essential challenge for qualitative research is to gain cooperation in research. However, the response to the fieldwork was very positive. Almost all of the contacted persons were willing to participate in an interview. There might be three reasons for this high success rate. First, the desire on the interviewees' side to gain recognition for their work. Second, the interviewer as an external and foreign person, who might arouse interest with regards to how foreign countries see Japanese robotics. Third, the choice to use Japanese as the interview language, which means on the one hand, interviewees being able to explain their original motivation and on the other hand, being able to communicate in the interviewees' mother tongue is likely to reduce the barrier for co-operation.

Nevertheless, it was from a time management perspective, in particular, a challenge to keep the balance between concessions to the interviewees and optimizing the interview schedule. On the one hand, there was the request for the interviewee's time and cooperation and on the other hand, it was important not ask for too much and adjust to the interviewer's own research schedule. Against the background of these research conditions it would have been disproportionate and cost many resources to i.e. travel from my base Kyoto to Tokyo for a single appointment. For this reason, it was essential to try to set the interviews after time and place.-This factor was a major motivation to request interviews and suggest certain dates well in advance before the planned interview period. After this, responses were collected and a schedule was set up on this basis. Only in a few cases did the original appointments have to be rescheduled and in total, aside from a few exceptional cases, the described approach worked out very well.

Since data collection is the heart of this study, a lot of time has been spent in preparation before each interview. There was no difference between the main and additional interviews with regard to the invested time for preparation. In doing so, attention was paid to the following elements as an essential part of the preparation: The individualization of the interview guideline, information acquisition about the interviewee, confirmation of the location and reminding the interviewee of appointments.

First, there was the adjustment of the interview guideline to a specific interviewee. This included the exchange of general words, such as robot, in the original guideline to a specific developer and its robots, as well as adding contact information of the interviewee, the interview date and time. Moreover, the interview guideline was reviewed with regard to the relevance for the interviewee. For example, in the case of care facilities, there was no need to ask about the development of a specific robot project, but rather to pay special attention to the usability or change of care through robots.

Second, there was the need to get information about the interviewee and of course his/ her company, organization or institution, as well as their robot project or relationship to the field of care. The collection of information started with the basics such as company size and went over to more specific information, such as recent activities, publications or newspaper articles of their activities. All relevant information has been collected as preparatory documents.

Third, there was an extended check of the interview location, so I could reach the location in time without getting lost and also have time to get through all relevant materials right before the interview. This point covers also the purchase of a train or bus ticket, and if necessary, booking accommodation.

Fourth, a reminder was sent to the interviewee right before the interview. This had the purpose of reminding the interviewee of the appointment and ensuring that all set times and dates were still fixed and correct.

Finally, there was a test run before every interview. This included a check of the individualized interview guideline at least three times on the day before the interview to avoid typing errors, and also reading preparatory documents (e.g. company and project related information, access).

The original expectation on what number of interviews could be feasible for single research project was 20. Thanks to an unexpected high response rate and cooperativeness, it was possible to reach the minimum objective of 20 interviews by October 2016. Furthermore, 39 interviews could be obtained in total. The majority of the main interviews with robot developers were performed from July to October. Twelve could be gained during an exhibition, the H.C.R. 2016 in Tokyo during October. This shows the potential of exhibitions for acquiring empirical data. The final interview list, numbered all the way through to 39, can be found in the Appendix. In the following I attach a list, numbered after the chronological interview dates among all interviews, for the 22 main interviews (see Table 5-1):

Table 5-1 Main Interview List

INR	Organization	Robot	Category
1	Toyota Motor	Human Support Robot (HSR)	Developer
2	Kato Denki	SUN Flower	Developer
3	Togo Seisakusyo	smile baby	Developer
4	Ory Laboratory	OriHime	Developer
6	INNOPHYS	Muscle Suit	Developer
7	Kito Seiki Seisakusho	i-me:ma	Developer
8	Ryoei	ROBO snail	Developer
10	Art Plan	aijō-kun	Developer
11	TacaoF	Little Keepace	Developer
12	RT.Works	RT.1/ RT.2	Developer

13	Panasonic	Resyone Service Robot	Developer
14	Nabtesco	Flagship Model ES03	Developer
15	Fujisoft	Palro	Developer
21	T-arts	Neruru & Yumeru	Developer
22	Aronkasei	kyūretto (Portable Toilet)	Developer
23	Clarion	KR-1000A	Developer
24	Bio sync	Aams	Developer
26	Santec	Dreamer	Developer
27	Sanyo Homes	yorisoi robotto	Developer
28	Fuji Machine MFG	Hug	Developer
29	Shintec Hozumi	Tecpo	Developer
39	Muscle	Robohelper Sasuke	Developer

Aside from the main interviewees with developers of robots, in total 17 additional interviews could be achieved during the period of July to December 2016. I started with visiting MHLW and two promotion centers in July and September. This had the advantage that, especially at the promotion centers, I got an overview about the actual outcomes of efforts made by ministries and engineers. Due to the high cooperation of robot developers, I had the chance to extend my investigation on care facilities at the later stage of my fieldwork, namely from October to December. The additional interviews are classifiable into the following categories (see Table 5-2): Research institutions, promotion, care industry, discontinued projects and others.

Table 5-2 Additional Interview list

INR	Organization	Category
5	Ministry of Health, Labor and Welfare, National Rehabilitation Center for Persons with Disabilities, Yokohama Rehabilitation Center, Japanese Association of Occupational Therapists	Ministry, Promotion
9	Nagoya Welfare Equipment Plaza	Promotion
16	Meijo University	Discontinued Project
17	The Hyogo Institute of Assistive Technology Robot Rehabilitation Division	Promotion
18	Toyohashi University of Technology, Center for Human-Robot Symbiosis Research, Interaction & Communication Design Lab. ICD-LAB	Research Institution
19	Toyohashi University of Technology, Center for Human-Robot Symbiosis Research	Research Institution

20	Social Welfare Corporation Aisankai	Care Industry
25	National Institute of Advanced Industrial Science and Technology Robot Innovation Research Center	Research Institution
30	Japan Quality Assurance Organization JQA	Promotion
31	A・Fun	Other
32	Mitsubishi Heavy Industries Mechatronics Systems	Discontinued Project
33	Nagoya Institute of Technology	Research Institution
34	Hospital, National Center for Geriatrics and Gerontology Center of Assistive Robotics and Rehabilitation for Longevity and Good Health	Care Industry/ Promotion
35	Meijo University	Research Institution
36	Aiseikan & Kobayashi Memorial Hospital, Toyota College of Nursing	Care Industry
37	The Hyogo Institute of Assistive Technology, Rose Life Kyoto	Care Industry
38	Daiwa House	Promotion

Through the additional data, it is possible to get a deeper understanding of trends and problems within the emerging field of care robotics. Japan’s focus on industrial promotion with METI (see Chapter 3.3) in the leading position is traditionally centered on the maker. For this reason, it is valuable to go into the field and see how robots that were supported primarily by an industry-driven promotion system are accepted by users; in other words, to especially discover the implementation and usability of care robots. This data collection about implementation, the diffusion side, is to some extent the first feedback regarding practicability and acceptance of engineers’ visions.

Among the additional interviews, there are also two projects which had been terminated for certain reasons. These projects give precious insights into the problems and conflicts of technological change from an idea to diffused invention. Since the history of technology is the history of success (see also chapter 2.1), usually unsuccessful inventions are forgotten and disappear without being noticed. It is difficult to get access to such discontinued inventions, because nobody usually announces their failure. Thereby access to the two mentioned projects was random and only possible because of previous research and networking efforts in 2011, whereby contact with two developers and their projects had been established. On the occasion of fieldwork, I remembered their projects and contacted them.

At the end of this chapter, I want to provide a list of research related activities. This serves on the one hand the purpose of documentation, but also gives an impression about developments within the field of care robotics in 2016. The activities are listed in chronological order and classified in four categories (see Table 5-3 – Table 5-6).

Table 5-3 List of Attended Conferences, Seminars or Working Groups

Date	Activity	Place
17.-18.12.2015	National Convention of the Japan Association of Certified Care Workers Topic "A Meaningful, Satisfying and Rewarding Job - Let's Convey the Community, Country and World to the Appeal of Care"	Kuwana (Mie)
13.06.2016	4th Working Group on the Practical Application of Robots in the Medical and Care Field	Obu (Aichi)
30.06.2016	4th Care and Rehabilitation Robot Seminar	Kobe (Hyogo)
28.07.2016	5thCare and Rehabilitation Robot Seminar	Kobe (Hyogo)
26.09.2016	5th Working Group on the Practical Application of Robots in the Medical and Care Field	Obu (Aichi)
12.-13.11.2016	6th Japan Robot Rehabilitation and Care Research Conference	Kobe (Hyogo)

Table 5-4 List of Attended Exhibitions

Date	Activity	Place
19.-21.04.2016	Medtec Japan 2016 http://www.medtecjapan.com/	Tokyo (Tokyo)
26-27.05.2016	Service Robot Development and Technology Exhibition http://www.srobo.jp/	Osaka (Osaka)
02.-04.06.2016	19th International Home Care and Rehabilitation Exhibition "Welfare 2016" http://www.nagoya-trade-expo.jp/welfare/	Nagoya (Aichi)
10-12.20.2016	43th International Home Care and Rehabilitation Exhibition "H.C.R. 2016" https://www.hcr.or.jp/	Tokyo (Tokyo)
19.-21.10.2016	Japan Robot Week	Tokyo (Tokyo)

Table 5-5 List of Attended Robot Assisted Therapy Committee Activities

Date	Activity	Place
28.02.2016	Steering Committee Meeting and 11th Student Research Result Presentation Meeting	Tokyo (Tokyo)

16.07.2016	Robot Assisted Therapy Meeting	Ageo (Saitama)
17.07.2016	Steering Committee Meeting and Robot Assisted Therapy Study Group	Tokyo (Tokyo)
29.10.2016	Steering Committee Meeting and Robot Assisted Therapy Study Group	Tokyo (Tokyo)

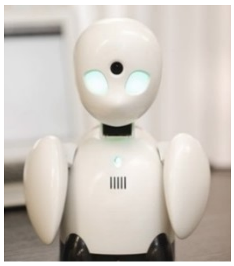
Table 5-6 List of Presented Papers

Date	Activity		Place
06.-08.10.2016	The 3rd International Conference on Universal Village (UV2016)		Nagoya (Aichi)
	Paper:	Ready for the "Robot Revolution" ? – Japan's Attempts to Solve Societal Issues by the Implementation of Advanced Robotics "	
	Presenter:	Benjamin Rabe (University of Duisburg-Essen), Martin Rathmann (Heidelberg University)	
	Comment:	Paper awarded with the "Best Paper Award	
15.-17.12.2016	The 17th SICE System Integration Division Annual Conference		Sapporo (Hokkaido)
	Paper:	Care Robots in Aging Japan – A Survey on the Technical and Social Feasibility of Robot Technology	
	Presenter	Martin Rathmann (Heidelberg University)	

5.2 The Interviewees and their Robot Projects

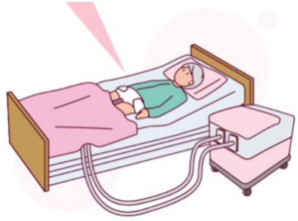
After explaining the fieldwork, I want to introduce the robots. A picture is worth a thousand words and I cannot agree more with this phrase. It is much faster to get an impression about what a robot is when there is a picture of it. In the following, there is list of all companies (INR) with their robot projects and the priority area of the robots (see Table 5-7) This helps to be able to visualize the robots better, which in turn makes it easier to follow the analysis of empirical data (see Chapter 6).

Table 5-7 Overview of Robots from the interviewed Organizations
(Aichi Robot Industrial Promotion 2015; Aronkasei; biosilver 2019; Clarion 2019; egao n.d.; Fuji n.d.; Fujisoft 2019; INNOPHYS 2018; Kato Denki 2019; Kowa 2019; Mucle; Nabtesco; Ory Laboratory n.d.; Panasonic n.d.; RT.Works n.d.; Ryoei 2019; Sanyo Homes; scrio 2019; Shintec Hozumi 217; T-arts 2019; Togo Seisakusyo n.d.; Toyota Motor n.d.)

INR	Company	Robot	Priority Area	Picture
1	Toyota Motor Corporation	HSR (Human Support Robot)	Others (Daily Life Support)	
2	Kato Denki, Inc	SAN Flower	Monitoring Systems (Facilities/ Private)	
3	Togo Seisakusyo Corporation	smile baby	Monitoring Systems (Daily Life Support)	
4	Ory Laboratory Co., Ltd.	OriHime	Monitoring Systems (Daily Life Support)	
6	INNOPHYS	Muscle Suit	Transfer Aids (Wearable)	

7	Kito Seiki Seisa-kusho Co.,Ltd.	i-me:ma	Monitoring Sys-tems (Facilities)	
8	Ryoei Co., Ltd.	ROBO snail	Mobility Aids (Out-door)	
10	Art Plan Co., Ltd.	aijō-kun	Transfer Aids (Non-Wearable)	
11	Kowa Co., Ltd. (Brand: TacaoF)	Little Keepace	Mobility Aids (Out-door)	
12	RT.Works Co., Ltd.	RT.1/ RT.2	Mobility Aids (Out-door)	
13	Panasonic Corpora-tion, Eco Solutions Company	Resyone Service Ro-bot	Transfer Aids (Non-Wearable); Mobility Aids (In-door)	

14	Nabtesco Co., Ltd.	Flagship Model ES-03	Mobility Aids (Outdoor)	
15	Fujisoft Incorporated, Yokohama Office	palro	Monitoring Systems (Daily Life Support)	
21	T-arts Company Ltd.	Neruru & Yumeru	Monitoring Systems (Daily Life Support)	
22	Aronkasei Co., Ltd.	kyūretto (Portable Toilet)	Toilet Aids(Predictive Toileting)	
23	Clarion Co., Ltd.	KR-1000A	Monitoring Systems (Facilities/ Private)	
24	bio sync Co., Ltd.	aams	Monitoring Systems (Facilities)	

26	Santec Co., Ltd.	Dreamer	Toilet Aids(Predictive Toileting)	
27	Sanyō Homes Co. Ltd.	yorisoi robotto	Transfer Aids (Non-Wearable)	
28	Fuji Machine MFG. Co., Ltd.→After 2018/04 FUJI Co. Ltd.	Hug	Transfer Aids (Non-Wearable)	
29	Shintec Hozumi Co., Ltd.	Tecpo	Mobility Aids (Outdoor)	
39	Muscle Corporation, Ltd.	Robohelper Sasuke	Mobility Aids (Non-Wearable)	

6 The Presentation of Empirical Data: Discovering the Mindset of the Japanese Engineer

The research interest is to reveal the latest developments within the field of care robotics and robot technologies (RT), and the actual social relevance of these technologies. The central research question (CRQ) of this study is what kind of robots may be able to mitigate care problems and generate new solutions, and even improve the Japanese population's general health. This can also be a blueprint to solving care issues in other aging societies. To this end, I formulate three hypotheses (see Chapter 1.2): the lack of information thesis, the labor replacement thesis and the relevance of environment thesis. The response to them will give deep insight into the research interest on the state of the art within the field of care robotics.

The empirical data from fieldwork is presented in two parts. From a theoretical perspective, this allows (see Chapter 2) the coverage of a wide range (e.g. personal background, development structure and understanding of social contribution) of topics connected with technology development. From a practical perspective, this approach reveals the factual status of the diffusion of care robots. Both parts are structured on the base of nine categories derived from the research questions (see Chapter 2 and 3). In doing so, ongoing analysis follows these nine categories, whereby the analysis of additional interviews has a reduced number of categories.

In the last chapter (see Chapter 7) of this study, I provide a comprehensive closing view, which includes the verification of my three working hypothesizes, as well as the definition of the limitations of care robotics and, on the basis of this analysis, I try to carefully forecast the future of care robotics in Japan.

This chapter covers the presentation and discussion of empirical data from the interviews of the 22 robot projects (INR) with 27 interviewees (IP). The analysis of the interview data draws upon three elements. First, the structure of the interview guideline with its interview questions (IQ), which serves as the basic structure for the analysis. Second, the interview matrix, where all the information from interview data is summarized into one big graph (see Appendix), including the key points of responses from all interviewees. The interview matrix makes the data of 39 interviews with over 54 interviewees accessible and facilitates analysis of interview material into a manageable work package. Third, selected quotes (see Chapter 3) from various transcripts help to track the content of each interview. Furthermore, over the course of this chapter, the interviewees function in two ways: as representatives of their robot projects and as individual experts within the field of robotics. The latter individual perspective is particularly important, when the interviewees evaluate developments, trends and limitations of care robotics as experts.

I want to make a few remarks on the handling of the interview data and the citation system of this study. All interviewees consented to the use of interview data for the purpose of research and further publications. Nevertheless, all interviewees' names have been coded for responsible handling of data and as a precaution to avoid possible problems regarding further publication of this study. A short description of each interviewee, company and their robot project is provided in chapter 5.2. The complete description is attached in the form of a list in the appendix (see Appendix).

In the case of direct quotations, English translation is used in the main text and the Japanese original is placed in the footer. For a better readability, syntax errors have been fixed. The same applies for punctuation errors, which are corrected, too. Filler words (e.g. 'hm', 'aha', 'oh') are left out and breaks over three seconds are indicated as [pause].

INR marks a reference to the robot project itself, and IP is used for a statement by an interviewee. Additionally, the robot and company name are specified for better traceability. This means, for instance, that a reference from IP01 from the first interview (INR01: HSR: Toyota Motor) is as follows: INR01-IP01 (HSR: Toyota Motor). If the content is in general, and not the engineer himself, about the robot project, it is only "INR01 (HSR: Toyota Motor)". For references and traceability, in the case of direct quotation, the time segment within the interview is given, on the basis of ISO 8601 (ISO 2004) for representing dates and times (hh:mm:ss). Moreover, time segments complement direct quotations, e.g. (IN01-IP01 00:35:19 - 00:37:59). All other references, as well as the interview matrix which is the base for the following analysis, can be found in the appendix (see appendix).

6.1 Category 1: Self-Introduction and Current Position

A closer look at individual background and its relevance for current robot-related positions leads to deeper understanding of personal motivation for developing care robots. There are several similarities, but also noteworthy differences, among the 27 interviewees of the 22 care robot projects. All information about this category can be found in chapter 4.3.1.

There might be a correlation between birth decade (IQ1.2) and views on robots, resulting from pop cultural influence by anime and manga. When having a closer look at the birth year, one birth decade sticks out: the post-war generation from the fifties and especially the sixties. Sixteen of the 27 interviewees are born in the fifties or sixties (see Figure 6-1), the decade of post-war robot manga such as Astro Boy[78] (1952) or Tetsujin 28-gō[79] (1956). Post-war manga, and especially Astro Boy, have an optimistic view on technology, where technology serves as an important superficial instrument to create a positive future for war-ravaged Japan. One difference between Astro Boy and Tetsujin 28-gō is that in the latter, robots are machines that are remote-controlled by humans and the former possess an independent personality. These images might flow into the concept of robots as technical solutions even for social problems.

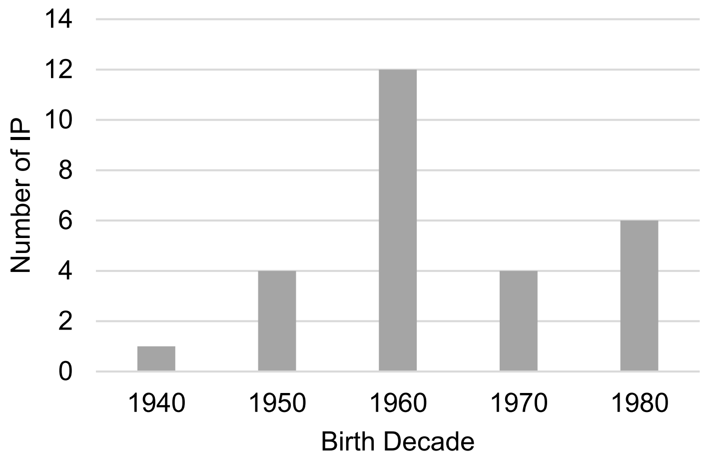


Figure 6-1 Birth Decade of IP
(n=27)

The remaining ten interviewees, the next generation of robot developers, were born in the seventies or eighties. In contrast to the post-war manga and anime, the seventies and eighties were a time with a much more differentiated view on robots. A few influential manga are Doraemon[80] (1969), Manzinger Z[81] (1972) and prominent anime such as Mobile Suit Gundam[82] (1979). On the one hand, pop culture portrayed robots such as Doraemon as independent companions and helpers for everyday life. On the other hand, in Mobile Suit Gundam or Manzinger Z, robots serve as tools to enhance human abilities

78 In Japanese: tetsuwan atomu 鉄腕アトム
79 In Japanese: tetsujin nijūhachi-gō 鉄人 28 号
80 In Japanese: doraemon ドラえもん
81 In Japanese: majingā zetto マジンガーZ
82 In Japanese: kidō senshi gandamu 機動戦士ガンダム

to overcome general insurmountable obstacles, or to avoid disaster. Both positive, but also different, perspectives on technology and robots pictured in various manga and anime during the decades affect not only the expectations of developers, but also of society, towards care robotics (see category 8: expectations).

The analysis of educational background (IQ1.3) suggests that male technicians dominate the development of care robots. Only three of 27 interviewees were female[83] and of those, only one was a professional caregiver[84]. The fact that no external professionals from the field of care participate in the R&D process leads to two implications: one, male engineers develop technical solutions for a field that they are practically not familiar with. Two, they develop for a domain which is predominantly female. This in turn leads to unused care robots, because they are not in demand and thus have only a low acceptance within the field.

The female development representative of Takara Tomy A.R.T.S[85] illustrates that gender might change views of robot development to a more user-orientated view, when talking about her interest in robots. *"Rather than being interested in robots, I feel that there are still many things we, as a toymaker, can do for seniors, and the emotional customer feedback or perhaps I should say they are really loving it [the robot toys], while on the other hand this makes me feel I am doing something worthwhile"* [86]. In her understanding, robots are more or less a means to an end. Rather than developing a high-tech robot, her focus and motivation derive from the user.

Out of 27 developers, 19 graduated from university (see Figure 6-2), of which 13 studied engineering and five natural science[87]. The remaining two university graduates graduated with literature[88] and education[89]. The domination within the 27 interviewees reveals a clear trend of the male technician within R&D, and the absence of established expertise from the field of care. Because of the dominating personal background of male technicians, the danger is that robot development takes place without the involvement of

[83] INR02-IP02 (SAN Flower: Kato Denki), INR21-IP30 (Neruru & Yumeru: T-arts), INR39-IP54 (Sasuke: Muscle)
[84] INR39-IP54 (Sasuke: Muscle)
[85] In the following Takara Tomy A.R.T.S is written in its acronym T-arts.
[86] INR21-IP30 (Neruru & Yumeru: T-arts) 00:02:06-00:02.31 ロボットに興味がわくというよりも、シニア向けに我々玩具メーカーができることってまだまだいっぱいあるんだなっていう気がして、お客様からもすごく熱い声というか、本当にかわいがっていただいているようなので、それに対してやりがいは感じてますね。
[87] Mathematics: INR15-IP2 (palro: Fujisoft) 2; architecture: INR11-IP17 (Little Keepace: TacaoF), INR21-IP30 (Neruru & Yumeru: T-arts), INR27-IP36 (yorisoi robotto: Sanyo Homes); chemistry: INR22-IP31 (kyūretto: Aronkasei)
[88] INR24-IP33 (aams: bio sync)
[89] INR29-IP38 (Tecpo: Shintec Hozumi)

knowledge and understanding of the needs from the field of care. To avoid the development of high-tech solutions that do not match care demands, at some point in the development process, knowledge of caregivers or the elderly have to be accessible.

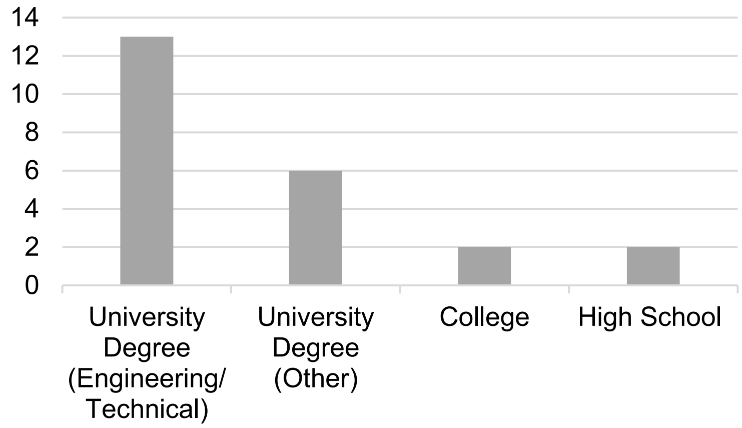


Figure 6-2 Educational Level of IP[90]

Among the interviewees, there exist two major patterns for motivation to develop care robots (IQ1.4.): It was either an unconscious or a conscious decision to invent robots. Two thirds of the interviewees paved their way to a robot-related position with their active decision to study engineering or natural science, and by graduating from university. The remaining one third consists of college or high school graduates, of whom three went to a technical high school[91] or college, and one to a nursing school[92].

Coincidence and a general interest in technology and natural science mark the pattern of the unconscious decision to design robots. From the interviews conducted, the representative of Toyota[93] is exemplary for a developer who loved to create things[94] and came to robotics through his work in the field of automotive. In the words of Toyota's representative:

> *"I majored in mathematical engineering and control theory at university and in order to apply it I joined Toyota. For a while, I was involved in car controlling. From 2000, we started to prepare for the robot exhibition at the Aichi Expo 2005. At the time, I was responsible for the system and control of the*

[90] The result of 23 goes back to the number of useable response for eduction level.
[91] INR04-IP06 (OriHime: Ory Laboratory), INR08-IP13 (ROBO snail: Ryoei), INR26-IP35 (Dreamer: Santec)
[92] INR39-IP54 (Sasuke: Muscle)
[93] INR01-IP01 (HSR: Toyota Motor)
[94] In Japanese, the love of creating things named as, monozukuri ものづくり.

> *robots. Through the Aichi Expo and global challenge, we continued to develop robots as company policy and in order to accelerate collaborative research with Europe, I have been sent to Toyota Motor Europe in Brussels, Belgium for about three years. I was researching together with other European robot developers. For some time after returning to Japan in 2009, I was involved in several projects that mainly centered on human robot interaction, and from 2016 I focus on life support robots".*[95]

Beside the decision for a major in a technology-related subject, the Aichi Expo 2005 led to his current position. This means besides educational background, external events influence not only an individual career, but also a company's activities. The representative of Toyota summarized this very well, when he said, *"in younger years I was interested in anime, but was not expecting to do it [robots] as my future work. After joining an automobile company, I happened to be involved in robot development, but it became interesting when I started it [robot development].*"[96]

The same applies to the engineers of the communication robot smile baby at Togo Seisakusyo. First, they had no special interest in robots, but after a while, got interested in the development of their new field of work[97]. Another example is the representative of Fujisoft[98], who is now in charge of the development and distribution of the communication robot palro. After his major in mathematics, he joined Fujisoft's mobile service division and then, with a METI program in 2008, started the development of palro. In the end, a governmental program by METI was the incentive for the development of Fujisoft's robot. For the robot developer at T-arts, her career was different. She[99] joined T-arts and was in charge of analog gaming, and had switched companies to come back to Takara Tomy's subsidiary T-arts Arts, which was starting the healing partner project Neruru[100] and Yumeru[101]. In summary, although educational background improves probability for developing a robot, external impact factors and chance lead to current positions in most

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[95] INR01-IP01 (HSR: Toyota Motor) 00:00:38-00:02:11 大学で専攻していた数理工学、制御理論を車に応用したくてトヨタに入社、しばらくは車の制御に携わっていました。2005 年の国際博覧会、愛・地球博に向けて、2000 年頃からロボット出展のための準備に取り掛かりはじめました。その当時の担当は、ああゆうロボットのシステム、制御でした。愛・地球博終了後、会社の方針でロボットの開発を継続することになり、自身はヨーロッパとの共同研究を加速させるために、3 年ほどベルギー・ブリュッセルにあるトヨタモーターヨーロッパに出向。ヨーロッパのロボット開発者との研究を進めていました。2009 年帰国後しばらくは人協調ロボットを中心にしたプロジェクトに数件関わって、2016 年より生活支援ロボットを中心に携わっています。

96 INR01-IP01 (HSR: Toyota Motor) 00:02:14-00:02.39 子供のころのアニメは興味を持ったきっかけですが、将来の仕事にしようとは思っていませんでした。自動車会社に入社して、たまたまロボット開発に関わることになりましたが、いざ始めてみたら面白くなってきましたね。

[97] INR03-IP04 (smile baby: Togo Seisakusyo), INR03-IP05 (smile baby: Togo Seisakusyo)

[98] INR15-IP22 (palro: Fujisoft)

[99] INR21-IP30 (Neruru & Yumeru: T-arts)

[100] 夢の子　ルネネ

[101] 夢の子　ユメル

cases. This point will be discussed in detail in chapter 6.2 (research framework) and chapter 6.3 (research focus or robot project).

A basic interest in robots, but taking no special actions, is characteristic for the conscious decision to design robots. Already at a young age, there existed an interest for creating things and therefore an affinity for robots. Pop culture and especially anime in general[102], such as Manzinger Z[103], Astro Boy and Tetsujin 28-gō[104] seem to be an inspiration for the decision for a career as an engineer. For one group of the interviewees, to become an engineer, who designs robots or other machines, was more or less a childhood dream. It was less important to improve society.

There is a gap between desire and the technical state of the art, which is partly the result of pop culture and recent presentation within the media. Independent moving humanoid robots such as ASIMO or wakamaru or the android *Geminoid HI-3 –HI-5 or Geminoid F*[105] of Prof. Ishiguro Hiroshi from Osaka University influenced the public opinion. The representative of Artplan explains the gap between desired and feasible robots.

> *“Robots are usually supposed to be humanoids. We are producing industrial robots, machines to replace people. […] Moreover, the definition of robot is that, it is a[n unmanned] machine programmed to ‘do like this’ within ‘these conditions’. The definition [of a robot] is that by setting assumed conditions in advance, it will act like it [the program] in that case. Right now, we have the name ‘robot’ on various welfare equipment, even if no person is controlling it. That is not a robot. […] Some machines with the name robot are controlled by a person from the beginning to the end. In the past these machines have been called robot, too. For example, within the anime Tetsujin 28-gō’ from my childhood, they [machines] moved by remote control and have been recognized as a robot. But now, when a person controls something it is not viewed as a robot. Speaking in manga terms, a robot has to be like Astro Boy. In the current era, Tetsujin 28-gō is not a robot. The definition of a robot is that people give commands, robots move by themselves and judge what to do.”*[106]

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102 INR01-IP01 (HSR: Toyota)
103 INR23-IP32 (KR-1000A: Clarion)
104 INR39-IP52 (Sasuke: Muscle)
105 In Japanese: jeminoido HI - 3 – HI – 5 ジェミノイド HI-3 – HI-5, jeminoido F ジェミノイド F
106 INR10-IP16 (aijō-kun: Art Plan) 00:08:18-00:11:07 ロボットというと、通常は人型のものが想定されるんですよね。我々は産業用ロボット、つまり人に代わる機械を作っています。[…]で、ロボットの定義というのは、あらかじめ「このような条件」では、「このようにする」とプログラムされたとおりに動く機械[無人で]というものなんです。あらかじめ想定した条件を設定しておいて、そうなった場合にそのように動作するということが定義なんですよ。今色んな福祉機器に「ロボット」という名前がついていますけど、人が操縦しているじゃないですか。それはロボットじゃないんです。[…]今あるロボットと名前のついている機械の中には、人が最初から最後まで操縦しているものがありますよね。昔はそれでもロボットと呼んだ、例えば私が小さいときのアニメ「鉄人 28 号」は操縦している、でも遠隔操作で動いているロボットと認められていたんです。でも今は、人が操縦するものはロボットじゃないんですよ。漫画で言うと「鉄腕アトム」のようでないといけないんです。今の時代、「鉄人 28 号」はロボットじゃない。人が指令を与えて、自分で動く、やるべきことを判断する、というのがロボットの定義ですよね。

The ideal of how a robot has to be, as well as the understanding about what a robot is, changed over time and so did knowledge about technology. The post-war generation of robots consists not only of independent humanoids like Astro Boy, but also mainly of remote-controlled robots such as Tetsujin 28-gō and Manzinger Z. Nevertheless, nowadays in particular, within society the prevailing image of a robot is the one of an independent humanoid. Society assumes that robots nowadays are almost as advanced as their pop cultural templates. The representative at Ryoei notes that the report of the media left a vague image about what robots can do.

> *"Right now, Japan is a powerful nation in robotics, but I think the research and development was back in the period of national rapid growth. When I worked for Fujikoshi, Japan's major manufacturers such as Fanuc, Yasukawa Engineering, Kawasaki Heavy Industries and others grew steadily. Perhaps I evolved an interest about 'what is a six-axis robot?', 'what kind of job can you do with a robot?', when watching the media, who featured this [robots]."*[107]

For him, media coverage on robots was motivation to go further into robotics. However, in contrast to children who became engineers and have a high technical proficiency, the average member of society stayed with limited technological knowledge with his questions unanswered. Thereby not only interest in technology, but rather technical knowledge, serves as a necessary condition which is typical for the pattern of the unconscious decision to design robots. To be precise, whether this technical affinity leads to a position related to robot development depends on coincidence. Coincidences can be personnel shuffle within the company on a robot project[108] or an order from a supervisor or a company's president[109]. In other words, under other circumstances, it would not be surprising if one of the interviewees would be in another position in the natural sciences or somewhere else.

In contrast to unconscious affinity to robots, whereby technical knowledge is only a prerequisite and not necessarily motivation for being able to fulfill current robot development, there is a pattern of a conscious and active decision to design robots in the future. However, the motivation for this varies from personal experience or special family background, to an active contribution to society. Unlike unconscious decision, where opportunity came

[107] INR08-IP13 (ROBO snail: Ryoei) 00:05:20-00:05:51 今はロボット大国の日本だけど、そのための研究開発が国内で急成長していた時期だったと思います。私は不二越に就職したんですけれど、日本のファナック株式会社、安川エンジニアリング、川崎重工といった大手メーカーがどんどん成長していました。それがメディアにも取り上げられているのを見て、「6 軸ロボットって何だろう」「ロボットってどんな仕事ができるんだろう」って興味を持ったところがあったかもしれませんね。
[108] E.g. INR01-IP01 (HSR: Toyota Motor), INR22-IP31 (kyūretto :Aronkasei)
[109] E.g. INR26-IP35 (Dreamer: Santec), INR03-IP04 (smile baby: Togo Seisakusyo), INR03-IP05 (smile baby: Togo Seisakusyo)

through a degree in a technical subject, personal reasons affected conscious decision for future work rather than a technical affinity. The personal background of a representative of TacaoF illustrates this personal motivation.

> *"I am from Kobe and when I was in elementary school, there was a big earthquake called the Great Hanshin Earthquake. I wanted to rebuild the city Kobe and since high school, I went to an architecture related school. In the meantime, the way of thinking has changed from urban development to build living. Therefore, in order to make welfare equipment, I entered the Kōwa Group at the beginning in the planning and development division, as well as in the product development division. […]"*[110]

For him, the great earthquake was the formative experience and motivation to contribute to society, in particular the reconstruction of the city Kobe. No big vision was needed. Even a formative personal or family experience can serve as a deciding factor to contribute to society. A second representative of TacaoF explains that his grandfather motivated him.

> *"I originally like to create things and entered a technical university in Osaka. At the time, when I was doing something related to creating things in the future, my grandfather collapsed because of a brain infarction. My parents' house is in Kyoto, but the university was in Osaka, I was not able to take care of my grandfather and listen to my grandmother's serious stories all the time. The contribution that I could not do, [was the motivation] when becoming a member of society, I thought that I could make a contribution for my grandfather. At this time, I learned that there are manufacturers of welfare equipment and I joined the Kōwa Group*[111]*. Since I originally wanted to create things, I was placed in the product development department, when joining the company. […]"*[112]

Thereby interest is mainly on making a contribution to society to some extent, rather than being extremely interested in robots themselves. Even in the case of the representative of Ryoei, the deteriorating health conditions of a relative led to his current position of

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[110] INR11-IP17 (Little Keepace: TacaoF) 00:00:55 -00:01:29 私元々神戸出身でして、小学生の時ですかね、阪神大震災という大きな地震があったんです。それがきっかけで神戸の街を復興したいと思い、建築関連の学校に高校から進んで、その間に街づくりっていうところから生活を作るっていう方に考え方が変わってきたんです。それで福祉の用具を作ろうと、この幸和製作所に最初は企画開発部、商品開発の方で入りました。[…]

[111] TacaoF is a subsidiary company of the Kowa Group.

[112] INR11-IP18 (Little Keepace: TacaoF) 00:02:15-00:03:02 元々ものを作るのが好きで、大阪の工業大学に入りました。何かものづくりに携わる仕事がしたいと考えていた時に、僕の祖父が脳梗塞で倒れまして。実家が京都の方にあるのですが、大学が大阪だったので、なかなか祖父の面倒を見るということがなくて、祖母の大変な話をずっと聞いてたんですね。自分ができなかった分、社会人になってから、おじいちゃんに貢献できることがないかなって考えたときに、こういう福祉用具のメーカーがあるっていうのを知りまして、この幸和製作所に入社しました。元々ものが作りたかったというのがあったんで、私も入社した時は商品開発部に所属しておりました。 […]

designing a robot wheelchair[113]. In the case of the representative of Ory Laboratory[114], who develops the communication robot OriHime, his personal background served as motivation for starting to develop communication robots. He was partly not able to attend junior high school and became a stay-at-home child due to personal difficulties. Already before starting OriHime, he loved to create things and designed an automatic wheelchair during high school. All these developers have something in common: that they are not fussy about if they develop a machine that they can label care robot or welfare equipment. It is mainly about contributing to society through technology. I discuss the social contribution in particular in chapter 6.9 (Contribution of Robots for Society).

In summary, the majority of developers are male engineers with only a few females and non-technicians. When formulated a bit exaggerated, this is in the end, the now-adult child, who wants to develop high-tech tools to test if social problems are solvable through technology. These male engineers grew from children who want to help into adults who want to see if technology can solve social problems as they perceive them. Therefore, there is a risk that robot projects are only technology-driven and forget about the needs of the field, rather than designing from a practical viewpoint and including end-users.

Furthermore, within the 22 robot projects with 27 interviewees, there was an affinity with manga and anime, in particular Astro Boy, and I assume that pop culture inspired many engineers. Nevertheless, six of the 27 interviewees explicitly attached importance to robot-related manga and anime for their current position as a robot developer[115]. At least for the developers, it is undeniable that to some extent pop culture had an impact on their career choice. The combination of pop culture and their technical affinity often lead to a wish to create things and in doing so, to a greater or lesser extent, to their current position. Apart from that, pop culture has deep influence on society, too, in particular on images of what robots should do, what they look like and how a robot should be. Society projects a high degree of independence in manga, such as Astro Boy or Doraemon, or the advanced technical state of robot technology in anime, such as Mobile Suit Gundam, onto current robots, which have to meet these expectations (see Chapter 6.8) to be accepted.

From a theoretical perspective, collected data shows three single inventors who were passionate to design robots and make a social contribution with them[116]. According to Dierkes, Hoffmann, and Marz (1996) the stereotype of an inventor is a person who is

[113] INR08-IP13 (ROBO snail: Ryoei)
[114] INR04-IP06 (OriHime: Ory Laboratory)
[115] INR04-IP06 (OriHime: Ory Laboratory), INR08-IP13 (ROBO snail: Ryoei), INR12-IP19 (RT.1/ RT.2: RT.Works), INR13-IP20 (Resyone: Panasonic), INR15-IP22 (palro: Fujisoft), INR39-IP52 (Sasuke: Muscle)
[116] INR04-IP06 (OriHime: Ory Laboratory), INR08-IP13 (ROBO snail: Ryoei), INR39-IP52 (Sasuke: Muscle)

deeply driven by a vision, and who is most likely successful to gain consensus to materialize his vision into reality. All of the three inventors, as well as the inventor of the communication robot Orihime, the mobility aid ROBO snail or the transfer aid Sasuke, were convinced that their invention makes a difference within their field. The majority became a robot developer because they were moved to a robot-related position through job shuffle[117] or because they had been placed on a robot project. In that case, the theory assumes that it will become difficult to gain consensus with other relevant social groups of the development process.

6.2 Category 2: Research and Development Framework

Aside from personal motivation and background, the structure in which robot development takes place has significant influence on the outcome of development. Even if the aim was to get insights into development background, several of the given responses did not perfectly match the original question. Therefore, in the course of the interview, I asked a further similar question (see Chapter 6.3) to get the information needed. In many cases, the response to development history often involved the motivation for the robot development, its starting point. All information about this category can be found in chapter 4.3.2.

The background of development forms the basis for development. This includes not only the development incentive, but also how the robot project is valued within the embedded organization (IQ2.1). According to the theoretical vision concept (cp. Dierkes, Hoffmann, and Marz 1992, 154), an idea is more likely to go through the course of development if the incentive for development is an internal one. Externally or artificially (e.g. governmental programs, promising market forecasts) created incentives are hardly able to reach enough consensus. Furthermore, in most cases, the appreciation of an idea within an organization connects to the budget and human resources assigned to the robot project.

Demographic change and its related challenges clearly served as an incentive to getting involved in care robotics. The steadily aging society and decreasing labor force sets high incentives, or even creates a rush for companies to get into the field of care robots. The representative of Toyota outlines their optimistic attitude towards the potential of robotics for society, when mentioning that, *“As the population of the world and Japan ages and*

[117] In Japanese: jinji idō seido 人事異動制度

fewer babies are born, we [Toyota] want to support and overcome this with robot technology. Our purpose in developing so many robots and investing in research is to be prepared for the declining birthrate and aging society.” [118] It is true that care robotics can provide technical solutions for social issues. For example, care robots can reduce the physical burden on the caregiver or increase the quality of care. Toyota intends to improve the quality of daily life with, as its name suggests, Human Support Robot (HSR). Thereby the activities of major companies such as Mitsubishi, Honda and Toyota can serve as role models and inspiration for other smaller companies. Especially in areas such as care robotics, where the future is uncertain, leading companies are pioneering for smaller companies. Their direction might reduce the estimated risk for smaller companies with only limited financial and human resources.

Having said this, there is a fine line between profiting from the high economic potential and socially supplying the field of care with accepted, feasible and affordable care solutions. Among the 22 robot projects, there is a relatively even split between socially and economically motivated companies. One group of companies wanted to contribute to society with its development[119]. The other group jumped on the care robot train, just because of financial incentives[120]. The reasons are promising market forecasts, or to develop a second mainstay due to a weak main business. The economically motivated group consists of companies in particularly from Aichi prefecture and the automotive sector[121]. The representative of Ryoei, with their mobility aid ROBO snail, stands for the economically motivated group. He mentions their motivation openly, when saying, *“since NEDO is the primary institution [for robot development], and since we started the development of robot devices for nursing care, [we thought,] if we participate in the partnership [program], we could get the tools for development at the same time.”* [122] In the most cases, these companies shoulder low financial risk, because they benefit form governmental or

[118] INR01-IP01 (HSR: Toyota Motor) 00:02:53-00:03:24 世界と日本は少子高齢化が進んでいるので、それをロボット技術で支援し、乗り越えることです。多くのロボット開発の研究目的は少子高齢化に備えたものです。

[119] INR01 (HSR: Toyota Motor), INR04 (OriHime: Ory Laboratory), INR06 (Muscle Suit: INNOPHYS), INR11 (Little Keepace: TacaoF), INR12 (RT.1/ RT.2: RT.Works), INR14 (Flagship Model ES-03: Nabtesco), INR21 (Neruru & Yumeru: T-arts), INR22 (kyūretto: Aronkasei), INR27 (yorisoi robotto: Sanyo Homes), INR39 (Sasuke: Muscle)

[120] INR02 (SAN Flower: Kato Denki), INR03 (smile baby: Togo Seisakusyo), INR07 (i-me:ma: Kito Seiki Seisakusho), INR08 (ROBO snail: Ryoei), INR10 (aijō-kun: Art Plan), INR15 (palro: Fujisoft), INR23 (KR-1000A: Clarion), INR24 (aams: bio sync), INR26 (Dreamer: Santex), INR28 (Hug: Fuji Machine MFG), INR29 (Tecpo: Shintec Hozumi)

[121] INR03 (smile baby), INR07 (i-me:ma: Kito Seiki Seisakusho), INR08 (ROBO snail: Ryoei), INR23 (KR-1000A: Clarion), INR28 (Hug: Fuji Machine MFG), INR29 (Tecpo: Shintec Hozumi)

[122] INR08-IP13 (ROBO snail: Ryoei) 00:06:25-00:06:42 NEDO が主体になって、ロボット介護機器開発を始めたので、そこにパートナーシップとして参加すれば開発のツールも一緒にもらえたんです。初めて取り組むことに関して、そのプロジェクトに入り込むことで安心感がありました。

prefectural subsidies. Nevertheless, the priority lies on the main (automotive) business, and care robotics is more or less an experiment with mostly low human resources. From a theoretical point of view, the lack of equipment makes one aware of a lack of consensus.

The socially driven group of companies can be divided into two subgroups. Companies and their developers who want to connect their work economically to the aging society or silver market, and those developers who are committed to change society for good with their pioneering inventions. Toyota is an illustrative example of the former group. The company Kowa, with its subsidiary company TacaoF and RT.Works, who are aware of the potential of robot technology in the silver market, are representatives of the latter group. In this sense, the motivation of TacaoF is to improve an original product through benefitting from robot technology at the same time. The representative of TacaoF illustrates this with their Little Keepace, when pointing out:

> *"Originally, we had nothing to do with robots. Well I think that it was explained, but we created something called silver car[123], a walking aid for the daily use of the elderly like a shopping cart. Here there appeared a problem, which was impossible to solve with analog things. In particular, uphill, downhill or steps. By any possibility, when we searched for a way to solve this issue, which is not solvable with analog forces and conventional [walking] aids, we found that it was using robotics."[124]*

The simple thought is to expand the product line. In the case of TacaoF, this interpretation is in a positive way, and robotics serve as a means to an end to achieve their goal. Robot technology enables what has not been possible with mechanics. It is the solution-oriented approach to kill two birds with one stone, achieving economic growth and improving product quality. Robot technology might be the next big economic market, which might be a secure anchor for companies. He compares this with the search for new products after declining business opportunities in television.

> *"At the time, television stopped making a profit, I think that the Japanese domestic maker thought about what to do next and that [robots] came to their mind. When I was at Funai Electrics, I was thinking about the future society and especially since Japan is a rapidly aging country, the numbers [of elderly people] will increase, right? The number of elderly people is increasing, so I was wondering, if there is nothing useful for them on the market. However,*

[123] shirubā kā シルバーカー is a Japanese-English word, which is understood in standard English as 'walker for an aged person'

[124] INR11-IP17 (Little Keepace: TacaoF) 00:04:35-00:05:14 もともと、うちはロボットではない…まぁ説明あったと思うんですけど、お年寄りが日常で使うような、お買い物で使うような歩行補助車、シルバーカーというものを作ってきました。そこからどうしてもアナログのモノでは解決できない問題が出てきてるんですね。それが、上り坂、下り坂、あとは段差だったりだとか。どうしても、アナログの力、従来の機器では解決できなかったことを解決したいという方法を探しているうちにたどり着いたのがロボットだったんです。

> *you cannot change things suddenly, and so, as an electronic maker, when thinking about using your technology for commercialization, it has to do something with a motor and sensor."*[125]

The concept of RT.Works the RT-driven walker RT.1 and RT.2 is comparable to the concept of Little Keepace, a walker expanded with robot technology. Rather than economic potential, it is paramount for him that there is a meaningfulness to the work, or something that can be achieved through his work. Robot technology provides a technical approach for an existing social problem.

Even if there is an innovative or groundbreaking idea paired with a vision at the beginning, this does not automatically mean that it will be a sure-fire success. There is a certain consensus needed to be able to lift an idea onto a more materialized level. The representative of Ory Laboratory illustrates this problem when he talks about the past in the development of the tele-communication robot OriHime, *"for the first two years I was doing the development alone, because I was not able to get people's understanding. Then, I got a team of three people, and as the number of patients increased, there was the feeling that it might be possible to build quite a lot of teams."*[126] For him, starting without enough supporters was difficult. It took some time to convince others and receive support. The course of development could have ended at this point, because only a groundbreaking idea does not lead to an artifact.

The organizational framework integrated within development is essential for the successful materialization of a first vague idea into a final robot. In the words of Dierkes, Hoffmann, and Marz (1996), there is a necessity to synchronize the processes of communication between several cultures of knowledge. For this reason, the framework especially includes the size of the development division (IQ2.1.1), because the provided human resources and development environment gives insights into the value and priority given by an organization. Additionally, the communication habits, or more clearly, the instrumentalization of communication as a tool for sharing ideas or overcoming problems directly affects the development process.

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[125] INR12-IP19 (RT.1/RT.2: RT.Works) 00:17:18-00:18:10 [テレビが]儲からないってなったときに、何か新しいものをやろうと、日本国内のメーカーは特に次は何をやろうということをすごく考えていたんだと思うんですよ。我々が船井電機だった時は、これからの社会のことを考えたら、高齢化社会、特に日本は高齢者先進国なので、たくさん[お年寄りが]増えますね、と。高齢者は増えるんだけど、じゃあマーケットとしてその人たちの役に立つものがないかなぁというのがひとつです。でもいきなり変わったことはできないので、電機メーカーとして、持ってる技術を使って商品化できるものと言ったら、まさにモーターとか、センサーを使った何かというところだったんですね。

[126] INR04-IP06 (OriHime: Ory Laboratory) 00:02:17- 00:02:46 まず初めの 2 年ほどは、理解者が得られなかったので、一人でやってました。そこからは 3 人のチームになって、患者さんも増えたので、かなり多くのチームで造れるようになっていった感じはありますね。

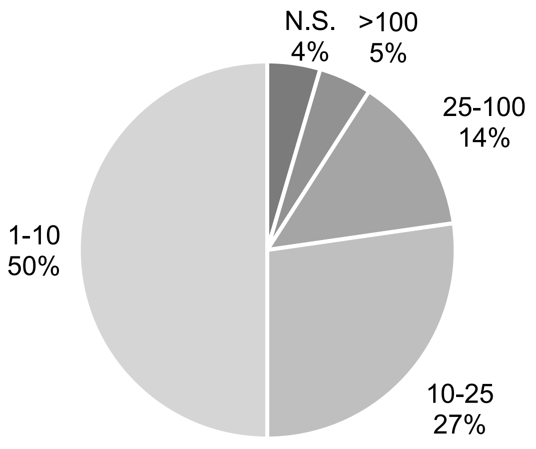

Figure 6-3 Division Size of the Robot Project
(n = Number of Projects)

When having a closer look at the size of the development division within the companies (see Figure 6-3) of the various robot projects, several structural facts become visible. First, half of the companies maintain development divisions of fewer than ten persons. A quarter has fewer than 25 involved persons, and the remaining quarter has more than 25 persons contributing to the development. Among the responses from the various robot projects, only one, Toyota, has a development division of 200 persons[127]. Three are over 25, with a staff of 50[128], 40[129] or 38[130], four have 20[131] and another four[132] are between 13 and ten. The rest are under ten, whereby two are three[133] or just one[134]. Generally speaking, in absolute numbers, larger companies (e.g. Toyota, Panasonic, Fujisoft) provide more human resources for the development of robots. Nevertheless, when having a look at the relative numbers, smaller companies might have relatively more human resources tied around robot development. This applies especially for smaller companies, who are doing their main business in robotics[135]. In addition, several companies have

127 INR01 (HSR: Toyota Motor)
128 INR28 (Hug: Fuji Machine MFG)
129 INR15 (palro) Fujisoft
130 INR02 (SAN Flower: Kato Denki)
131 INR11 (Little Keepace: TacaoF), INR12 (RT.1/ RT.2: RT.Works), INR29 (Tecpo: Shintec Hozumi), INR39 (Sasuke: Muscle)
132 INR06 (Muscle Suit: INNOPHYS), INR14 (Flagship Model: Nabtesco), INR23 (KR-1000A: Clarion), INR24 (aams: bio sync)
133 INR03 (smile baby: Togo Seisakusyo), INR10 (aijō-kun: Art Plan)
134 INR21 (Neruru & Yumeru: T-arts)
135 E.g. INR04 (OriHIme: Ory Laboratory), INR12 (RT.1/RT.2: RT.Works),

development partners to whom they externalize tasks of development[136]. This includes fields with a lack of experience, or simply outsourcing the production of the robot.

Thereby the development structure varies among the companies. Taking a closer look at division names or involved divisions reveals different groups of concepts and incentives for robot development. The four different development types are project-driven, hardware, multi-divisional and business-driven.

One group is project-driven robot development within a specific robot developed mostly in one single division, or the integration of one project in a bigger division. Project-driven development makes all necessary resources for the development of a specific robot available within one division. Other divisions are included for indirect development tasks such as marketing or sales. The advantages of this development type are clearly the strict focus on one robot project and the canalization of the necessary resources. Larger companies[137] tend to have robot project divisions such as Toyota (Human Support Robot Project), Panasonic (Robot & Rehab Business Development Department) and Fujisoft (palro Department). Smaller companies do not separate development related tasks and conduct them in one overall division[138].

The general hardware development group consists of an R&D division for the development[139] of not just one robot, but several robots or other products in general. Thereby, not R&D-related fields are externalized. A variation of the single development type is the multi-divisional type. The multi-divisional development group has a single robot division for hardware, which is connected to other divisions, such as sales and marketing for non-technical related tasks. There is a pattern of research plus an additional division[140], or research and another division combined as one[141]. In both groups, there are small and medium-sized companies which limit human and thus development resources. The advantage of this development type is that the more or less strong separation between development and non-development tasks, the further the focus on hardware[142] development.

[136] INR11 (Little Keepace: TacaoF), INR23 (KR-1000A: Clarion), INR27 (yorisoi robotto: Sanyo Homes), INR28 (Hug: Fuji Machine MFG), INR29 (Tecpo: Shintec Hozumi)
[137] INR01 (HSR: Toyota), INR13 (resyone: Panasonic), INR15 (palro: Fujisoft)
[138] INR04 (OriHime: Ory Laboratoy), INR12 (RT.1/ RT.2: RT.Works)
[139] INR03 (Smile baby: Togo Seisakusyo) Development Department, INR8 (ROBO snail: Ryoei) Robot Design Department, INR23 (KR-1000A: Clarion) Hardware Development Department
[140] E.g. INR39 (Sasuke: Muscle) Development Division and Health Care Division
[141] E.g. INR6 (Muscle Suit: INNOPHYS) Sales and Development Department, INR24 (aams: bio sync) Research and Development Center
[142] Hardware means the technical artifact, the robot itself. Software means the system or interface for the application.

The last group is business-driven development whereby a company integrates a specific robot development into a business development division. Especially with this type, the motivation for development or the incentive is clear: Expected economic profit. Rather than having an innovative vision, the objective is to design a marketable and profitable product[143]. The background for this might be to develop a second mainstay from the main business, or to make business opportunities arising from demographic transition. The former are often automotive suppliers, who want to be more independent from their dependent main business. According to Dierkes, Hoffmann, and Marz (1996) the creation of an artificial idea is difficult and thus, following the argumentation of their theory, problems with getting enough consensus for their development are likely to occur.

From a theoretical perspective, division size and cooperation partners have a strong impact on the course of development. The more people involved in the robot project, the more likely it is to get consensus, which is enough to see a project materialize. On the other hand, the more there is a need for synchronization of communication to be able to keep the project running successfully. In other words, more human resources make a robot more likely to materialize, but it complicates communication and creates the need for institutionalized project coordination.

Another important element within the course of development is how engineers exchange information (IQ2.2; see Figure 6-4) with other involved persons. The reason for that is that, even a groundbreaking idea is not able to materialize and thus diffuse within society if it is not possible to get a certain consensus among other influential actors. SCOT terminology calls this the relevant social group, which is able to steadily close interpretative flexibility about an invention, and thus pave the way for later diffusion. The method of choice for developers to get a broad consensus about their robot is to constantly involve other relevant groups and exchange information with them. This prevents different opinions on the robot and the risk of unsuccessful development. The importance of information exchange cannot be underestimated.

[143] INR22 (kyūretto: Aronkasei) New Business Development Department, INR28 (Hug: Fuji Machine MFG) Business Development Department, INR29 (Tecpo: Shintec Hozumi) Global Project Planning Department

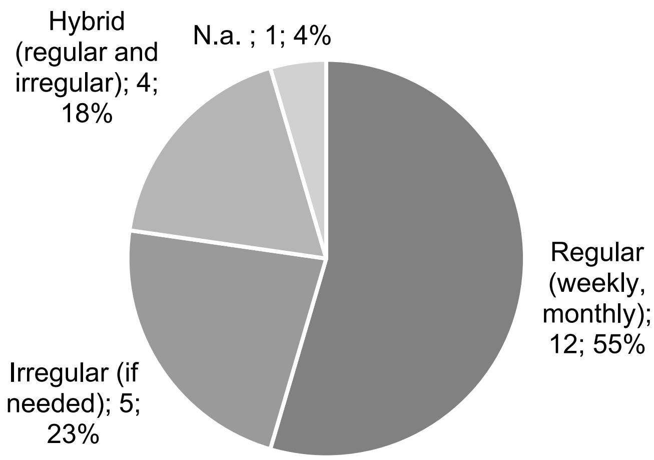

Figure 6-4 Types of Information Exchange
(n = Number of Projects)

Among the 22 robot projects, the most common type, with twelve projects, exchange of information is through the form of a regular meeting. The majority of the companies have weekly meetings within their company or the division. There are a few variations of regular information exchange. A few companies limit the main information exchange on a higher hierarchical level[144], such as the leader level. From the theoretical perspective of the vision concept, this can lead to the problem that the lower hierarchical level might not support the concept behind development. To some extent[145] the meetings make use of modern meeting forms, such as Skype, to connect with external cooperation partners and others[146]. Regular meetings have the advantage that they encourage continuous discussion of the development and a comparison of information. Their limitation is to some extent in hindered flexibility, which companies try to overcome through a high, in most cases weekly, frequency.

The other quarter consists of an irregular or hybrid culture of information exchange. The irregular exchange culture characterizes itself through a smaller development division[147] without the need for regular meetings. The only exception is Nabtesco with a medium

[144] INR06 (Muscle Suit: INNOPHYS), INR15 (palro: Fujisoft)
[145] INR11 (Little Keepace: TacaoF), INR23 (KR-1000A: Clarion)
[146] INR02 (SAN Flower: Kato Denki)
[147] INR04 (OriHime: Ory Laboratory), INR10 (aijō-kun: Art Plan), INR24 (aams: biosync)

sized development division. The representative of Nabtesco, who is in charge of the development of the Flagship Model ES-03[148], explains the reason for their integral division structure.

> *"Since our company [Nabtesco] has a certain size, aside from welfare, each division has its own room, where sales are sales, quality assurance is quality assurance, and administration is administration and so on. Only the welfare division is special, because everyone is in the same room. For that reason, we always have communication that includes information exchange. Well, if there is a commercialization process, then a team [of ten people in total] will follow this process. Out of the ten people, a team is organized and meets, if necessary, to take care of issues like [product] costs or to decide the policy. For each division that differs from the welfare division, where this is all in different rooms.* [149]

At Nabtesco, the division is located in one room in order to create a supportive environment for development. The integration of several sections makes it possible to exchange information in a fast way, so that no problems or misunderstandings occur. In the terminology of the vision concept, this integration of several sections promotes synchronous preadaptation and the establishment of a functional equivalent, or simpler, putting several sections into sections ensures that all speak the same language.

The last type of information exchange is hybrid culture, which combines regular and irregular. Three of the four hybrid types combine a weekly meeting in the company with as-needed-meetings either within the company[150] or with their external partners[151]. Only at Sanyo Homes[152], development-related information exchange takes place as needed and there is a monthly meeting with external partners.

The mentioned three types of cultures of exchange are the major types dominating within the companies. It can be expected that there are more hybrid exchange models within the group of regular information exchange cultures. However, efforts of the various companies show that they more or less try to utilize information exchange to promote the

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[148] The abbreviation Flagship Model replaces the longer name of the exact model Flagship Model ES-03. The reason behind this is simple; the ES-03 is the technical abbreviation for the generation of the prototype. ES-03 means it is the third generation and thus newer generations are marked with higher numbers (e.g. ES-04, ES-05).

[149] INR14-IP21 (Flagship Model: Nabtesco) 00:04:24-00:05:34 うちはある程度の規模がある会社なので、福祉以外のそれぞれの部署に関しては営業は営業、品証 は品証[品質保証]、管理は管理っていう別の部屋にいるんですよね。福祉だけは特殊で、全員同じ部屋にいるんですよ。だから常に情報交換を交えたコミュニケーションはしてますね。それで、商品化に関するプロセスがあって、そのプロセス通りに進めようっていうチームがあるんですよ。その 10 人 のうちの何人かでまたチームが組まれていて、その人たちは何か解決しなければいけないコストなどの課題とかの方針を決めなきゃいけないときは都度集まるようにしてますね。

[150] INR03 (Smile baby: Togo Seisakusyo), INR39 (Sasuke: Muscle Corporation)

[151] INR28 (Hug: Fuji Machine MFG)

[152] INR27 (yorisoi robotto: Sanyo Homes)

idea behind the robot and reduce avoidable problems during the course of development. It is interesting that the understanding of information exchange is only development-driven and excludes the end-user. None of the interviewees mentioned the inclusion of the user in the meetings. This causes a high probability for issues with acceptance on the user-side, because there is a high chance that they have to test finished prototypes, which fail to satisfy their demands.

Another important aspect of the development process is participation (IQ2.3), e.g. in special programs run by the government or in joint-development projects. Most of the companies make or made use of subsidies, which made it possible, especially for smaller companies, to try to get into the field of care robotics without carrying high financial risk. The most common are METI subsidies, which in particular are aimed at developers. In addition, there are subsidy programs by MHLW, or prefectural support. Only one[153] of the 22 robot projects receives no subsidies. Apart from receiving financial resources, participating in governmental programs brings the advantages of know-how and professional support in a business field, which the majority of the companies are unfamiliar with. The representative of TacaoF (Little Keepace) explained the win-win of the subsidies for a company unfamiliar with robots.

> *"First, our company has originally no robot technology. Therefore, we had to get the technological knowledge somewhere through cooperation. On the contrary, as for us, we have information about the market, on what can be sold, and the sales capabilities. This means that the advantage for us is that if it is possible to create a good thing, we can take advantage of our strengths [sales capabilities] and at the same time, when investing in robot business, we can hedge the risk through an external cooperation partner. "*[154]

In this sense, the governmental subsidy programs also function as door openers even for non-technological companies. Furthermore, developer-driven subsidies by METI created the growth of various care robot projects, especially for small and mid-sized companies. Toyota's representative explained his company's unanswered willingness to contribute to national robot development, when mentioning that *"[we would have joined a program] if they had talked to us, if we could contribute, we would go to their place, and*

[153] INR23 (KR1000: Clarion)

[154] INR11-IP17 (Little Keepace: TacaoF) 00:08:59-00:09:33 まず、うちの会社はロボットの技術というのはもともと持っていないんですね。なので、技術はどこかに協力を得なければいけない。反対に、うちとしてはどういったものが売れるのかとかいうマーケットの情報だったり、営業力を持っているので、いいものさえできれば売れるという、うちの強みを生かしてロボット事業に対する投資は外部に協力いただくことでリスクヘッジを行ったっていうところがメリットです。

think about a strategy together. "[155] Apart from being overlooked, it remains an open question, whether the restrictions and limitations, which go hand in hand with governmental support programs, are attractive enough for larger companies with large financial resources and R&D know-how.

On the downside. even for small and mid-sized companies, their activities in robotics do not automatically mean that they join governmental support programs. The government might be able to draw attention to a relevant field such as care robots and set incentives for companies to enter the field. Having said this, the representative at Clarion, which is originally a company from the automotive sector, acknowledges the role of the government as a pioneer, but at the same time limits this when mentioning, *"We have no particular cooperation on development. Originally, the government rapidly promoted care robots and to some extent we just jumped on it, but when it came to the actual development, we did not cooperate with somebody. So far, there is no need to work together with someone, because we can do it alone."*[156]In other words, it is more complicated to get companies involved in support programs if there is no need or incentive to do so. The main reason for this might be the conditions of the programs, such as fixed development schedules or security regulations. The representative of RT.Works gets to the heart of this point.

> *"There is support with the cost or financial assistance, but it is a tradeoff. The government requests [us] to proceed within a specific schedule. I think it is really a little hindering that the assistance can't be given if you don't conform to their rules. Generally what we want to do matches, but as you go through the details, there are times when you think, e.g. 'I do not have to do it so far' or ask 'really, you do not have to do this?'. Since we are a private company, we have to make products and make profits and to manage the company, but I do not think that this matches exactly their policy. That is why there is a shift within the direction of each side."*[157]

[155] INR01-IP01 (HSR: Toyota Motor) 00:04:40-00:04:47 声がかかれば、貢献が出来れば、そのところに行って、戦略を一緒に考えていて、しています。

[156] INR23-IP32 IP32 (KR-1000A: Clarion) 00:06:20-00:06:52 開発に関して協力というのは特にないですね。元々介護ロボットって国の方でどんどん推進していきましょうっていうことで、それにある程度は乗っかってはいるんですけど、実際に開発するときにそちらと手を組んでやるっていうことはなかったですね。今の時点ではどこかと手を組むほどではなく、我々だけでできてしまうので

[157] INR12-IP19 (RT.1/RT.2: RT.Works) 00:27:55-00:29:05 費用というか、お金の補助はあるんですけど、それとトレードオフになっている、国は国で、こういうスケジュールでこういう風に進めなさいとある程度決まりがあるんですね。その決まりに沿わないとどうしても実施できないんで、そこが本当にちょっとあれ[障害]ですよね。やりたいこととしては大体あっているんですけど、細かいところまで見ていくと、例えば、「そこまで必要ないんじゃないかなぁ」っていうところもやらないといけないし、或いは、「これやらなくてもいいの？」っていうところをやれなかったりとか言うのがあります。我々は民間企業なので、製品を出して、利益を出して、会社を経営しないといけないんですけど、これはその一部であるんで、こちらの方針とぴったり一致しているわけではないと思うんですね。だからお互いの方向性にずれが生じてくることはありますね。

He, as one example for other developers, illustrates that not only the desirable outcome of a care robot can vary, but also that the conditions of the support programs can limit developers. In particular the timed milestone, which companies have to fulfill within specific periods, causes pressure on the developer. In other words, development speed has to be modified to the schedule of the support programs. The representative of Santec explains the problems that go hand in hand with accepting the conditions of the programs when he points out that; *"there was the control of the subsidies [as a condition for the development subsidies] and the development speed, which we did not match. There were not enough people to do certain things within certain periods, and our biggest obstacle was that we could not proceed as scheduled."* [158] The support programs exclude companies which are not able to meet the requirements. In the end, this pressure can slow down the development process of companies, especially with limited financial and human resources.

The need to follow a strict schedule and adjust to the requirements of support programs ignores an essential part of technology development: its unpredictability. The representative of Fuji Machine MFG expresses his displeasure about the program guidelines on their development process.

> *"Since I did a development [project], there are circumstances such as that in the evaluation phase we couldn't complete the machine in time and that hastened the development. If all goes well, there would be no problem with first thinking about a concept, then design the robot and get it evaluated, but in reality, various problems occur during the development process."*

As for technologic development in general, it causes problems to put the course of development into a rigid corset. On the one hand, certain milestones within support programs prevent companies from only withdrawing money without being able to create a prototype of a robot. On the other hand, innovation is an explorative process whereby it is only natural that unexpected problems arise, or the original concept changes.

Furthermore, official requirements can easily come into conflict with the original development objective. The representative of Sanyo Homes explains this dilemma, while showing sympathy for the government at the same time, *"Since we use the national budget, there are a lot of details to be checked, such as safety matters, or taking care of this, or checking this rigorously. This makes it sometimes difficult to not lose the original*

[158] INR26-IP35 (Dreamer: Santec) 00:16:03-00:16:23 [開発補助金の条件として] 補助金の抑制があったのと、我々の開発のスピードが追い付かなかった んですよ。この期間にここまでしなさいということに対して、我々には人が足りなかったし、スケジュール通りに進められなかったというのが一番大きいですね。

goal."[159] This mismatch of official requirements and the development concept can destabilize the general development project and can lead to an unreasonable burden. Beside deadlines and content related requirements, the governmental support program causes a lot of paperwork which the developers evaluated. Both points are in particular a problem for smaller companies with limited human resources. The representative of Muscle goes one step further when he criticizes that the government becomes too set on the development process itself.

> *"For us the trouble was that we could not work in our own pace. The pace of the country. There is the process of the government, but we do not need such a thing, we want to do it our way. […] there are hearings, gates, and the check of the progress. We do not like that, because the goal is to develop a product, the progress does not matter. So it is hard to adapt the development process to the country."*[160]

However, the ultimate issue is that support programs have a limited timeframe. The representative of INNOPHYS[161] gets to the heart of the problem with the governmental subsidies when summarizing that the *"disadvantage is that we receive money, but this is not continuing. Only during a project. When it is over, it is over. "*[162] This applies especially for funding provided by METI, whose interest used to be to create marketable products. The economic-oriented METI forgot two things in particular during the beginning of their subsidy programs. First, there is a need for subsequent guidance after development, because otherwise there is a high chance that developed prototypes will not reach the end-user, because they had not been included into the development process. Second, there is a need for a connection between the developer with the user-side. Otherwise, even if a care robot finds its way into a care facility, it will stand around most of the time, because it does not fit the needs of caregivers. Nevertheless, there is an awareness of this problem, which is why METI and MHLW started to work closer together.

159 INR27-IP36 (yorisoi robotto: Sanyo Homes) 00:07:17-00:07:50 さすがに国家予算を使うんだから、安全面など、これだけには配慮しなさいだとか、こういうチェックを厳しくやりなさいだとか、細かな確認事項が多かったです。それが本来の目的さえ失われるぐらいに厳しいこともありますね。

160 INR39-IP52 (Sasuke: Muscle) 00:05:33-00:06:24 苦労したのは、自分のペースで仕事を進められない。国のペース。国のプロセスがあるんだけど、僕らはそんなものいらない、こうやりたいと。[…] ヒヤリングとゲートがあって、進捗のチェックが入るわけです。僕らはそういうのではなくて、製品を開発するのが目的だから、途中経過はどうでもいい。だから開発のプロセスを国に合わすのが大変。

161 マッスルスーツ

162 INR06-IP11 (Muscle Suit: INNOPHYS) 00:11:07-00:11:21 欠点はね。お金はくれるんだけど、継続しない。プロジェク単位。終わったらおしまい。

6.3 Category 3: The Robot Project

After getting the developer's personal background and the organizational framework wherein the development takes place, the third subchapter deals with the robot itself, its past, present and future. Further information about the questions of this category can be found in chapter 4.3.3.

The reason for developing robots (IQ3.1) varies among companies. However, the trigger (IQ3.1.1) to getting started with robots is either idealism or an economic interest. The former entered the field of robotics before 2008 and the latter after 2008 (see Figure 6-5). An important detail is that the major governmental programs for creating an environment for the development of robotics started in 2008. NEDO made the beginning with its project 'project for practical application of service robots' (NEDO 2011) between 2009 and 2013. At the end of the project, there were the 'robot safety center' (NEDO 2014) and the ISO13482 for service robots (METI 17.02.2014). The following period specialized in the 'priority areas to which robot technology is to be introduced' (METI 2014e) set by METI and MHLW, with fixed areas to canalize the support on robots with an expected high need (METI 2014b). In a certain sense, METI, MHLW and NEDO provide an orientation for care robotics. This in turn made it possible even for smaller companies to easily access information and enter the field without the need to start from scratch.

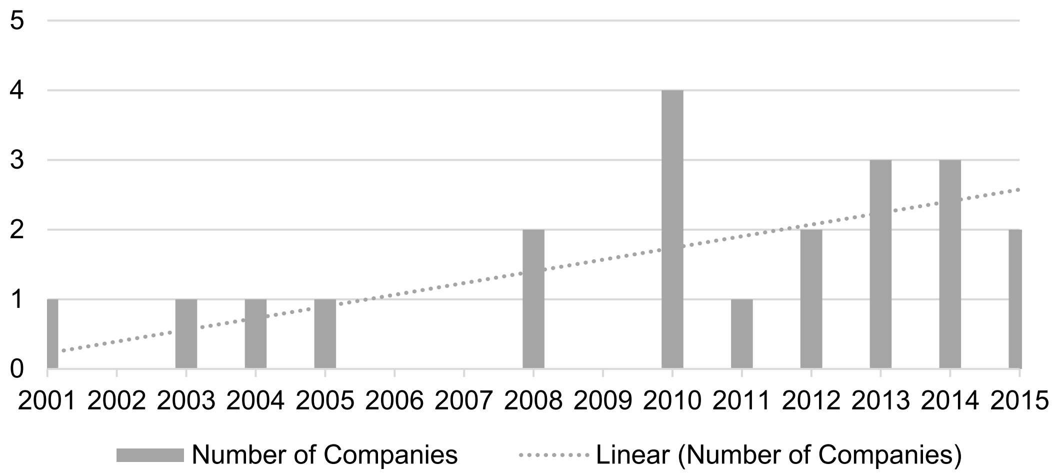

Figure 6-5 Number and Year of Companies starting Robot Development

Companies driven by idealism are characterized by robot development since the early 2000s[163], a period where service robotics was still in its infancy. Toyota Motor[164] started its general development of service robots in 2000, whereby the Aichi Expo served as an early goal. The feedback from the Expo marks the start of the Human Support Robot project, and set the course for future robot development at the same time. The representative of Toyota Motor recollects, "*The Aichi Expo in 2005 was a big milestone. For it, we started to develop a robot that interacts with humans in 2000, with the belief that it will be a main product or program of the future."*[165] In the case of Muscle with its robohelper Sasuke, the Shanghai Expo in 2010 was the incentive for entering care robotics. Thereby the reason was the lack of good welfare equipment within the field of care in Japan. The representative of Muscle vivaciously illustrates the process from the first idea at the Expo to the development concept.

> *"The world standard is equipment for transfer and mobility, right? And also Japanese manufacturers worked hard on it, but they aren't in use. So, I was asking why their products are not used and the thing that remains with the most impression is that the transfer is similar to the crane on construction sites. […] It was often requested to be carried more gently. Based on this opinion, I came up with the idea of Sasuke, but then I asked myself how a gentle transfer would look for me. And I couldn't remember that I didn't want to be carried or that it was painful to be carried in piggyback ride and hugged by my mother."*[166]

Both examples have in common that they want to contribute to society and the Expos inspired them. These examples illustrate the impact of international events on national companies as a source of inspiration. In the course of this, especially large companies

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[163] Robot projects, which started in the early 2000s are INR01 (HSR: Toyota Motor), INR06 (Muscle Suit: INNOPHYS) and INR21 (Neruru & Yumeru: T-arts). Additionally there are robot projects driven by the wish of making a contribution to society, but started in the 2010s, such as INR04 (OriHime: Ory Laboratory), INR12 (RT.1/RT.2/ RT.Works) or INR27 (yorisoi robotto: Sanyo Homes).

[164] In the early 2000s, Japan experienced a period of service robotics. Large companies such as Mitsubishi Heavy Industries, Sony and Honda media-effectively presented their own service robots. However that may be the case; Toyota Motors is one of the few remaining pioneers from this period. Mitsubishi Heavy Industries finished their service robot wakamaru in 2016, Honda ASIMO in 2019 and Sony discontinued AIBO. In the meantime, Sony totally revised and restarted AIBO in its fourth generation, as aibo, in 2017.

[165] INR01-IP01 (HSR: Toyota Motor) 00:06:07-00:06:34 2005年の愛知万博が大きなマイルストーンですね。それに向けて、2000 年頃から人と協働するようなロボットが、将来の核になるような製品、事業になるだろうということで開発を始めたのがきっかけです。

[166] INR39-IP52 (Sasuke: Muscle) 00:13:26-00:14:57 [移乗機器と移動機器が] 世界標準はそれなんですよね。で、日本のメーカーもそれを入れようって努力してきたけど、せっかく入れても使わない。それでなぜ使わないかというのをいろいろ聞いたところ、一番印象に残っている理由は、運ばれる様子が工事現場のクレーンに似ていると。 […] もっと優しく運んでほしいという意見が多かったです。その意見を基に、僕がSasuke の発想にたどり着くんだけど、自分に対して優しい運び方って何かって自分自身に聞いてみたんです。それは子供のころにお母さんにおんぶされたり、抱っこされたりしてたときで、一度も苦しいとかいやだと思ったことがなかった。

can play an important role as role models and motivate small and medium-sized companies to follow their area of development.

The visionary belief in a future where robots help to solve social issues might lead to an attempt to involve the user-side already at an early stage. The HSR-project characterizes itself through various cooperation partners in the health care sector. Toyota Motor's representative goes further into this user-integrative approach when saying, "*I think we did our best to bring it to places where you can use it. Even outside the project, we deal with rehabilitation robots and have a close connection to the hospital experts. I think it is important to design things, which actual patients can use*".[167] It is important to include the field at an early stage of the development process, and also to think about the user everyday environment. This includes daily life as well as attitudes towards care equipment. The representative of RT.Works explains the problem of prejudices, "*First, in the case of RT.1, when you see other so-called care equipment and conventional mobility aids in sales, they look bad. Although we want the products to be used, in fact when we talk to the user of mobility aids, there is a negative image about it, such as 'I am embarrassed to have one' or 'it is over, when I have to use one*.'"[168] Understanding of the field and the end-user enables a development that meets demands. It enables companies to put effort into points with an originally lower priority for the company, but a high user-priority. This in turn is likely to connect to an invention that the end-user integrates into his daily life and then spreads within society.
Having said this, too strong a focus on robotics might lead to misunderstandings. The representative of OriHime illustrates the risk of misleading images when pointing out that "*First, it is about robots, they don't move by themselves. There is a specific image that robots are moving alone. For example, AI loaded robots or robots that have much stronger powers than humans. OriHime is close to a puppet. It is small, doesn't have power and can't judge alone. However, the biggest feature is the person who manipulates it*."[169] Robots should serve as a means to an end and improve the quality of life.

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[167] INR01-IP02 (HSR: Toyota Motor) 00:06:45-00:07:31 使えるところまで持っていくということに関して、かなり一生懸命やっていると思います。このプロジェクト外でも、リハビリロボットなどを取り扱っているが、病院の専門家とかなり密接に話を進めています [...] 。実際の患者などに使えるものを出す、ということが大事だと思っています。

[168] INR12-IP19 (RT.1/RT.2: RT.Works) 00:29:57-00:30:40 まず最初の RT1 の場合に思ったのは、いわゆる介護機器、従来の歩行車が発売されてるのを見ると、かっこ悪いんですね。我々は商品を実際に使ってもらいたいんですが、実際歩行器の使用者にお話を伺ったときに、「持つのが恥ずかしい」、「あれを使い始めたら終わり」みたいな、マイナスなイメージなんですよ。だから、見た目はかっこいいねと言われるようなものにしようと。それで RT1 のデザインは、ちょっと変わった、ちょっとかっこいいものにしようとしました。

[169] INR04-IP06 (OriHime: Ory Laboratory) 00:06:54-00:07:36 まずロボットなんだけど、自分では動かないこと。ロボットというと自分で動くイメージがあって、例えば AI が積んであったりとか、人間よりはる

The prevailing images of robots directly influence the options of developable robots. For successful development, communication with the user is unavoidable, because it can overcome misunderstandings on the possible application range and lead to a broad consensus.

Companies driven by economic interests try to connect the technology of their main business with the steadily aging society and its high expectations. This group is characterized by a mostly technology-driven approach, because the companies try to transfer their main business to the field of care. The motivation is the promising market forecast that suggests high profits on the Japanese silver market within a short time. In addition, companies whose main business is dependent on economic trends try to get more independent through entering a new business sector. This applies especially for companies from the automotive sector, namely automotive suppliers or associated companies[170]. However, this does not mean that the aim is to replace the main business. It is more or less an adjustment on the economic development, as the representative of Kito Seiki Seisakusho emphasizes, "*Japan was influenced by the Lehman shock[171], the sales of Kito Seiki and other small and medium enterprises (SME) almost halved. Affected SME thought that they must start a new business and then established the 'next-generation robot research group' in Aichi prefecture*."[172] Rather than a groundbreaking vision, the robot is only a means to an end with the intention of making the company sustainable. The representative of Santec gets even clearer about this when he explains the reason for the development.

> *"The CEO came up with the story 'there is such a product, but I want to build it myself. Until this story, the company Santec had nothing to do with care. Our specialty is metallic molds. Precision metallic molds is a very different business sector and its products tend to be very dependent on economy. If economy is good, sales will go up, but if it falls, the production for metallic molds will quickly decline. Because we wanted to make the difference in sales as small as possible, we looked for something to stabilize the income*

かに強い力を持ったロボットが多い中で、[OriHime は] 操り人形に近い感じ。小さいし、力を持っているわけでもないし、自分で判断するわけでもない。けれども、そこに操作している人を投影する、創造させることができるというのが最大の特徴です。

170 INR02 (SAN Flower: Kato Denki), INR03 (smile baby: Togo Seisakusyo), INR07 (i-me:ma: Kito Seiki Seisakusho), INR10 (aijō-kun: Art Plan), INR23 (KR-1000A: Clarion), INR28 (Hug: Fuji Machine MFG), INR29 (Tecpo: Shintec Hozumi)

171 In addition, the representative of Art Plan (aijō-kun) mentioned the Lehman shock as a moment, which animated him to rethink the company's portfolio.

172 INR07-IP12 (i-me:ma: Kito Seiki Seisakusho) 00:14:20-00:15:54　日本はリーマンショックの影響で、鬼頭精器などの中小企業の売り上げが半分ぐらいに減ってしまった。影響を受けた中小企業は、何か新しい事業で仕事を受注しなければいけないという思いで、愛知県では「新世代ロボット研究会」を設立した。

> *and had an eye on care, than when looking for something to earn money with care occurred.”*[173]

Thereby the approaches of Santec and Kito Seiki Seisakusho are representative economically motivated companies. Already at the beginning of development there is a gap between the company’s economic orientation and the target group, namely the end-users with natural focus on the usability of technology. This creates the risk of an ever-increasing gap, which in the end is the risk of non-achievable consensus on the robot and its area of application follows. The consequence of this is that a non-familiar field is entered, and thus there is the high risk of not meeting the demand of the new target group.

A slightly different example of what is meant to be influenced by an external event is Kato Denki’s SUN Flower. The original idea was to invent a detector for usage in earthquake areas to locate buried persons. The representative of Kato Denki changed the original concept from a detection device for buried people into one to locate lost hiking elderly or dementia patients because of the higher application possibilities. The Tōhoku earthquake and tsunami in 2011, and a law change for television waves, lead to a rethinking of the use of the original technology, and in the end built the starting point for the development of SAN Flower[174]. Kato Denki tries to make use of technology and meet a potential demand.

The companies, and they are aware of these circumstances, have to get an understanding of the new field within a short period, or their activities are likely to remain unsuccessful. Thereby companies establish contact to universities[175], care facilities[176] or other institutions[177] to get the needed access to the field. Each of these approaches has its advantages. Especially, establishing contact to the field of care at an early stage influences the development outcome immensely. The approach of Fuji Machine MFG’s Hug illustrates the advantages of including the field. Hug’s developer talks about how they proceed, *“At the beginning, we had no knowledge about the field of care. Therefore, we*

[173] INR26-IP35 (Dreamer: Santec) 00:07:03-00:08:01 社長が、「こんな製品があるけど、自分のところで造りたい」という話を持ち込んできたんです。このサンテックという会社はそれまで全く介護分野のことをやったことがない。我々の得意分野は金型なんですよ。精密金型っていう全然違う業種のことをやっていて、それの製造は景気に非常に左右されやすいんです。景気が良ければ売り上げは上がるけど、逆に落ちれば金型の製造量もがたんと落ちてしまう。その売り上げの差をできるだけフラットにしたいという思いから、安定して収入が得られるであろう介護に目をつけて、何か稼げるものがないかと探していたところこれを見つけてピンときたということだそうです。
[174] INR02-IP03 (SAN Flower: Kato Denki)
[175] E.g. INR07 (i-me:ma: Kito Seiki Seisakusho)
[176] E.g. INR28 (Hug: Fuji Machine MFG)
[177] E.g. INR03 (smile baby: Togo Seisakusyo)

had to listen to people from various care facilities. However, without an actual thing, no further talk is possible. This meant, that first of all, we decided to design a machine that can do any kind of transfer."[178] Fuji Machine MFG decided to develop a prototype to test the acceptance towards their concept of a robotic transfer-aid. The prototype served as the consultative framework for further development, because Hug's developer thought it necessary to create something to talk about, instead of abstract talks about transfer methods. This decision was cost intensive and risky. In the case of feedback demanding major changes of the robot at the stage of a prototype, adjustments become technically complicated and cost intensive. Hug's developer recollects the feedback process as, *"first, we created a full-spec machine that could do anything and brought it to the facilities. Then we pulled out things from comments such as 'this is too big', 'this feature is nice' or 'this function is unnecessary'."*[179] Nevertheless, user feedback served as a source for improvement and, in turn, to an accepted robot. The attitude of taking the user and its needs seriously is critical for successful materialization of a vision into an artifact and its diffusion within society.

In contrast to this, the representative of Ryoei illustrates where the gap between the developer and the user can lead to when he talks about the beginning of their project ROBO snail.

> *"There is neither an accelerator nor a brake, but it [the robot] can physically move. In addition, it is sporty and it aims at you to let you want to go out because of the mobility aid. However, in 2013 when I presented it at the design examination committee, which is some kind of the interim report, in Tokyo, Mr. Ōkawa scolded me with 'care doesn't need to be fun.' At that time, I changed the direction by being told that, 'this robot is dangerous. Make it safer.'"*[180]

To have no experience with the field of care easily leads to robot development that does not understand the needs of the potential user. The inventor's vision did not receive enough consensus, but even more, he was urged to change the concept to meet demand

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[178] INR28-IP37 (Hug: Fuji Machine MFG) 00:12:50 -00:13:15 最初は自分たちも介護業界に対して、何も知識がなかった。それで、いろんな施設の方に話を聞くんですね。でも、実際にモノがないとそこから何の話もできないので、まずは移乗に関して何でもできる機械を作りましょうということになりました。

[179] INR28-IP37 (Hug: Fuji Machine MFG) 00:13:26-00:13:39 まず何でもできるフルスペックのモノを造って、施設に持ち込んで、「これは大きすぎるよ」、「この機能はいいね」、「この機能はいらないね」っていう風に、そぎ落とすようなイメージですかね。

[180] INR08-IP13 (ROBO snail: Ryoei) 00:17:14-00:17:44　アクセルもブレーキもない、体感的に動かせる。さらにスポーティで楽しい、出かけたくなるような歩行器を最初は目指していたんです。けれど 2013 年、中間報告にあたる東京の設計審査会でプレゼンテーションをしたところ、オオカワ先生に「介護に楽しさはいらない」とえらく怒られてしまいまして。その時に「このロボットは危ない。もっと安全なものを作りなさい。」と言われたことで方向を転換しました。

and in the end get more support. From a theoretical perspective, the response to a setback requires high internal motivation to continue and change the course of the development.

Even though economic orientated companies try to access new markets, that does not mean that they have no visions. In the case of Fujisoft's communication robot palro, a financial subsidies program marked the start of development. However, there was vision behind the communication robot. The idea of a robot as a companion comes from the CEO. The CEO was inspired by the movie Iron Man[181], in which the AI system Jarvis shows up. Similar to Jarvis from the movie, palro intends to be a home agent, which one can interact with or gets things done for you, and not to be a robot that you can touch only. This means that an official program initiated the development, but the design was free and based on the CEO's idea.

This implies that the two motivations described can be difficult to distinguish and might go hand in hand with each other. In this context, I want to go further into companies which entered robotics because of their customers[182]. Thereby, a company combines an economic motivation with a social orientation. It is a hybrid. All have in common that they to some extent have experience with products for elderly people. In the case of TacaoF and Nabtesco, it is professional knowledge with mobility aids; for Aronkasei, it is toilets; and then T-arts comes with entertainment devices in general. The decision to match their original products to robot technology is based on an analysis of user needs. It is the transfer of customer feedback into a new sellable product. The focus on customer needs simplifies development immensely, because it reduces the risk of rejection by the end-user. At the same time, the development becomes no sure-fire success with a fast diffusion product at the end of the process. TacaoF, with its mobility aid Little Keepace, is an illustrative example of this user-centered development. The representative of TacaoF remembers the course of development.

> "As initially intended to be a robot, […].we put product design in it, made it a robot-like walking robot and when we announced the concept model, we got a very high market evaluation. Then, we thought concretely about what elderly really can use. When we did the verification, elderly people resisted using the robot and from that point onwards we made a major direction change in 2007 or 2008."[183]

[181] The movie Iron Man is based on Marvel comics and is about the billionaire engineer Tony Shark, who fights the evil, in his weaponized armor suit. The element of using technology as something to extend the human power is not new. It also appears in Japanese Anime such as Mobil Suit Gundam.

[182] INR11 (Little Keepace: TacaoF), INR14 (Flagship Model: Nabtesco), INR21 (Neruru & Yumeru: T-arts). INR22 (kyūretto: Aronkasei)

[183] INR11-IP18 (Little Keepace: TacaoF) 00:11:02-00:12:03 当初はロボットということで、 […] プロダクトデザインを入れて、ロボットらしい歩行ロボットを作っていたんですけど、実際それをコンセプトモデ

Even though good customer feedback to their products initialized the development of Little Keepace, the mobility aid had problems withstanding practical tests by the user. The user did not request the intended design. However, user feedback on the new invention allowed a change in the direction of development. The combination of an economic motivation and social orientation makes it easier to close the interpretative flexibility. In other words, this combination facilitates that the robot design meets user expectations. The representative of T-arts recollects the early stage of the development process when saying, *"I guess the start was in 2004. At this time, I focused on a toy for children and in particular on sleep. It was a toy that you can become somewhat friendly with by sleeping together. It turned out that it was actually bought by elderly people and that it would be better to polish it for them. I guess that was already around 2006."*[184] In contrast to TacaoF, Nabtesco or Aronkasei, it was the other way around for T-arts; children were the intended target group, but eventually elderly became the main purchasers. This led to an adjustment of the concept towards use within the daily life of elderly people. Nevertheless, all of the hybrid-type companies have in common that the customer encouraged and indirectly influenced the further development course.

The initiator behind the robot project (IQ3.1.1) gives further insights into development structure and the strength of the vision. There are three types of initiations: The top-down, company-intern and inventor-lead initiation of the project. Having said this, there is no strict separation of the types. It is possible that the inventor-lead initiation is combined with one of the other two types. On the one hand, in the case that the inventor is the CEO of a company, it is theoretically possible that the development structure is a top-down one. On the other hand, if the CEO initialized development, the process can be a cooperative one.

First, there is the classical top-down initiation, where the CEO has an idea and leaves the practical implementation more or less to his employees. The risk is the implementation of the idea, especially if there is no clear communication. In the case of the toilet aid

ルとして発表したとき、非常に市場の評価を得たんです。けれども、じゃあ実際に高齢者が使えるのかっていうところを具体的に考えて、検証を行ったときに、高齢者には、やはりロボットを使うことに抵抗感があるので、そこからやはりデザイン面だったりっていうのは、2007 年か、2008 年ぐらいに大きく方向転換をしました。

[184] INR21-IP30 (Neruru & Yumeru: T-arts) 00:05:37-00:06:18 一番最初は 2004 年ですね。当時は子供向けにやろうと思ってて、その中でも睡眠に焦点を当てていました。一緒に睡眠することで仲良くなっていくおもちゃですよみたいな感じでやってたけど、実際買われていたのは高齢者の方々で、それだったらよりそちら向けに磨いていった方がいいんじゃないかということになったんです。もう 2006 年ぐらいからでしたね。

Dreamer developed by the company Santec, the CEO brought a prototype to his employees with the request to rebuild it, but left the technical specifications open. In the end the employees had to decrypt it, which took some time[185]. On the other hand, the visionary idea of the CEO can serve as a clear guideline and can stabilize development[186]. At the same time, the idea to enter care robotics can derive from the main business. In that case, the basic technology came from the main business and is adjusted to care robotics, whereby the reason can have several causes. The innovator CEO, who wants to create something new by combining their business with robotics[187] or an economic downturn, is forced to rethink business activities[188]. In addition, a good product with a high customer satisfaction can also lead to enter a still unknown business field[189]. The representative of Nabtesco explains the decision for starting the Flagship Model, *"First, Conpal[190] got high evaluations by the users, but they wanted further improvement. This is the so-called voice of the customer. When you pick up the customer's voice about this product, you can analyze that such things will become necessary."*[191] The positive voice of the customer caused a rethinking of the product range and motivated them to diversify further. Both Nabtesco and TacaoF used to offer welfare-related equipment but had no connection to robotics until this point. The advantage of starting development based on the customer voice is that such a development is likely to receive a fast and broad consensus among the target group, and thus will have fewer problems to diffuse within society.

Second, we have the stereotypical inventor[192], who is convinced of his idea and wants to realize it through development. The advantage of the inventor-lead initiation type is

[185] INR26-IP35 (Dreamer: Santec)
[186] In the cases of INR12 (RT.1/RT.2: RT.Works), INR15 (palro: Fujisoft) and INR28 (Hug: Fuji Machine MFG) the CEO made a proposal for the development, which served as a guideline and thus as a support for the development of the robot.
[187] In the case of INR22 (kyūretto: Aronkasei) the company has years of experience with standard toilets, but when thinking about the future market, the combination of toilets and robot technologies seems appealing.
[188] INR07-IP12 (i-me:ma: Kito Seiki Seisakusho) was initiated as an answer to the Lehman shock. As an automotive supplier, which is dependent on economic trends the company and project associated companies wanted to get more independent with a new side business.
[189] INR11-IP17 (Little Keepace: TacaoF) and INR14-IP21 (Flagship Model: Nabtesco), where both initiated, because of positive customer feedback on other products of the companies.
[190] Conpal is a mobility aid by Nabtesco. The sales started in 2013 and since then Conpal steadily received updates.
[191] INR14-IP21 (Flagship Model: Nabtesco) 00:14:21-00:14:56 まず、このコンパルはユーザーから非常に評価をいただいてるんですけど、もっと改良してほしいという要望があるんですね。いわゆるボイスオブカスタマー。この商品に関するボイスオブカスタマーを拾っていくと、こういうものも必要になってくるというのが分析できるんです。
[192] To name just a few examples: The developers of INR03 (smile baby: Togo Seisakusyo) and INR06 (Muscle Suit: INNOPHYS) were university professors, who looked for a partner in the industry to commercialize their research. Additionally there is a wide variety of reasons for the robot development, the idea of an employee was continued (cf. INR21 (Neruru & Yumeru: T-arts)), a patent was finally attempted to be used (cf. INR24 (aams: bio sync)) or the field of care should be improved by technology (cf. INR27 (yorisoi robotto: Sanyo Homes) and INR39 (Sasuke: Muscle)).

the high motivation of the developer, because he has his vision and has a personal interest in successful development. The disadvantage is that, especially if the inventor is only a single individual, persuasive efforts might be necessary to being able to start the development. An illustrative example is the representative of Ryoei, who brought up his personal request to develop a mobility aid on the company's agenda, caused by an experience from his close family. He explains his motivation as *"in my own family, a person, who really worked hard for the world, did suffer after the effect of a brain infarction and he had no longer a free body, which is why I want to create the mobility aid."*[193] Even in the case of OriHime, the start of development was a personal experience of being ill and not being able to attend school for a long time. The experience of loneliness and the desire to overcome this feeling through technology caused the development of OriHime[194]. In both the cases of ROBO snail and OriHime, the developers started with very limited human and financial resources. This leads to the fact that development, especially in the beginning period, takes more time and has the risk to fail. This in turn shows how important consensus is, and how it can influence the development environment. Nevertheless, the personal motivation or in the terms of the vision concept of an individual mobilizer is an important, if not the most important, element that can stabilize the development process. How and where an idea forms is secondary as long as it anchors within the individual. Theoretically, it is possible that the inventor is the CEO of a company[195], which combines the inventor-lead initiation with a top-down structure. The representative of Art Plan describes his very special way to gather ideas.

> *"Information swirls around a lot, but it depends on whether you can grab it or not, which is depending on if you think about it. Even if there is a thought, if you don't think with your head, useful information will go away. When I start thinking that I have to do something from now on, I am always thinking, so that it even appears in my dreams. Meanwhile, when you are relaxed, alpha waves[196] emerge and a plan comes out. So, when I think about things, I take a bath."[197]*

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[193] INR08-IP13 (ROBO snail: Ryoei) 00:21:25-00:21:45 自分の身内で、本当に世の中のために頑張っていた人が脳梗塞で後遺症を負ってしまって、自由な体でなくなってしまったということで歩行器を作りたいと思いました。

[194] INR04-IP06 (OriHime: Ory Laboratory)

[195] Cf. INR02-IP03 (SAN Flower: Kato Denki), INR04-IP06 (OriHime: Ory Laboratory), INR10-IP16 (aijō-kun: Art Plan), INR39-IP52 (Sasuke: Muscle)

[196] Alpha waves emerge when the brain is relaxed, in particular with closed eyes, or reflecting (e.g. solving a math problem).

[197] INR10-IP16 (aijō-kun: Art Plan) 00:30:00-00:30:56 情報というのはいっぱい飛び交っているけど、ただそれを掴むかどうかは、それを常に頭の中で考えているかどうかにかかっているんですよ。思いがあっても、頭で考えていないと、有益な情報は通り過ぎて行っちゃうんですよね。私は、これから何かしないといけないと考え始めたら、夢にもそれが出てくるぐらい頭の中でしょっちゅう考えているんですよ。そんな中、リラックスしていて α 波が出たときに、案が出るんです。α 波が出るのは、お風呂に入っているときや、眠りから覚めかけている時などです。だから、私はものを考えるときは、お風呂に行くんです。

For him, Inspiration is taking a bath. Ideas come from a relaxed environment and not under pressure. This is coherent with the vision concept, according to which visions are not artificially creatable. Personal experience or an aha-experience, for instance through a relaxed bath or other events, can be an important pool of ideas. This applies also for external events such as the World Expo[198], earthquakes[199] or economic crisis[200].

Third, there is the cooperative-intern initiation, where company employees have influence on the development. The start marks a first vague proposal or goal. This can be a goal such as the presentation of the state of the art at the World Expo[201] or simply the proposal for new business activities[202]. In both cases, the realization of the proposal or goal was open. The employees left with the decision of what and how to do. The advantage of this approach is that the employees carry the development, because they actively decide what they want to do. The disadvantage is that until a consensus about the future product is reached, there is a high chance to fail, because none of the proposed ideas might be strong enough or have enough potential to materialize. A good and positive example is Nabtesco[203] with its Flagship Model. The company decided to start a new business and created a division for this. In contrast to the other division, where there was a strict separation of responsibilities (see Chapter 6.2.), the new division created for this project was open. All related areas were put together in one division with the intention that this would lead to brainstorming and more discussions of the project.

Already in 2016, most of the robot projects, in numbers 16 of 22, were already commercialized and available on the market for sale or rental (IQ3.2). The remaining eight projects are in their evaluation period or only had to undergo small adjustments[204]. The evaluation period includes test runs in facilities or hospitals[205]. That the vision of a devel-

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198 Even if the initiation type is cooperative the development of Toyota's HSR (INR01-01 HSR: Toyota Motor) was indirectly caused by the world expo in Aichi in 2005.

199 The developer of Kato Denki (cf. INR02-03 (SAN Flower: Kato Denki) wanted to develop a technology to detect buried people in areas hit by an earthquake. Later he experienced that this technology has the potential to detect lost children or elderly.

200 INR10-IP16 (cf. INR10-16 (aijō-kun: Art Plan) explained that he gets his ideas in a relaxed environment, when taking a bath. Nevertheless, at a later point he discloses the reason for the necessity for development. Familiar to Kito Seiki Seisakusho's i-me:ma (cf. INR07-IP12 (i-me:ma: Kito Seiki Seisakusho)), the origin lies in the Lehman shock in 2008 and the urgency to stabilize the company in the future.

201 Cf. INR01-IP01 (HSR: Toyota Motor)

202 Cf. INR13-IP20 (resyone: Panasonic), INR23-IP32 (KR-1000A: Clarion) or INR29-IP38 (Tecpo: Shintec Hozumi)

203 Cf. INR14-IP21 (Flagship Model: Nabtesco)

204 E.g. INR29 (Tecpo: Shintec Hozumi), where the technology for the mobility aid is developed, but the material for the frame has to be selected.

205 E.g. INR01-IP01 (HSR: Toyota Motor) became object for cost coverage by the health insurance. The next step before entering the market is to collect data and get evidence by hospitals.

oper overcame the obstacles of the development process proves a certain strength, because if an idea is only an idea, it is not able to reach enough consensus to materialize. The next step is the diffusion within society. Therefore, the interpretative flexibility must steadily reduce until the robot's area of application becomes clear.

Nevertheless, the sales figures for the market-ready robots (IQ3.2.2) remain low in most cases. There are a few exceptions with more than 500 sold units[206], but the majority is under 100. What is striking is that the robots with higher sales figures are less cost-intensive and relatively low-tech ones, such as mobility aids or monitoring systems. It can be assumed that the promotion programs of AMED (AMED 2015b) with high financial support for care facilities, which aimed at starting to use of care robots, increased the sales figures for the following years.

As for the future development or the business plan (IQ3.2.1), there are four patterns: Technological-driven, evaluation-oriented, environment adjustment and market-centered approaches. The evaluation-oriented group plans to get its robots into care facilities to collect more data. This includes differentiated feedback by the user and evidence on their robots. In the following you can find the review of the invention according to user needs, thus reaching a wider audience with a demand-adjusted product. A higher consensus helps to steadily reduce interpretative flexibility and find the final desired area of application. In contrast to this, the market-centered companies[207] act more reserved. For them, the future part of their robot depends on how the user will accept it. It is about the reduction of risk, as the representative at Clarion explains, *"For now, this is our first product, so there are no talks about designing the next version. First, we put it out into the world and see the reactions of the market. Then we decide the next strategy."*[208]

The technological-driven development plan is on the improvement of the robot itself. However, this varies from just optimizing the robot or smaller changes[209], such as making the robot lighter, smaller or more reliable, to adding new features. Thereby new features can be a comprehensive update on the robot and the further combination with other technologies as the representative of RT.Works illustrates.

> *"What we really want to do is […] trying to make use of the walking data by making it visible such as where you go and so on. For example, this kind of*

[206] For 2016: INR06 (Muscle Suit: INNOPHYS) 1200 units, INR11 (Little Keepace: TacaoF) 500 units, INR15 (palro: Fujisoft) 600 units, INR23 (KR-1000A: Clarion) 500, INR24 (aams: bio sync) 2000 units
[207] INR03 (smile baby: Togo Seisakusyo), INR23 (KR-1000A: Clarion), INR24 (aams: bio sync)
[208] INR23-IP32 (KR1000A: Clarion) 00:11:00-00:11:23 今の時点では、これが初めての製品なんで、次のバージョンを作るとかいう話はないんですけど、まずは世の中に出して、まずは様子、マーケットの反応を見てから次の作戦を練るという形ですね。
[209] E.g. INR 06 (muscle Suit: INNOPHYS), INR 11 (Little Keepace: TacaoF), INR22 (kyūretto: Aronkasei)

> *data can be collected in hospitals, and then be compared with one year ago or it can be used for health management every month. Now, I want to use the data gathered by RT.1 for monitoring and health management."*[210]

In the case of RT.Works, the mobility aid RT.2 is supposed to improve quality of life through the combination of robot and IT technologies. This also shows to what degree the developer is convinced of his invention. In the terminology of the vision concept, this is the individual mobilizer or cognitive activator. The former is the motivation for the developer, and the latter is his catalyst for new ways of thinking, thus steadily working on the improvement of his invention.

A small group of companies focuses on the environment of the robot either on development, the integration into daily life or the sales concept. This includes legal issues, as the representative of INNOPHYS makes clear, *"From a risk management's point of view [the future business plan] is formed. Organizations are insured for machine troubles or for work-related injuries, but if it comes to individuals, a personal insurance has to be sold."*[211] A robot cannot just be delivered to the user; there has to be some kind of after-service whereby insurance is an important element. The question of responsibility for occurring problems cannot be left open and has to be cleared for broad diffusion within society. In addition, user satisfaction or in other words, the after-service, is another non-negligible element. The representative of Ory Laboratory illustrates very well their intended approach with the user in the center when saying, *"We don't provide the robot, we provide a service. We don't want to provide a robot life; we want to provide a service that allows the users to stay there [in their lives]. For example, even if the robot gets broken, we want to replace it immediately and when there is a new version of OriHime, we will exchange it, too."*[212] Besides their belief in OriHime as a tool to increase quality of life, to center not on the robot but the user is a pragmatic way to reach a wide audience.

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[210] INR12-IP19 (RT.1/RT.2: RT.Works) 00:36:37-00:37:30 我々が本当にやりたいのは、 […] どこを歩いてるとかの歩行データを見れるようにしたりして、活用しようとしているんですよ。こういうデータをたとえば病院とかで蓄積して、1 年前と比べてどうだったとか、毎月の健康管理に使えると思うんです。今だったら見守りと健康管理を、RT1 などで集めたデータをうまく使ってやっていきたいなと。

[211] INR06-IP11 (Muscle Suit: INNOPHYS) 00:20:19-00:20:45 リスクマネジメントの観点からこの形態にしています。団体は機械のトラブルが起こったときのためや、労働災害に備えて保険に入っているが、個人相手となると、こちらから個人用の保険をつけて販売しなければいけなくなるため。

[212] INR04-IP06 (OriHime: Ory Laboratory) 00:11:14-00:11:30 うちが提供しているのは、ロボットではなくサービスなんですよね。ロボットがいる暮らしを提供したいわけじゃなくて、使う人がそこ[自分の暮らし]に居続けることができるというサービスを提供している。例えば、ロボットが壊れたとしても、確実にすぐ交換したいし、新しいバージョンの OriHime ができたら交換しますっていうことをしています。

An indicator to see how confident companies are in the value of their robot is to look at if they are intended for mass production or not (IQ3.3). Market maturity is the precondition for mass production. Mass production is one tool to make it possible to reach a high diffusion rate of a care robot or several ones within society. Only two[213] of 21 responses[214] did not have a plan for mass production in 2016. Around one third[215] would like to increase the production scale if the market development is good, and the other third[216] already has specific plans for mass production. However, the decision for mass production comes along with a change of production processes. This implements several major adjustments of the original product, because what was previously possible by handwork might be unpractical through mass production[217].

The target market (IQ3.3.1) is almost only Japan (see Figure 6-6). Almost half of the companies consider only Japan as their main market. For SME, the expansion to foreign markets requires a certain knowledge of international trade and furthermore, binds human resources[218]. Especially companies which entered the field of care robotics in the recent years are busy with the development of their robot and its adjustment to the needs of the Japanese market. They simply do not have enough freedom now to keep up with foreign markets and their practices, such as special safety regulations. The representative of Nabtesco[219] thinks the other way around, when he evaluates foreign markets as difficult even because of their different regulations. Additionally, even if most market forecasts for care robotics are very promising, the experienced reality with only small sales figures for most companies is still different. Rather reluctant behavior is consciously or unconsciously the prevention of economic risks. These companies might expand their business if the domestic response is positive, and they will get direct business inquiries[220].

[213] INR02 (SAN Flower: Kato Denki), INR03 (smile baby: Togo Seisakusyo)
[214] One interviewee (INR01-IP01 HSR: Toyota Motor) gave no response to the IQ.
[215] INR07 (i-me:ma: Kito Seiki Seisakusho), INR08 (ROBO snail: Ryoei), INR12 (Rt.1/RT.2: RT.Works), INR22 (kyūretto: Aronkasei), INR23 (KR-1000A: Clarion), INR24 (aams: bio sync), INR28 (Hug: Fuji Machine MFG), INR 29 (Tecpo: Shintec Hozumi)
[216] INR04 (OriHime: Ory Laboratory), INR06 (Muscle Suit: INNOPHYS), INR13 (resyone: Panasonic), INR14 (Flagship Model: Nabtesco), INR15 (palro: Fujisoft), INR21 (Neruru & Yumeru: T-arts), INR27 (yorisoi robotto: Sanyo Homes), INR39 (Sasuke: Muscle)
[217] INR06-IP11 (Muscle Suit: INNOPHYS)
[218] E.g. INR26 (Dreamer: Santec)
[219] INR14-IP21 (Flagship Model: Nabtesco)
[220] E.g. INR22 (kyūretto,: Aronkasei) INR 23 (KR-1000A: Clarion)

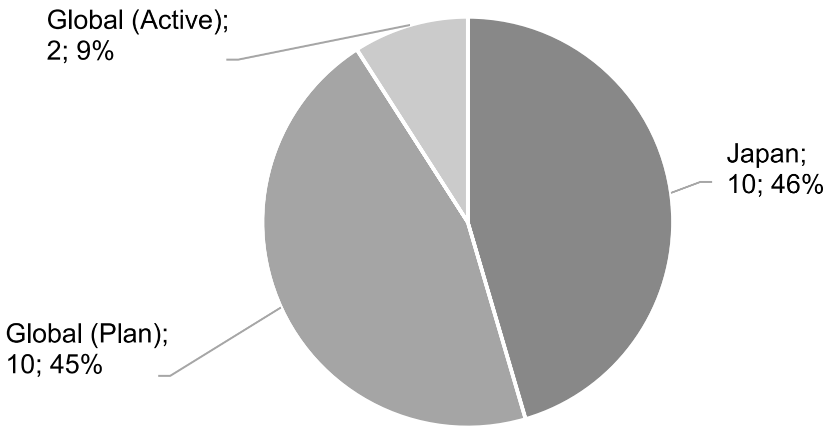

Figure 6-6 Companies desired Target Market for Care Robots

(n=22)

A bit less than half of the other companies are more optimistic, but not active in foreign markets in 2016. They would consider expanding their business under certain circumstances. In the first instance, they want to get experience in the domestic care market[221] before going abroad with their products. Besides the positive evaluation of market potential, the increased interest of other aging countries in Japanese care robotics fosters business opportunities. Among others, the representatives[222] of Art Plan and Muscle received business inquiries from foreign companies. Furthermore, the opportunities to present their own products increased. The representative of Fujisoft picks up the Tokyo Olympic Games as an important stepping-stone for getting in touch with foreign countries.

> *"Tokyo Olympics "We are in the situation that we proceed with the preparations [for international business]. As a trigger, recently, there are various requests for the Tokyo Olympic Games. For this year [2016], there was the ministers' meeting for information and Communication of the MIC in Takamatsu, […] where we, in collaboration with NICT's multilingual translation engine, demonstrated multilingual translation with palro."*[223]

This illustrates on the one hand that putting robotics on the national political agenda builds awareness of current developments and efforts in care robotics even outside of

[221] E.g. INR13, INR28 (Hug: Fuji Machine MFG), INR29 (Tecpo: Shintec Hozumi)
[222] INR10 (aijō-kun: Art Plan) inquiries from Singapore, South Korea and China and INR39 (Sasuke: Muscle) from Australia
[223] INR15-IP22 (palro: Fujisoft) 00:07:44-00:09:00 準備を進めている状況ではあります。きっかけとしては、最近ではやっぱり 2020 年の東京オリンピック開催に向けて、いろいろ要望があるんです。今年だと、伊勢志摩サミットの関連行事で総務省の情報通信大臣会合[223]っていうのが高松であったので、[…] NICT[223]の多言語翻訳のエンジンと連携して、palro に多言語翻訳を行わせるようなデモをしました。

Japan. On the other hand, this enlivens domestic companies for business activities outside of Japan, and thus in the end strengthens the export economy – or even becomes the next Japanese export hit. At the same time, Japan's robot makers have to compete on the international market when deciding to export. The representative of RT.Works talks about the resulting consequences of this when saying that *"The product [RT.1/ RT.2] itself, for example, could be produced by a Chinese manufacturer as well. If we compete there, we will eventually compete only about the costs. On the top of that, we want to enrich various services in terms of communication technologies and make it our management axis.*[224] Currently Japanese companies might have a technical advantage on the international market, but in the end, the application of the robot is critical to success. Rather than the hardware of the robot, the software and how to make use of it will lead to success.

Against the background of the current development status of most robot projects in 2016, and their long way to mass production, it is not surprising that the majority focus on the domestic market. Only two of the 22 companies are already active abroad. However, in both cases it is not business, but joint developments[225] or testing their inventions in a different environment[226]. Thereby two large companies illustrate ambivalence within the developers of care robots. On the one hand, there is pioneer Toyota Motors with a proactive and open attitude towards international joint development. On the other hand, there is Panasonic that first wants to get experience in the domestic market before making the decision to go abroad. Both companies illustrate the status in care robotics in Japan, whereby Panasonic represents the majority of Japanese companies still focusing on the domestic market to first get experience with their new business.

Current development status, production volume and willingness to export reveals how realistic wide-scale implementation of robotics in the field of care is. In addition, it shows how realistic it is to replace humans and their labor with robots (see Chapter 1.2). Even if in the technology nation of Japan care robotics are still in their infancy, and technical and practical teething problems have to be overcome first to reach the point when care robots, or care equipment based on robot technology, will become a habit within the field of care.

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[224] INR12-IP19 (RT.1/RT.2: RT.Works) 00:37:34-00:38:12 モノ自体は、例えば中国のメーカーとかもいずれ作れてしまうと思うんです。そこで勝負すると結局コスト面でのみの競争になっちゃうので、我々はその上に、通信機能の面でいろいろサービスを充実させて、そっちを経営の軸にしたいと思うんですよね。
[225] INR01 (HSR: Toyota Motor)
[226] INR04 (OriHime: Ory Laboratory)

6.4 Category 4: Usability Tests

So far, the previous subchapters have focused on the developer as an individual, the development framework and the course of the robot project. The following subchapter highlights the practical relevance. In particular, this involves practical trials in the later area of application and the knowledge gained from it. Further information about the questions of this category can be found in chapter 4.3.4.

Even if some of the care robots were still at the level of prototype (IQ4.1), the majority of companies performed practical trials (see Figure 6-7). Only four[227] still had no opportunity to test their robot within a care environment. This was for various reasons, such as technical development status[228], security standards[229] or problems in finding a cooperative care facility[230]. Among the 22 robot projects, 18 could gain a cooperation partner for getting first experience with their invention. Having said this, a closer look at practical tests reveals a different picture, because the process of finding a care facility and the length of the practical test limit the informative value of this, in general, positive fact.

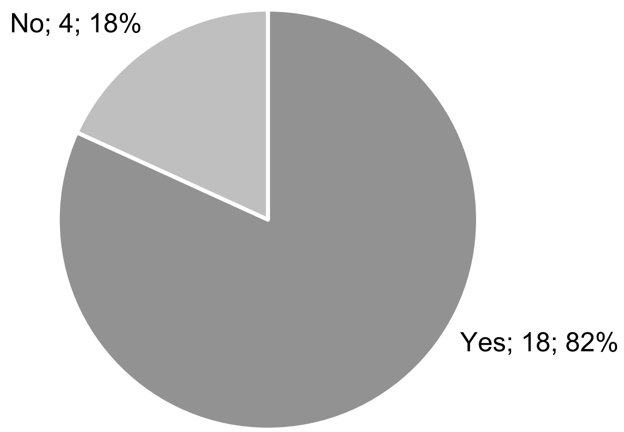

Figure 6-7 Opportunity for Human Robot Interaction (HSR)
(n=22)

[227] INR01 (HSR: Toyota Motor), INR08 (ROBO snail: Ryoei), INR14 (Flagship Model: Nabtesco), INR27 (yorisoi robotto: Sanyo Homes)
[228] In 2016, INR01-IP01 (HSR: Toyota Motor) and INR27-IP36 (yorisoi robot: Sanyo Homes) had been tested only with the developers and internal persons.
[229] In the case of the Flagship Model, according to INR14-IP21 (Flagship Model: Nabtesco) Nabtesco wanted to fulfill their company-internal security standards first, before testing the mobility aid with possible end-users.
[230] INR08-IP13 (ROBO snail: Ryoei)

The search for cooperation partners (IQ4.1.1) in the field was not simple. Ryoei joined the partnership project of NEDO, which should match developers to care facilities, but this was no help as the developer of ROBO snail explains, *"Actually, we joined the NEDO [partnership program]: However; de facto there might have been no opportunity to get it [to test the robot] done. Even if we joined the partnership [program], nobody was introduced to us and we had to do it ourselves, but then we joined the Cluster of Aichi Prefecture*[231] *and saw a way."*[232] The official program did not meet the expectations of the developers. This also implies that, at least for 2016, the scope of national support projects was not sufficient, and regional solutions were better tailored to the needs of the developers. In addition, companies which finally found a care facility that was willing to let them test their robot had a hard time with the search. The representative of Muscle makes clear the contradiction behind the problem of finding a care facility to do practical tests.

> *"If you try to test in a care facility, they will not let you. If it can't pass the ethical norms, it is not possible. However, for the product, I have to use people, so that I have to carry people in an experiment. There is a contradiction that you want to do, but can't. I want to design a machine that carries people, but I can't carry people until the machine is completed to 100%."*[233]

Care facilities want reassurance whether the robot or its prototype conforms to in particular security norms, and do not want to be subject of any kind of trouble. Here we have a chicken-egg problem, because without testing, improvement is nearly impossible. The developer of the robohelper Sasuke becomes even clearer about this issue when arguing, *"it is a big problem. From the standpoint of the government, we have to complete various tests and they claim that only perfect ones [robots] should carry people. On the other hand, we can't design a product without bringing it [into the care facilities and]*

231 He refers to the Aichi Robot Cluster or in Japanese aichi robotto sangyō kura sutā suishin kyōgikai あいちロボット産業クラスター推進協議会

232 INR08-IP13 (ROBO snail: Ryoei) 00:34:28-00:34:55 実は、NEDO [パートナーシッププログラム] に入っていたけれども、 [ロボットを試す] なかなかやってもらえるところがなかったという実情があったかもしてないです。パートナーシップ [プログラム] に加入したものの、誰も紹介してくれなくて、自分から行動しなくちゃいけなかったんですけど、愛知県のクラスターへの入会で、道が見えてきました。

233 INR39-IP52 (Sasuke: Muscle) 00:09:46-00:10:10 施設で実証実験しようと思ったら、させてくれない。倫理基準っていうのを通ってないと、できない。でも製品として人を扱わないといけないから、実験で人を乗せてみないとだめ。やりたいけどできないっていう矛盾があるわけ。人を乗せるための機械を作らないといけないけど、機械が 100%完成するまで人は乗せられない。

getting people carried."[234] For one thing, we have official regulations that hinder developers testing, and in the end, improving their robot and for another thing, we have low willingness to cooperate with the developers on the facility side. The latter issue might be caused by a high workload within the care facilities, thus only very limited space for testing innovations and concerns about disturbing work routines through the robot.

In addition, performing practical tests does not automatically mean that they are long-term tests over several months. Kito Seiki Seisakusho tested i-me:ma only twice for two hours within 2015; Aronkasei carried out a monitor study of kyūretto within a care facility and private homes; and Fuji Machine MFG ran tests with its Hug around 30 times for a maximum of three hours each time, to just name a few examples[235].

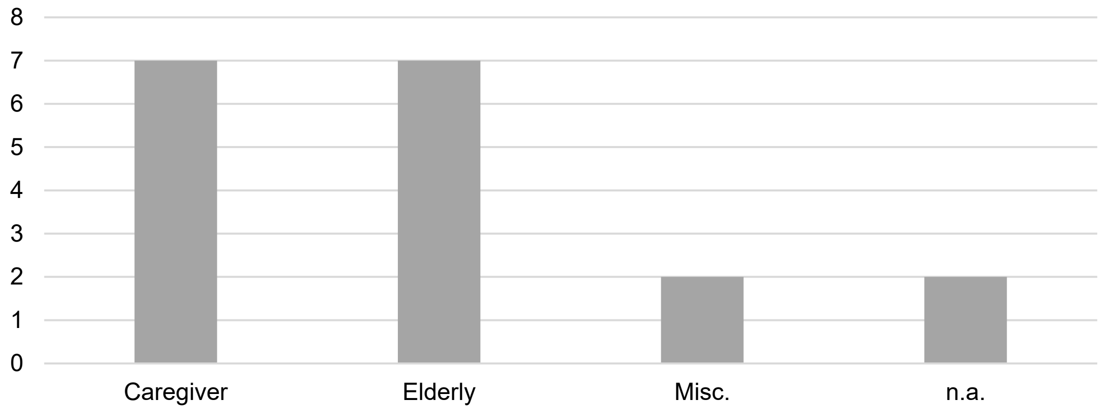

Figure 6-8 Target Group for Practical Tests with the Robot (n=18)

Among the 18 developers (see Figure 6-8), who cooperated with the field, half tested their invention with elderly[236] and half with caregivers[237] (IQ4.1.2). A reason for this is the priority group of the robots. The group that had practical tests with elderly consisted of three mobility aids, two communication robots, one monitoring system and one toilet. These are all robotic devices that center on the elderly as a user rather than caregivers,

[234] INR39-IP52 (Sasuke: Muscle) 00:10:25-00:10:42 大きい問題。絶対国の立場としてはいろんな試験が済んで、完璧なもの [ロボット] しか人を乗せたらだめという主張なんです。一方僕たちは、 [介護施設に] そこまで持っていくためには人を乗せてみないと商品開発できない。
[235] INR07-IP12 (i-me:ma: Kito Seiki Seisakusho), INR22-IP31 (kyūretto: Aronkasei), INR28-IP37 (Hug: Fuji Machine MFG)
[236] INR02-IP03 (SAN Flower: Kato Denki), INR03 IP04 (smile baby: Togo Seisakusyo), INR11-IP17 (Little Keepace: TacaoF), INR12-IP19 (RT.1/RT.2: RT.Works), INR21-IP30 (Neruru & Yumeru: T-arts), INR26-IP36 (Dreamer: Santec), INR29-IP38 (Tecpo: Shintec Hozumi)
[237] INR07-IP12 (i-me:ma: Kito Seiki Seisakusho), INR13-IP20 (resyone: Panasonic), INR22-IP31 (kyūretto: Aronkasei) INR23-IP32 (KR-1000A: Clarion), INR24-IP33 (aams: bio sync), INR28-IP37 (yorisoi robotto: Sanyo Homes), INR28-IP37 (Hug: Fuji Machine MFG)

and even more are useable in a private environment as well. These robot projects aim at the lucrative and large silver market. The group which centers on the caregiver comprises mainly transfer aids (four robots), monitoring systems (three robots) and toilets (one robot). All technologies intend to reduce the burden of the caregiver and lead to a better workflow. The field of care has a high demand for solutions for their urgent problems, such as occupational disability due to high physical burdens. Very specific needs and a smaller market size, because of the limited scope of the solution-orientated inventions, indicate this target group. Lastly, there have been two communication robots (Ori-Hime and palro)[238] which were not tested with elderly or caregivers. This lies in that the nature of communication robots and their scope of application is versatile. In 2016, Ori-Hime was tested within an educational, welfare and private environment, whereas palro was tested within the employees of Fujisoft.

For the developer, the most valuable gain from cooperation with the field is user feedback (IQ4.1.3). Thereby users evaluate the invention from their very own perspective which the developers have not considered. For example, the test period of i-me:ma of Kito Seiki Seisakusho revealed that contrary to the expectations, the wireless connection was not stable enough to ensure smooth operation of the robot[239]. Besides that, the fact that such a problem might have been avoided through visiting care facilities, this shows that there is a missing understanding about the work environment within care facilities. The representative of Toyota Motors had a real aha-moment when he was looking for cooperation partners.

> *"Speaking in the terms of HSR, it seems that, before our offer to the Yokohama rehabilitation [center], there were talks with another research institution, about working together. I heard that they [these other research institution] brought a robot with them and they Yokohama rehabilitation center] asked, 'Are you honest about putting this into a house?!'. Therefore, they said that there was no practical test, nothing. After we heard that opinion, we pretty much reduced the size. […] However, in actual use, it is easy for people to make movements that are difficult to predict. Rather than that, we received the opinion that a natural movement of the [robot's] body is good. […] That's why we incorporated the opinion about a larger redesign."*[240]

[238] INR04-IP06 INR15-IP22 (palro: Fujisoft)

[239] INR07-IP12 (i-me:ma: Kito Seiki Seisakusho)

[240] INR01-IP01 (HSR: Toyota Motor) 00:13:08-00:14:27 生活支援ロボットで言うと、横浜の総合リハビリテーション [センター] には、本社がオファーする前に他の研究機関から一緒にやりませんかっていう話があったそうですが、彼らの持ってくるロボットは、そもそも「こんなもの家に入れられるか。」っていうもので、だから実験も何もないじゃないですかっていう状態だったそうです。我々は、その意見を聞いたうえでかなり小型に絞りました。[…] ただ、実際使ってみると、人が予見しにくいような動きが出やすいんです。それよりは、 [ロボットの] 体を動かして出る自然な動きがいいという意見を受けて、[…]そのために大きな設計のデザインに対する意見は取り入れています。

Cooperation opened developers' eyes to the needs of the field which they previously did not understand. This led to even larger change in robot design. In terms of SCOT, this involvement of a relevant social group led to discourse about the interpretative flexibility of the invention, which in turn the developers answered with an adjustment of the design closer to users' needs. This ensures relevant consensus or in other words, the support for further development. As already mentioned before (see Chapter 2), even the best and most revolutionary vision will not materialize when only its inventor supports it.

In many cases, feedback was contrary to the expectations of the developers. Positive as well as negative feedback gives not only the opportunity to change the design and concept (IQ4.1.4), but also to surmise a potential market. In the case of Fujisoft's palro, their representative recollects why they took the decision to extend their effort in the field of care when saying, *"It [palro] was brand new and everyone was very pleased by everything. Because of this, the market opened in this [towards care facilities] direction."*[241] It is needless to say that positive feedback is easier to implement in the development process than negative. First practical tests of a robot within a care facility can lead to a gap of the intended concept with current circumstances. The representative of bio sync spoke about their first experience with aams when he verbalized that

> *"[They told us that] the concept is good, but it is very difficult to use. Especially the point of using a computer and the network. Most of the people who actually work in the care industry are women, and they often care for people at the age of their own mother. Therefore, they don't use computers very often. It is quite difficult to place such software in such a place."*[242]

This example illustrates one of the basic issues of robot development in Japan: Male engineers develop for female users. In addition, the user participates in the development process at a very late stage, whereby the transaction costs can become high or a redesign of the robot can end the project. This issue could easily be prevented through user participation at an early development stage. It is, then, all the more regrettable that this issue is very widespread in Japan. On the opposite side, even more than that, it raises new issues and reveals new opportunities for application; it gives general feedback from

241 INR15-IP22 (palro: Fujisoft) 00:10:50-00:11:02 [palro が] 真新しいので皆さんに非常に喜んでいただいていました。それがあったからこそ、そちら [介護施設に] にマーケットを開こうというきっかけになりました。

242 INR24-IP33 (aams: bio sync) 00:15:53-00:16:38 コンセプトはいいけど、すごく使いづらい [と言われた] 。パソコンを使うっていうところと、ネットワークを使う点が特に。介護業界で実際に働いている人たちの多くは女性で、自分の母親ぐらいの歳の人たちの面倒を見ることが多いので、あまりパソコンを使って仕事をすることがないんです。そういうところでこういうソフトウェアを入れるっていうのはなかなかハードルがあるなと。

the user to developers. This in turn can lead to a rethinking of the development process and trouble-free developments in the future.

Another question with that needs to be answered is what is made out of feedback. Three companies were largely immune to feedback and made no or only minor changes.[243] Since the care robots of these companies reached a late stage of the development process, the reason might be overall positive feedback, or the high transaction costs for changing the concept or design. The rest made several improvements on the basis of user feedback (see Figure 6-9). Thereby user feedback serves as a framework for the user to express their wishes. This in turn gives the developer the opportunity to react to user feedback and to incorporate their suggestions into the robot project.

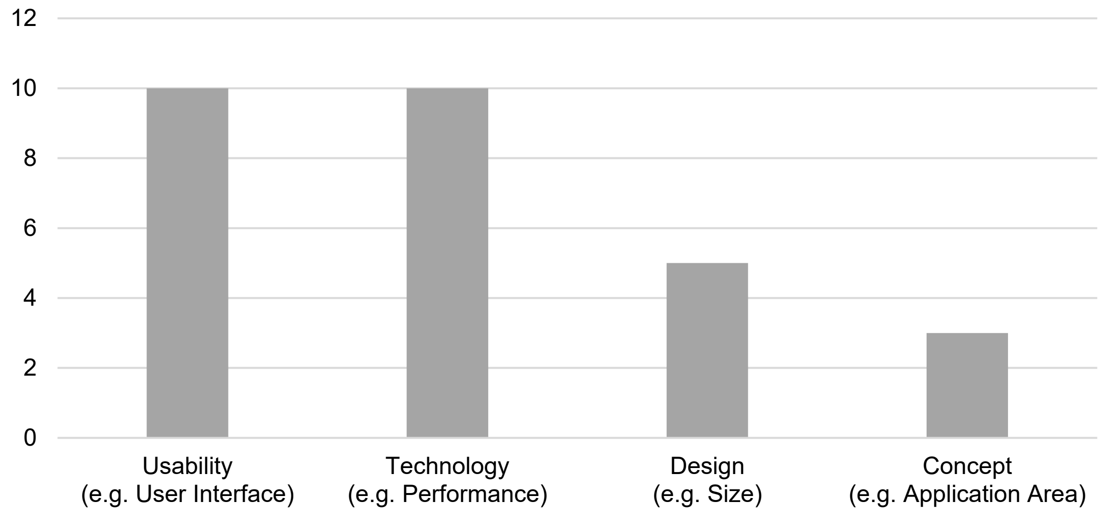

Figure 6-9 Improvements based on User-Feedback (Multiple Answers Possible)

The evaluation of the responses to the IP shows that most improvements (IQ4.1.4) were on usability[244] and technology[245]. Technical adjustments begin with smaller changes of e.g. just the size of the robot for making it fit for the application environment[246] ,or major

[243] INR06-IP11 (Muscle Suit: INNOPHYS), INR21-IP32 (Neruru & Yumeru: T-arts), INR22-IP33 (kyūretto: Aronkasei)

[244] INR02-IP03 (SAN Flower: Kato Denki), INR03-IP04 (smile baby: Togo Seisakusyo), INR04-IP06 (Muscle Suit: INNOPHYS), INR10-IP16 (aijō-kun: Art Plan), INR11-IP17 (Little Keepace: TacaoF), INR12-IP19 (RT.1/ RT.2: RT.Works), INR13-IP20 (resyone: Panasonic), INR23-IP32 (KR-1000A: Clarion), INR24-IP33 (aams: bio sync), INR26-IP35 (Dreamer: Santec)

[245] INR01-IP01 (HSR: Toyota Motor), INR02-IP03 (SAN Flower: Kato Denki), INR04-IP06 (OriHime: Ory Laboratory), INR07-IP12 (i-me:ma: Kito Seiki Seisakusho), INR12-IP19 (RT.1/ RT.2: RT.Works), INR13-IP20 (resyone: Panasonic), INR21-IP30 (Neruru & Yumeru: T-arts) INR24-IP33 (aams: bio sync), INR26-IP35 (Dreamer: Santec), INR39-IP54 (Sasuke: Muscle)

[246] INR01 (HSR: Toyota Motor)

changes of adding a new function such as voice recognition[247] or a chair for resting[248]. The latter example illustrates the motivation behind the development of the robotic device. The representative of RT.Works explains this in detail, "*this is the chair for a break [of RT.1], but it is not here [on the user-side]. When taking a break and feeling tired, you have to walk there and take a rest. Well, and then feel fine and walk again. So, as a result, if you have a chair, the distance you can walk will increase. That's why I really wanted to add a chair before the release.*" [249] This reflects the attitude of the developer, who in the case of RT.1/ RT.2, not only wants to create a product, but also create something with additional value for the user. The example of RT.1/ RT.2 is interesting for another reason, because the feedback shows the gap between the official guidelines and the practical needs of the user. Beside the chair for taking a break, there was another modification: the removal of a previously installed brake. According to the official guidelines, security was much more important than usability. The representative of RT.Works touches upon this context when explaining, *"there are no brakes here [at RT.1], right? There used to be, but I removed them. After all, when using it, there is no need for a brake to control. However, at that time [during the development] it was demanded by the national program guidelines. So I put it on for safety, but it wasn't used in the end, so I finally removed it."* [250] The official guideline for the development of robots, when participating in the subsidy programs, called for a high safety status. This is unavoidable to ensure that the robot is not affecting the user. However, the safety status might overshoot and in the end lead to a robot which becomes impractical to use. With the end of participation in the program, the developer is free to decide, how to finalize the robot and on this account, it makes sense to question the previous guidelines in order to being able to place a robot that balances security and usability.

Technical modifications are mostly an integration of the robot into the care environment and its requirements. For this recognition, the user is not absolutely necessary. In contrast, user feedback causes changes on the usability, whereby this means in most cases

[247] INR21 (Neruru & Yumeru: T-arts)
[248] INR12-IP19 (RT.1/ RT.2: RT.Works)
[249] INR12-IP19 (RT.1/ RT.2: RT.Works) 00:41:00-00:41:30 これ [RT.1 の] 休憩用のいすなんですけど、あれはここ [利用者側] にはないんですよ。休憩するときって、疲れたらあそこまで歩いて休むじゃないですか。で、元気になったらまた歩く。それで結果的に、いすがあると歩ける距離が延びるんですね。だからぜひ椅子が欲しいっていうので、発売前に椅子を追加したというのがひとつです。
[250] INR12-IP19 (RT.1/ RT.2: RT.Works) 00:41:54-00:42:34 こっち [RT.1] にはブレーキないじゃないですか。最初はあったんですけど、取っちゃったんですよ。なんでかって言うと、そもそもこっちを使っているときに自分で操るブレーキは必要ないんですよ。でも当時は国の事業方針で、ブレーキが必要だったんですね。だから要は安全のためにつけておいたんですけど、結局使うことがないので最終的には外しました。

a simplification of the user interface[251], or improvement of the robot's handling by e.g. making it easier to grip[252]. Simple usability makes it easy to use the robotic device and to get used to it. The participation of the user leads to higher acceptance and eventual diffusion, because the consensus finding, or in SCOT terminology the discourse on the interpretative flexibility about the concept behind the robot, is faster compared to the development process where the developer is working alone on the invention.

Having said this, only a few companies made changes on general design[253] and the concept[254] of their robot. The reason behind this is probably the mostly positive feedback on their robot projects, which the companies received and the high transaction costs of changing the direction of the development process. The reason for the changes on the concept or design of the robot can be a rethinking of the practical implementation of the robot, or an extension of the original version. In the case of the monitoring system aams, whereby the developers revised the technical and user interface to match the user group because of a previously poor understanding of the care environment. The monitoring solution aams was too complicated for less technically-interested middle-aged female caregivers. On the other hand, Panasonic modified resyone to a robo-bed, whereby now only one caregiver can handle the bed, which previously two caregivers had to do. Even if usual designing and conceptual modifications come with a high transaction cost, they immensely enrich the robot and this in turn connects to higher acceptance, which is critical for broad diffusion within society.

However, it has to be kept in mind that the field of care consists of a difficult work environment. Labor shortage and the increasing number of people in need of care lead to a high workload and busy work routines, with only a limited space for testing care equipment or getting familiarized with new devices. From the beginning, the work environment makes it difficult to bring in-development prototypes into care facilities. The caregiver easily takes the prototypes as an obstacle in the work routine. In addition to this, most caregivers are female and, generally speaking, middle-aged; a target group which definitely has a low technical affinity. For developers, this creates a chicken-and-egg problem, because to design a robot with a high acceptance among the user is not possible without practical tests, and practical tests are in turn only possible with a mostly finished

[251] INR24-IP33 (aams: bio sync)
[252] INR11-IP18 (Little Keepace: TacaoF)
[253] INR01-IP01 (HSR: Toyota), INR04-IP06 (OriHime: Ory Laboratory), INR24-IP33 (aams: bio sync), INR28-IP37 (yorisoi robotto: Sanyo Homes), INR39-IP54 (Sasuke: Muscle)
[254] INR04-IP06 (OriHime: Ory Laboratory), INR12-IP19 (RT.1/ RT.2: RT.Works), INR13-IP20 (resyone: Panasonic)

robot. This creates a vicious cycle that has to be overcome somehow in the future (see Chapter 7).

6.5 Category 5: Vision and Ideal

Slowly the picture of development completes. Chapter 6.2 highlighted the structure and environment for robot development; chapter 6.3 analyzed the past, present and near future of the robot project; and chapter 6.4 gave a first impression about test runs within the field of care. The latter is in particular relevant because in 2016, there were in general only limited test periods with care robots in Japanese care facilities. Lastly, this subchapter will deal with the existence or non-existence of a vision behind development.

From a theoretical point of view (see Chapter 2), a vision has to be anchored in the present and future. As time goes by, a vision constantly experiences its realization and the distance between desire and feasibility gets smaller until the vision materializes through the artifact. This chapter takes a closer look at the vision itself and is divided into three parts. In addition, all information about the category and interview questions is provided in chapter 4.3.5.

As expected, when asked about motivation or the objective of development (IQ5.1), there are no surprises within the social and business-driven robot companies (see Chapter 6.2). One of the social-driven developers, the representative of INNOPHYS, explains the future goal of the transfer aid Muscle Suit in more detail. The major business of the company is care, but in the future, they want to expand to other markets, such as the agricultural industry, with their invention to address a broader audience[255]. This clearly demonstrates the momentum of development, whereby positive reinforcement contributes to high motivation to challenge, or to try to transfer their own technology, and to improve the quality of work in new fields with a comparable demand influenced by the overaging society.

Among the business-driven companies, there are three notable types of developers. On the one hand, the top-down decision of the company to enter robotics creates opportunities to bring in personal ideas, which can dominate development and set its future direction. The developer of ROBO snail illustrates this clearly when raising his hand to be in charge with the new development of a care robot. He brought his personal experience, of the illness of a relative and instrumentalized the new activity area in his own way[256].

[255] INR06-IP11 (Muscle Suit: INNOPHYS)
[256] INR08-IP13 (ROBO snail: Ryoei)

On the other hand, the developers of smile baby became interested little by little in developing a robot for care. The idea or concept of the robot took possession of them, to say it in the terms of the vision concept. As a result, they are motivated to develop smile baby and show, through successful development, the opportunities of care robotics for society and their company. In other words, the top-down order to enter a new business field transferred into a bottom-up initiative with the potential to directly influence the future direction of the company. This shows that developers' attitude towards development makes a great difference, and that the original intention can change e.g. from social-driven to business-driven, or the other way around.

The developer of Dreamer revealed the story behind his way to care robotics. For Santec, the development of Dreamer was rather like opening a black box. The original concept behind Dreamer remains unknown, because Santec took over the development on the basis of an already existing, unfinished project from another company. The developer of Dreamer illustrates the difficulties that arise from this situation when saying, *"Basically, the company that used to design the product was a completely different company, and so we had absolutely no information. We only saw that there is such a thing and tried to imitate it"*[257]. Later he adds that, *"we didn't start ourselves, a company was in between, and said that the original developer would no longer create it, so they looked for a company to create a new one. There we raised our hands"*[258]. For one thing, it is the absolute exception finding an unsuccessful robot prototype and being able to redesign it. Usually an unsuccessful invention will disappear in silence with nobody noticing it (see Chapter 2). For another thing, according to the vision concept and STS, consensus is a critical factor for continuous, and in the end, successful development of an invention. The reason why the original developer discontinued the development remains unknown. However, to implant or overtake foreign ideas either leads to a second chance for the artifact to restart in a new environment, with the chance to get enough consensus, or to a second failure because unconsciously familiar problems will occur during the course of development. In the case of Dreamer, it is likely to be the former, because the development made a new prototype.

The next step is the evaluation of how motivation, or the objective of development, is connectable to society. In other words, can the robot project create an additional social

[257] INR26-IP35 (Dreamer: Santec) 00:18:29-00:18:45 基本的に言うと、以前製品を作っていた会社は、今と全然違う会社だったので、情報の提供は全くなかったです。こういうものがあるっていう、機械の現物だけ見て我々が真似していくような。

[258] INR26-IP35 (Dreamer: Santec) 00:19:23-00:19:45 自分たちから作るといったわけではなく、間に会社が入って、その会社が、前の開発者ともめてその開発者がもう作らないっていうことを言ったので、新しく作ってくれる会社を探してたんです。そこに我々が手を挙げたと。

value (IQ5.1.1), and how is this measurable? The initial problem of care robotics is familiar to service robots, because both are difficult to evaluate. In most cases, industrial robots automatize a task and create measurable improvement in terms of e.g. speed or accuracy. They create a quantifiable value. In contrast to this, service robotics as well as care robots are more orientated on quality. They are by nature more difficult to evaluate. The representative of bio sync gives a good example when talking about their monitoring system aams,

> *"There are quite a lot of things, which can't be quantified. To give one example, by introducing [aams], it will probably not make it possible to reduce the number of staff. So I think, when facilities have this kind of thing, family members feel relieved to leave their elderly dependents [in a facility] or after that the turnover rate within the care industry is high and when having this [e.g. a monitoring system] the caregiver can work free from anxiety. It would be nice if this could be quantified."*[259]

If the high acquisition costs are set into relation to its measurable value, they are likely to lead to a reluctant attitude to purchase care robotics. The major issue for convincing care managers and facilities remains how to put the benefits of using care robots into quantifiable numbers, even if the use of robots within the daily work routine connects to an improvement of the quality of work. The representative of Fujisoft explains the problem of getting evidence and the expectations towards care robots, when saying,

> *"After all, I think care robots can substitute people and can improve the efficiency of work or lead to a reduction of the staff numbers. So far from the evidence of interacting with palro, in gymnastics, there is the same effect, if people do it. On the contrary, this means, that not people, but also palro can create the same effect, so [in the case of using palro] it can connect to the reduction of a specific staff number. However, such data has not been taken yet."*[260]

There already are gymnastic lessons with palro as an instructor in elderly facilities. Nevertheless, it remains difficult to get data, even if the benefit is clearly experienced. For the caregiver, care robots can improve the work environment, but it is difficult to convince management because there is no proof of the robot's effects. That means unless the

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[259] INR24-IP33 (aams: bio sync) 00:18:12-00:18:56 数値化できないことが結構多くて、例を挙げるとこれを [aams の] 導入したことによって、スタッフの数を減らせるかといったら多分減らせないと思うんです。だからこういうものを入れている施設に、家族が被介護者を安心して預けられるとか、あとは介護業界は離職率が結構高くて精神的にきついところがあると思うんで、これ [例えば、見守りシステム] を入れているから、安心して働けるとかいうのが数値化できればいいと思うんですけどね。

[260] INR15-IP22 (palro: Fujisoft) 00:13:32-00:14:22 やっぱり介護ロボットとかだと、人に代われるものだと思いますので、いかに業務を効率化できただとか、[スタッフの] 少人数化に繋がったとか、そういったところだと思います。今までエビデンスで palro に触れてもらったから、体操でこういう効果が出たとかというのは人がやっても同じことなんです。逆にそれは、人じゃなくて palro で同じ作用が出るということなので、数字化というところでは、[palro を使うことによって] 人がこれだけ削減できましたっていうところにつなげられると思います。ただ、実質そういうデータはまだとれていません。

management can be supplied with evidence, broad implementation of care robots will be unlikely.

There is a need to rethink what can be achieved with the implementation of care robots away from effectiveness to quality. The initial question must be what opportunities arise through care robots, rather than if robots can replace someone. The representative of Fujisoft comes to the heart of this,

> *"People often say that care has to be done by people, and I don't mean that palro can substitute human labor, but I would like to say that it can be a presence, which can fill in for a little while. It would be very cold, when the communication would only be left to robots. Therefore, it should not be done for a long time, but when you really must do something at this moment, palro can fill in for a little while. Insomuch that, the content of this story here, it [palro] becomes a communication opportunity for the family and staff. We are aiming at the activation of the communication with other people."*[261]

The use of a robot should create space for interaction. Especially in the example of the communication robot palro[262], a common misunderstanding that communication robots are designed to substitute communication, becomes clear. Even their developer agrees that to leave the communication entirely to robots leads to a dehumanization of communication and care. A communication robot should be a medium to communicate, not a medium to replace communication. This way of thinking applies also for other robots, such as transfer or mobility aids, which do not intend to replace but to extend interaction. The representative of RT.Works summarizes this discussion very well when saying, *"I think that the participation of the elderly in society will increase. In some cases, it is said you gain strength by moving, but I think the gain is more mentally, there is a sense of 'being able to communicate', 'being involved in society' or 'being active'. Well, that's where structure of [the daily] life changes."*[263] The objective of care robotics is not limited to efficiency; it rather should be about increasing the quality of life and work. For the caregiver, this means to work free from anxiety and for the care recipient, this means being able to participate in society. The robot is nothing more than a tool and the means

[261] INR15-IP22 (palro: Fujisoft) 00:14:38-00:15:24 介護はやっぱり人によるものだと言う人が多いんですが、人の仕事を palro が代わりにできるわけではなくて、ちょっとした間を埋めてくれる存在として利用してもらいたい。話し相手もロボットだけにさせてしまうと非常に冷たいものになってしまうんです。だから別にずっとそれをさせておくわけではなくて、どうしても手を離せないときに PALRO に相手をしてもらって、ちょっとした間を埋めてもらう。それで、ここで話した内容 [palro が]が、家族やスタッフと話すきっかけや話題作りになるなどして、他の方とのコミュニケーションの活性化に繋がるっていうところを狙っています。

[262] Cp. INR04-IP11 (OriHime: Ory Laboratory). The developer of the communication robot OriHime mentioned as well that the robot has to be a medium for communication not to replace communication.

[263] INR12-IP19 (RT.1/ RT.2: RT.Works)00:49:05-00:49:37 高齢者の社会参加が増えると思ってるんです。それは結局移動することによって体力がつくって言うのもあるんですけど、それより精神的に、「コミュニケーションができている」「社会参加している」「活躍している」っていう意識があるので、そういうところで [日常] 生活の仕組みが変えられるんじゃないかなぁと。

to an end. In this context, mobility-aids such as RT.1, RT.2, Little Keepace or the Flagship Model are very illustrative of how the use of a robotic device can improve daily life for the user.

In the end the question remains if it is desirable to replace human labor. The representative of Fujisoft points out that people are likely to resist robots, if they are intended to substitute their work, *“a small reduction can numerically be shown, but it will in an opposite way be detestable. People will think that their work will be taken.”*[264] On the one hand, the management level of care facilities might be convinced by a possible reduction of staff and the involved cost savings. On the other hand, the staff that might be replaced is unlikely to welcome technology under such circumstances. This is a major point when thinking about the diffusion of care robotics and how to achieve a wide utilization rate of care robots within care facilities. If the implementation process takes place from an economic perspective without the involvement of the final user, care robotics will not make the integration into daily work routines within care facilities. For extensive diffusion not only within the field of care but also within society, communication of arising opportunities is critical.

Other companies keep the evaluation of success much simpler when reducing their success to sold units. The representative of Nabtesco is frank about the reason behind this, *“We can also produce numerical and quantitative numbers on the effects of this welfare device through clinical evaluation, but it is difficult to quantify how it is used after it is sold on the market.”*[265] It is much easier to quantify success by sales numbers because *“our company looks at shipments and sales more than that. There we decide if this business is a success or a failure”*.[266] Having said this, this approach is only possible for companies which develop products for broad markets, such as it is in the case of mobility aids like the Flagship Model or Little Keepace. In the care industry, it is often about niche application for niche markets, or markets with limited sales at the same time. An invention can provide a technical solution for only one problem, such as the transfer from wheelchair into bed. Mobility aids or monitoring systems are rather an exception than the rule.

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[264] INR15-IP22 (palro: Fujisoft) 00:15:40-00:15:48 少人数化は数字として出せるけど、それを出すと逆に嫌がられる。仕事を取られると思うんです。

[265] INR14-IP21 (Flagship Model: Nabtesco) 00:26:10-00:26:50 この福祉機器も、臨床評価で数値的な、定量的な効力、効果を出すことはできるんですけれども、それが市場で販売された後にどう使われてっていうのを数値化するっていうのは難しいと思います。

[266] INR14-IP21 (Flagship Model: Nabtesco) 00:27:26-00:27:42 会社はそれより、出荷台数、販売台数を見るんですよ。そこで、この事業が成功か失敗かというのを判断します。

The design of a robot (IQ5.2) reveals the concept and ideas behind its development. The robot's design is the materialization of developers' ideas, and thus it transfers an abstract image into a concrete form. On the one hand, there is the design itself, which might stimulate emotions such as familiarity or even reluctance (cp. Mori 1970). It is the business card of the idea, and the end-user will welcome a thoughtful design which is not limited to the developer's thoughts, and also to the expectations of robots within the later target group. On the other hand, the finding process of the design and its decision-maker (IQ5.2.1) can directly influence the stability of further development of the robot (see Figure 6-10). The more people share the concept and idea behind a design, the more the robot development can overcome future points of friction and conflicts of interests. There are four approaches to get to the decision of a design: Developer, designer, in-house or a trial-and-error dominated decision-making process.

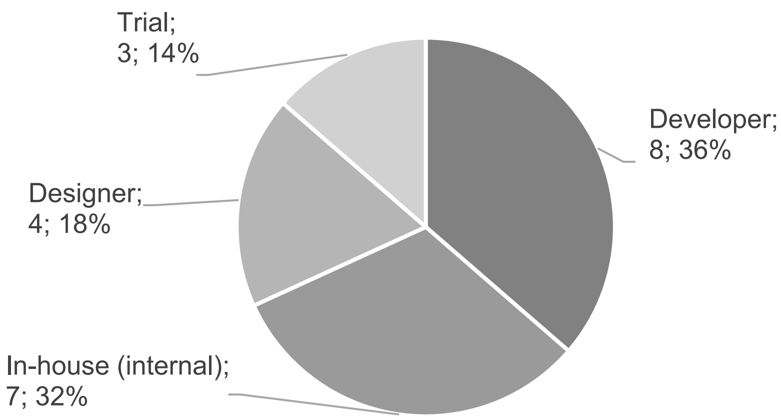

Figure 6-10 Decision-Maker behind the Robot's Design (n=22)

The classical approach of designing a robot is that the developer decides the design. Among the 22 robot projects, the design of eight robots[267] was developer-based. The advantage of this approach is the direct transfer of the developer's idea into the desired design. From a theoretical perspective (see Chapter 2.4), the opportunity to personalize the design according to the developer's imagination can increase motivation. The personal design serves as a pictorial representation of the concept behind development,

[267] INR02 (SAN Flower: Kato Denki), INR03 (smile baby: Togo Seisakusyo), INR04 (OriHime: Ory Labroatory), INR08 (ROBO snail: Ryoei), INR21 (Neruru & Yumeru: T-arts), INR24 (aams: bio sync), INR26 (Dreamer: Santec), INR27 (yorisoi robotto: Sanyo Homes)

and thus can help to overcome problems and to communicate the robot project to other relevant social groups.

The representative of Sanyo Homes talks about the relevance of instrumentalization of design, *"when talking about robots, people have a strong and hard image, but the design [of yorisoi robotto] is clothes. I tried to think the other way around, how to put a robot in there. I want to do it fashionable, whenever it is worn."*[268] In the case of yorisoi robotto, it was intended to avoid the term robot because it does not harmonize with the origin of development. Integration into the user's daily life without any uncomfortable feeling is the main intention of the project. Rather than emphasizing robot technology, the design has origins in bionics. The representative of Sanyo Homes talks about the idea of copying nature.

> *"The concept behind the robot is that if you have this robot [yorisoi robotto] you can go where you want to go. It is the design of a bee. I want to protect the bottom in the case of a fall and after that you have something at places, where you can easily break, such as your stomach and shoulder. I put a sensor in these areas, so that the back is straight and the posture becomes better. Since it looks like a bee I gave it the name bee jacket."*[269]

It is a soft concept, whereby technology intends to be a shell for the user and improve their quality of life. Even the developer of OriHime is not emphasizing robotics, but the user, when talking about the design, *"Why the face looks this way is because it is like a Nō-mask*[270]*. OriHime's face should be able to look like various faces. I think, people should imagine [the face]."*[271] Rather than OriHime as a robot, OriHime intends to enable communication with family and relatives that live far away. Thereby in a special sense, the design intends to nourish the imagination of the user. This orientation on the user and his environment is because the both mentioned robot projects are socially driven. Rather than economic success, value for the user is paramount.

[268] INR27-IP36 (yorisoi robotto: Sanyo Homes) 00:29:36-00:30:24 ロボットっていうと、硬くて強いイメージがあるんですけど、これ [寄添いロボット] のデザインは洋服なんですね。そこにどうやってロボットを入れようかっていうのを逆に考えました。いつ着ててもおしゃれなものにしたい。

[269] INR27-IP36 (yorisoi robotto: Sanyo Homes) 00:31:31-00:32:28 このロボット [寄添いロボット] があれば、自分の行きたいところに行けるというコンセプトがあって、蜂のようなデザインがまずあるんです。お尻 […] 転倒した時にここを守りたいとか、あとはおなかや肩など、皆さんが骨折しやすいところには何かしら着けています。この辺りは背中がまっすぐになって姿勢が良くなるように、ここにセンサーを入れています。それがまるで蜂の姿に見えたんで、名前を蜂ジャケットと付けました。

[270] A Nō-mask (能面) from the traditional Japanese Nō-theater.

[271] INR04-IP05 (OriHime: Ory Laboratory) 00:16:31-00:16:51 なんでこんな顔をしているのかという意味では、能面のような。OriHime の、いろんな顔に見えてくるっていう。人間が [顔を] 想像すればいいって私は思ってます。

Another popular approach[272] on the robot design is the in-house approach. Thereby the design is decided by a collaborative process. The representative of Toyota Motor illustrates that process when saying,

> "We did not refer to anything. […] In the end, there are two ways to choose a design: a funny design or a more tool-like simple design. In terms of Star Wars, it would be R2-D2 or C-3PO[273]. In the questionnaire that we send out, we asked inside and outside the company, what design would you prefer. The answer was divided in half-and-half. That's why we decided for the functional design rather than the funny."[274]

The democratization of the decision process to find a design that will earn a majority takes more time in the beginning, but in the later phases of development, this investment of time pays off because the involved actors in general support the robot project. In addition, there are several ways to get to a design. The employees of a company can directly submit ideas,[275] or designers submit a design concept and employees vote on them[276].

When thinking about how to market a product, companies often assign the design of their products to design divisions, or even external designers with the design of their later product. Among the 22 robot projects, the design of four of the robots[277] were based on the ideas of design divisions or professional designers. In the case of the robohelper Sasuke, the internationally-awarded designer Kita Toshiyuki[278] developed the concept of the design[279]. The design is the face of the product and a welcome point for critics. Assigning internal or external designers can reduce the risk of misunderstanding the conceptions of the target group. This is a professional approach with a high orientation on the later target market, and thus from a design perspective reduces the risk of rejection by the market.

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[272] INR01 (HSR: Toyota Motor), INR11 (Little Keepace: TacaoF), INR12 (RT.1/ RT.2: RT.Works), INR13 (resyone: Panasonic), INR14 (Flagship Model: Nabtesco), INR22 (kyūretto: Aronkasei), INR23 (KR-1000A: Clarion)

[273] Within in the Star Wars universe, there is on the one side a machine-like R2-D2 which can interact with its environment via various tools. On the other side, there is a humanoid protocol droid C-3PO which can communicate with people in its environment. When compared with the former one, the latter one is more design-driven with its concept of a humanoid robot appearance to be able to interact with humans beings.

[274] INR01-IP01 (HSR: Toyota Motor) 00:18:35-00:19:53 余り何かを参考したということは無いですね。[…] 結果的にデザインを選ぶのに二通りあって、ファニーなデザインか、もう少し道具のようなシンプルなデザインかになるんです。スターウォーズで言うと、R2D2 か C3PO かといった感じで。我々が発信するアンケートで、どっちのデザインが好きか社内外で聞くと、意見が半々ぐらいに分かれます。だから我々は道具寄りにしようということで、ファニーというよりは、機能的、ファンクショナルなデザインを取っています。

[275] E.g. INR23 (KR-1000A)

[276] INR14 (Flagship Model: Nabtesco)

[277] INR07 (i-me:ma: Kito Seiki Seisakusho), INR10 (aijō-kun: Art Plan), INR15 (palro: Fujisoft), INR39 (Sasuke: Muscle)

[278] Kita Toshiyuki also designed wakamaru the communication robot of Mitsubishi Heavy Industries.

[279] INR39 (Saskue: Muscle)

Some companies[280] pursue a trial-based design approach, whereby the design is influenced by technical specifications or other pragmatic choices. In other words, the design itself develops within the course of general development, and there is not necessarily a fixed expectation on the shape of the robot. The representative of Shintec Hoizumi with their mobility aid Tecpo demonstrates the trial-based design approach when he explains the history behind the current design[281].

> "In 2014, we originally joined the METI project, and presented something new, but at that time, we were instructed that this was too new. In the past, there were problems or accidents with walking aids, and since it developed like this, we better not change it. Based on that, the model of 2015 is the one of an existing walking aid. […] Since our company can't make the frame [of a mobility aid], we looked for a place we could work together with and in the end started to think about how we can do it on our own. So the idea is to base it on an existing walking aid coming from our past efforts.*"[282]*

Shintec Hoizumi started with the development of required technology for a mobility aid when realizing that they needed a frame for their technology. The original intention was to use an existing frame of a walking aid, but after an unsuccessful search, there was no other choice than to modify Tecpo in the style of an existing model. In the case of Fuji Machine MFG, the design of Hug is mostly based on technical specifications and no other design would have been technically feasible. In the end, technology sets limits on the design. As long as the resulting design does not interfere with the user's demands, the invention is likely to be accepted. In the case of a discrepancy between the developer's design and the user, this can lead to problems, which are difficult to adjust.

One, if not the most, essential part within development is the existence of a vision or at least a set goal (IQ5.4), which all involved actors work towards. It is the lowest common denominator, which provides structure and serves as a source of motivation. The existence of a vision or goal is the most powerful part within the development process. There are four possible combinations (see Figure 6-11)[283]: The existence of only a vision, the

[280] INR06 (Muscle Suit: INNOPHYS), INR28 (Hug: Fuji Machine MFG), INR29 (Tecpo: Shintec Hozumi)
[281] E.g. INR29-IP38 (Tecpo: Shintec Hoizumi)
[282] INR29-IP38 (Tecpo: Shintec Hozumi) 00:22:28-00:23:25 もともと 2014 年の経産省のプロジェクトに参加していた時に、うちから斬新なものを出したんですけど、そのときにあまり斬新なものもどうかなというご指導もあったんです。それは、過去に歩行車の事故とか問題とかがあって、ああいう形に出来上がってきたから、それを変えない方がいいのかなっていう話でした。それを踏まえて 2015 年度のモデルも既存の歩行車のスタイルにしました。 […] 自社ではフレームができないものですから、協働できるようなところを探したりだとか、自社でやるんだったらどうするんだってところを考えながら進めました。だから既存の歩行車をベースにしましょうという考えは、過去の取り組みの中から、今に至っています。
[283] Among the 22 robot projects, five provided no details about if there is a vision behind their development or a specific development plan for the development[283]. That means that the mentioned description and division into the four combinations rests on the data of the 17 robot projects with a response.

existence of only a development plan, the coexistence of vision and plan, or the existence of neither a vision nor a plan.

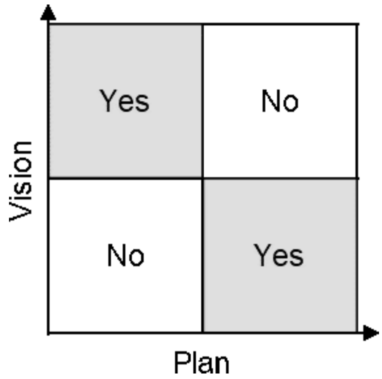

Figure 6-11 Development Patterns of the Robot Projects

Most robot projects, in numbers 15, rest on a vision or plan. The narrow majority, with eight, is a combination of the group of the visionaries with or without a plan. Thereby there are companies which only set an informal goal[284] set, and companies which interlace the idea behind development into the development plan[285]. The clear advantage of a vision behind development is that there is something to work towards for all of the involved actors. This can be the crucial factor to overcoming motivation or other development-related issues. Even if it is only informal, one of the representatives of Togo Seisakusyo explains why their idea matters for the whole company when saying *"Our company depends on cars, so when our idea grows, at some point the idea of our company also starts to grow."*[286] In opposition to the top-down approach, development can serve as a bottom-up approach to change the way of organizational thinking. The developer's motivation can convince other employees and thus in a long perspective, influence the positioning of the company.

Apart from that, companies usually have a plan for their development with set milestones to achieve. For this reason, the division of a vision without a plan and a vision with a plan remains vague. If there is no clear response to this question, the classification bases on the responses from the previous categories. The feature of the robots that is not based

[284] INR03 (smile baby: Togo Seisakusyo), INR04 (OriHime: Ory Laboratory), INR21 (Neruru & Yumeru: T-arts), INR26 (Dreamer: Santec), INR27 (yorisoi robotto: Sanyo Homes)
[285] INR02 (SAN Flower: Kato Denki), INR08 (ROBO snail: Ryoei), INR12 (RT.1/ RT.2: RT.Works)
[286] INR03-IP04 (smile baby: Togo Seisakusyo) 00:27:35-00:27:46 むしろうちの会社は自動車にべったり[286]なので、我々の考えが大きくなってくると、会社の考えも大きくなってくるようなところがあるんですね。

on a formulated vision is when single developers[287] or small development units[288] perform the development. Small numbers of personnel are easier to handle even without a written goal because the demand to synchronize communication is low. For example, the developer designs Neruru & Yumeru alone, whereby there is no need to write a goal down.

A plan classically guides the development process, and there can be a vision or no vision behind this plan. The similarity is the existence of a development plan, but the significant difference is the existence of a vision, and thus motivation behind the development. Technology development without a vision tends to be an operational process, whereby the connecting element for the involved actors is simple work. The existence of a vision makes a difference because it gives a project strength in problematic or difficult times, and thus holds the involved actors together. This point is especially important for care robotics, an emerging field with no experience to rely on. In this context, theory (see Chapter 2) takes up the position of a provisional language for all involved relevant social groups and actors to be able to communicate, and get nearer to the closure of the interpretative flexibility, which will define the future application area of the robot.

On the one hand, there is a group of visionaries[289]. Their decision to write down their vision and interlace it into development serves the function of communication. For example, the developer of SUN Flower and the developer of RT.1/ RT.2 instrumentalize their plan to gain understanding for their project within the company. The representative of Kato Denki expresses how difficult it was to gain understanding of his vision, which moves away from the main business of the company.

> *"Until now, we have been focusing on car security, and we are now in the 26th year [as of July 2016]. However, it is very difficult for the employees to understand that with IT technology people can be found or their current position can be located. They tell me 'I don't understand the meaning'. Finally, recently some people began to understand me, but I had a hard time getting understanding, and it seemed that at the beginning nobody was able to imagine where and how to use it."*[290]

[287] INR04 (OriHime: Ory Laboratory), INR21 (Neruru & Yumeru: T-arts)
288 INR03 (smile baby: Togo Seisakusyo), INR26 (Dreamer: Santec), INR27 (yorisoi robotto: Sanyo Homes)
[289] INR02 (SAN Flower: Kato Denki), INR08 (ROBO snail: Ryoei), INR12 (RT.1/ RT.2: RT.Works)
[290] INR02-IP03 (SAN Flower: Kato Denki) 00:08:53-00:08:28 今まではカーセキュリティが中心で、26 年目 [2016 年 7 月現在] に入りますが、自動車の盗難防止装置をやっていたんですね。ところが、この IT 技術を使って人を発見できるとか、居場所が分かるという技術を、社内の人に理解してもらおうというのが非常に大変で、「意味が分からない」と言われてしまいました。やっと最近分かってくれる人も出てくるようになってますが、なかなか理解してもらうのに苦労したし、どこにどう使うんだっていうのも、最初はイメージがわかなかったみたいですね。

The robot project meant a break with the company's traditions. The development plan served as a tool for communication. Even if the opinions about the concrete design of the robot vary, when all of the involved actors look in the same direction, development is rather likely to succeed. Thereby the vision or goal can figure as a communication platform to enable even non-technical actors to participate in development (see Chapter 2). In the case of the developer of ROBO snail, the development plan functions as a tool for the one-person development to explain the need of the project to the top and rest of the company. In both cases, it is a tool for gaining understanding and necessary consensus for future development.

The next combination is the existence of only a development plan without a specific vision behind it[291]. There is an above average number of economically driven companies within this group. These companies[292] transfer user-feedback on their product into a new robotic invention. This does not necessarily mean that there is no consensus on the value of the robot; it simply means that a more or less technical development plan serves as guideline for development. Thereby the product is in the focus of the development, and there is no need to become set on robot technology. The representative of INNOPHYS illustrates this in a positive way when saying,

> *"The robot itself isn't useful. 'Useful' means things such as welding robots in a factory or transport robots, but other robots are almost not useful. We aim to design useful things for people's daily lives, not for killing time or entertainment. This machine is not a robot. There is neither a power source nor a controller [in our robot]. So it doesn't have to be a robot, if it's useful."*[293]

Besides the simple fact that he sees robots as useless, it shows the pragmatism behind development. A common sense to create a marketable product led to development. One problem is the reaction towards changing circumstances within the course of development, and on the market. If development is smooth, it is likely to be successful. However, if a problem occurs, the wish to create a financially successful product might not be enough to keep development running.

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[291] INR01 (HSR:Toyota Motor), INR06 (Muscle Suit: INNOPHYS), INR14 (Flagship Model: Nabtesco), INR15 (palro: Fujisoft), INR22 (kyūrettol: Aronkasei), INR23 (KR-1000A: Clarion), INR29 (Tecpo: Shintec Hoizumi)

[292] E.g. INR14 (Flagship Model: Nabtesco), INR22 (kyūrettol: Aronkasei), INR23 (KR-1000A: Clarion), INR29 (Tecpo: Shintec Hoizumi)

[293] INR06-IP11 (Muscle Suit: INNOPHYS) 00:29:24-00:30:18 ロボットそのものだけでは役に立たないんです。役に立つというのは、工場で溶接するロボットや搬送用のロボットのようなものを言っているが、他のロボットはほとんど役に立っていない。暇つぶしや、エンターテインメントではなく、人の生産活動の役に立つものの生産を目指しています。今のこの機械 [ムッスルスーツ] はロボットではないんです。パワーソースも、コントローラーもないし。だから、役に立つなら、ロボットでなくてもいい。

This becomes clear when looking at the last combination of no vision and no plan[294]. A loose cooperation with some kind of goal, which cannot be defined by the involved actors and without a concrete development plan, will have a difficult time developing an outcome. The representative of Kito Seiki Seisakusho says a little more on the current state of the development of i-me:ma when pointing out that,

> "*Until then, the companies that came together for the joint development haven't worked on robots and have had work besides this project. At that time, the Lehman shock lead to reduced business, but compared to this time, now the economy recovered, and each company became busy with their main business again. So, among the CEOs of each company, the necessity to develop a robot weakened."*[295]

The motivation for development rests on nothing more than economic reasons. The trigger for development is the desire to develop something that connects to company profits, but this trigger is no strong motivation that keeps all involved actors together and synchronizes their opinion towards a common goal. Through the absence of a vision and development plan, there is a high probability that the project will fail. However, that the development of technology or a specific robot takes place in a haphazard way is unlikely. Research and development (R&D) require human and financial resources, something that companies tend not to waste.

6.6 Category 6: Development Problems and their Solution

After having taken a closer look at the project from various angles such as the development structure (see Chapter 6.2), the project origins and status (see Chapter 6.3), the connection to the field (see Chapter 6.4) and the idea behind the robot (see Chapter 6.5), the focus now switches to development problems and solutions to occurring obstacles. The information on this category and its questions can be found in chapter 4.3.6.

During the course of development, it is likely for unpredictable issues appear (IQ6.1). Thereby, the developer can solve internal problems in an easier way than external ones, with a certain dependence on other actors or circumstances. The responses on the ob-

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[294] INR07 (i-me:ma: Kito Seiki Seisakusho), INR10 (aijō-kun: Art Plan)

[295] INR07-IP12 (i-me:ma: Kito Seiki Seisakusho) 00:41:41-00:42:43 共同開発で集まった各会社は、それまでロボットに携わったことがなく、このプロジェクト以外に仕事があった。当時はリーマンショックで本業の分量が減っていたが、今はその時よりも経済が回復していて、またそれぞれの本業が忙しくなってきた。だから、各社社長さんの中で、どうしてもロボットを開発したいという気持ちが弱くなっているかもしれない。

stacles to robot development are divisible into four categories (see Figure 6-12): Technical, environmental, social and market-related issues. Several developers gave multiple responses.

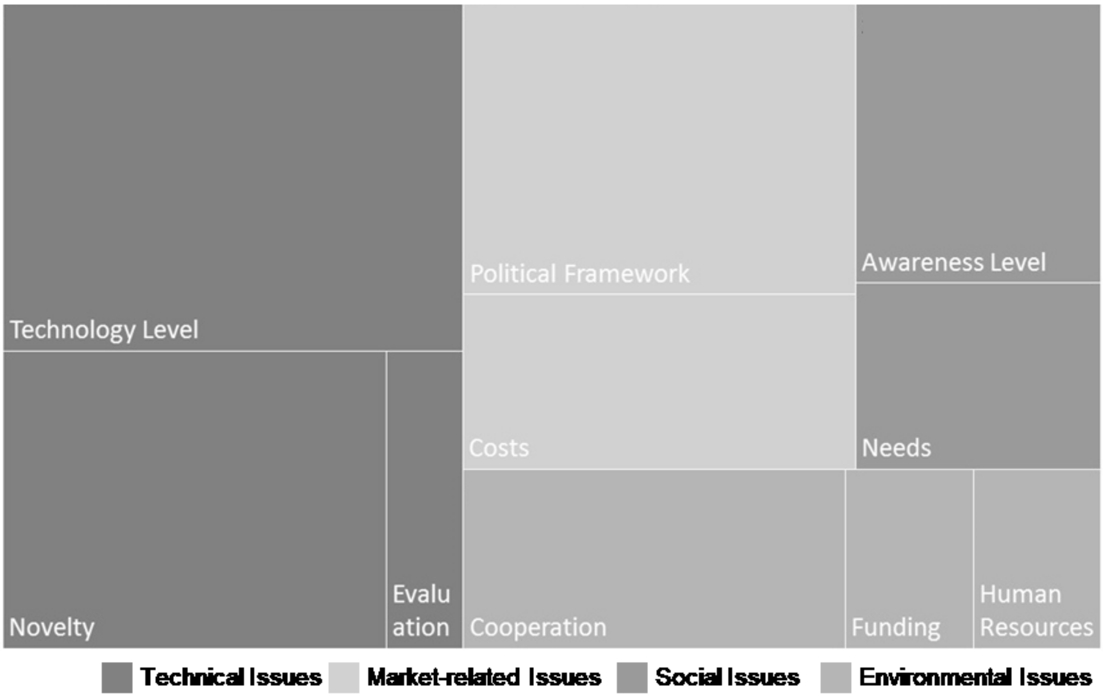

Figure 6-12 Obstacles to the Robot Development

During the course of development, technical issues seem to be the most hindering[296]. The essence of innovation is novelty, creating something that has not existed before and has no blueprint to follow. Novelty leads to various issues. Since it is a new invention, the developer has to decide everything because there is no example to follow[297]. Even if the developers ask caregivers or the elderly, that does not mean that their answer is the correct one, because even they have no experience with such things. Furthermore, especially because it is a new machine, the developers have to ensure a certain safety standard[298]. Finally, yet equally important, not only for the companies but also for society, it applies that there is certain expertise and experience with industrial robots, but not with care robots[299]. For developers, this means they have to figure out how to design a care robot, and for society how to make use of this new field.

[296] E.g. INR02 (SAN Flower: Kato Denki), INR11 (Little Keepace: TacaoF), INR12 (RT.1/RT.2: RT.Works), INR13 (resyone: Panasonic), INR39 (Sasuke: Muscle)
[297] INR12-IP19 (RT.1/RT.2: RT.Works)
[298] INR13-IP20 (resyone: Panasonic)
[299] INR39-IP52 (Sasuke: Muscle)

That is why the state of technology is important[300]. There is a gap between the expectations of society and the technically feasible. Due to advanced and sophisticated images of robots within the media and pop culture, average people without a technical background cannot simply evaluate what is technically possible. The developer of HSR illustrates this fundamental issue, when saying,

> *"Even the robots that have been developed up to now, people only see that with pushing a button various things can be done or that AI can win in Go[301], but forget about that simple human actions such as sitting or picking things are actually still very difficult for robots. However, these aspects are getting more advanced, but even if current AI research, including research and work progressing further, my impression is that there are still many things to do."*[302]

The representative of Fujisoft, which develops palro, an AI-based communication robot, underlines this statement when expressing,

> *"In terms of technology, people have the unreasonable expectations that you can talk with humanoids. After all, speech recognition has evolved along with technology, but because there are quite difficult things, cheating is a bad way of saying, but [unreasonable expectations] have to be covered with communication. The old robots speak and do only defined things, but since the mobile phone and Siri came out, people try to start various talks [with robots and machines]. Although, it started to evolve a demand for AI that can respond to this, all companies are still in development."*[303]

The limitations of the state of the art lead to two conclusions; on the one hand, low-tech devices are more likely to diffuse within society and on the other hand, there is the need for a dissemination of information. An extended understanding on the side of the caregivers about the technically feasible would lead to lower expectations and a more realistic evaluation of technology, which in turn would connect to a higher acceptance of a new invention.

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[300] E.g. INR01 (HSR: Toyota Motor), INR03 (smile baby: Togo Seisakusyo), INR08 (ROBO snail: Ryoei), INR12 (RT.1/RT.2: RT.Works), INR15 (palro: Fujisoft), INR21 (Neruru & Yumeru: T-arts), INR29 (Tecpo: Shintec Hozumi)

[301] Go is a strategy board game for two players played with black and wihe stones. It is often compared with chess. It was originally invented in China, but is popular in Japan, too.

[302] INR01-IP01 (HSR: Toyota Motor) 00:24:03-00:24:46 今まで作ったロボットでも、人が隣にいて、ロボットを見てボタンを押しているだけで、多様なことができてしまったり、人工知能が囲碁で勝ったなどといったすごい部分は既にあるが、座ったり、物を取ったり、人間が簡単にやっている動作が、実はロボットにとってはまだ難しい。ただ、こういった面はどんどん進歩していっていて、現在も AI に関して、作業を含めた研究なども進んでますが、まだやることはたくさんあるなといった印象です。

[303] INR15-IP22 (palro: Fujisoft) 00:18:33-00:19:33 技術面では、人の形をしていてお話ができるというと、過度な期待をされるんです。やっぱり技術と共に、音声認識とかは進化していくんですけど、なかなか難しいところではあるので、ごまかすというと悪い言い方になりますけど、[過度な期待] それをコミュニケーションでカバーしながらやっていくというのが難しいところではありますね。昔のロボットなら決まったことを言って、決まったことをやるような形なんですけど、携帯で Siri とか出てきてから、皆さん[機械と、ロボットと]雑談をするように、いろんな話を投げかけるようになってきてしまったので、それに対応できる人工知能とか AI が求められ始めていますが、まだどこのメーカーも開発中です。

The next category, environmental issues, relates to the internal and external structure of development. Thereby one problem is cooperation[304]. The majority of these companies have problems with finding partners for testing their robot, which is an access problem to the care field. However, when development includes other companies, cooperation problems can occur because the attitude towards development might differ. The representative of Kito Seiki Seisakusho illustrates this conflict when saying "*There are a lot of things that need to be done to increase the robot's completion rate. However, I don't know how many people each company provides for this development project. A development system that includes only people isn't enough*."[305] It is not enough to agree on joint-development; all involved actors need to be synchronized to ensure that all continue the project with the same idea and resources. Otherwise there is the risk of discontinuation of the project at some point. Following up to this, there are other minor issues with the development environment such as how to evaluate the robot[306] for later development purposes, or how to receive enough funding[307] and human resources[308] to be able to continue the project in the future.

Another relevant aspect is the obstacles that relate to society. On the one hand, there is limited knowledge about the field of care[309]. Thereby, the developer of yorisoi robotto points out a fundamental issue within development when saying *"I am working with a robot developer and they usually start with the hardware. If you start with the hardware, it will end up in getting away from the user demand.[310]."* From the beginning, Japanese engineers take the wrong approach when focusing on technical specifications, and neglect the importance of understanding the user. This inevitably leads to a rude awakening for many developers after the first test runs with care facilities when they realize that the technical standard is high, but the robot doesn't meet the user's demands. On the other hand, developers, especially with a lack of care knowledge, are aware of this issue and try to understand the mindset of the caregiver. The representative of Clarion illustrates this when saying *"We used to do only car audio systems, so until now our customers*

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[304] INR03 (smile baby: Togo Seisakusyo), INR07 (i-me:ma: Kito Seiki Seisakusho), INR26 (Dreamer: Santec)
[305] INR07-IP12 (i-me:ma: Kito Seiki Seisakusho) 00:43:05-00:43:45 今これからロボットの完成度を上げるためにやらなければならないことがたくさんあるけど、そのために各会社からどれだけの人がこの開発事業にあたってくれるのかわからない。人を交えた開発体制が不十分です。
[306] E.g. INR28 (Dreamer: Santec)
[307] E.g. INR02 (SAN Flower: Kato Denki)
[308] E.g. INR04 (OriHime: Ory Laboratory)
[309] E.g. INR23 (KR-1000A: Clarion), INR27 (yorisoi robotto: Sanyo Homes)
[310] INR27-IP36 (yorisoi robotto: Sanyo Homes) 00:33:57-00:34:10 ロボット開発の会社とも一緒にやっていますけど、そういうところはハードから入るんですね。ハードから作ってしまうと、どうしても現場の需要から離れてしまう。

were automobile manufacturers, but this time it will be used in a care facility, so it was quite difficult to gasp these kinds of needs. As we didn't have any opinions, which we could use for this product, the development was hard, because we had to search and listen from scratch.[311]" In the end, to create a successful product, one needs an open mind that tries to think out of the box and the willingness to familiarize with the field of care.

The other side is the awareness level of the robot[312]. Even if the best and most demanded robot was developed without any awareness within the field of care, it would end as an unsuccessful invention because nobody would know about its existence. The developer of aijō-kun goes to the heart of this when saying, *"it is difficult to raise awareness. Now it is three years [since the completion of the robot], and finally, inquiries are coming. Therefore, it takes three or four years to raise awareness. After that, it will be known quickly, but it is difficult to go there."*[313] The problem here is that not all companies have the capabilities, or the developers the motivation, to overcome this lean period. In addition, this shows the clear advantage of a marketing campaign for promoting care robotics on a national level. This has to be an addition to the financial support for developers or care facilities. The developer of aijō-kun would go so far as to say, *"When the awareness level increases, even major companies have no other choice than to use aijō-kun."[314]* Regardless of aijō-kun, the problem of diffusion and domestic economic market growth can partly be solved by a structural approach to the awareness level.

The second largest group[315] relates to the market, whether it is on defining an environment to place robots on the market or to give incentives for the user to purchase care robots. The representative of INNOPHYS urges for a clear framework, which captures new inventions and makes entering the market easier when saying, *"Since it is a non-existing thing, it is a completely new machine and thus there are not many regulations.*

[311] INR23-IP32 (KR-1000A: Clarion) 00:19:01-00:19:31 とにかく我々はこういうカーオーディオばっかりやっていたので、それまで車のメーカーだけがお客さんだったのが、今度は一般の施設が使うということで、そこの、どういうものが欲しいかというニーズはなかなかつかめなかったですね。製品に生かせる意見が手元になかったので、一から調べたり聞いたりっていうのが開発の中で大変だったかなと思います。
[312] E.g. INR03 (smile baby: Togo Seisakusyo), INR10 (aijō-kun: Art Plan), INR22 (kyūretto: Aronkasei)
[313] INR10-IP16 (aijō-kun: Art Plan) 00:46:03-00:46:26 認知度を上げていくことが [難しい] 。[完成から] 今 3 年経ってきて、ようやく少しずつ問い合わせが入ってくるようになりましたね。だから、認知度が上がるまで 3-4 年はかかりますよね。その後は早く知れ渡っていきますが、そこに行くまでが大変ですね。
[314] INR10-IP16 (aijō-kun: Art Plan) 00:47:38-00:47:51 認知度がガンガン上がれば、大手も愛移乗くんを使わざるをえなくなってくる。
[315] INR06 (Muscle Suit: INNOPHYS), INR11 (Little Keepace: TacaoF), INR14 (Flagship Model: Nabtesco), INR22 (kyūretto: Aronkasei), INR24 (aams: bio sync)

However, if you try to use this device for rehabilitation, it has to be recognized as a medical device and if you can't clear the regulations, it doesn't enter the market. [316] The representative of TacaoF sees the need for the creation of a system, which is able to react to current developments when saying *"speaking about the legal revision, of course there is a category for mobility aids, which can be covered by care insurance, but by adding robot technology it becomes a new category. So it is necessary to get this recognized by care insurance again."*[317]. It is about the political framework needed to support the emerging field of care robots, because only enthusiastic proclamation that the future of Japan's care industry will be care robotics is not enough to bring all relevant social groups together. This will not lead to sure-fire success and needs a professional approach to it.

In the end, an important factor for broad diffusion within society is the price of the robot. High costs are a serious obstacle for diffusion[318], but for lower costs, there needs to be cheaper production which is only possible through changing to mass production, and this is in turn only possible through higher demand. This makes for a vicious cycle which is hard to overcome at the early stage of a product's life. The representative of bio sync is aware of this issue when saying, "*When you try to introduce care robots, there is no financial support for the facility. It is a very expensive machine, so introduction rather doesn't move ahead*."[319] For him, the solution for this issue is simply to give economic incentive through coverage by care insurance. Thereby, even if the market forecasts are optimistic and the awareness among society is increasing, this is something that developers have only limited influence on. It is a feeling of helplessness which comes to the surface when the representative of bio sync explains the topic, *"[aams] is not covered by the insurance. […] We can't do anything about it, whether it will become subject of care insurance, because everything is left to the country. There is nothing but to pray*."[320] The

[316] INR06-IP11 (Muscle Suit: INNOPHYS) 00:30:36-00:31:17 既存のものではなく、全く新しい機械なので、規制などはあまりないです。でも、これをリハビリに使おうとすると、医療器具として認められなければならなくなって、既存のマーケットに設けられている規定をクリアできなくて、なかなかマーケットに入っていけない。

[317] INR11-IP17 (Little Keepace: TacaoF) 00:27:11 -00:27:36 法改正といえば、歩行車というジャンルはもちろん介護保険適用なんですけれども、ロボット技術を搭載することによって新しいジャンルになってしまうんで、また新たにこれを歩行者として認めてもらう必要があるんですね。そこ […]国を動かす[317]っていうところが非常に大変だったかなっていう気は…

[318] E.g. INR08 (ROBO snail: Ryoei), INR14 (Flagship Model: Nabtesco), INR24 (aams: bio sync)

[319] INR24-IP33 (aams: bio sync) 00:22:40-00:23:01 介護ロボットに関しては、導入するとき、施設にお金の援助がないんですね。非常に高額な機械なので、なかなか導入が進んでいかない。

[320] 00:23:19-00:23:53 これ [aams] は保険対象じゃないんですよ。 […] 介護保険の対象になるかどうかについては、我々は何もできない、すべては国にゆだねられているので、ただ祈るしかないですね。ただ、世の中介護ロボットが一般的になってきているので、この先 AAMS が保険対象になることはあり得ると思います。

choice of words makes the difference; it is the contrast of having to pray for the occurrence of an event. It seems that the fate of care robotics lies in the hands of supernatural forces. This is not the basis of trust needed to animate companies to enter a hopefully emerging market.

The next step is to look at specific obstacles (IQ6.1., IQ6.2.) during development (see Figure 6-13) in detail. Even if the distribution of the given examples slightly differs from the problem categories, the given examples of the problems that leave an impression tell how it is with development and market maturity. The responses from the 22 robot projects lead to a division of the following major categories: Technical issues, design issues, environmental demands and minor or major issues.

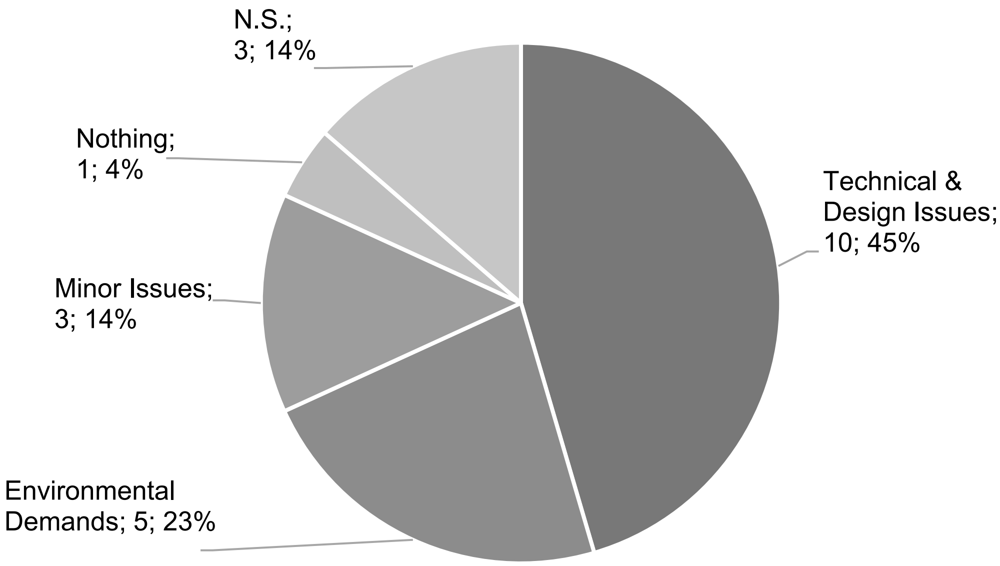

Figure 6-13 Specific Obstacles for the Robot Project (n=22)

One third[321] of the companies mentioned technical design-related issues. These include problems with the interface or display[322], materials[323] or movement of the robot[324]. Regardless of the need to understand user demands, the previous step before is to overcome the main technical issues, because otherwise test runs in the natural environment of the user are unfeasible. There are no capabilities for adjusting the concept of the robot to user needs as long as the developers struggle with technical specifications. In addition, three robot projects[325] had problems with the design of their robot, which includes the balance between finding the right size, design and functions. This suggests that the state of the art within care robotics is not as advanced as assumed, which represents additional valuable input for answering the thesis on the lack of information (see Chapter 1.2). Companies[326] that are in contact with care facilities experienced greater distance between their development and the future area of application. In this context, the initial problem is that a review and an improvement of the robot are not possible without an evaluation on the basis of collected data in cooperation with care facilities[327]. Cooperation with care facilities is a win-win scenario for both sides, because the developers get[328] an understanding of workflows within care facilities, and the user can give feedback concerning the invention to make sure that further development goes in the desired direction. The developer of aams admits that they did a wrong assessment of user needs and realized a disconnection between their development and the user. What the developers thought would be helpful turned out to be not useful at all[329]. Other developers could adjust the robot to the needs of their target group. One illustrative example is the robohelper Sasuke, whose original contact point for the transfer was the neck, but after realizing that keeping a certain body tension for the transfer is essential, they redesigned it to the head[330].

The last subdivision covers a wide variety of issues. On the one hand, there is Toyota Motor[331] with its HSR, that struggles with major problems and on the other hand, there

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321 INR02 (SAN Flower: Kato Denki), INR03 (smile baby: Togo Seisakusyo), INR04 (OriHime: Ory Laboratory), INR06 (ROBO snail: Ryoei), INR11 (Little Keepace: TacaoF), INR14 (Flagship Model: Nabtesco), INR21 (Neruru & Yumeru: T-arts), INR23 (KR-1000A: Clarion), INR26 (Dreamer: Santec), INR27 (yorisoi robotto: Sanyo Homes)
322 INR02 (SAN Flower: Kato Denki), INR04 (OriHime: Ory Laboratory)
323 INR06 (Muscle Suit: INNOPHYS), INR26 (Dreamer: Santec)
324 INR03 (smile baby: Togo Seisakusyo)
325 INR11 (Little Keepace: TacaoF), INR23 (KR-1000A: Clarion), INR27 (yorisoi robotto: Sanyo Homes)
326 INR07 (i-me:ma: Kito Seiki Seisakusho), INR24 (aams: bio sync), INR28 (Hug: Fuji Machine MFG), INR29 (Tecpo: Shintec Hozumi), INR39 (Sasuke: Muscle)
327 E.g. INR28 (Hug: Fuji Machine MFG) faced the problem of getting access to care facilties.
328 INR07 (i-me:ma: Kito Seiki Seisakusho)
329 INR24-IP33 (aams: bio sync)
330 INR39-IP53 (Sasuke: Muscle)
331 INR01 (HSR: Toyota Motors)

are RT.Works and Fujisoft with their inventions[332], which focus on minor adjustments. Thereby the former illustrates a developer that is looking for the wider context of his robot, and the latter for developers that have already reached a certain technical level and have the capabilities to enter the phase of refinement. Among all 22 robot projects, only one developer[333] stated having not experienced a memorable problem during the development process, even if the produced units of aijō-kun remain relatively low, with 50 units in 2016 (see Chapter 6.4).

The existence or absence of a specific problem (IQ6.2.1) solving approach (see Figure 6-14) reveals further insight into development structure. It gives development a basic stability in the case of problems or crises, and furthermore reveals how the developer reacts and overcomes occurring problems.

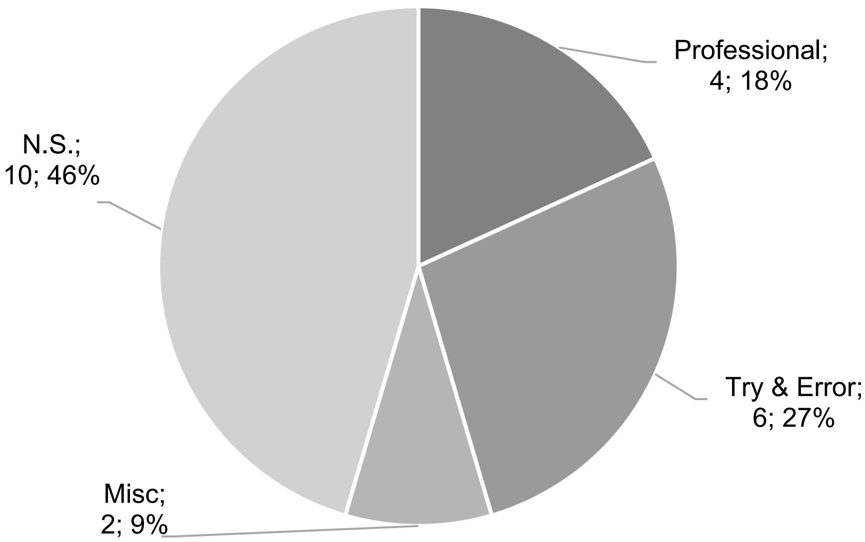

Figure 6-14 Approach to the Development Problems (n=22)

Among the respondents of the companies, the majority[334] approach problems with a simple trial-and-error method. Thereby the developer performs test runs until the result is satisfactory. The representative of Santec, where the toileting aid Dreamer is created,

[332] INR12 (RT.1/ RT.2: RT.Works), INR15 (palro: Fujisoft)
[333] INR10 (aijō-kun: Art Plan)
[334] INR02 (SAN Flower: Kato Denki), INR03 (smile baby: Togo Seisakusyo), INR04 (OriHime: Ory Laboratory), INR07 (i-me:ma: Kito Seiki Seisakusho), INR11 (Little Keepace: TacaoF), INR26 (Dreamer: Santec)

illustrates what this means to the invention when saying that "*First of all, I have to try it [the toilet aid] by myself first. I can't say anything about it, without having put it under my buttocks and slept with it for one night*."[335] It is not only about developing a functioning product, but also about understanding the needs of the user by seeing through their eyes to get acceptance by the target group. Having given this self-experimental example, it is not a given fact that the developers test their own invention. In the end, there is the tendency that the developer cannot empathize with the user of the market for which they design their care robots. The reason behind this varies. On the one hand, smaller companies[336] with limited organizational resources, such as human resources which simply do not have the capacity for structural access to a problem-solving approach. On the other hand, some companies lack experience with the development of care-related technologies[337] and are mostly from the automotive sector. In both cases, it is difficult to develop or have a structured approach to problems. On the contrary, bigger companies[338] with organizational backup and resources usually have a professional approach to solving occurring obstacles. Thereby the company has the resources to train their employees to be able to overcome problems with a certain approach. For example, Nabtesco's welfare division discusses development-related issues with technical experts in their Tokyo headquarters. To have the capacity to overcome development problems with a certain structural framework is a huge advantage for technology development, which can transfer the development into a successful one.

6.7 Category 7: Market Potential and Barriers

After having started with the personal background and the motivation for developing robots (see category 6.1), the logical extension of analysis is on the development framework (see category 6.2) and robot projects (see category 6.3) with its outline, as well as in the next step which is building up a connection with the field (see category 6.4). The four first categories are the foundation for extending analysis to the diffusion of care robots. For this, it is necessary to focus on emerging issues and their solutions. First, individual problems and their solutions (see category 6.6) and then, with this category on a general level, market potential and related problems such as concerning creation and

335 INR26-IP35 (Dremer: Santec) 00:23:09-00:23:24 まず自分が一番最初に [排泄支援機器] 試してみないと。ちゃんと一晩お尻の下に敷いて寝てどうなんだというのも、やってみないと何とも言えない。

336 E.g. INR04 (OriHime: Ory Laboratory), INR26 (Dreamer: Santec)

337 INR02 (SAN Flower: Kato Denki), INR03 (smile baby: Togo Seisakusho), INR07 (i-me:ma: Kito Seiki Seisakusho)

338 INR01 (HSR: Toyota Motor), INR13 (resyone: Panasonic), INR14 (Flagship Model: Nabtesco)

accessibility are standing in the center of interest. Further information about this category and its questions can be found in chapter 4.3.7.

Demographic change provides tailwind for the investment and development of care robotics (IQ7.1). The relevant social groups related to the development side, such as METI and companies, see care robotics as a chance to revive the Japanese economy and simultaneously solve Japan's demographic problem. This optimism is based on the assumption that the population will become older and, at the same time, the need of care increases, whereby the domestic labor market cannot balance labor needs for caregivers. This leads to a general gold-rush atmosphere among companies and motivates them to extend their business to the care industry without experience in this domain. Companies expect high profits and a new sales market for their technology. The evaluation of the market potential for care robots reflects this optimism (see Figure 6-15). The developers of 18[339] of the 22 robot projects assess the market potential as positive. Only three[340] judged the market as negative or difficult, and one[341] gave no details. There are two groups of optimistic developers.

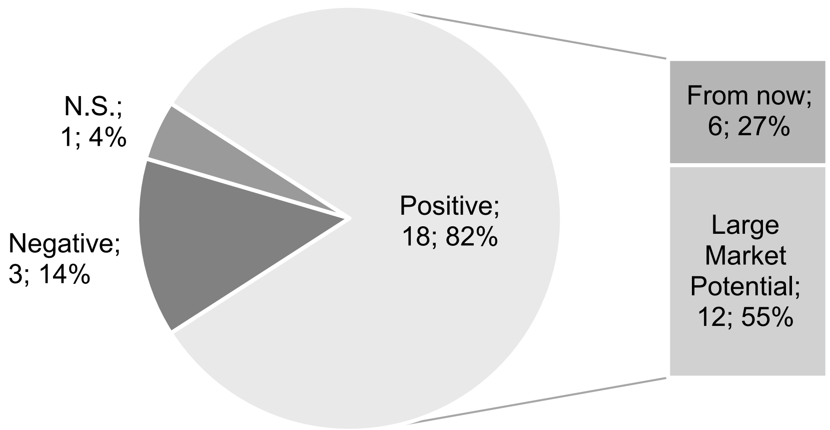

Figure 6-15 Evaluation of the Market Potential for Care Robots (n=22)

[339] INR01 (HSR: Toyota Motor), INR02 (SAN Flower: Kato Denki), INR03 (smile baby: Togo Seisakusyo), INR04 (OriHime: Ory Laboratory), INR06 (Muscle Suit: INNOPHYS), INR10 (aijō-kun: Art Plan), INR11 (Little Keepace: TacaoF), INR12 (RT.1/ RT.2: RT.Works), INR13 (resyone: Panasonic), INR15 (palro: Fujisoft), INR22 (kyūretto: Aronkasei), INR21 (Neruru & Yumeru: T-arts), INR23 (KR-1000A: Clarion), INR24 (aams: bio sync), INR27 (yorisoi robotto: Sanyo Homes), INR28 (Hug: Fuji Machine MFG), INR29 (Tecpo: Shintec Hozumi), INR39 (Sasuke: Muscle)

[340] INR07 (i-me:ma: Kito Seiki Seisakusho), INR08 (ROBO snail: Ryoei), INR14 (Flagship Model: Nabtesco)

[341] INR26 (Dreamer: Santec)

On the one hand there are ones[342] who assume a large market potential right now and on the other hand are the ones[343] who assume that the market will grow in the near future. Thereby, one thing does not rule out the other: They can serve each other. The responses show the wide spectrum of underlying thoughts for this positive evaluation. There are developers who surmise a large market potential for no special reason[344]. The high frequency of information on topics related to demographic change in e.g. the Japanese media probably influences this attitude. Other developers are convinced that only robots can support an aged society[345]. The lack of alternatives, such as migration, exerts pressure on society and urges for a solution, or at least alleviation, of the current situation. Another group goes into a slightly different direction and sees the future market potential not on the Japanese market, but on overseas markets. The representative of Fuji Machine MFG raises an interesting thought. He states that, *"I think there is potential, but after all the resources to purchase robots are decided by the government, so I think that there will be no significant [market] growth in Japan. Rather than that, I think that overseas is better for business. So if you want to do [business] within the country, you have to rapidly reduce the price*."[346] According to this perspective, the critical success factor for the Japanese market is the price of the robot, because the financial support sets limits to sales opportunities. This argumentation is only logical when it considers that some experience with care robots as a product have to exist at least in some market, such as the Japanese one. It seems reasonable to get experience on the domestic market first and then extend the business to other countries. Japan can function as a blueprint. and it is likely that other aging countries will welcome technical care solutions from Japan.

On the other hand, other optimistic developers see real potential for care robots in the future[347]. There are various reasons for this belief, such as business development, the mindset within the field of care or missing solutions to issues of demographic change.

[342] INR01 (HSR: Toyota Motor), INR03 (smile baby: Togo Seisakusyo), INR10 (aijō-kun: Art Plan), INR12 (RT.1/ RT.2: RT.Works), INR13 (resyone: Panasonic), INR15 (palro: Fujisoft), INR22 (kyūretto: Aronkasei), INR24 (aams: bio sync), INR27 (yorisoi robotto: Sanyo Homes), INR28 (Hug: Fuji Machine MFG), INR29 (Tecpo: Shintec Hozumi), INR39 (Sasuke: Muscle)
[343] INR02 (SAN Flower: Kato Denki), INR04 (OriHime: Ory Laboratory), INR06 (Muscle Suit: INNOPHYS), INR11 (Little Keepace: TacaoF), INR21 (Neruru & Yumeru: T-arts), INR23 (KR-1000A: Clarion)
[344] E.g. INR24-IP33 (aams: bio sync)
[345] E.g. INR22-IP31 (kyūretto: Aronkasei)
[346] INR28-IP37 (Hug: Fuji Machine MFG) 00:26:19-00:26:55 潜在力はあると思うんですけれども、結局ロボットを買っていただく財源が国からって決まってるので、大きく国内で [市場が] 伸びることはないんじゃないかと思いますね。どちらかというと海外の方が、ビジネスとしてはおいしいのかなと思いますますけど。だからもし国内で [ビジネスを] やろうと思ったら、価格をグンと下げるとかしないとダメかな。
[347] INR02 (SAN Flower: Kato Denki), INR04 (OriHime: Ory Laboratory), INR06 (Muscle Suit: INNOPHYS), INR11 (Little Keepace: TacaoF), INR21 (Neruru & Yumeru: T-arts), INR23 (KR-1000A: Clarion)

The latter is the most mentioned reason. Thereby, the line of argumentation of the representative of Clarion is very typical and illustrates the logic behind this thought.

> *"After all, in Japan, while the number of elderly people increases, the number of people, who care decreases. The point is that more and more people have to receive service, but there is a negative spread of decreasing service providers. In order to balance this, I think we have to hire foreign workers or robots. There are still many hurdles to get people from overseas to come, so I think people should do it and should be replaced more and more by robots. So there is a demand"*[348]

The argument is, because there are problems to attract foreign workers, there has to be another way to solve the labor shortage, especially within the field of care. In this case, the assumption is furthermore that even the increase of female and older workers is not realistic. Consequently, technology and in particular, robotics, is the desired solution for the problem by makers and the government. This greatly simplifies the complexity of the original issue, whereby political countermeasures besides robotics exist and let the user-side out of the argumentation, which has to put the robots into their daily practices.

In addition, prober business channels for robots are still missing. Especially for companies which are not familiar with the field of care, there is the need to find their appropriate business channel, or in other words, their target market. The representative of Kato Denki explains this in a very illustrative way.

> *"[The market growth] is in the days ahead. […] There is a care company called Tsukui[349], which is doing day care service for the elderly. After that, the shoes maker Achilles[350] produces shoes with the SUN tag integrated and the three of us will start a project together. Now, nobody knows about this product, nor does anybody know that you really will be found, if you use it [the shoes with the integrated sensor] this way. We were able to experiment, but as a business, we still have not found sales channels for customers, and I think this will be from now."*[351]

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[348] INR23-IP32 (KR-1000A: Clarion) 00:21:09-00:21:51 やっぱり日本ですと年寄りが増える一方、介護する人がどんどんいなくなってる。要はサービスを受ける側はどんどん増えるのに、サービスする側は減っていくていう逆ざや状態になってるんで、それを補うためには、やっぱりロボットか海外からの労働者っていうのを雇わなきゃいけないかなと思ってます。海外の方に来てもらうっていうのはまだいろいろハードルがあるので、今人がやっていて、代われるところはどんどんロボットが代わっていかなきゃいけないと思います。だから需要はありますね。

[349] More information about Tsukui are under the company's website: https://www.tsukui.net.

[350] More information about Achilles Shoes can be found on the company's website: https://www.achilles-shoes.com/.

[351] INR02-IP03 (SAN Flower: Kato Denki) 00:13:57-00:15:05 これからです。[…]ツクイさんっていう介護事業者さんで、お年寄りへデイケアサービスをやってる方々なんですね。あと、靴メーカーのアキレスさんにこの小型の SAN タグがポケットに入るような靴を作ってもらって、3 社合同でプロジェクトを始めます。まだまだ、製品そのもの [センサー搭載の靴] もみんな知らないでしょうし、こうやって使っていただくと本当に見つかるっていうことも、誰も知らないんです。実験するものはできたんですけど、ビジネスとして、お客様に使っていただける販売チャネル [チャンネル] がまだできてないので、これからだと思ってます[…]。

The quest of finding the right business channel illustrates three issue: first, the problems of empathy for the field of care; second, a business plan which is worked out during development; and third, a lack of awareness of robots among society. The companies themselves could solve the first two issues. The government could provide further guidance with the business plan after the development process is over. The last issue is more complicated, because it needs more time to foster awareness. Market potential is great, but the market size remains small because there is still resistance to using robotic devices. Diffusion would move forward faster if care robots would become a target of care insurance.[352]

There is a small group of companies that sees the chances for robotic devices on the care market as difficult.[353] The reason for this is that very positive forecasts with their delightful growth expectations are hard to believe. The representative of Nabtesco explains his skepticism in detail.

> *"METI predicts 400 billion yen in 2035, but it is unlikely that this will happen. In fact, as a Japanese citizen I like the word cordiality. So you are always told 'Are you going to be cared for by a robot?' Moreover, there is the living environment situation in Japan and since compact and lightweight things are required simultaneously, there are core users, but no standard [user]. The market for care robots is growing rapidly now, but I think it's probably going to settle down around ten to 20 billion yen."*[354]

There is no doubt about the fact that the market for care robots will grow, but it is simply hard to believe that the market will grow so fast and so big. Now there are too many obstacles, such as the mindset within the field of care and also within society, to overcome before care robots will find their way into the work routine of caregivers. The representative of Ryoei, goes even further with this skepticism when he states "*The [care] industry says that the size [of the market] doesn't ever rise, as the government says. It won't become so big and it isn't such a sweet industry. They [representatives of the industry] told us that if you want to make money there, Ryoei was clearly told that we better stop.*"[355] This statement clearly illustrates that it cannot be said that the care industry is

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352 INR21-IP30 (Neruru & Yumeru: T-arts)

353 INR07 (i-me:ma: Kito Seiki Seisakusho), INR08 (ROBO snail: Ryoei), INR14 (Flagship Model: Nabtesco)

354 INR14-IP21 (Flagship Model: Nabtesco) 00:37:42-00:38:44 今経済産業省が 2035 年に 4000 億円という予測をしていますが、そうなるとは思いにくいです。実際日本人の国民性として、心のこもったとかいう言葉が好きなんですよね。そこで必ず「ロボットに介護されるんですか？」って言われるじゃないですか。プラス日本の住環境事情っていう住んでる環境の事情があって、コンパクトで軽くてっていう点も並行して求められるんで、コアユーザーはいらっしゃるけど、スタンダード [ユーザー] にはならない。今介護ロボットの市場はどんどん伸びてきていますけれども、やっぱり 100 億～200 億で落ち着くんじゃないかと思います。

355 INR08-IP13 (ROBO snail: Ryoei) 00:43:07-00:43:33 その [市場] 規模が、国が言っているほど、福祉のニーズが右肩上がりに高くなっていくというようにはならないと、 [介護] 業界の方は言っていますね。そ

simply welcoming robots, and this limits this validity of market forecasts. The difference between the current state and the predicted 400 billion yen in 2035 is simply too large, and the forecasts remain vague about how this multiplication of size will be achieved.

In fact, all of the companies feel some kind of problem for broad diffusion within society (IQ7.2, IQ7.2.1), regardless of optimistic assessment of the future of care robotics. Only one gave no useable response[356]. Thereby the problems can be categorizable as follows (see Figure 6-16): The cost of the robot, the mindset within the care industry and technology-driven inventions.

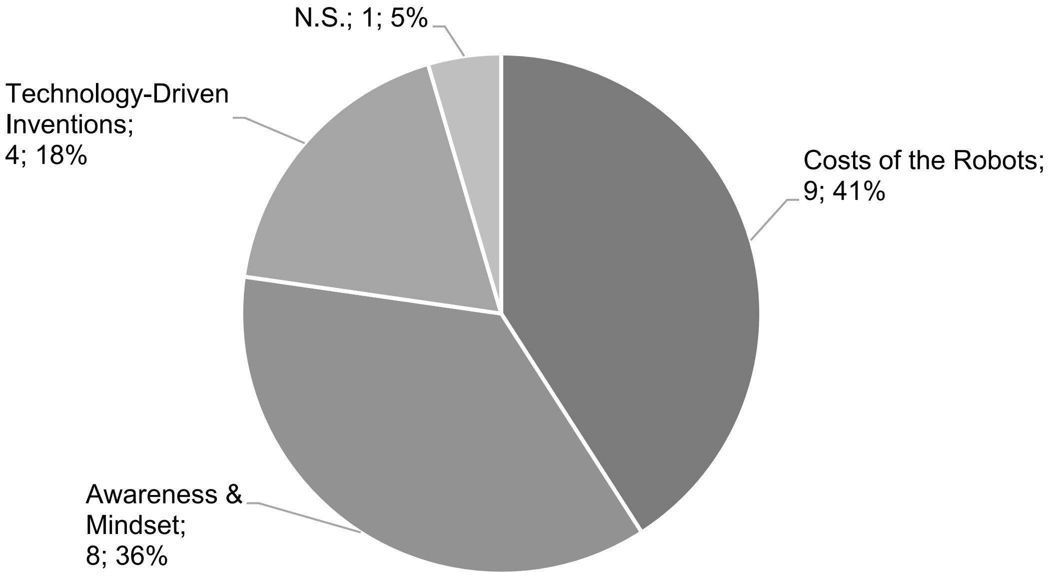

Figure 6-16 Obstacles for the Diffusion of Service and Care Robots (Multiple Responds Possible)

Almost half of the companies[357] which develop care robots see the costs of the robot itself as the main obstacle for stagnate diffusion. At the same time, even the developers feel a high demand for technical solutions for the field of care. However, the financial situation of care facilities is not good and for this reason, the suggestion of the developers is to provide considerable financial resources to make it easier to purchase robots. The

こまで多くはならない、そんなにおいしい業界ではないですよ、と。ここで儲けようとしているなら、リョーエイさんはやめておいた方がいいとはっきり言われました。

[356] INR10 (aijō-kun: Art Plan)

[357] INR07 (i-me:ma: Kito Seiki Seisakusho), INR11 (Little Keepace: TacaoF), INR13 (resyone: Panasonic), INR14 (Flagship Model: Nabtesco), INR21 (Neruru & Yumeru: T-arts), INR22 (kyūretto: Aronkasei), INR23 (KR-1000A: Clarion), INR26 (Dreamer: Santec), INR28 (Hug: Fuji Machine MFG)

representative of Clarion speaks frankly about this topic when pointing out that, *"the field of care, in other words, the care facilities have no money. Even if there is a good robot and they really want to use it, if it is expensive, there is no financial source and for this reason, the country has to subsidize and make it possible to put a robot into the facilities for a cheap price. I think this kind of national measure is necessary."*[358] Already at this point the question remains if subsidies can solve the whole problem of stagnating diffusion. The representative of Fujisoft is more critical about this and provides a more detailed explanation.

> *"When actually going to various care facilities, the [market potential] is very high. After all, there is much heavy work, and in fact, there aren't many places, where care robots have been implemented. However, the biggest bottleneck are the costs, because they [care facilities] have no money and there are many places that can reach out [to buy a care robot]. At this point, if the care insurance and subsidies flow well into the care industry and maker don't just wait for it, but rather try to show the effects, robots will eventually diffuse within society. In fact, there is a high demand, but I still feel that that there is no balance [between the cost and demand side]."*[359]

It is not only the subsidies and about care robots as a target of care insurance, but also about the developers becoming proactive. The developers are responsible for the success of their inventions as well. Their first step is that there is an urgency to understand the needs of the care industry, and in particular the workflows within a care facility. The second step is to develop creative solutions for existing demands and then trying to adjust their inventions to the field, or even better, letting the user participate in development already at an early stage.

However, there is another aspect related to this problem: The combination of uselessness and high costs are two points for stagnant diffusion. It is not only the high costs and limited financial resources that the care facilities can use, it is rather more the low price-value ratio of the care robots available on the market. The representative of Panasonic become quite clear about this when pointing out that, *"It is often said that robots have a*

[358] INR23-IP32 (KR-1000A: Clarion) 00:22:03-00:22:32 介護の世界、要は介護施設とかはお金を出せない。いいロボットができたとしても、それが高いものだと、本当は使いたいけど、財源がないんでっていうところで、そういうところを国が補助して、安い値段でロボットを施設に入れていってあげるっていう国の施策が必要かなと思いますね。

[359] INR15-IP22 (palro: Fujisoft) 00:22:10-00:23:14 実際色々な介護施設に行っていると、非常に [市場潜在力が] 高いと思っています。やっぱり負担の大きい仕事が多く、実際介護ロボットが導入されていないところも多いんですね。ただ、一番ネックなのがコスト面、[介護施設は] お金を持ってないので、どうしても[介護ロボットを買うこと] そこに手を伸ばさないところが多いんです。そこは介護保険とか補助金がうまく介護業界に流れ、かつメーカー側もそれを待ってるだけではなくて、効果を示すための足固めをしていれば、ゆくゆくはロボットが社会に広がっていくのではないかと思います。実際ニーズは高いんですが、まだ [コスト面とニーズ面の] そのバランスが取れてない気がします。

cost problem. In addition, they are useless and not useful. It is good that they are designed, but, in fact, I think that they are not useful in practice are two points [of that problem]."[360] It is undeniable that there is great potential, because care robotics have not diffused and there is high need and urgency to improve the situation within the field of care. In this context, the actual high costs limit diffusion, but not only are the costs an obstacle; also, the limited application possibilities limit diffusion. For the latter, it is not the costs that have to decrease, but rather the technology has to improve.

Almost half[361] of the companies declared the mindset within the care industry and the awareness of care robots as the diffusion issue. Thereby, a quarter[362] of these companies view the persisting mindset within the field of care as an obstacle for the diffusion of care robots. At the same time, the low presence of care devices in general and the tendency to do care by hand give care robots a difficult position. If care devices in general are not used, how should robotic devices become part of the daily work routine? The governmental activities, and especially the promotion centers, play an important role for disseminating information about current developments and the benefits of robots among the public. In the long term, this increases the awareness of robotic devices and fosters a rethinking of current work practices. When people do not know what is technically feasible, wrong expectations lead to low acceptance, or rejection, of technology. For diffusion, there is the need of fostering knowledge of robots before everyone can use them. The representative of Ryoei explains this context very clearly.

> *"There is an increasing awareness among the general public about the actual technical level of machines and what the ISO [international safety standard] and that useful things are dangerous. In that case, I think the way of thinking will change when becoming more familiar with the thought of how dangerous things will become useful. I think that you need to know nothing about machines and can use care robots, such as we use TVs and washing machines. Those who are asked to use the robot have to do it consciously without worries, and in order that everyone is able to use it, you still need to understand [at the moment] the robot itself and machines. For that purpose, I heard that the producers have to make efforts for society."*[363]

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[360] INR13-IP20 (resyone: Panasonic) 00:20:50-00:21:04 ロボットはコストの問題が良く言われますね。もう一つは使えない、役に立たないと。作ってもらったのはいいけど、実際現場では使い物にならないというその[問題の] 二つの点だと思います。

[361] INR03 (smile baby: Togo Seisakusyo), INR04 (OriHime: Ory Laboratory), INR06 (Muscle Suit: INNOPHYS), INR08 (ROBO snail: Ryoei), INR12 (RT.1/ RT.2: RT.Works), INR24 (aams: bio sync), INR29 (Tecpo: Shintec Hozumi), INR39 (Sasuke: Muscle)

[362] INR04 (OriHime: Ory Laboratory), INR06 (Muscle Suit: INNOPHYS), INR08 (ROBO snail: Ryoei), INR24 (aams: bio sync), INR39 (Sasuke: Muscle)

[363] INR08-IP13 (ROBO snail: Ryoei) 00:44:18-00:45:28 一般の方にも、機械はどういうステップを踏んで設計されているか、国際安全規格の ISO がどんなものかという認識が広まって、便利なものは危ない、それなら危ないものをどう使っていけば便利になるかという考え方が身についていけば変わっていくと思います。介護ロボットは、テレビや洗濯機といった家電のように、機械のことを何も知らなくても扱えるものじゃないと思います。ロボットは、それを使ってもらう方の意識、安心してみんなが使えるようになる

This shows that wrong expectations can easily connect to low acceptance or even rejection of technology, when people do not know what is technically feasible or available. For that reason, there is an urgency to foster general knowledge of robots as a foundation for diffusion within society. The example of the car illustrates this very well[364]. It is indisputable that many people die in car accidents every year, and yet people use cars because there is a social consensus about the benefits of this technology. For the technology of the car, society did a risk assessment on expected risk and benefits with the result that the benefits outweigh the risks. This has to happen for care robots as well, and providing information is the foundation for this social discussion. An obligatory use of care robots can be a way to boost this process[365], because it forces people to deal with care robots and get used to them rapidly, so that it might be possible to eradicate prejudices and misunderstandings.

The rest of this group[366] believes that the lack of awareness of care robots is the major hurdle for care robots. The example of smile baby of Togo Seisakusyo clearly illustrates how companies struggle with the low awareness of their inventions. In the words of the developer of smile baby, "*There is no awareness [of the smile baby/ robots]. Since it [smile baby] was taken up on television in the Chūbu region, such as Aichi prefecture, there is some awareness, but there is no awareness so far in Japan as a whole, including in the Kantō and Kansai region […].*"[367] The actual issue is not the low awareness itself, but rather its consequences. For companies, it leads to only a few or no business inquiries and thus keeps sold units low. For the field of care, it leads to a persistence of the state of the art with a high fluctuation of staff due to high physical and psychical burdens. This is also partly an answer to the lack of information thesis (see Chapter 1.2). In the end, the persistent mindset of the care sector and low awareness are mutually dependent. The solution to this probably is simply to bring care robots closer into the care site and society. This will little by little lead to discussion, and a social consensus on this topic will close the interpretative flexibility about how this technology can create a benefit for society. This in turn will little by little change the mindset within the field of care, opening it to the implementation of care robots, and thus initiate broad diffusion.

には、[今のところに] まだまだロボットそのもの、機械のことを理解してもらう必要があるでしょう。そのためにも作り手が社会に対して努力していかなくてはいけないという話を聞いたことがあります。

364 INR06-IP11 (Muscle Suit: INNOPHYS)

365 INR04-IP06 (OriHime: Ory Laboratory)

366 INR03 (smile baby: Togo Seisakusyo), INR12 (RT.1/ RT.2: RT.Works), INR29 (Tecpo: Shintec Hozumi)

367 INR03-IP05 (smile baby: Togo Seisakusyo) 00:33:30-00:33:58 [スマイビ・ロボットの] 知名度が無いです。愛知県などの中部県内ではテレビで取り上げられたりするので、その範囲での知名度はあるんですけど、関東、関西を含めた日本全体で考えるとまだそこまでない […] 。

The remaining companies[368] are the self-critical ones, because they view the often technological-driven development of robots as the main problem for the current low diffusion rate. The issue is simple, and the representative of Sanyo Homes gets to the heart of it when pointing out: "*What I simply think is that everyone is proud of their machine, and that they can't sell with just boasting of their great machines. […] Even if you accumulate and create so much technology, the elderly, who are the target, haven't asked for this."*[369] There is the tendency of technology centrism on the engineer's side, who develops, because he can and wants to design, the best robot that is possible regardless of user needs. This inevitably leads to a gap between the developer and the user side, and only the inclusion of the user can avoid this gap, which as soon as the prototype of the robot is developed is difficult to correct.

In addition to this, care robotics as a field is still at its very beginning and there are many problems to solve. The representative of Toyota Motors speaks frankly about it when stating, "*Speaking for robots in general, since technology isn't developed enough, and it isn't possible to get into a big market. On the other hand, among the current technologies, there are unique ideas that can produce a great market value.*"[370] Even if there are some shining examples such as paro or HAL that catch a lot of attention, technology is not advanced enough to be applied within care facilities on a broad scale. Only a rising awareness on the current state of technology, and building up a relationship with the field already on an early stage, can solve the issue of technology and technology-driven development.

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[368] INR01 (HSR: Toyota Motor), INR02 (SAN Flower: Kato Denki), INR15 (palro: Fujisoft), INR27 (yorisoi robotto: Sanyo Homes)

[369] INR27-IP36 (yorisoi robottto: Sanyo Homes) 00:36:51-00:37:27 単純に思うのは、皆さん機械 [性能] 自慢をしてしまうんで、こんなにすごい機械ができたよっていう自慢だけでは売れないと思うんです。[...] そんなに技術を集めて作ったとしても、対象となる高齢者はそこまで求めてないと。

[370] INR01-IP01 (HSR: Toyota Motor) 00:30:27-00:31:12 ロボット全般に関して言うと、一つはまだ技術が足りていないので、大きな市場に踏み出せない、その一方で、今ある技術の中でも、ユニークな発想でものすごい市場価値を生み出しているものもあります。

The next step (IQ7.2.2) is to think about how to improve the current situation (see Figure 6-17). Apart from four companies with no usable response[371] and two single suggestions[372], two major suggestions emerge which are intended to lead to better diffusion: Considerable financial support[373] and the persuasion of the field[374].

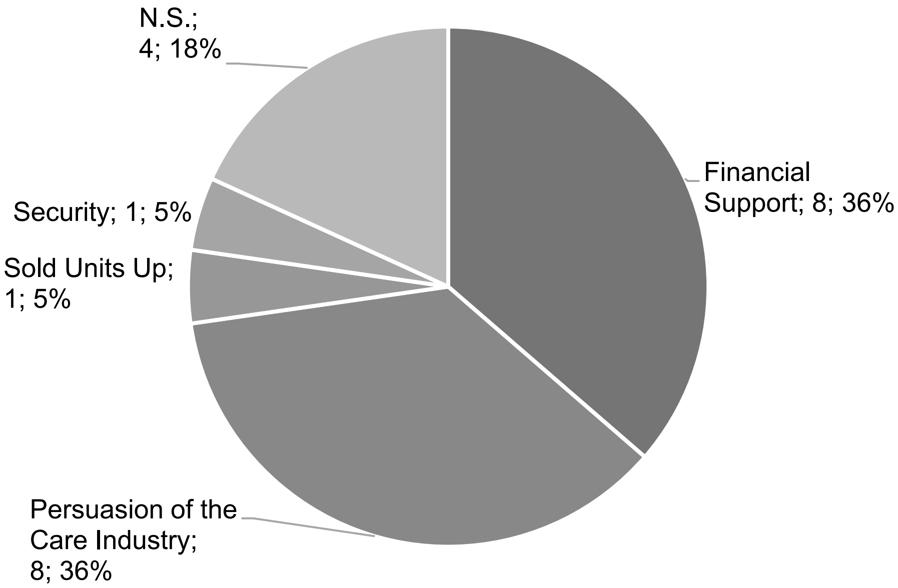

Figure 6-17 Necessary Improvements for the Diffusion of Service and Care Robots (n=22)

On the one hand, the suggestion is that subsidies for implementation or coverage by the care insurance system will leverage care robots. Thereby there is a balanced ratio between the group of companies that favor subsidies[375] and the group that favors coverage by care insurance[376]. Regardless which of the two mentioned suggestions is favored,

[371] INR11 (Little Keepace: TacaoF), INR12 (RT.1/ RT.2: RT.Works), INR15 (palro: Fujisoft), INR26 (Dreamer: Santec)

[372] The two robot projects with a single suggestion, which fit to none of the categories are INR01 (HSR: Toyota Motor) and INR07 (i-me:ma: Kito Seiki Seisakusho). The former suggests an improvement of security and the latter the need for more sold units to lower the price through economies of scale.

[373] INR02 (SAN Flower: Kato Denki), INR03 (smile baby: Togo Seisakusyo), INR10 (aijō-kun: Art Plan), INR14 (Flagship Model: Nabtesco), INR21 (Neruru & Yumeru: T-arts), INR22 (kyūretto: Aronkasei), INR23 (KR-1000A: Clarion), INR28 (Hug: Fuji Machine MFG)

[374] INR04 (OriHime: Ory Laboratory), INR06 (Muscle Suit: INNOPHYS), INR08 (ROBO snail: Ryoei), INR13 (resyone: Panasonic), INR24 (aams: bio sync), INR27 (yorisoi robotto: Sanyo Homes), INR29 (Tecpo: Shintec Hozumi), INR39 (Sasuke: Muscle)

[375] INR10 (aijō-kun: Art Plan), INR14 (Flagship Model: Nabtesco), INR22 (kyūretto: Aronkasei), INR23 (KR-1000A: Clarion), INR28 (Hug: Fuji Machine MFG)

[376] INR02 (SAN Flower: Kato Denki), INR03 (smile baby: Togo Seisakusyo INR14 (Flagship Model: Nabtesco), INR21 (Neruru & Yumeru: T-arts)

this approach clearly sets the responsibility for successful diffusion of care robotics on the government. This argumentation makes it easy for the developing companies especially when arguing for the need of subsidies, because they may shirk the responsibility to get a closer connection to the field of care and thus offer inventions on demand.

The suggestion to leverage care robotics through subsidies is grounded on two advantages. First, subsidies enable companies to sell their care robots at a certain price and thus produce a certain number of their robots, which in turn leads to lower production in general. The representative of Aronkasei points out these advantages when saying *"After all, when it is time, I want the government to support the implementation [of care devices] and enable the maker to produce a certain number. By doing so, the sourcing costs decrease and as a result, we can buy parts at low prices and cheaply supply them to our customers."*[377] The clear advantage is that the maker can sell the products and to a certain extent, the economics of scale lead to cheaper and more profitable production. Nevertheless, a higher number of robots put into the field of care also means the chance of getting better feedback on the technology and usability of a robot. This is an important factor to adjusting robots and getting closer to user demands.

Second, subsidies lower the inhibition threshold to get, and thus to use, care robots. The representative of Art Plan advertises the advantage of financial subsidies when saying

> *"So, not only robots, but assistive devices in general become needed. Under such circumstances, they have to be diffused. Nobody probably knows yet. It's finally the time, where they search if there is anything. The MHLW was carrying out the following, to cover 100% of the costs for one facility for assistive devices up to a limit of 3 million yen. Usually, half or 2/3, but I heard 100% for the first time. If that happens, everyone will raise their hand. So we [the maker] got business inquiries- At the same time they will search for information. It seems that you get subsidies, so what shall we buy. If there are no subsidies, nothing will be checked."*[378]

Financial subsidies for care robots reduce organizational risk and might be the incentive to try a certain type of care robot, because it reduces barriers and makes them more

[377] INR22-IP31 (kyūretto: Aronkasei) 00:25:35-00:26:00 やっぱりある時期になったら、国から [介護機器を] 導入するための支援をしてもらって、メーカー側に一定の台数を作らさせてほしいんですね。そうすることによって調達コストが下がりますんで、それによって我々も安い値段で部品が買えて、お客様に安く供給できると。

[378] INR10-IP16 (aijō-kun: Art Plan) 01:03:49-01:04:42 だから、補助器具はロボットという形に限らず必要になってくるんですよ。そういった中で、それはやはり普及させていかなければいけない。皆さんまだ知らないでしょう。今になってやっと、何かないかどこかで調べるんですよね。前厚生労働省がやっていたのは、1 施設当たり 300 万円を上限に 100%補助器具などの購入費用を負担していたんです。普通なら半分、もしくは2/3。100%なんて私も初めて聞きました。そうなったら皆さん手を上げてやりますよね。そこで私たち [メーカー側] のところにも問い合わせ来ましたね。そういうときは調べるんですよ。なんか補助金がもらえるらしいぞ、じゃあ何買おうっていう。 [補助金] それがなかったら何も調べない。

accessible for care facilities. It can serve as an advertising medium to create interest on the user side. Nevertheless, subsidies are a risky venture, because there is the problem of sustainability. Especially at the early stage of diffusion, subsidies lead to an artificial rather than natural demand. Through setting an amount that is too high, the beneficiary has only limited incentive to reflect the new technology. This applies for the maker, who expects further subsidies to distribute their robots and for the care facilities, because the need to extensively think about which technology fits best into their environment remains low. In other words, if the financial burden is too low, care facilities can purchase a robot which they, in the end, do not use and thus will end up putting in storage. It is a thin line to foster an emerging market or to spoil the developer and user side. A healthy market can only develop through steadily reducing subsidies and transferring them into a natural demand for new technology. The undeniable good thing about subsidies for care robots is that it can increase the interest of society, promote discussion about the use of technology and generate first experiences with this new technology. This triangle has to be transformed into a healthy market over the long term.

In contrast to subsidies, coverage through the care insurance system has several other advantages, because it forces rethinking of the insurance system and its topicality in general, and to redefine the future form of care. The redefinition of care insurance provides space to strengthen the position of care equipment in general. Regardless of care robotics, this revision of care insurance can be the critical incentive to switch from hand-based to equipment-based care, which not only connects a diffusion of care robotics, but rather leads to an increased quality of work. Against the background of demographic change and the expected care crisis, either way, there is the need to discuss the future of care within the government and society. The suggestion to improve the situation for the diffusion of care robots focusses on the user perspective rather than on developers. Care insurance adjusted to the current needs of care and the care recipient can close the interpretative flexibility, and thus the social discourse, about what contribution care robots can make within a steadily aging society.

On the other hand, other companies see the lever for successful diffusion in the persuasion of the field of care,[379] or the change of the care mindset[380]. In one way or another, the focus lies proactively on the user side and their expectation towards care robots. Thereby, the term persuasion refers to the act of making the field more familiar with the

[379] INR06 (Muscle Suit: INNOPHYS), INR13 (resyone: Panasonic), INR24 (aams: bio sync), INR27 (yorisoi robotto: Sanyo Homes), INR29 (Tecpo: Shintec Hozumi)
[380] INR04 (OriHime: Ory Laboratory), INR08 (ROBO snail: Ryoei), INR39 (Sasuke: Muscle)

benefits of robotics, which they might have not thought about before. The representative of INNOPHYS sees the main problem for the low diffusion of care robots in the persisting mindset of hand-made care, and the resulting aversion to care devices and technology in general. There is the need to convince the care sector about the technological benefits, as he argues when pointing out, "*In Japan, people who care are conservative and they have to use new things. They don't understand [the benefits of new things] easily. […] You have to take people with no resistance to machines, and spread their feedback 'it was good to use'*."[381] His idea is to start with the caregiver with a high technical affinity, who give good grades to care robots and with this feedback, you can convince non-innovators. The positive feedback and a steadily increasing circle of supporters within the field of care can then actuate a diffusion process within society.

In the end, even the act of persuasion requires changes to the current mindset within the field of care. The representative of Ory Laboratory is convinced that current care robots face the problem that there is still no need to make use of robots when arguing that:

> *"It's a time, when you don't have to use a robot, but from now it will be the phase, when it's says 'yes, let's use a robot'. For example, everyone thinks 'yes, let's use the phone' and nobody wants to move from there. When you try to implement a new system, how do you explain its effects? You explain and try to be understood that with this you can do things that you haven't been able before. Then there is a rather big wall, when it comes to the action."*[382]

Care robots are a new technology and care robotics itself is a new field. For this reason, an existing and comparable equivalent is likely to lead to smoother acceptance and integration into the field of care and its workflows. This equivalent is care devices in general. From a theoretical perspective, the existence of the functional equivalent (see Chapter 2.5) can pave the way for a new technology, in this case care robots, and this in turn can change the work routine within the field of care into an era where robots are needed. Visionary speaking, it is the transition from traditional into a new era which overcame all current obstacles. However, the representative of Muscle sees the urgency to change

[381] INR06-IP11 (OriHime: Ory Laboratory) 00:33:55-00:35:00 日本の場合、介護する人がコンサバティブで、新しいものを使うということを怖がる、嫌がる。[新しいもののメリットを] なかなか理解してもらえない。[…] 機械に抵抗のない人から使いだしてもらって、「使って良かったよ」という口コミの声で評判を広めてもらうこと。

[382] INR04-IP05 (OriHime: Ory Laboratory) 00:24:01-0024:36 まだロボットを別に使わなくてもいいじゃんっていう時代だけど、これからは「ロボットでいいじゃない」というフェーズになってくる。例えば、いまみんな「電話でいいじゃない」って思っていて、そこから動きたくない。新しいシステムを導入しようと思った時に、その効能をいかに説明するか。これがあれば今までできなかったような、電話だけじゃなくてこういうことができるようになるよ、ということを説明して、かつ理解してもらった、そしたら行動させようかというところになると、結構大きな壁がある。

the existing way of how inventions reach the field when criticizing “*if we don’t start to change the way of thinking [not using care devices] and the structure of the field of care, with only delivering things and say please use it’ [care robots] they probably won’t diffuse.*”[383] The solution to this issue might be a robot quota or an obligation to use robots for specific tasks. Especially at the early stage of diffusion and a gridlocked situation, the obligation to use a specific technology leads to rethinking of existing work patterns and connects to a new way of working. However, this approach must include care devices in general, because otherwise it falls too short. The change of the existing way of working and the attitudes towards care devices can help to achieve MHLW’s goal to reduce the burden within the field of care. At this point, an obligation to use care devices and robots might make a difference.

The assessment of ministerial activities (IQ7.2.3) towards the development and diffusion of care robots shows the awareness of the different fields of competence. Even if MHLW is involved, METI is the main contact for developers and their companies. Thereby, the argument is that first there has to be a certain production number to reduce costs, and in the next step making robots the objective of care insurance.[384] Since care robots are still in the early days and robots have to be innovative, it might not be a surprise that METI has the lead role. Half of the companies evaluate the activities of the government, mainly represented through METI and MHLW, as positive[385] and four gave no usable response to this question[386]. However, there are also companies that evaluate the ministerial activities as ambivalent[387] and there are critical voices, too[388]. The former sees a problem within the field of competence of the involved ministries. Both representatives of TacaoF talk about this frankly.

> *IP17: “I have the impression that MHLW sees the safety of the elderly in the first place. And METI, oh.”[389]*

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[383] INR39-IP53 (Sasuke: Muscle) 00:38:50-00:38:58 [介護機器を使わない] そういう考え方とか仕組みから現場を変えていかないと、モノだけ渡して「どうぞ使ってください」っていうのでは [介護ロボットが] 多分普及はしない。
[384] INR01-IP01 (HSR: Toyota Motor)
[385] INR01 (HSR: Toyota Motor), INR03 (smile baby: Togo Seisakusyo), INR06 (Muscle Suit: INNOPHYS), INR07 (i-me:ma: Kito Seiki Seisakusho), INR08 (ROBO snail: Ryoei), INR12 (RT.1/ RT.2: RT.Works), INR13 (resyone: Panasonic), INR14 (Flagship Model: Nabtesco), INR15 (palro: Fujisoft), INR22 (kyūretto: Aronkasei), INR24 (aams: bio sync)
[386] INR02 (SAN Flower: Kato Denki), INR10 (aijō-kun: Art Plan), INR21 (Neruru & Yumeru: T-arts), INR27 (yorisoi robotto: Sanyo Homes)
[387] INR11 (Little Keepace: TacaoF), INR39 (Sasuke: Muscle)
[388] INR04 (OriHime: Ory Laboratory), INR23 (KR-1000A: Clarion), INR26 (Dreamer: Santec), INR28 (Hug: Fuji Machine MFG), INR29 (Tecpo: Shintec Hozumi)
[389] INR11-IP17 (Little Keepace: TacaoF) 00:30:45 -00:30:54 厚労省の方も、高齢者の安全とか、そういうところを第一に見てるっていう風な印象があったのかなっていう風に感じますが…。経産省はね。

> *IP18: "The METI doesn't have a result. They developed robots, but they haven't been marketable at all, so I think it would have been better to look, from a practical perspective, at products that go into circulation."*[390]

The argumentation is that the different focuses of the ministries with METI focusing on developers and MHLW on the care industry inevitably lead to problems. Thereby the problem is that the promotion of only development, and in the end marketable products, does not necessarily connect to an assumed market. To avoid such problems, a centered approach that gives all the competence to one ministry instead of two is needed. The critical voices on ministerial activities illustrate this further. The representative of Clarion becomes even clearer when he says, *"[the ministries] are doing various activities, but in the end this hasn't reached the field. They are doing something, but it doesn't reach reality. At this point, I think it isn't an activity that really considers the field."*[391] Especially the approach of METI, which primarily supports companies and promotes the development of marketable products, is problematic, because it forgets the needs of the assumed target market. Of course, there might be a chance to develop a robot that the caregiver accepts from the beginning, but with a significant number of companies from non-care related fields with no experience, the development of this instant wonder is unlikely. In addition, different fields of competence make it more difficult to coordinate development and diffusion efforts for care robots effectively.

The answer to the question (IQ7.3) of who is responsible in the case of a robot caused accident (see Figure 6-18) reveals a mixed and divided result with not all of the companies replying to the question[392].

[390] INR11-IP18 (Little Keepace: TacaoF) 00:30:55-00:31:08 経済産業省は結果がちょっと伴ってないんですね。ロボットを開発はしたけど、それが全然市場化されてないので、もう少し現場だったり、流通するような商品っていうところを見越してもよかったのかなぁと思いますね。

[391] INR23-IP32 (KR-1000A: Clarion) 00:23.04-00:23:26 [主務省] 活動をいろいろやってはいるんですけど、結局それはなかなか実現場まで落ちていない391。やってはいるけど実になっていない。というところで、本当に現場のことを考えたような活動になっていないのかなと思ってますね。

[392] INR03 (smile baby: Togo Seisakusyo), INR07 (i-me:ma: Kito Seiki Seisakusho), INR10 (aijō-kun: Art Plan), INR12 (RT.1/ RT.2: RT.Works)

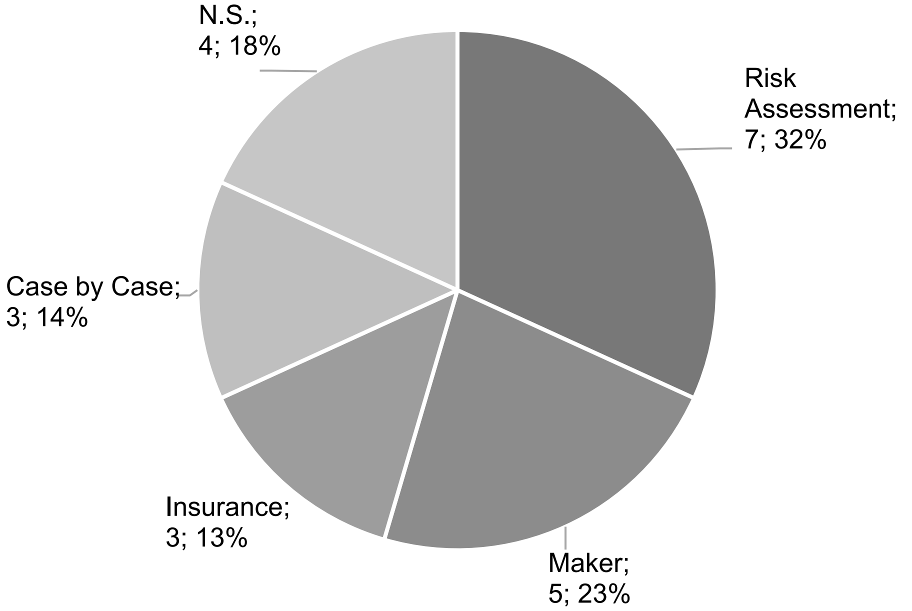

Figure 6-18 Responsibility for Accidents caused by Care Robots (n=22)

Ahead of the answer to the question, who is responsible in the case of an accident caused by a robot, the majority[393] of companies see the necessity of risk assessment not only within the organization, but in particular on a social level. All involved relevant social groups have to weigh all the options and possible scenarios before they declare themselves in favor of care robots or against them. Thereby discussion is not limited to security itself, but rather has to evaluate benefits in relation to the risk of this technology. The representative of Muscle gives an illustrative example when he talks about the attitudes toward the use of cars.

> *"There are many people in the country, who go on security. It is useless if there are zero accidents, and that they won't allow it otherwise. I ask them 'which do you think is more dangerous, the care or bike that are driving there?' and then everyone says the car is more dangerous. Then I ask 'why do you allow this, but don't allow the other?' After all, there has to be a balance between the risks and benefits, and if it is beneficial, some risks should be tolerated. In the case of the car, this is guaranteed with training and insurance. To get a license, you have to learn how to use it and use it safely. Those who pass it receive a license, and only those people can drive. The other is that even if something goes wrong that you can cover it with insurance and don't damage your own life. So that you can use it with a sense of security. I also want that robots become like this."*

[393] INR02 (SAN Flower: Kato Denki), INR04 (OriHime: Ory Laboratory), INR08 (ROBO snail: Ryoei), INR15 (palro: Fujisoft), INR27 (yorisoi robotto: Sanyo Homes), INR29 (Tecpo: Shintec Hozumi), INR39 (Sasuke: Muscle)

It is indisputable that every year many people die in car accidents, and yet the car is the favored means of transport. In the case of the automobile, society closed the discussion on how to use this technology. It achieved consensus on its usage and thus the interpretative flexibility disappeared. For integration into the daily work routine in care facilities and diffusion on a social level, care robotics have to go through the same process. At the end of this process, the result must be in favor of the benefits of care robotics, because otherwise the motivation to use this technology will remain low. Thereby it is helpful to realize and not forget the fact that every technology entails risks, and only an evaluation that includes all relevant aspects leads to broad acceptance within society. The answer to the security aspect can be a license system[394], e.g. with the ISO13482 for personal robots (ISO 2014).

Apart from that, makers have the responsibility to inform the end user about the technical possibilities and connected risks[395]. This communication process is important to foster awareness and in doing so to enable society, namely the user, to form an opinion about care robotics. In the course of this, the training of potential end-users is one way to gain understanding and knowledge about care robotics[396]. The provision of information and the training of the user complement each other and build the foundation for a future societal discussion on the topic. Nevertheless, to avoid an imbalance through the developing companies, a risk assessment of new technology has to include all relevant social groups, and in particular the future user, without pushing the responsibility for the outcome to only one side.

The second largest group is the one of the companies[397] that see the responsibility not on the user, but on the maker side. It may be useful to extend the circle of responsibility to welfare organizations, which integrate care robots into their workflow[398]. This conception of responsibility in the case of an accident strengthens the position of the user. Having said this, companies are likely to bear only the incurred costs of accidents based on technical reasons, and they exclude misusage-based accidents. A good example for this approach is the car[399], whereby makers are liable for technical issues, such as suddenly inflating airbags. Against this background, it is essential to establish a certain security

[394] INR29-IP38 (Tecpo: Shintec Hozumi)
[395] INR15-IP22 (palro: Fujisoft)
[396] INR02-IP03 (SAN Flower: Kato Denki)
[397] INR11 (Little Keepace: TacaoF), INR14 (Flagship Model: Nabtesco), INR21 (Neruru & Yumeru: T-arts), INR23 (KR-1000A: Clarion), INR24 (aams: bio sync)
[398] INR11-IP17 (Little Keepace: TacaoF)
[399] INR21-IP30 (Neruru & Yumeru: T-arts)

standard[400] which can be relied on in the case of an accident, and which simplifies further procedures.

After answering the question of responsibility, it is important that all actors involved in the use of care robots can react to occurring consequences. Some kind of an insurance system could solve, or at least improve, the situation[401], especially for developers to protect themselves against the risk of high claims for compensation. Again, the automobile provides a good example, because the experience with how to handle the consequences of accidents can serve as a blueprint for care robotics. The representative of Aronkasei clarifies his expectations on the establishment of security standards.

> *"It depends on the cause, but most of the responsibility is on the maker side. However, as for the country, I hope that the standards for such robots will be prepared sooner. Because we [as makers] produce goods on the base of these plans. In the case of an accident caused by a failure, which isn't conform to the standards, it is the responsibility of the maker."*[402]

Thereby, security certification ensures a certain standard and clarity, when the makers are responsible for technical deviations or issues resulting from e.g. material-related deviations and defects. Security certification is an important step to making an environment which is able to integrate care robots into everyday care available. Insurance can cover uncertainties on the maker side, but also on the user side, as it is in the case of the automobile.

Finally, yet importantly, since it is a young and emerging field, the experience with this new technology is limited and furthermore no test cases exist. When the field matures, some kind of standardization on how to react to issues resulting from human-robot-interaction will develop. Until this point, a case-by-case pattern might solve the question of responsibility[403]. However, technical progress will make the judgment more complicated. The representative of Panasonic poses the problem of autonomy when saying, "*When it becomes a robot with autonomy, I think it will be a difficult problem, when an accident occurred due to the autonomy. Nowadays, even if it is called a robot, it only moves as*

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[400] INR24-IP33 (aams: bio sync)

[401] INR01-IP01 (HSR: Toyota Motor)[401], INR06-IP11 (Muscle Suit: INNOPHYS), INR26-IP35 (Dreamer: Santec)

[402] INR22-IP31 (kyūretto: Aronkasei) 00:27:33-00:28:01 原因にもよるんですけど、大部分の責任はメーカーサイドにありますよね。ただ国としては、そういうロボットに対する規格はもっと早く準備してほしいですよね。その企画に従って我々 [はメーカー] が商品を造るので。規格に沿っていないことが原因である事故に関しては我々メーカーの責任になります。

[403] INR13 (resyone: Panasonic), INR22 (kyūretto: Aronkasei), INR28 (Hug: Fuji Machine MFG)

instructed by a human, so I think that isn't different from an ordinary machine."[404] For now, to some extent, the technical possibilities limit the scope of damage. Accidents that occur within the human-robot-interaction dominated by the human are less complicated than the future interaction with robots, whereby the robot might get the lead position. The latter topic area is much more complex and cannot be solved by the maker alone. For example, Matsuzaki and Lindemann (2016) posit their discovery of an autonomy-safety-paradox within service robotics. According to the authors, the paradox is that, on the one hand, more security supports the autonomy of robots, but on the other hand, autonomy leads to the higher likelihood of an accident. The robot's autonomy in turn creates the complex issue of who is responsible for the accident. There is a need for fundamental discussion on a societal level, which includes philosophers and ethicists.

6.8 Category 8: Expectations towards Care Robots

The first four categories are the foundation for understanding the robot projects in their full complexity, including the personal motivation (see category 6.1), the development and project environment (see category 6.2 and category 6.3) and the connection to the field (see category 6.4). In the following, two categories will highlight the robot project's future development plan (see category 6.5) and related development issues (see category 6.6). The remaining categories are uncoupled from the companies' specific robot projects and development efforts. Thereby, the developers serve as experts within their field and their assessment of current developments are valuable to draw a picture of the nature of the present situation. The previous category focuses on market-related issues and the general problems for the diffusion of care robots (see category 6.6). This chapter deals with national and international expectations of care robots. The complexity of expectations divides into three topics: International development of robots, characteristics of Japanese robots and expectations of technology. The information about this category can be found in chapter 4.3.8.

The most apparent finding about the evaluation of foreign (IQ8.1) and Japanese (IQ8.1.1) robot development is the lack of knowledge about robotics itself. Even among the group of developers, who should be familiar with the state of the art and are likely to have better

[404] INR13-IP20 (resyone: Panasonic) 00:24:54-00:25:14 自律性のあるロボットになると、その自律性に起因して起こった事故というのは厄介な問題になると思います。今はロボットと言っても、人が指示した動きしかしないので、その範囲では、普通の機械と変わらないと思ってます。

access to topic-related information, the response rate remains low. 15 of the 27 interviewed developers[405] could not respond or specify the state of foreign robot development, nor could classify Japanese robotics in an international context. On the basis that even the engineers are not well informed about their own topic, it is unlikely that the population is better informed. One developer[406] suggests starting to begin even one step earlier with information about care devices in general before discussing the state and future of robotics.

This is an important insight to answering the lack of information thesis (see Chapter 1.2). The lack of available information about recent developments in international robotics within Japan makes it difficult to realistically evaluate robotics[407] and set Japanese development activities into a broader context. The access problem of information, and the lack of knowledge about robotics among engineers and within society, sets a difficult base for fast and broad diffusion of robots within society, because it rather leads to misunderstandings and misconceptions that probably turn out to be obstacles for using robots.

The responses of the ten[408] developers who were able to answer the question on the characteristics of foreign robotics (IQ8.1) show a clear result (see Figure 6-19): Above all there is the prevailing view[409] on foreign, and in particular American, robot development as a pioneer spirit-based or military-driven robot development. In this connection, it is worth mentioning that even inventions resting upon a pioneer spirit have a high probability to be influenced by funding from the military or its guidance. In comparison to Japan, where robot development is more decentralized among various ministries, the robotic research under the DARPA umbrella, with its solid financial backing, brings in general different possibilities to design robots. On the one hand, DARPA as one organization bundles efforts to develop robots, which especially includes the localization of financial resources and on the other hand, the motivation to develop robots is rather a

[405] INR02-IP02 & INR02-IP03 (SAN Flower: Kato Denki), INR03-IP04 & INR03-IP04 (smile baby: Togo Seisakusyo), INR07-IP12 (i-me:ma: Kito Seiki Seisakusho), INR08-IP13 (ROBO snail: Ryoei), INR10 (aijō-kun: Art Plan), INR11-IP18 (Little Keepace: TacaoF), INR12-IP19 (RT.1/ RT.2: RT.Works), INR14-IP21 (Flagship Model: Nabtesco), INR22-IP31 (kyūretto: Aronkasei), INR23-IP32 (KR-1000A: Clarion), INR26-IP35 (Dreamer: Santec), INR29-IP38 (Tecpo: Shintec Hozumi), INR39-IP53 & INR39-IP54 (Sasuke: Muscle)
[406] INR29-IP38 (Tecpo: Shintec Hozumi)
[407] INR02-IP02 & INR02-IP03 (SAN Flower: Kato Denki), INR07-IP12 (i-me:ma: Kito Seiki Seisakusho)
[408] INR01-IP01 (HSR: Toyota Motor), INR02-IP03 (SAN Flower: Kato Denki), INR04-IP06 (OriHime: Ory Laboratory), INR06-IP11 (Muscle Suit: INNOPHYS), INR13-IP20 (resyone: Panasonic), INR15-IP22 (palro: Fujisoft), INR24-IP33 (aams: bio sync), INR27-IP36 (yorisoi robotto: Sanyo Homes), INR28-IP37 (Hug: Fuji Machine MFG), INR39-IP52 (Sasuke: Muscle)
[409] INR01-IP01 (HSR: Toyota Motor), INR02-IP03 (SAN Flower: Kato Denki), INR04-IP06 (OriHime: Ory Laboratory), INR06-IP11 (Muscle Suit: INNOPHYS), INR15-IP22 (palro: Fujisoft)

pragmatic one, with an objective of applicability rather than basic research for societal benefits.

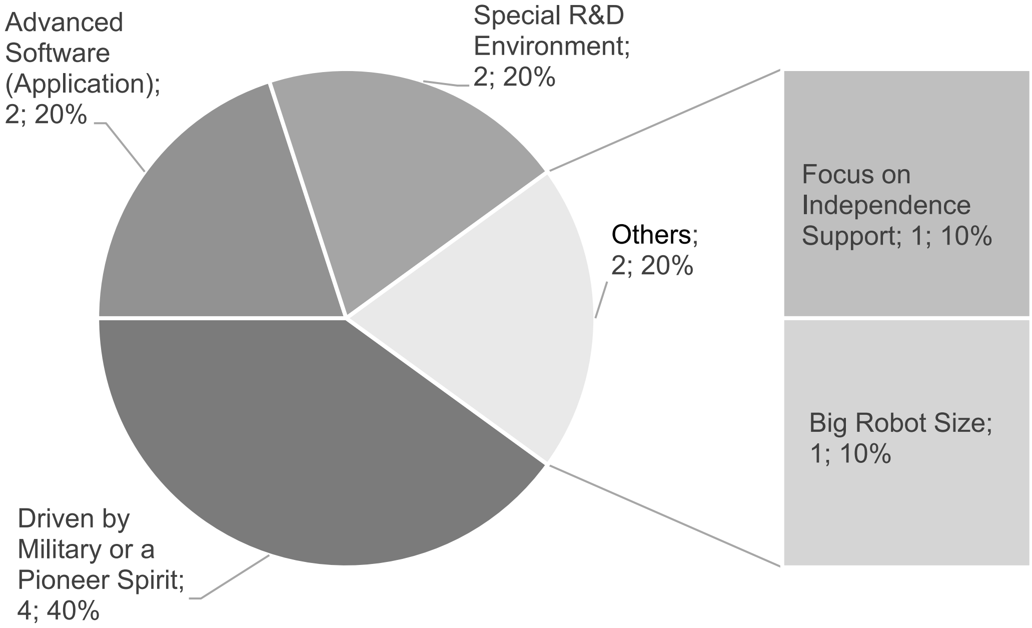

Figure 6-19 Characteristics of Foreign Robotics (n=10)

Apart from that, other developers[410] have a positive opinion about the R&D environment for robot development in other countries, and in particular the feeling that there are less concerns on security[411] and that the integration of the user into the development process already at an early stage is easier[412]. Robot development is imagined as less bureaucratic, because of permissive legislation. This in turn led to easier access to care facilities for test runs, and the opportunity to match user-needs right from the beginning. Probably against this background, some developers[413] mentioned software[414] development as a strength of foreign robot development. In other words, the focus is not on the development of an advanced technology which has as much technical features as possible; it is on balancing technology in such a way that it is applicable. The umbrella organization

[410] INR27-IP36 (yorisoi robotto: Sanyo Homes), INR39-IP52 (Sasuke: Muscle)
[411] INR39-IP52 (Sasuke: Muscle)
[412] INR27-IP36 (yorisoi robotto: Sanyo Homes)
[413] INR01-IP01 (HSR: Toyota Motor), INR24-IP33 (aams: bio sync)
[414] Thereby the understanding of the term ‘software’ refers to the usability of the robot and mostly neglects the technology side. According to this understanding, hardware refers to the ‘hard’ side of technology with its technical specifications, whereas software links to the ‘soft’ side of technology and the concepts for its application in a broader sense.

DARPA might explain why there is an impression of a constructive R&D environment and application-oriented development, or simply the existing difficulties that the developers have to face when trying to get the user involved into the development process in Japan (see Chapter 6.4).

The remaining responses are more or less side notes, such as one developer expressing the imagination of foreign robots as big-sized robots[415], or the impression of the development of care robots with a focus on self-dependence of the elderly rather than the care side[416].

Based upon the evaluation of the images of foreign robot development, the developers verbalized their perceptions (IQ8.1.1) about Japanese robot development (see Figure 6-20). At the same time, however, only ten developers[417] gave useable responses that, when linked to the previous responses on foreign robotics, contextualize their perceptions on Japanese robots and its R&D environment. Two developers[418] also stated that they see no major differences between foreign and Japanese robotics. Apart from this, there are primarily three views of Japan: Robotics as hardware-driven, R&D problem-driven or governmental and business-driven.

[415] INR28-IP37 (Hug: Fuji Machine MFG)
[416] INR13-IP20 (resyone: Panasonic)
[417] INR01-IP01 (HSR: Toyota Motor), INR02-IP03 (SAN Flower: Kato Denki), INR06-IP11 (Muscle Suit: INNOPHYS), INR11-IP17 (Little Keepace: TacaoF), INR13-IP20 (resyone: Panasonic), INR15-IP22 (palro: Fujisoft), INR21-IP30 (Neruru & Yumeru: T-arts), INR24-IP33 (aams: bio sync), INR27-IP36 (yorisoi robotto: Sanyo Homes), INR39-IP52 (Sasuke: Muscle)
[418] INR04-IP06 (OriHime: Ory Laboratory), INR10-IP16 (aijō-kun: Art Plan)

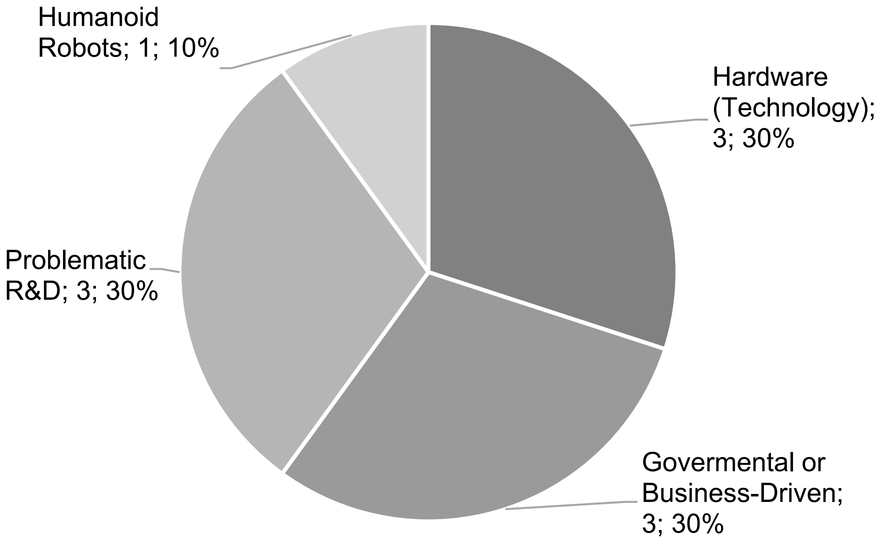

Figure 6-20 Characteristics of Japanese Robotics (n=10)

There is a consensus among one third of the developers[419] that Japanese robotics stand out with their technical level. This fits the picture of the technology-driven developer, whose interest is rather to design a high-tech robot than a low-tech solution that the caregivers can use immediately. Several developers noted the urgency to further improve the technical level of their robots before being able to enter care facilities, let alone the care market (see category 6.7.). In addition, the problems that the developers face with technology are being rated as one of the most important obstacles within the development process (see Chapter 6.6). This allows the conclusion that, on the one hand, a lot of effort is put into the technology side of the robot, and in turn a high spectrum of theoretically possible application fields exist. On the other hand, there is the tendency to forget about the application scenario of the robot. The developer of aams[420] praised American robot development, because they are able to wrap up the technically feasible with the desired. The important question which the developers have to answer is about the intended use of technology rather than about the sufficiency of technology.

Another third of the developers[421] thinks that there is a difficult environment for the development of robots in Japan. One criticism is concerned with the direct R&D environment with regard to security standards. The representatives of Sanyo Homes and Muscle

[419] INR01-IP01 (HSR: Toyota Motor), INR11-IP17 (Little Keepace: TacaoF), INR24-IP33 (aams: bio sync)
[420] INR24-IP33 (aams: bio sync)
[421] INR15-IP22 (palro: Fujisoft), INR27-IP36 (yorisoi robotto: Sanyo Homes), INR39-IP52 (Sasuke: Muscle)

criticize that it is difficult to perform test trials within care facilities, because in Japan the focus is only on whether security standards are fulfilled or not[422]. This strict focus forgets about the need to test the robot already at an early stage of its development. Early test periods improve the quality of the robot, making it easier to get an impression on the risks within the human-robot-interaction, and this leads to faster and more user-centered development. Thereby the issue of security standards is a question of how to handle a possible accident. Even the best technology will cause an accident at some point in the future. For this reason, the question of who will be responsible in the case of an accident has to be addressed. An insurance for robots and robotic devices can improve the reliability of a robot whether it is a first prototype or a marketable product. This supports the R&D environment and diffusion within society because it reduces the fear of trying or buying a robot.

Another criticism[423] is that Japan's development is not international. It is a closed development environment within a small community with limited output because of language barriers. Foreign countries have open software and open structures which lead to faster development and thus higher chances for the success of technology in general. The developer of palro illustrates this when saying:

> *"The community of developers is small, the difference in open RDM [Research Data Management] and ROS [Robot Operating System]. The ROS is an open source and all try various things, but the output is very different to America. Even if there is a community in Japan, it is more or less only a mailing list. In addition, I think the language barrier is quite big. Not all Japanese engineers speak English."*[424]

In the age of globalization and the internet, an open environment is the basis for the emergence of a large community. Organization of the environment is important for the community. Information exchange through various channels makes the information accessible for everyone, and thus it's simpler to participate. This is further supported through English as a world language in the most countries. A large part of the world population speaks English, so could theoretically, when having the knowledge needed,

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[422] INR27-IP36 (yorisoi robotto: Sanyo Homes), INR39-IP52 (Sasuke: Muscle)
[423] INR15-IP22 (palro: Fujisoft)
[424] INR15-IP22 (palro: Fujisoft) 00:28:25-00:29:35 開発者のコミュニティが少ないというか、元々のオープン RDM [Research Data Management] というのと、ROS [Robot Operating System] の違いっていうのが、ROS はオープンソースでいろいろ皆さんにばらまいて、いろいろ試してもらってっていうところにあるんですけど、パワーが全然アメリカと違ったんですね。日本だとコミュニティと言っても、ある程度メーリングリストがあるだけで。あとは、言葉の壁もかなり大きいと思うんです。すべての日本の技術者が英語を喋れるわけではないですし。

easily participate in the course of development, which is a clear developmental and locational advantage for English speaking countries. Japan with Japanese as a language of communication might be less attractive for researchers and engineers.

In this context, the representatives of Toyota and Fujisoft raise two interesting points: The current developments of the labor market, and the risk of care robotics running into the danger of national isolation. The two representatives refer to the period of national isolation until the Meiji Restoration in 1853[425]. Thereby they talk about a possible period of the isolation of technology[426], and the isolation of human resources[427]. The former neologism points to current technology-driven robot development. A result of this might be the creation of robots that only fit the needs of Japanese society (e.g. bathing aids), but forget about the need for transferability of technology. In that case. the care robots will not develop into the next economic hit, because they could only be placed on the domestic market with its limited size. The latter neologism shows the issue of the attractiveness of Japan as a labor market for foreign workers. Regardless of other labor migration issues, the language barrier, or in other words the need to study Japanese, makes Japan an obstacle and less attractive as a country for employment.

The remaining third of the developers[428] see the development of care robots in Japan as governmental or business-driven. On the basis of the previous description of the specifics of foreign robotics, it is easier to contrast what is special for Japanese robotics. Against the background of the evaluation of in particular American robotics as military-driven, one developer[429] contrasts Japanese robotics as business orientated. The representative of Panasonic even goes further and specifies care robotics in America and Europe as focused on strengthening the independence of the elderly at home, whereas in Japan the effort goes in the direction of the field of care to relieve the nursing crisis[430].

The representative of INNOPHYS goes beyond that and formulates a clear criticism of the current development approach, with its focus on the maker or technology side of care robotics in Japan, when he argues that *"Japan's approach [on the development of robots] is bureaucratic, inflexible, dreamless and pays too much attention to what others might*

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425 They lean on the sakoku 鎖国 terminology of Japan's self-isolation during the Edo-period (1603-1868). The Meiji restoration supersede the over two hundred of years persistent period of national isolation (sakoku jidai 鎖国時代).
426 INR15-IP22 (palro: Fujisoft) calls it gijtsu sakoku 技術鎖国.
427 INR01-IP01 (Toyota Motor: HSR) labels it jinzai sakoku 人材鎖国.
428 INR02-IP03 (SAN Flower: Kato Denki), INR06-IP11 (Muscle Suit: INNOPHYS), INR13-IP20 (resyone: Panasonic)
429 INR02-IP03 (SAN Flower: Kato Denki)
430 INR13-IP20 (resyone: Panasonic)

think. For this reason, no innovation emerges. There is a revolution, but no innovation.“ The main argument is the lack of innovation in Japanese development efforts. This argument is consistent with the previous evaluation of robotics as being strong on the technology side, but weak on the application or software side. Especially companies which started care robotics as a side business mostly adapt their technology to the field of care. Thereby it is rather a reuse of technology than groundbreaking new innovation. For Japan in general, the country is good at the recreation or the improvement of already existing technology, but struggles when it comes to developing something from scratch.

Nevertheless, the representative of INNOPHYS also makes a positive note on Japanese robotics when he states that, *“I think it is good that there are a lot of things. However, rather than to design the things that the researcher or developer wants, it must be a marketing approach that focuses on things users can use. We [as developers] have to develop, what the market wants. Otherwise, you can’t do anything good forever.“*[431] There is the need to switch from a technology-driven approach that develops things that developers want and, thinking that they might help within a care facility, to development which centers on the user and his needs and desires. Otherwise, acceptance will remain low and thus robots will not diffuse. The user and the target market must be kept in mind when developing care robots, so as to prevent the field becoming only a playground for engineers to impress society with their toys.

Lastly, one developer[432] specifically mentioned the fixation on a human appearance with bipedal walking as a characteristic of Japanese robot development. Simply put, the focus is on humanoids in Japan for all robot-related fields, especially for service and care robotics. This point receives further attention later in this category (IQ8.2) with a specific focus on Japanese robots and their linkage with culture.

After having taken a closer look at the characteristics of foreign and Japanese robotics, the focus shifts to the competitiveness (IQ8.1.2) of Japan in an international comparison (see Figure 6-21). Here, too, there is quite a high rate of no responses; nine out of 27 developers[433] were not able to reply to this topic. The results are divided into two cate-

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[431] INR06-IP11 (Muscle Suit: INNOPHYS) 00:37:31-00:38:18 色々なものがあっていいと思うけど、作り手となるリサーチャーやデベロッパーが作りたいものを作るのではなく、ユーザーが使えるものを作る、マーケットインのやり方じゃないといけない。マーケットが希望するものを作らなければならない。そうじゃないと、いつまでたってもいいものはできない。

[432] INR21-IP30 (Neruru & Yumeru: T-arts)

[433] INR02-IP02 (SAN Flower: Kato Denki), INR03-IP04 (smile baby: Togo Seisakusyo), INR08-IP13 (ROBO snail: Ryoei), INR10-IP16 (Aijō-kun: Art Plan), INR24-IP33 (aams: bio sync), INR29-IP38 (Tecpo: Shintec Hozumi), INR39-IP52, INR39-IP53 & IP54 (Sasuke: Muscle)

gories, namely a positive and a negative assessment of Japan's international competitiveness. The number of responses[434] which see Japan in a good international competitive position slightly outweighs the pessimistic ones[435]; it is 13 against 11. Nevertheless, some developers responded with ambivalence, and mentioned a positive aspect and a negative one at the same time[436].

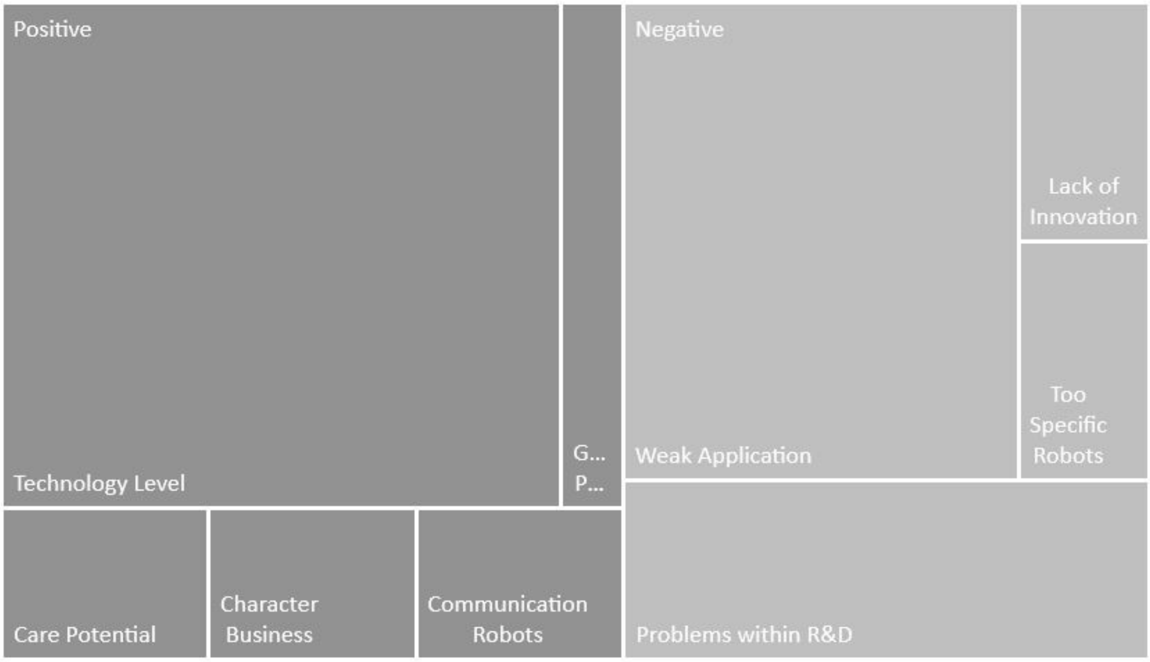

Figure 6-21 Attitudes toward the International Competitiveness (Multiple Responds)

When talking about the international competitive position of Japan, there is a wide optimistic consensus among developers about the long experience with industrial robots being a clear advantage for Japan. This consensus includes the positive evaluation of

[434] INR01-IP01 (HSR: Toyota Motor), INR02-IP03 (SAN Flower: Kato Denki), INR03-IP05 (smile baby: Togo Seisakusyo), INR04-IP06 (OriHime: Ory Laboratory), INR06-IP11 (Muscle Suit: INNOPHYS), INR11-IP11 (Little Keepace: TacaoF), INR11-IP12 (Little Keepace: TacaoF), INR12-IP19 (RT.1/ RT.2: RT.Works), INR13-IP20 (resyone: Panasonic), INR15-IP22 (palro: Fujisoft), INR21-IP30 (Neruru & Yumeru: T-arts), INR23-IP32 (KR-1000A: Clarion), INR28-IP37 (Hug: Fuji Machine MFG)

[435] INR02-IP02 (SAN Flower: Kato Denki), INR03-IP05 (smile baby: Togo Seisakusyo), INR06-IP11 (Muscle Suit: INNOPHYS), INR07-IP12 (i-me:ma: Kito Seiki Seisakusho), INR12-IP19 (RT.1/ RT.2: RT.Works), INR14-IP21 (Flagship Model: Nabtesco), INR22-IP31 (kyūretto: Aronkasei), INR23-IP32 (KR-1000A: Clarion), INR26-IP35 (Dreamer: Santec), INR27-IP36 (yorisoi robotto: Sanyo Homes), INR28-IP37 (Hug: Fuji Machine MFG)

[436] INR02-IP02 (SAN Flower: Kato Denki), INR06-IP11 (Muscle Suit: INNOPHYS), INR12-IP19 (RT.1/ RT.2: RT.Works), INR28-IP37 (Hug: Fuji Machine MFG)

the long experience with industrial robots itself[437], or sees the high technological level as beneficial for Japan in the world[438].

The former group especially leans on the combination of history and the high technological standard, which led to Japan's leading position within industrial robotics. However, developers are aware of the fact that even the market for industrial robots is a constantly changing[439], and thus it cannot rest on its laurels. Industrial robotics and the related market consist of products that address specific tasks within the automation process. This makes it relatively easy to meet the demand of this market. In contrast, service robotics, and furthermore care robotics, are emerging fields with a short history. For this reason, past experiences cannot be relied on and the acquisition of information becomes key for developing appropriate and in-demand robots.

The latter group simply highlights Japan's position as a forerunner in advanced robotics. In the course of this, the recognition is towards the high standard of technology and product quality in general[440], as well as on technological competence[441] or potential[442]. The logic behind this argument is that a good base in technology automatically makes Japan more likely to be successful on the international market. However, it is not a surefire success, because the key for international success is the adaptation of a Japanese invention into the specific markets.

In addition, there are non-categorizable interesting responses on competitiveness. On the one hand, it is stated that a rapidly aging society makes robotics absolutely necessary to solve future social challenges, and will eventually lead to a diffusion of care robotics even outside of Japan. On the other hand, it was said that Japanese people are good at harmonizing an existing technology with an existing need, or simpler, picking up on a need[443]. This perspective is understandable because the developer of T-arts works in a field, namely the toy industry, which strongly has to adjust their products to the needs of their potential customers. The developer of OriHime to some extent goes further into this when explaining:

> *"I think there is still competitiveness. However, I think that from now [Japan] has to look at the world. I think that Japan can compete, especially if it is a*

[437] INR01-IP01 (HSR: Toyota Motor), INR06-IP11 (Muscle Suit: INNOPHYS), INR23-IP32 (KR-1000A: Clarion), INR28-IP37 (Hug: Fuji Machine MFG)
[438] INR02-IP03 (SAN Flower: Kato Denki), INR03-IP05 (smile baby: Togo Seisakusyo), INR11-IP17 (Little Keepace: TacaoF), INR12IP19 (RT.1/ RT.2: RT.Works), INR13-IP20 (resyone: Panasonic)
[439] INR01-IP01 (HSR: Toyota Motor)
[440] INR02-IP03 (SAN Flower: Kato Denki), INR12-IP19 (RT.1/ RT.2: RT.Works)
[441] INR03-IP05 (smile baby: Togo Seisakusyo), INR11-IP17 (Little Keepace: TacaoF)
[442] INR13-IP20 (resyone: Panasonic)
[443] INR21-IP30 (Neruru & Yumeru: T-arts)

> *character business with creating anime like sensations. Nevertheless, this isn't limited to Japan anymore, other countries also started this, but I still think that Japanese people have an advantage at it."*[444]

Character design and the resulting character business are the intersection of technology, product design and user-demand. The strength is the conceptualization of an abstract technology through a certain character and making it understandable and usable for the end-user. The character gives technology a face with memorability. This approach can create many chances for certain kinds of robots. As for communication robots, the rather cautious position on communication robots can give Japan and its developers a first advantage to becoming the leader within this field. For other kinds of robots, such as monitoring systems, it is much more difficult to give the technology a face through transferring it into a certain character.

However, there are also quite a large number of critical voices about Japan's international competitiveness. It is striking that the responses constitute a consensus on the high technological Japanese standard, or in other words, praise of the hardware side of robotic inventions, but at the same time there is criticism on the application of this hardware[445] and the R&D environment[446].

The major criticism, which weakens Japan's international competitiveness, is the lack of concepts for the use of hardware. For one thing, there is technologically advanced hardware, and then the software-side is evaluated as expandable. The representative of Fuji Machine MFG explains the background behind this.

> *"Industrial robots are producing profits, so that companies which buy them can spend a lot of money. However, for care robots in Japan, for example, a transfer can be done even by people. So even if you don't have a robot, it will be manageable somehow. Since you don't make a lot of money [through the introduction], in that sense it isn't easy to buy [a robot]. The cost efficiency is low. For example, just because you introduce a robot that doesn't mean that you only need 1/10 of the employees. The effect, on which the management can base a judgement, is low.*[447]

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[444] INR04-IP06 (OriHime: Ory Laboratory) 00:37:35-00:38:12 競争力はまだあると思う。ただし、これからは世界を見なければいけないと思っています。日本はまだキャラクタービジネスの方向、面白いキャラクターを作ったりというアニメ的な感覚であればいける [競争力が高い] と思います。ただこれは今日本だけじゃなくて、他の国もやり始めていますけど、それでもここに関しては日本人が得意とするところがあるんじゃないかと思っています。

[445] INR02-IP02 (SAN Flower: Kato Denki), INR03-IP05 (smile baby: Togo Seisakusyo), INR07-IP12 (i-me:ma: Kito Seiki Seisakusho), INR12-IP19 (RT.1/ RT.2: RT.Works), INR23-IP32 (KR-1000A: Clarion), INR28-IP37 (Hug: Fuji Machine MFG)

[446] INR22-IP31 (kyūretto: Aronkasei), INR26-IP35 (Dreamer: Santec), INR27-IP36 (yorisoi robotto: Sanyo Homes)

[447] INR28-IP37 (Hug: Fuji Machine MFG) 00:29:52-00:30:46 産業用ロボットは利益を生むものなので、購入していただける企業さんは潤沢にお金を使っていただけるんですけれども、介護ロボットは日本だと、例えば移乗は人でもできちゃうじゃないですか。だからロボットがなくても何とかなってしまう。そこ

It is the totally uneven market characteristics and size of the market for industrial and care robots. Industrial robots are the ideal choice for improving repetitive tasks through automatization and so lead to more profit. Production is much easier to automatize than care. Service and care robots are suitable for a market which is not about profit, but rather mostly about the improvement of quality. Humans can do most tasks, such as lifting or entertain people, cheaper and faster than a robot. For this reason, the market volume is much more limited. In contrast to industrial robots, care can be done without care robots, which makes their implementation more difficult.

The challenge is the connection of hardware and software. With the development of advanced technologies only, this challenge will be insurmountable[448]. This is difficult especially for the companies which start to develop the hardware, namely the robot, first or even have a patent from another field, such as automotive, and try to transfer it to the field of care. For them it is often a quest for creating a demand that does not exist. The best hardware is worthless if there is no use for it. There is a considerable backlog of offering convincing services with technology[449] and accessibility for sales[450]. This brings the risk that various Japanese robots will end as toys[451], which are nice to look at but never made it into daily life.

The pessimistic voice on the applicability is followed by a group of critical voices on the R&D environment in Japan. R&D in Japan is good, but takes too long. The representative of Santec comes to the heart of it when setting Japan's R&D effort into a wider context.

> *„I can only compare with China and Korea, but there are already familiar things in China, if you go with such an image, we might become late. On the contrary, while we try to enter into foreign markets, Chinese makers come to Japan and see what products exist. They produce the same products and introduce them. I think we don't need to be embarrassed at the moment.“*[452]

The technological level is high, but it takes time. In the meantime, China tries to copy Japanese technology, but still misses the experience. But there is the risk that they will

[導入によって] でお金を大きく儲けるわけではないので、そういった意味では、 [ロボットは] なかなか簡単に購入というところには至らない。費用対効果が薄いというんですかね。例えばロボットを 1 台導入したからといって、従業員が 1/10 で済むというわけではないので、経営者としては効果が薄いとしか判断できないんじゃないかなと思います。

[448] INR12-IP19 (RT.1/ RT.2: RT.Works)

[449] INR23-IP32 (KR-1000A: Clarion)

[450] INR03-IP05 (smile baby: Togo Seisakusyo),

[451] INR02-IP02 (SAN Flower: Kato Denki)

[452] INR26-IP35 (Dreamer: Santec) 00:26:55-00:27:26 まだ中国と韓国としか比べられないんですけど、もうすでに中国では同じものが出ていると、そういうイメージで行くと、ちょっと出遅れたかなと。我々が、外国に進出することにこうして足踏みしている間に、逆に中国のメーカーが日本に来てこういうものがあるよ、同じものを造ってるよって紹介するのを見て、我々が今尻込みしている場合じゃないなと思います。

be faster in the end. The delay in the R&D process is due to a rigid development system[453] and its financial support, which pays attention to fixed temporal milestones rather than creativity and the need for temporal flexibility. Nevertheless, there might not be any alternatives, because once an idea made the process until the prototype stage, it is safe and has a high standard[454]. The background for this is the self-expectation not only of the developers, but also of the government to develop technologically advanced robots, which in turn automatically limits the way technology can be developed.

The remaining responses deal with innovation. One response addresses the lack of innovation, when arguing that it is not enough to be strong in production[455] because service robotics are about being innovative and coming up with new and creative solutions for certain issues. The other response is about the transferability of Japanese innovations, which are said to be too specific for other countries. The representative of Nabtesco sees this specialization as a risk for Japan's international competitiveness when saying *"If this [specialization] goes on, it may be the same as with the mobile phone. The Galapagos mobile phone[456]. There is the possibility of creating too many products that are unique to Japan."[457]*. There are too many inventions tailored for the Japanese market which might not have a chance on the international market. Japan risks being left behind again, such as with the mobile phone, which was produced in Japan but in the end other countries took the leading role.

The comparison of foreign and Japanese robotics gave a first impression on possible unique features of Japan, such as the mention of humanoid design. In the following, this uniqueness (IQ8.2.) becomes the contextual focus (see Figure 6-22). The responses to this topic give important insights for the evaluation of the second hypothesis, the labor replacement thesis (see Chapter 1.2) about robotics being a unique approach for solving social problems in Japan. However, even this topic has a low response rate, because eight out of 27 developers[458] leave it unanswered. It seems to be difficult to distinguish

[453] INR22-IP31 (kyūretto: Aronkasei)
[454] INR27-IP36 (yorisoi robotto: Sanyo Homes)
[455] INR06-IP11 (Muscle Suit: INNOPHYS)
[456] The term Galapagos mobile phone (in Japanese: garapagosu keitai ガラパゴス携帯) has its origins in the Galapagos syndrome, which means the isolation from the international market with its own domestic specifications. The metaphor comes from the Galapagos Islands, which are isolated and developed their own indigenous species of flora and fauna that only exists there and has now chance to survive somewhere else.
[457] INR14-IP21 (Flagship Model: Nabtesco) 00:46:24-00:46:39 このままいくともしかしたら、携帯電話と同じようになってしまうかもしれないですね。ガラパゴス [ガラパゴス携帯] ですよね。日本独自の商品を作りすぎてしまう可能性があるかもしれないですよね。
[458] INR01-IP01 (HSR: Toyota Motor), INR02-IP02 (SAN Flower: Kato Denki), INR03-IP04 & IP05 (smile baby: Togo Seisakusyo), INR24-IP33 (aams: bio sync), INR29-IP38 (Tecpo: Shintec Hozumi), INR39-IP52 & IP54 (Sasuke: Muscle)

the characteristics of one's own cultural environment and to put it into words. Apart from that there are five categories: security and quality of technology, attention to detail, humanoid design, a special environment for robots, or nothing special. Whereby the two categories about special features, namely humanoid design or nothing special, each feature in three developers' responses.

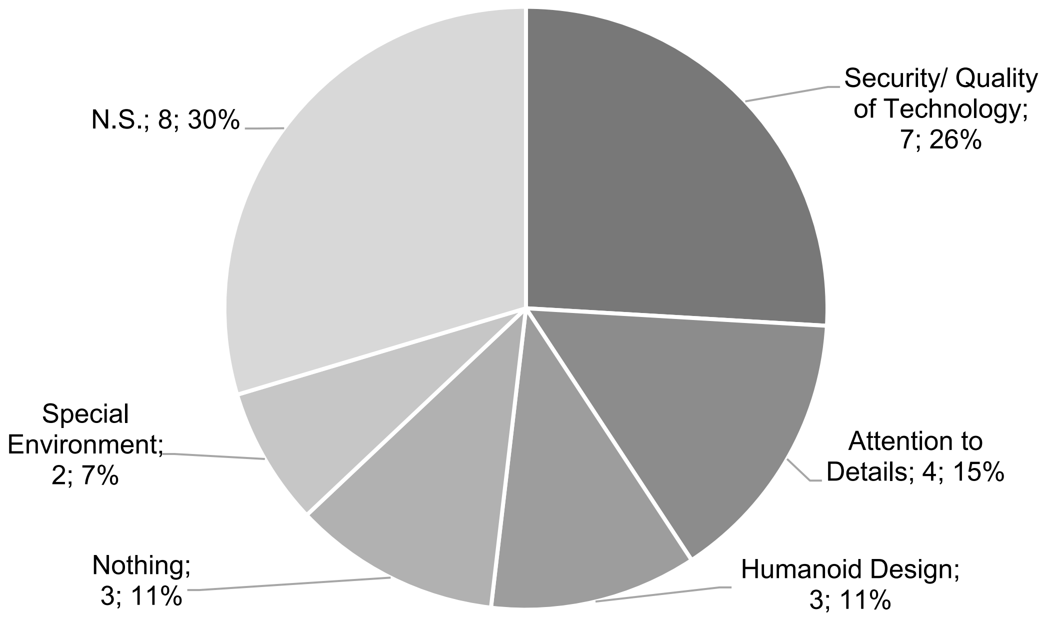

Figure 6-22 Characteristics of Japanese Robots (n=27)

It is no surprise that the majority, seven, of the developers[459] emphasize the advanced level of technology as a special feature of Japanese robotics. This is seamless continuation of the technology-driven development approach pursued by a larger part of the companies. Japanese robot technology, especially its hardware, is perceived as sophisticated. This includes the safety and quality[460] of the robots, and takes place against the background of the positive experience with industrial robots. For this reason, it appears only natural when the developers highlight the smooth movement[461] or the continuous process improvement through robotics[462]. In addition, there is the possibility that single

[459] INR02-IP03 (SAN Flower: Kato Denki), INR08-IP13 (ROBO snail: Ryoei), ,INR11-IP18 (Little Keepace: TacaoF), INR12-IP19 (RT.1/ RT.2: RT.Works), INR22-IP31 (kyūretto: Aronkasei), INR26-IP35 (Dreamer: Santec), INR27-IP36 (yorisoi robotto: Sanyo Homes)
[460] INR12-IP19 (RT.1/ RT.2: RT.Works), INR27-IP36 (yorisoi robotto: Sanyo Homes)
[461] INR26-IP35 (Dreamer: Santec)
[462] INR22-IP31 (kyūretto: Aronkasei)

makers design robots as units without the need to adjust to products of certain suppliers[463]. Success within the field of industrial robotics seems to become a sure thing and within this own way of thinking, it is only logical for engineers to try to transfer it to other fields such as service and care. Nevertheless, there is also a critical voice[464] which recognizes the strength of the hardware, but at the same time does not neglect the problems in other areas, such as AI.

Following a technical focus, another group of developers[465] sees the attention to detail as a specifically Japanese feature. Thereby the argumentation stays primarily on a technical level. Rather than paying attention to details in general, it involves an attempt at fine adjustment of technology on the consumer[466]. It is less the approach to design on the base of a demand or the need of the user; rather it is the other way around, and often just adjusting an existing technology to the user. In doing so, there is the risk of creating problems to match the demand. However, one advantage is to bring a somehow developed technology to the user.

A smaller group[467] brings up the desire to design humanoid robots as a possible characteristic for Japanese robotics. This was already mentioned in the previous question (IQ8.1.1), when the focus was on development characteristics. The developer of palro points out, that „*for example, if you picture a robot, it will naturally become a humanoid*.“[468] This applies especially to the design of communication robots, which is no surprise because Fujisoft is only developing robots for communication. Against the background of the application area, interaction with humans, the argument is that humanoid robots are easier to integrate into a human environment. The given reason behind this is probably the high visibility and frequency within pop culture, above all in anime and manga. Nevertheless, at this point, the open question about cultural influence factors, such as pop culture, gives only restrained feedback on culture and its impact. The majority of the responses is rather technical-driven or unclear about this topic. One developer[469] even said that in Japan, the focus was too much on humanoid design and often forgets about the feasibility of technical parameters.

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[463] INR08-IP13 (ROBO snail: Ryoei)
[464] INR02-IP03 (SAN Flower: Kato Denki)
[465] INR11-IP17 (Little Keepace: TacaoF), INR14-IP21 (Flagship Model: Nabtesco), INR23-IP32 (KR-1000A: Clarion), INR28-IP37 (Hug: Fuji Machine MFG)
[466] INR14-IP21 (Flagship Model: Nabtesco)
[467] INR13-IP20 (resyone: Panasonic), INR15-IP22 (palro: Fujisoft), INR39-IP52 (Sasuke: Muscle)
[468] INR15-IP22 (palro: Fujisoft) 00:30:53-00:31:02 例えば、みんなロボットの絵を描いたりすると、自然と人型になると思うんですよね。
[469] INR39-IP52 (Sasuke: Muscle)

In contrast to the previous groups, there are several developers[470], who, regarding to robotics in Japan, see nothing special. There are two arguments for this: the existence of anime and manga[471] also abroad and the service understanding. The former argues that nowadays anime and manga are highly present even in foreign countries. This part of the formerly Japanese pop culture became a part of an international pop culture and thus the images within this genre are no not limited to Japan. The latter highlights that the difference, not the appearance of the robot, but the way of how service is performed, matters. The developer of aijō-kun makes this clear, when he says,

> *„First of all, the design of the robot is given by the designers' specifications of the device. On these specifications the device is created. However, service robots don't have such specifications. They are designed on the base of what kind of environment and service should be provided. So for example the design, which is based on service, is different in Japan and Germany, because of the culture and the way of service. Even if the functionality is the same, I think the way of giving service is different.“*[472]

Industrial robots are developed on the basis of certain clear specifications because they are used in a closed environment. This does not apply for service and care robots, because they are used within an open environment. Even if there might be a difference within culture, basically the functions are the same. Rather than a cultural impact on the design, the cultural impact is strongest on the manifestation of service itself.

Another smaller group of two developers[473] emphasizes a special environment for robotics. The representative of INNOPHYS[474] believes in a positive environment for robots, because of the high acceptance of robots. The representative of T-arts[475] also thinks that there is something special about Japan. At the same time, neither of them is able to specify where this belief comes from. This illustrates how difficult it is to put something as abstract as culture into words.

[470] INR04-IP06 (OriHime: Ory Laboratory), INR07-IP12 (i-me:ma: Kito Seiki Seisakusho), INR10-IP16 (Aijō-kun: Art Plan)
[471] INR04-IP06 (OriHime: Ory Laboratory)
[472] INR10-IP16 (aijō-kun: Art Plan) 01:11:30-01:12:10 ロボットの設計にはまず設計者から装置の仕様をもらうんですよ。その仕様に基づいて装置を作る。でもサービスロボットというのはそのような仕様をもらうんじゃなくて、どんな状況が想定されるか、どんなサービスが提供されるべきかというのに基づいて造られていくわけです。で、そういったサービスに基づく設計というのは、日本の場合と、例えばドイツの場合では文化が違うから、サービスのやり方も違う。機能的には一緒でも、サービスの与え方が違うと思います。
[473] INR06-IP11 (Muscle Suit: INNOPHYS), INR08-IP13 (ROBO snail: Ryoei), INR21-IP30 (Neruru & Yumeru: T-arts)
[474] INR06-IP11 (Muscle Suit: INNOPHYS)
[475] INR21-IP30 (Neruru & Yumeru: T-arts)

The first step was to get an idea about possible characteristics of robotics in Japan, but also abroad. The next step is to gain deeper insight into what might influence the acceptance of robots in Japan. For that reason, the topic is about possible cultural impacts (IQ8.2.1) and the influence of culture on robot development. (IQ8.2.2) Thereby the question actively addresses terms such as anime, karakuri puppets[476] or religion.

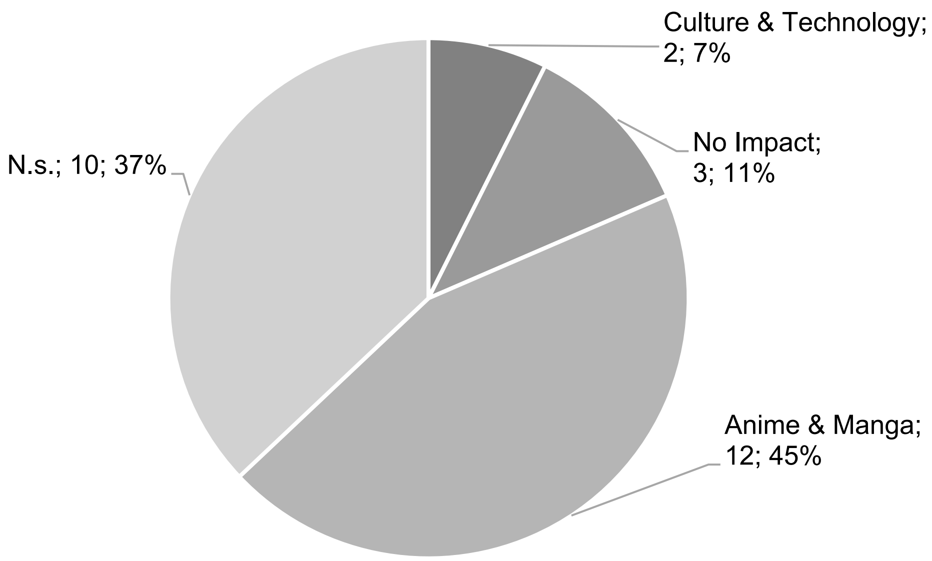

Figure 6-23 Cultural Impact on Robotics in Japan (n=27)

When asked about the general cultural impact on robotics in Japan, excluding non-answers[477], the interviews revealed that there are three kinds (see Figure 6-23) of named impacts: a general impact by culture and technology, no impact and popular culture. The first two groups are in relation to the last group much smaller. The majority of respondents believe that pop culture has an impact on Japanese robotics.

As for culture, the representative of Kato Denki points out that personification of objects might be a reason why robots are accepted in Japan[478]. This establishes a connection to Shintoism, according to which a soul is inherent even in inanimate objects such as

[476] In Japanese: karakuri ningyō からくり人形.
[477] INR02-IP03 (SAN Flower: Kato Denki), INR03-IP04 (smile baby: Togo Seisakusyo), INR04-IP06 (Ori-Hime: Ory Laboratory), INR06-IP11 (Muscle Suit: INNOPHYS), INR07-IP12 (i-me:ma: Kito Seiki Seisakusho), INR15-IP22 (palro: Fujisoft), INR22-IP31 (kyūretto: Aronkasei), INR24-IP33 (aams: bio sync), INR39-IP53 & IP54 (Sasuke: Muscle)
[478] INR02- IP03 (SAN Flower: Kato Denki)

stones or trees. As for technology, the representative of Muscle argues with a touch of criticism that high technological standards call for the utilization of technology within society[479]. Both statements have in common that robotics is legitimized by a separate logic under a framework of religion or technological progress.

Another small group of three developers sees no special impact on robotic development in Japan. Their responses show that Anime and Manga had no impact[480] at all, as well as were never heard before[481]. This is an interesting and strong statement, because it stands against the background of the previously asked questions about foreign and Japanese R&D characteristics for robots.

The by far most frequent group of responses[482] is related to modern pop culture as an important influence factor for robotics in Japan, either positively or negatively, whereby the majority[483] of these developers attribute a positive influence from anime and manga. Pop culture, with their representatives' anime and manga, are likely to pave the way for basically high acceptance towards robots[484]. The developer of ROBO snail goes even further concerning the impact of culture on the acceptance of robots when he emphasizes that "*Since I am involved in robotics, I heard a lot of lectures. As mentioned, I think that anime, and in Nagoya karakuri puppets are facts [for getting familiar with robots]*."[485] They even said it to be a fact, which in the case of engineers motivates them to further work on the development of robots, or in the case of society, to create a certain interest in robots through images from anime and manga. It is an interconnected relationship between pop culture and robotics. The one influences the other.

A particular robot is representative of technology of a particular time[486]. In parallel, a certain robot anime represents a certain desire towards technology. An appropriate met-

[479] INR39-IP52 (Sasuke: Muscle)
[480] INR14-IP21 (Flagship Model: Nabtesco)
[481] INR11-IP17 &IP18 (Little Keepace: TacaoF)
[482] INR01-IP01 (HSR: Toyota Motor), INR03-IP05 (smile baby: Togo Seisakusyo), INR08-IP13 (ROBO snail: Ryoei), INR10-IP16 (aijō-kun: Art Plan), INR12-IP19 (RT.1/ RT.2: RT.Works), INR13-IP20 (resyone: Panasonic), INR21-IP30 (Neruru & Yumeru: T-arts), INR23-IP32 (KR-1000A: Clarion), INR26-IP35 (Dreamer: Santec), INR27-IP36 (yorisoi robotto: Sanyo Homes), INR28-IP37 (Hug: Fuji Machine MFG), INR29-IP38 (Tecpo: Shintec Hozumi)
[483] INR03-IP05 (smile baby: Togo Seisakusyo), INR08-IP13 (ROBO snail: Ryoei), INR12-IP19 (RT.1/ RT.2: RT.Works), INR13-IP20 (resyone: Panasonic), INR21-IP30 (Neruru & Yumeru: T-arts), INR23-IP32 (KR-1000A: Clarion), INR27-IP36 (yorisoi robotto: Sanyo Homes)
[484] INR03-IP05 (smile baby: Togo Seisakusyo), INR23-IP32 (KR-1000A: Clarion), INR27-IP36 (yorisoi robotto: Sanyo Homes)
[485] INR08-IP13 (ROBO snail: Ryoei) 00:56:40-00:57:01 自分がロボットに携わって、いろいろ講演会を聞いてきました。おっしゃる通りアニメ、名古屋は特にからくりに関しても [ロボットがそれらによって親しみやすいものになっているということ] 事実[485]だと思います。
[486] INR12-IP19 (RT.1/ RT.2: RT.Works)

aphor is that of a temporal snapshot. The developer of resyone illustrates this interconnection when pointing out that, *"It is often said that there is a robot anime, such as Astro Boy or Doraemon, and when it comes to robots that everyone thinks of such [robot anime] things. The same applies for Mobile Suit Gundam. So it's easy to want to attribute or connect the humanoid form to robots."*[487] On the one hand, there are common robots in pop culture such as Astro Boy, Doraemon or Mobile Suit Gundam, which are also addressed in the interviews[488] and became icons or even synonyms for a certain type of robot. Astro Boy is an illustrative example for this; he serves as the ideal for a human-friendly humanoid robot, which is emulated by many robot developers in Japan. On the other hand, such symbolic characters can create high expectations towards technology.

One more thing is that the statement of the developer of ROBO snail is among all the interviews the only one that specifically addresses karakuri puppets. This suggests that karakuri puppets might not be as relevant as expected from the literature (cp. (Decker 2014; Ishihara 2014; Sone 2008)).

The minority[489] of the developers attributes a negative influence of culture, in particular anime and manga. Thereby one point that was viewed as positive by other developers is now considered as a negative impact factor: humanoid robots within pop culture. What is critical about humanoid robots within anime and manga, such as Astro Boy, is that they lead to high expectations towards developed robots. Real robots are measured by their iconic brothers and sisters from the media. Where in the West the focus lies on functionality with no special desired design for robots, in Japan there is a concrete understanding about what a robot has to look like, which is like a human-being[490]. One developer even mentions that Japan is overly concerned with robots as humanoids[491]. Thereby the ideal of Astro Boy anchored itself in the mind of the Japanese. As long as technology can fulfill this ideal, there is no problem. It becomes difficult when the state of the art does not match pop culture[492]. In the case of an unanswered desire, acceptance turns into rejection, which I label with the term 'Astro Boy syndrome'.

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[487] INR13- IP20 (resyone: Panasonic) 00:27:53-00:28:16 日本はよく言われるようにですね、ロボットアニメというのがあって、鉄腕アトムとかドラえもんとか、ロボットと言えばああ [ロボットアニメ] いうものをみんな想像するんですよ。ガンダムもそうですよね。だからああいう人間の形をしたものをロボットと言いたくなるというか、ロボットに繋がりやすい。
[488] Cp. INR13-IP20 (resyone: Panasonic), INR21-IP30 (Neruru & Yumeru: T-arts)
[489] INR01-IP01 (HSR: Toyota Motor), INR10-IP16 (aijō-kun: Art Plan), INR26-IP35 (Dreamer: Santec), INR28-IP37 (Hug: Fuji Machine MFG), INR29-IP38 (Tecpo: Shintec Hozumi)
[490] INR01-IP01 (HSR: Toyota Motor)
[491] INR29-IP38 (Tecpo: Shintec Hozumi)
[492] INR10-IP16 (aijō-kun: Art Plan)

Another aspect that is often forgotten when talking about the positive images of robots within pop culture is the way of thinking within the field of care. The developer of Hug is ambivalent about the influence of pop culture when he states that, *"I think robot anime is very popular. On the other hand, I think there is a difficult atmosphere to accept new things among the staff of the care facilities. Furthermore, there are many women who work in the care industry and I think they aren't watching robot anime."*[493] There is a general agreement about the popularity of robots as a popular motive within pop culture. However, the point that is made here is about the gender ratio within care facilities. The gender ratio is unbalanced. Many women, who are probably not interested in robot anime, work in care facilities, which makes widespread popularity from pop culture difficult to transfer to care robotics. The original positive association is gone.

In addition to the gender ratio and its related specifications, there is a traditional way of thinking about what care has to look like and how it has to be performed, which is an obstacle for new inventions. The developer of Dreamer disagrees with the positive influence of culture on care robotics when he critically says, *"I think it's the opposite. Things can't be left to robots. After all, people should do the main work and I think that robots should only work when people need them. I still disagree with leaving all to robots. With such an idea, I feel that Japan may lag behind with using robots*."[494] A traditional, or dominant, way of thinking is an obstacle for innovations, according to which robots should only be used from time to time, when they are needed. The main work is left to humans. This way of thinking hinders the diffusion of robotics and even the diffusion of care equipment, because the preference is to work without using any equipment.

The analysis of the personal impact of culture (IQ8.2.2) closes the evaluation of cultural influences on robotics in Japan. One stage earlier, the developers estimated the relationship of robots and culture. The next stage is the conclusion of this influence on their daily work (see Figure 6-24). Thereby, excluding the eleven non-answers[495], there exist three categories: no impact, a positive or a negative pressure on robot development.

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[493] INR28-IP37 (Hug: Fuji Machine MFG) 00:31:33- 00:31:57 ロボットのアニメとかはすごく普及していると思うんですけれども、ただ一方で、介護施設の方々は新しいものを受け入れにくいような雰囲気があると思います。さらに介護業界で働かれるのって女性が多いので、ロボットアニメを見ていたかというとまたそれはちょっと違うと思いますね。

[494] INR26-IP35 (Dreamer: Santec) 00:28:10-00:28:38 逆だと思う。ロボットには任せられない。やっぱり人がメインになって働くべきで、ロボットは人が必要とするときだけ働いてくれればいいと思います。ロボットに任せっきりにするのには私はまだ反対です。そういう考えで、日本はロボットを使っていくことに関して遅れていくんじゃないかなっていう気はしてます。

[495] INR02-IP02 & IP03 (SAN Flower: Kato Denki), INR06-IP11 (Muscle Suit: INNOPHYS), INR07-IP12 (i-me:ma: Kito Seiki Seisakusho), INR10-IP16 (aijō-kun: Art Plan), INR11-IP18 (Little Keepace: TacaoF),

Figure 6-24 Felt Social or Cultural Pressure of the Developers on the Robot Development (n=27)

The first two categories, the one[496] that attributes no impact or pressure through culture on the work, and the one[497] that sees a positive impact, remain short on their explanation for their opinion. The former one does not see any existing pressure from outside. Only one developer states that there is no pressure, but there is only a limited understanding on robot development. The latter one feels a certain pressure, which they regard as a positive pressure for their work. One argument[498] is that if the understanding of robots increases, diffusion is likely to accelerate. According to this belief, the wide presence of robots within anime and manga serves as an ideal breeding ground for the diffusion of care robots in Japan.

INR14-IP21 (Flagship Model: Nabtesco), INR15-IP22 (palro: Fujisoft), INR24-IP33 (aams: bio sync), INR39-IP52 & IP54 (Sasuke: Muscle)

[496] INR03-IP04 & IP05 (smile baby: Togo Seisakusyo), INR23-IP32 (KR-1000A: Clarion), INR28-IP37 (Hug: Fuji Machine MFG), INR29-IP38 (Tecpo: Shintec Hozumi)

[497] INR04-IP06 (OriHime: Ory Laboratory), INR08-IP13 (ROBO snail: Ryoei), INR11-IP17(Little Keepace: TacaoF), INR26-IP35 (Dreamer: Santec)

[498] INR04-IP06 (OriHime: Ory Laboratory)

The last group[499] consists of negative responses towards the impact of culture on their work. This group can be divided into developers[500] who feel a strong desire for humanoids, and the ones[501] who see high expectations from pop culture as an obstacle for their work.

It seems that there is a wide social consensus about humanoid robots in Japan. The difficulties existing are not about a positive or negative attitude towards robots; they are about the strong wish to integrate humanoids into Japanese society. The developer of resyone points out that *"Rather than not being understood, humanoids become the representative of robots and then all things that aren't like them are questioned. [If it's not a humanoid] I think there are cases where it's viewed like if it's not a robot."*[502] Humanoid design leads to misconceptions on the technologically feasible and fixed expectations about the design. There is a clear and prevailing image of what a robot is, as the developer of Neruru & Yumeru makes clear *"I think there are [expectations]. If it doesn't have a face you don't think it's a robot."*[503] A robot has to have a face, and probably facial expressions. The painted images of robots that move and act like their human model makes one forget how advanced or not advanced technology is in reality. The developer of HSR makes a critical note on robot design in general.

> *"Humanoids are robots that always have a difficult position. They look most interesting, they are top, but it's hard to make them useful and for complex functions the technology is still not enough. I think they need much more research. Although there was a contest at DARPA, where even average people couldn't get the impression that [humanoids] move smoothly. In comparison, Roomba504 is actually cleaning homes. It depends how you see this gap, I see it as the need that we have to proceed in both directions. Looking ahead, among current technology, emerge more and more useful things."*[505]

[499] INR01-01 (HSR: Toyota Motor), INR13-IP20 (resyone: Panasonic), INR21-IP30 (Neruru & Yumeru: T-arts), INR22-IP31 (kyūretto: Aronkasei), INR27-IP36 (yorisoi robotto: Sanyo Homes), INR39-IP53 (Sasuke: Muscle)

[500] INR01-01 (HSR: Toyota Motor), INR13-IP20 (resyone: Panasonic), INR21-IP30 (Neruru & Yumeru: T-arts)

[501] INR22-IP31 (kyūretto: Aronkasei), INR27-IP36 (yorisoi robotto: Sanyo Homes), INR39-IP53 (Sasuke: Muscle)

[502] INR13-IP20 (resyone: Panasonic) 00:28:42-00:29:01 理解されないというより、どうしてもヒューマノイドがロボットの代表になるので、そしたら何をもってそうじゃないものをロボットというか。[ヒューマノイドでなければ] ロボットじゃないんじゃないかと、そういう見られ方をするケースはあると思いますね。

[503] INR21-IP30 (Neruru & Yumeru: T-arts) 00:32:25-00:32:30 [期待は] あると思います。顔がついてないとロボットと思われないとか。

[504] Roomba is an automatic vacuum cleaner with sensors, which is capable of to navigating inside an apartment.

[505] INR01-IP01 (HSR: Toyota Motor) 00:36:55-00:37:59 ヒューマノイドはいつも難しい立場で進めているロボットですよね。見た目も一番面白いし、最高峰だけど、役に立つところまで持っていくのは大変だし、複雑な機能を使いこなすだけの技術もまだないので、息の長い研究であると思われています。DARPA[505] でコンテストはありましたが、まだ一般の人から見て、 [ヒューマノイドが] サクサク動いているような印象は持たれないレベルだったと思うんです。それに比べてルンバなんかは実際家で掃除してて…。そのギ

Even if humanoid design detracts from the current state of technology, it is important to do this kind of basic research. Nevertheless, the focus must set on functional robots, because this field will have its breakthrough earlier than the research on humanoid robots.

The fixed expectations on humanoid design roots in modern pop culture, namely anime and manga. The ambassador of Japanese robots and the humanoid design is probably Astro Boy. However, this does not mean that its impact is only positive. As the developer of kyūretto explains, *"There is something like Astro Boy and this influence is big. About pressure, for Japanese people Astro Boy is equal to a robot. So even when kyūretto is called a care robot, people question, if it is a robot. [The reason is,] because the image of human-design will clearly come to mind."*[506] The image of Astro boy is ambivalent. On the one hand, it raises the acceptance towards robots in general and serves as a catalyst for the diffusion of robots. On the other hand, it leads to fixed and inflexible expectations on robots, which can limit the acceptance for rather inconspicuous robots such as toilet aids. The developer of yorisoi robotto brings this to a general level when he states that, *"the influence of anime, impressed the image of what a robot is and there is an atmosphere that otherwise you shouldn't call it robot. Rather than to cling to this, I feel that the development [of robots] is delayed."*[507] It is not only that anime impresses specific images on robots; it is that if these images have to be fulfilled, and when they differ from the ideal of a robot drawn in anime, they get rejected. In the end, investing R&D resources for matching these expectations leads to slower development, which in general can become a disadvantage.

Even for the developer side, pop culture influences the outcome of development. The developer of yorisoi robotto urges us to not forget about the developer's own expectations toward robot design when he says *"Regardless of the user, there are also a lot of robot development which try to realize the world of anime, and those who came to my booth are proud of their technological competence or only chasing their dreams. I often think that they don't think about the user."*[508] The prevailing images of robots within pop

ャップをどうとらえるか、私としてはどちらもやっていかなければいけないと思います。先を見据えて、直近で今ある技術の中で、役に立つものがあればどんどん出していくというような。

506 INR22-IP31 (kyūretto: Aronkasei) 00:30:40-00:31:15 鉄腕アトムみたいなものがあって、その影響っていうのは大きいです。プレッシャーというか、日本人にとってロボット＝鉄腕アトムなんですよ。だからキューレットが介護ロボットって言っても、どこがロボットなんですかっていう。ヒューマナイズのイメージが鮮明に入ってきちゃうんで。

507 INR27-IP36 (yorisoi robotto: Sanyo Homes) 00:44:30-00:44:57 アニメの影響で、ロボットはこういうものだというように印象付けられてて、こうでなければロボットって言っちゃいけないかのような雰囲気があって。むしろそこにこだわってるんで、［ロボットの］開発が遅れているところもあるような気がします。

508 INR27-IP36 (yorisoi robotto: Sanyo Homes) 00:45:02-00:45:34 利用する側は関係なく、アニメの世界を実現しようとするロボットの開発も結構あって、私のブースに来られた方は、どこも開発者の技術力を自

culture influence children, who later became engineers and now these anime fans want to make their childhood heroes and idols become real. The developer of Sasuke closes the topic about the impact of pop culture very well when he concludes that the term robot itself is an obstacle for the maker[509], because it comes with expectations that everyone's robot project has to become Astro Boy. In other words, Japan has to overcome its Astro Boy syndrome for wide-spread diffusion of service and care robots.

In the following, there is a change of perspective from cultural impact factors to the social expectations on care robots. At the beginning (IQ8.3, IQ8.3.1), developers verbalize their assumed expectations on care robots and, in the end, their efforts to develop robots. Hereafter (IQ8.3.2), they evaluate from the engineer's point of view whether technology can meet the expectations of society. Thereby it is no surprise that, apart from the non-replies[510], all of the developers[511] who responded assumed that there are concrete expectations on technology. On this basis two major categories of expectations within society emerge (see Figure 6-25): social or economic[512], and technologically-driven[513] expectations. Only two responses[514] acknowledge expectations toward technology without being able to fit into one of the three mentioned categories.

慢してるとか、夢ばかりを追いかけて、使う人のことを考えてないんじゃないかということをよくおっしゃいますね。

509 INR39-IP53 (Sasuke: Muscle)

510 INR02-IP02 (SAN Flower: Kato Denki), INR11-IP17 & IP18 (Little Keepace: TacaoF), INR14-IP21 (Flagship Model: Nabtesco), INR22-IP31 (kyūretto: Aronkasei), INR26-IP35 (Dreamer: Santec), INR27-IP36 (yorisoi robotto: Sanyo Homes), INR28-IP37 (Hug: Fuji Machine MFG), INR39-IP53 & IP54 (Sasuke: Muscle)

511 INR01-IP01 (HSR: Toyota Motor), INR02-IP03 (SAN Flower: Kato Denki), INR03-IP04 & IP05 (smile baby: Togo Seisakusyo), INR04-IP06 (OriHime: Ory Laboratory), INR06-IP11 (Muscle Suit: INNOPHYS), INR07-IP12 (i-me:ma: Kito Seiki Seisakusho), INR08-IP13 (ROBO snail: Ryoei), INR10-IP16 (aijō-kun: Art Plan), INR12 (RT.1/ RT.2: RT.Works), INR13-IP20 (resyone: Panasonic), INR15-IP22 (palro: Fujisoft), INR21-IP30 (Neruru & Yumeru: T-arts), INR23-IP32 (KR-1000A: Clarion), INR24-IP33 (aams: bio sync), INR29-IP38 (Tecpo: Shintec Hozumi), INR39-IP52 (Sasuke: Muscle)

512 INR01-IP01 (HSR: Toyota Motor), INR03-IP05 (smile baby: Togo Seisakusyo), INR06-IP11 (Muscle Suit: INNOPHYS), INR07-IP12 (i-me:ma: Kito Seiki Seisakusho), INR10-IP16 (aijō-kun: Art Plan), INR12 (RT.1/ RT.2: RT.Works), INR13-IP20 (resyone: Panasonic), INR15-IP22 (palro: Fujisoft), INR23-IP32 (KR-1000A: Clarion), INR24-IP33 (aams: bio sync), INR29-IP38 (Tecpo: Shintec Hozumi)

513 INR04-IP06 (OriHime: Ory Laboratory), INR06-IP11 (Muscle Suit: INNOPHYS), INR08-IP13 (ROBO snail: Ryoei), INR21-IP30 (Neruru & Yumeru: T-arts), INR39-IP52 (Sasuke: Muscle)

514 INR02-IP03 (SAN Flower: Kato Denki), INR03-IP04 (smile baby: Togo Seisakusyo)

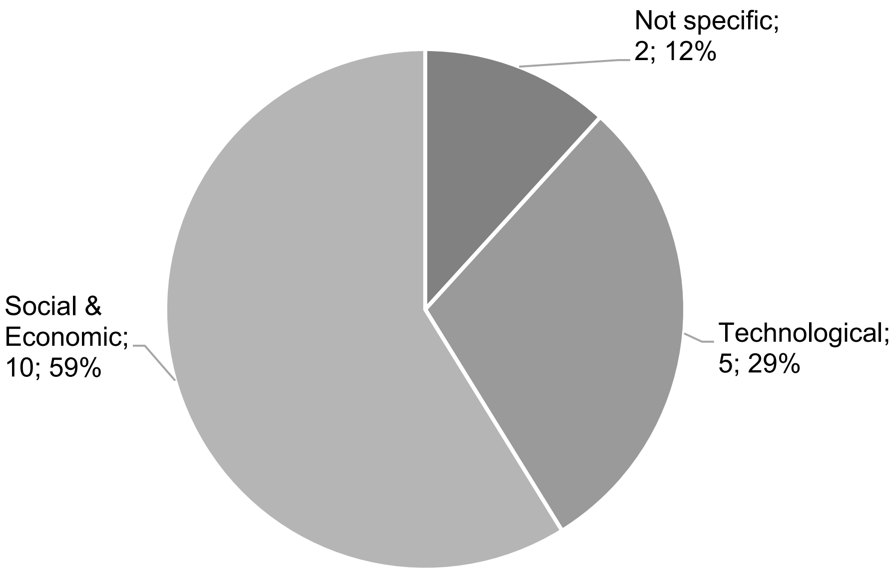

Figure 6-25 Origin of the Expectations on Care Robotics by the Government and Society (n=17)

Against the background of a steadily aging Japanese society, it stands to reason that most developers see the official and social responsibility of care robots in the mitigation of labor shortages and the burden on the welfare system. Care robots are the solution for labor shortage[515] within the care industry, and are supposed to support the elderly not only in care facilities, but also help them to master their everyday lives[516]. On a general level, it is assumed that the government[517] hopes that with decreasing prices through high production quantity, a market for care robots will emerge and at the same time care robots will diffuse within society. For the care industry, this means that care robots are expected to become a part of the care workflow.

Following up on this, on an individual level, robots and robot technology create the confidence to be able to live an independent life within their own homes[518]. The developer of HSR explains the different facets of expectations on care robots.

> *"I think there are [expectations]. Why are there expectations, because people want to do it by themselves, rather than to ask people, I think this point is in particular strong among people with disabilities. The other thing is that there are definitely not enough people in the care facilities, but it isn't that as long as it helps somehow that it will rely on everything. There are opinions that*

[515] INR07-IP12 (i-me:ma: Kito Seiki Seisakusho), INR13-IP20 (resyone: Panasonic), INR23-IP32 (KR-1000A: Clarion), INR29-IP38 (Tecpo: Shintec Hozumi),
[516] INR15-IP22 (palro: Fujisoft)
[517] INR03-IP05 (smile baby: Togo Seisakusyo), INR24-IP33 (aams: bio sync)
[518] INR01-IP01 (HSR: Toyota Motor), INR10-IP16 (aijō-kun: Art Plan)

> *robots do simple work and that [care giver] want to talk more and focus on psychical care or human work. I went as a volunteer [into care facilities], and for me it looked really busy, so that there is almost no talking."*[519]

Robots are only a means to an end, but there are three advantages of this approach. First, elderly who live at home are less costly for the welfare system. Second, robotic devices can serve the purpose of enabling people to spend time with the human part of care. This in turn is likely to increase the quality of care within care facilities. Third, elderly who can continue to live independently in a familiar surrounding with their own social network experience a higher life satisfaction and less stress, which connects to a higher quality of life.

Above all, the motivation for promoting care robots for the government and the motivation for users make use of robotic devices varies. The developer of RT.1/ RT.2 makes this clear when saying that *"I have the feeling that the average people haven't got many expectations on robots. It isn't about that they want or don't want to use a robot, it is about that they want to go to talk to their neighbors and that RT.1 is only a means to walk and it is understood that it is a robot. They don't want to have the robot RT.1".*[520] Again robots are a means to an end, and the elderly do not use them because a robot itself is desired. Especially when the development of a robot is technology-driven, there is a risk of forgetting about this initial position and of failing to meet demands with development. For the acceptance of the user, the starting point of the development of any kind of robot must be focused on how to increase the quality of care, rather than how to economically reduce the burden on the welfare state.

Nevertheless, both the diffusion of robots on an overall and individual level have the potential to kill two birds with one stone: to mitigate the burden on the welfare system and to stimulate economic demand.

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[519] INR01-IP01 (HSR: Toyota Motor) 00:37:57-00:39:08 [期待は] あると思います。ただ現実にはあまり動いていないです。どうして期待があるかというと、やっぱり人に頼むよりは自分でやりたいからなんです。そういうところだと、やはり障害のある人、不自由な人のそういった要望はすごく強いと思いますね。もう一つは、介護施設などは絶対的に人手が足りないので、「猫の手も借りたい」ではないが、単純な作業はロボットがやって、 [介護士が] もっと話し相手などに回るとか、心のケアをするとか、もっと人らしい仕事に専念したいという声があります。僕も [介護施設の] ボランティアに行きましたが、本当に忙しそうで、あんまり喋ってられないんですよね。

[520] INR12-IP19 (RT.1/ RT.2: RT.Works) 01:05:54- 01:06:41 一般の人たちは、ロボットだからと言ってあんまり期待はしてないという気はします。ロボットが欲しかったり、使いたいというわけではなく、近所の人と話しをしに行きたい、あそこまで行きたいという本当の目的があって、そのために歩く手段としてRT1 っていうのがあって、それはロボットなんだねという理解なんです。RT1 というロボットが欲しいわけではないんです。

Another topic of core significance is expectations towards technology, in particular robots themselves. The reason for this lies in pop culture and media coverage of robots. The former pictures a mostly advanced and humanoid being, and the latter picks up presentable and sensational individual cases. As a result, there is a gap between the technically feasible and glamorous robotic beings, which are basically dreams of the future. The developer of Sasuke gives a catchy example when he talks about research on androids.

> *"For example, Professor Ishiguro[521], who is making androids at Osaka University, is a good researcher. He is a very good researcher for the interaction between people. However, the media take up the tools he is working on funnily. Matsuko Deluxe[522] or the cute older sister's android have been a [media] story, but it's a different story, when it comes to their practical use. In the past he made a robot of Katsura Beichō [523], but this costs 80 million yen per unit. "[524] The Matsuroid costs 30 million yen per unit. Do you think this is suitable for the industry?*

There is a difference between media-effective research and real current research. Media coverage is important in order to raise awareness on robotics; however there is a thin line between the desirable introduction of current robots and spreading unrealizable expectations of technology. The inconspicuous robotic inventions, which are often not covered by the media, are exactly the ones that connect to the improvement of daily life.

In that regard, developers experience misunderstandings by average people about what is technically feasible. The developer of ROBO snail illustrates this when talking about the fair presence of his company when saying "*There is [pressure]. People who came to the exhibition to see our robots said 'This should be a robot? That's not a robot.' There is a stereotype of 'robots do everything. They will help with everything.' As already mentioned, I think robots won't diffuse unless there is awareness about that useful things are*

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[521] Ishiguro Hiroshi (Ishiguro Hiroshi 石黒 浩) is a robot researcher, who is also the director of the Intelligent Robotics Laboratory at Osaka University. His research and androids such as the Geminoid HI-2 or the Telenoid got worldwide media-coverage (*Bloomberg Businessweek*, November 01, 2016; A. Stafford, November 03, 2016).

[522] The android 'Matsuko Deluxe' (Matsuko Derakkusu マツコ・デラックス) has been designed on the TV personality with the same name. The android is call 'Matsuroid', a combines 'Matsuko' and an 'Android'.

[523] Katsura Beichō (Katsura Beichō 桂 米朝) was a famous rakugo storyteller in the third generation, who died in 2015. Already in its lifetime, Prof. Ishiguro Hiroshi from Osaka University created an android, which looks like Katsura Beichō, on the occasion of his 88 birthday. The android is displayed in the Sankei Hall Breeze (sankei hōru burīze サンケイホールブリーゼ) close to Osaka Station.

[524] INR39-IP52 (Sasuke: Muscle) 00:49:04-00:50:01 例えば大阪大学でアンドロイドを造っている石黒先生は研究者としては立派。人と人とのインタラクティブの研究者としてはすごく立派。でも彼がやっているツールがメディアに取り上げられて、面白おかしくなっている。マツコ・デラックスとかかわいいお姉ちゃんのアンドロイド造ったりして、[メディアの] 話題にはなっているけど、じゃああれは実用化できますかっていう話になる。前に桂米朝さんのロボットを作ったことがあるけど、あれは一体 8000 万円かかってる。マツコロイドも一台 3000 万円ぐらいかかってる。それが産業として通用しますかっていう話になる。

dangerous."[525] The actual state of technology is different, which average people are not aware of and thus they hold wrong expectations of robots. There are fixed expectations such as a robot has to be humanoid, is almighty[526], talks fluently[527] and does everything for its owner[528]. This in turn leads to low acceptance, because expectations are not fulfilled. The solution for this issue is that the communication about robots has to change. Otherwise existing misconceptions will remain significant obstacles for the diffusion of care robots.

Finally, there is the assessment by engineers as experts within their field concerning the technological sufficiency of robotic technology (IQ8.3.2) for widespread use in the care industry. The results (see Figure 6-26) are more than interesting, because if one excludes the non-answers[529], 50%[530] see the current state of the art as enough to meet expectations and 50%[531] evaluate it as insufficient.

[525] INR08-IP13 (ROBO snail: Ryoei) 00:57:54-00:58:17 [プレッシャーは] あります。展示会をやって、自社のロボットを見に来た人が、「これがロボットなの？こんなのロボットじゃないよ。」って言ったこともありますが、それはその人のロボットに対する既成概念、「ロボットは何でもやってくれる。なんでも手伝ってくれる。」っていう考え方があるんです。先ほどお話ししましたが、便利なものは危ないという考え方がないとロボットは広がらないと思いますね。

[526] INR04-IP06 (OriHime: Ory Laboratory)

[527] INR21-IP30 (Neruru & Yumeru: T-arts)

[528] INR08-IP13 (ROBO snail: Ryoei)

[529] INR02-IP02 (SAN Flower: Kato Denki), INR03-IP04 & IP05 (smile baby: Togo Seisakusyo), INR11-IP18 (Little Keepace: TacaoF), INR14-IP21 (Flagship Model: Nabtesco), INR21-IP30 (Neruru & Yumeru: T-arts), INR22-IP31 (kyūretto: Aronkasei), INR26-IP35 (Dreamer: Santec), INR39-IP52, IP53 & IP54 (Sasuke: Muscle)

[530] INR01-01 (HSR: Toyota Motor), INR02- IP03 (SAN Flower: Kato Denki), INR04-IP06 (OriHime: Ory Laboratory), INR06-IP11 (Muscle Suit: INNOPHYS), INR07-IP12 (i-me:ma: Kito Seiki Seisakusho), INR10-IP16 (aijō-kun: Art Plan), INR13-IP20 (resyone: Panasonic), INR28-IP37 (Hug: Fuji Machine MFG)

[531] INR08-IP13 (ROBO snail: Ryoei), INR11-IP17 (Little Keepace: TacaoF), INR12 (RT.1/ RT.2: RT.Works), INR15-IP22 (palro: Fujisoft), INR23-IP32 (KR-1000A: Clarion), INR24-IP33 (aams: bio sync), INR27-IP36 (yorisoi robotto: Sanyo Homes), INR29-IP38 (Tecpo: Shintec Hozumi)

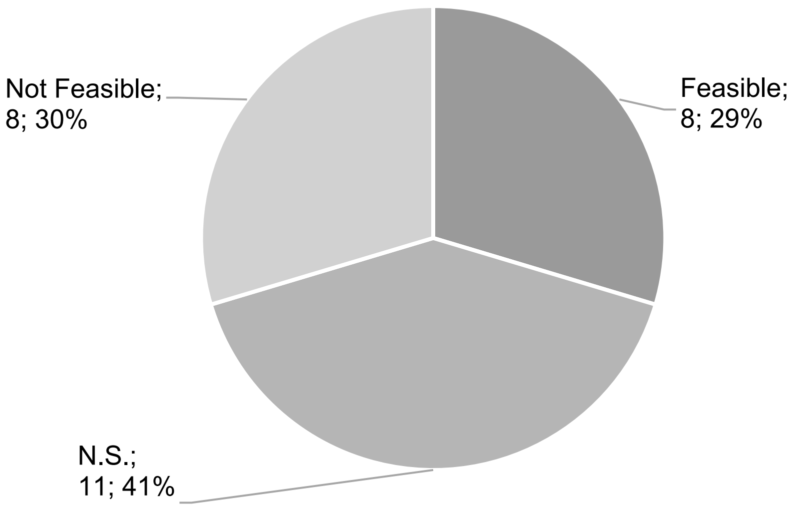

Figure 6-26 Technical Feasibility of Robot Technology for Use within the Care Industry (n=27)

The optimistic group of developers believes in the possibilities that robotic technologies offer for an over-aged society, and at the same time that the technological progress the fields of application increase. The wider availability of robotic devices in turn will have a positive impact on daily life and quality of life[532]. However, developers[533] are aware of the fact that fields will emerge which are predestined for the use of robotics, and which will have big hurdles for their use.

From a technical perspective, the following applications are feasible[534]: toileting, mobility, transfer, monitoring and medication or just repetitive labor. Thereby the robot is used as a tool, or to perform repetitive labor within these fields. In contrast to relatively simple fields, there is only limited potential[535] for areas with complex human interaction, such as emotions or communication. This means developers forecast difficulties for AI-related R&D.

In the end, there is high potential for low-tech solutions rather than advanced high-tech devices[536]. The reason is simple; low-tech devices designed for a certain task are more likely to be quickly mastered by caregivers, and thus are easier to integrate into the work

[532] INR04-IP06 (OriHime: Ory Laboratory)
[533] INR01-01 (HSR: Toyota Motor), INR13-IP20 (resyone: Panasonic)
[534] INR02- IP03 (SAN Flower: Kato Denki), INR06-IP11 (Muscle Suit: INNOPHYS), INR13-IP20 (resyone: Panasonic)
[535] INR06-IP11 (Muscle Suit: INNOPHYS), INR13-IP20 (resyone: Panasonic)
[536] INR10-IP16 (aijō-kun: Art Plan)

routine. For the near future, focus[537] lies on care robots for care facilities and the next step, when technology matures, will address the elderly at home.

The negative-minded group of engineers speaks almost with one voice; there is a mismatch between technology and user demand. They argue that the hardware, robot technology itself, is on a level that is good enough to be used in a care setting. The issue is the software of the robot, the concept side. In other words, the technology already exists, but Japanese engineers are weak in transferring technology in such a way that care givers want to use it.

Nevertheless, most developers recognize the problems of current care robots. For that reason, there are voices[538] which are convinced of the positive development for care robots.

6.9 Category 9: Contribution of Robots to Society

After having a closer view on the personal background of developers (see Chapter 6.1), the robot project (see Chapter 6.3), the project's organizational structure (see Chapter 6.2) or higher vision (see Chapter 6.5), as well as its connection to the field (see Chapter 6.4) and development problems (see Chapter 6.6), the focus switches to a general level with the evaluation of the care robot market (see Chapter 6.7) and the expectations on robot technologies (see Chapter 6.8). At the end of this general topic, it is important to understand how developers, as experts within their field, see care robots as a medium to make a contribution to society. The broad range topics vary from possible contributions to challenges of demographic change or the care workflow, to a forecast of the acceptance of robots within society, or the diffusion scale in the future as well as concrete considerations for personal use.

There are expectations that robotics is the technical solution to solve the problems of Japan's aging society (see Chapter 3). The evaluation (see Figure 6-27) of developers as engineers and experts within their field gives important insights about the capabilities of robot technologies for a steadily aging society (IQ9.1.). Thereby, only five developers[539] were not able to reply to this question. The remaining 22 developers[540] gave a

[537] INR07-IP12 (i-me:ma: Kito Seiki Seisakusho)
[538] INR08-IP13 (ROBO snail: Ryoei), INR15-IP22 (palro: Fujisoft)
[539] INR02-IP02 & IP03 (SAN Flower: Kato Denki), INR11-IP18 (Little Keepace: TacaoF), INR13-IP20 (resyone: Panasonic), INR39-IP53 & IP54 (Sasuke: Muscle)
[540] INR01-01 (HSR: Toyota Motor), INR02-IP03 (SAN Flower: Kato Denki), INR03-IP04 & IP05 (smile baby: Togo Seisakusyo), INR04-IP06 (OriHime: Ory Laboratory), INR06-IP11 (Muscle Suit: INNOPHYS), INR07-IP12 (i-me:ma: Kito Seiki Seisakusho), INR08-IP13 (ROBO snail: Ryoei), INR10-IP16 (aijō-kun: Art Plan),

mostly positive evaluation of robotics as a solution for social issues. There are strong supporters, simple supporters or partial supporters, as well as a few opponents of robotics. The information about this category and its questions are provided in chapter 4.3.9.

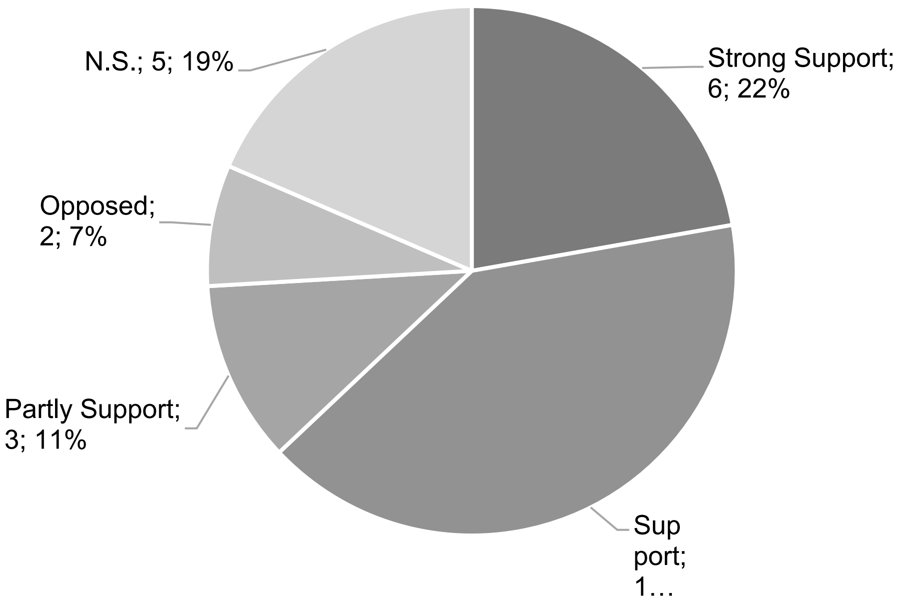

Figure 6-27 Opinions about Robotics as Solution to Solve Issues of an Aging Society (n=27)

The first group, consisting of almost a quarter of the developers[541], is the one of strong optimists. The majority believe that robots are able to balance not only the labor shortage in general, but also that within the field of care. The developer of HSR talks about why he thinks that robots will contribute to society when saying *"an obvious lack of labor is predicted. As I said, there may be three solutions [solving the labor shortage, improving the quality of care, reducing the care burden], but there is no single trump card. Then, I think it can be said that technology will be needed to complete the missing something."*[542]

INR11-IP17 (Little Keepace: TacaoF), INR12 (RT.1/ RT.2: RT.Works), INR14-IP21 (Flagship Model: Nabtesco),INR15-IP22 (palro: Fujisoft), INR21-IP30 (Neruru & Yumeru: T-arts), INR22-IP31 (kyūretto: Aronkasei), INR23-IP32 (KR-1000A: Clarion), INR24-IP33 (aams: bio sync), INR26-IP35 (Dreamer: Santec), INR27-IP36 (yorisoi robotto: Sanyo Homes), INR28-IP37 (Hug: Fuji Machine MFG), INR29-IP38 (Tecpo: Shintec Hozumi), INR39-IP52 (Sasuke: Muscle)

541 INR01-01 (HSR: Toyota Motor), INR03-IP04 & IP05 (smile baby: Togo Seisakusyo), INR21-IP30 (Neruru & Yumeru: T-arts), INR22-IP31 (kyūretto: Aronkasei), INR27-IP36 (yorisoi robotto: Sanyo Homes)

542 INR01-01 (HSR: Toyota Motor) 00:43:28-00:43:58 明らかな人手不足が予測されているんですね。さっき言ったような、３つほどのソリューション [労働不足解消、介護の質向上、介護負担軽減] はあるかもし

It is the awareness about the gravity of the situation that motivates thinking several scenarios through. More migration and incentives to work in the care industry are only two among various options for actions on the macro level. However, even if other measures would be effective, it would not be enough to sustain the current level of the welfare system[543].

From a daily perspective, there is a working-to-capacity situation within most care facilities. At this point, the advantage of robots is that they can work twenty-four hours a day seven days a week[544], which is not possible for care workers and even newly immigrated foreign labor. In addition, not only is the population in general is aging, but also the average age among the caregivers[545] is increasing. This means that preventive measures enabling aging caregivers to stay in their jobs as long as possible is crucial to optimize the available labor within the field of care.

Apart from that, the developer of yorisoi robotto points to an additional aspect: The increasing number of elderly people who live alone at home. He says that, *"I think [robots] they are always necessary. There are many elderly people living alone, and no one there to look after them, so we have no choice but to rely on robots."*[546] Robots might be a means to an end to improve the situation at home and enable the elderly to stay within their own four walls longer. This in turn directly increases quality of life, because the elderly can live in a familiar environment and do not have to adjust to a strange new place of living, the care facility. Moreover, elderly who live at home make less use of the welfare system and for that reason, contribute to mitigating the burden on it. Robots are a tool for this.

The largest group[547] is the one of general supporters of robots for care. This again includes the general belief that the high expectations on care robots[548] will connect to the diffusion of useable robots[549] and balance the labor shortage[550], as well as improve the

れないが、これといった決め手がない。そうすると、何か足りない分を補完する技術は必要とされるだろうということは言えると思います。

543 INR01-01 (HSR: Toyota Motor), INR03-IP04 & IP05 (smile baby: Togo Seisakusyo), INR27-IP36 (yorisoi robotto: Sanyo Homes)

544 INR27-IP36 (yorisoi robotto: Sanyo Homes)

545 INR22-IP31 (kyūretto: Aronkasei)

546 INR27-IP36 (yorisoi robotto: Sanyo Homes) 00:47:50-00:48:04 [ロボットが] 必ず必要だと思うんです。一人暮らしの高齢者が多く、それを守る人がもういないんだから、ロボットに頼らざるを得ない。

547 INR04-IP06 (OriHime: Ory Laboratory), INR08-IP13 (ROBO snail: Ryoei), INR11-IP18 (Little Keepace: TacaoF), INR12-IP19 (RT.1/ RT.2: RT.Works), INR15-IP22 (palro: Fujisoft), INR23-IP32 (KR-1000A: Clarion), INR24-IP33 (aams: bio sync), INR26-IP35 (Dreamer: Santec), INR28-IP37 (Hug: Fuji Machine MFG), INR29-IP38 (Tecpo: Shintec Hozumi), INR39-IP52 (Sasuke: Muscle)

548 INR11-IP17 (Little Keepace: TacaoF)

549 INR08-IP13 (ROBO snail: Ryoei)

550 INR23-IP32 (KR-1000A: Clarion)

situation within the care facilities[551]. Thereby, the reason for developing care robots and the need to use them remain almost the same during this study (e.g. see Chapter 6.8). Robots are the countermeasure for solving certain issues of an aging society[552]. The developer of Hug explains the wish behind this way of thinking when saying, "*I think people should just enjoy the parts that can be done with ease. It's fine not to feel bad about it, once they try it and realize how convenient it is, they'll never look back."*[553] The user then develops into an interested and proactive user. Robots should become a tool and be understood as a helping hand for solving issues in daily life and being able to live at home[554] as long as possible. One developer[555] expressed this in a visionary way, when he dreamed of a robot assistant age. For the moment, problems aside from technical sufficiency is the low level of awareness of care robots in general. At the moment, not enough people know about care robotics, how they look and what they can do. The level of diffusion will change when it is possible to change awareness of care robots.

However, there are also critical voices within this group; one developer[556] believes that the government is too fast in reducing the priority ages.

The third group[557] is less optimistic about robot technology, but in total still convinced that they can contribute to solving the issues of an aging society, even if it might be only a smaller contribution. There is a consensus within this group of developers that robot technology can connect to decreasing the labor burden. Even if robot technology cannot solve all problems, depending on the degree of care of the recipient[558], care robotics can help to reduce the burden of care, especially heavy labor[559], and in the end, by enabling caregivers to stay in their job, to reduce the costs for care itself. The group of partial robot supporters might be prosaic and less euphoric, but makes a realistic assessment on possible applications.

Nevertheless, there is also a small group of developers[560] who do not see the key for solving the issues related to demographic change in care robotics. On the one hand,

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[551] INR15-IP22 (palro: Fujisoft)
[552] INR26-IP35 (Dreamer: Santec)
[553] INR28-IP37 /Hug: Fuji Machine MFG) 00:32.54-00:33:06 楽できる部分は楽した方がいいと思うんですよ。敢えて辛い思いをしなくてもいいと思いますので、やっぱり皆さん一回使ってみて楽なのが分かったら絶対そっちに行くと思いますね。
[554] INR12-IP19 (RT.1/ RT.2: RT.Works)
[555] INR39-IP52 (Sasuke: Muscle)
[556] INR04-IP06 (OriHime: Ory Laboratory),
[557] INR02-IP03 (SAN Flower: Kato Denki), INR07-IP12 (i-me:ma: Kito Seiki Seisakusho), INR10-IP16 (aijō-kun: Art Plan)
[558] INR02-IP03 (SAN Flower: Kato Denki)
[559] INR10-IP16 (aijō-kun: Art Plan)
[560] INR06-IP11 (Muscle Suit: INNOPHYS), INR14-IP21 (Flagship Model: Nabtesco)

robots can only contribute to a limited range of issues[561], such as the labor shortage or the care burden, but cannot be a countermeasure to overcome an overaged society with all its complex issues. On the other hand, robot technology itself has a short range[562]. For dealing with the growing aging population and the increasing care demand, it is necessary to utilize robot technologies to solve single issues; it is necessary to develop an integrated design with robotics connecting to a social infrastructure, such as the health care sector. In other words, the pessimistic group of developers believes that rather than robotics being the magic which will help overcome demographic change, robotics can make a contribution to partly mitigate the burden of the steadily aging society.

After getting insight about whether developers think robotics can contribute to the issues related to a steadily aging society, the next step is to shed light on how this contribution will look in detail (IQ9.2). In doing so, after excluding the non-answers[563], four categories evolve for the expected sphere of influence of robots on the care industry (see Figure 6-28): The burden of work, the division of time, the environmental chances and the unclear impact.

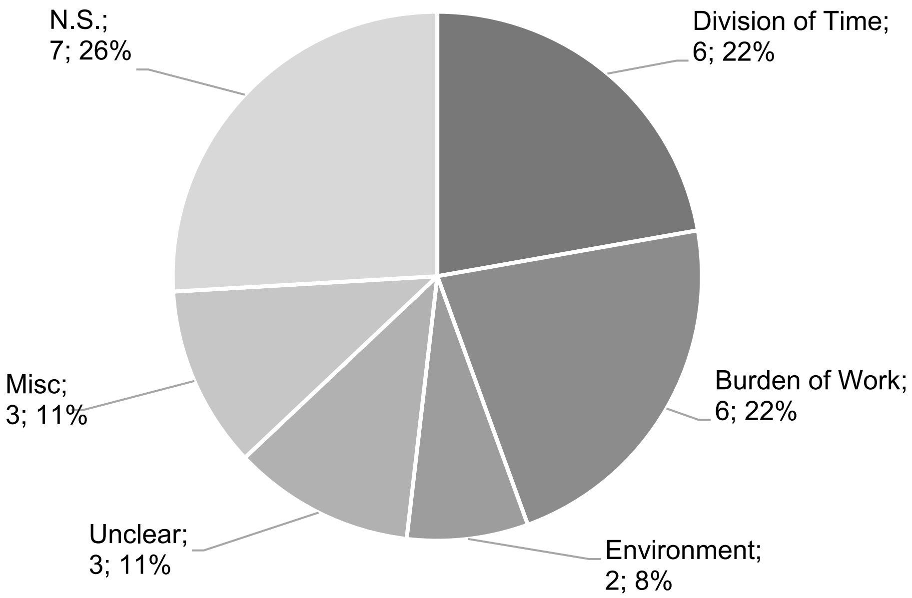

Figure 6-28 Expected Sphere of Influence through Robots on Care Work (n=27)

[561] INR14-IP21 (Flagship Model: Nabtesco)
[562] INR06-IP11 (Muscle Suit: INNOPHYS)
[563] INR02-IP02 & IP03 (SAN Flower: Kato Denki), INR11-IP17 & IP18 (Little Keepace: TacaoF), INR14-IP21 (Flagship Model: Nabtesco), INR21-IP30 (Neruru & Yumeru: T-arts), INR28-IP37 (Hug: Fuji Machine MFG), INR39-IP53 & IP54 (Sasuke: Muscle)

In doing so, the first two categories, the burden of work[564] and the division of time[565], are evenly split and together they make up over half of the responses in total. Ultimately, these two categories are complementary, because both refer to positive impact on working conditions. The developers, who believe that robot technology contributes to less difficult conditions at work, see chances for two kinds of devices.

These are, on the one hand, devices aimed at the physical burden of care. There are the directly supportive devices, which clearly and noticeably reduce the physical burden on staff. These kinds of devices cover wearable aids, toileting aids or bathing aids. For example, a caregiver can operate several robots and does not have to do the physical work himself. In this case, technology supports the act of work itself and in turn enables staff to work longer without physical problems.

On the other hand, these are devices that enable a better division of time. There are indirectly assisting devices, whose impact is more difficult to measure. These kinds of devices cover especially monitoring systems and communication robots. One example for this are monitoring systems in the rooms of the elderly, which track if there are any problems. Especially during night shifts with only a low number of staff, the fear of missing or overlooking an emergency call, or when two calls come at the same time, is an existing problem causing stress for the staff. Robot technology with sensors helps to be able to keep an eye on everything without having to go to each room, and allows staff to prioritize in the case of an emergency. Further examples are communication robots, which are put in the room and entertain the elderly for a while. It is important that this is made use of only for short periods, because the intention is not to replace communication.

The intention is that under certain circumstances, robots free caregivers to take care of people who need help urgently. In that case, robots are like board games, which can be played for a while. The developer of KR-1000A explains these advantages of the integration of robots into work when stating, *"At the end of the day, there will always be things that people have to do, like chatting with the elderly and other face-to-face activities. It's no problem if other tasks such as carrying something, preparing medicine, etc., are not done by people, but instead incorporated into the field of activities fit for robots."*[566]

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564 INR01-01 (HSR: Toyota Motor), INR03-IP04 & IP05 (smile baby: Togo Seisakusyo), INR07-IP12 (i-me:ma: Kito Seiki Seisakusho), INR27-IP36 (yorisoi robotto: Sanyo Homes), INR39-IP52 (Sasuke: Muscle)

565 INR01-01 (HSR: Toyota Motor)

566 INR23-IP32 (KR-1000A: Clarion) 00:28:59-00:29:28 結局どうしても人がやらなきゃいけない、例えば老人の方と会話したりとか、対面でやらなきゃいけないことは人がやって、それ以外の、何かを運んだりするとか、薬を準備したりとか、人がやらなくてもいいようなところはロボットがやるというようにしっかり活動分野を分ける。

It is about selecting which work has to be done by humans, or is desired to be done by humans, and which is not. Thereby the consensus among developers is that robots should free caregivers to be able to focus more on the human aspect of care. Rather than dehumanization, robot technologies should bring people together.

A small group of two developers[567] believes that robot technologies connect to an improvement of the work environment. This applies for the change of how work is done within the field of care in general. Japan lags behind in making use of care equipment, e.g. transfer boards or lifts, and robots might have the potential[568] to pave the way for a diffusion of care equipment in general. In addition, efficiency is likely to increase through technology.[569] Thereby. it is not important whether it is a robot or a care device in general that reduces the physical burden for caregivers. It is important that a technical device connects to better quality of care for the caregiver, and also for the care recipient.

The last group of developers[570] is vague about how in detail robots will have an impact on care work. The tenor of them is that test runs within care facilities in the future will show which kind of robot technologies are practical solutions for work processes. One argument is that the field of care, namely the caregiver, still does not understand robots[571]. In addition, some criticized that there is no time to train the staff on the robots, which keeps knowledge low and, in turn, won't convince anyone of the positive impact robotics can have. The developer of Dreamer expresses how he sees the course of diffusion when saying, *"I think there will be robots that look like the current ones, and I think it will be understood later that robots can really do an active part in care. But now there is no real robot itself, so I think we first have to develop robots."*[572] The point here is that, before speculating about what robots can do, there have to be a certain number of robots in use to be able to talk about them. Concerning this point, the increasing number of test runs and robots available on the market is a step in the right direction.

In addition, some replies belong to no specific category, but highlight interesting aspects. First there is the thought that robotics can solve the labor shortage[573]. Even if this is a common answer (see Chapter 6.8. and Chapter 6.9.), this aims at making care work

567 INR13-IP20 (resyone: Panasonic), INR24-IP33 (aams: bio sync)
568 INR13-IP20 (resyone: Panasonic)
569 INR24-IP33 (aams: bio sync)
570 INR12 (RT.1/ RT.2: RT.Works), INR26-IP35 (Dreamer: Santec), INR29-IP38 (Tecpo: Shintec Hozumi)
571 INR12 (RT.1/ RT.2: RT.Works)
572 INR26-IP35 (Dreamer: Santec) 00:31:09-00:31:23 当面は今みたいにロボットが先にあって、そのロボットが本当に介護で活躍できるかっていうのは後になってわかるんじゃないかなと思います。でも今はロボットそのものがないと何とも言えないので、まずはロボットを作るのが先かなっていう気はします。
573 INR04-IP06 (OriHime: Ory Laboratory)

more attractive by making use of more technology. It is about a change in the image of care as hard and badly paid work. Second, the care market is special, and so the opportunities for robot technologies to have an impact on care work itself are limited[574]. This makes it necessary to understand what the needs of the field of care are. After that, it is possible to develop something that can have a sustainable impact on the work environment. Third, in contrast to focusing on care facilities and the field of care in a narrow sense, trying a totally different approach for the development of robots might bring better results. The developer of ROBO snail explains this further when he talks about an experience from a lecture.

> *"As in the Aichi robot cluster, hospitals become places for test runs and the development proceeds in various areas. If hospitals jointly develop with a manufacturer like this, they can say 'it is easy to use robots in this situation' and if a system like the one in Aichi would exist somewhere else, things would be safe and spread more. I think the point here are the hospitals, because they also do nursing care. I often hear that you have to listen to the needs, but you shouldn't ask the care recipient what you should develop. The care recipient can't care for his own illness. The doctor at the hospital cures. Instead of asking the care recipient, what you want, proceed with the hospital. Of course, I think it is important to ask for the opinion of the final user […], but the opinion of the hospital is the one that can prescribe and cure. Rehabilitation is a word used by people who can prescribe. So I think it is important to listen to the ones, who can prescribe."*[575]

According to this argument, the key for successful diffusion of care robots is not the care facilities, it is the hospital. The reason for this is, on the one hand, professionalization of curing illnesses and thus improvement in the quality of life. On the other hand, in contrast to care facilities, hospitals have more knowledge and can collect more data to underline their findings.

The next step is to understand the chances and risks (IQ9.2.1.) developers see coming along with robots. The main advantage for the use of care robots is to free people from

[574] INR10-IP16 (aijō-kun: Art Plan)

[575] INR08-IP13 (ROBO snail: Ryoei) 01:02:24-01:04:15 愛知県のクラスターのように、病院が実証実験の場になって、各地区で開発が進んで、「こういう場合は、このロボットが使いやすい。」といったようにメーカーと共同開発した病院が発信していければ、愛知県のようにこういうシステムができれば、安全でもう少し広がりのあるものができていくんじゃないかと。そこのマスターは病院だと思ってます、介護だからこそ。ニーズで物を作らなくちゃいけないっていうのはよく聞く言葉なんですけど、[…] どういうものを作ったらいいのかということを被介護者に聞いてはだめだと仰っていたんです。被介護者は、自分の病気を自分で治せない。治すのは病院の先生だと。[…] どういうものが欲しいですかと被介護者に聞くのではなく、病院と進めていく。使う方の意見を聞くのも、もちろん大事だと思うんですけど、[…] 病院の先生の意見、つまりその病気を治して、処方することができる人の意見を聞く。リハビリという言葉は、処方できる人が使う言葉だと。だからその処方できる人の意見を聞くことが大事なんじゃないかと思います。

hard work, and enable them to spend more time on the interaction aspect of care[576], or even to enable elderly people to live in their familiar environment as long as possible. Two good examples are a toileting aid, which can prevent elderly from bothering their relatives or a caregiver; mobility aids can extend the range of movement and contribute to social participation. In other words, developers see a high potential to influence the quality of care and life in a positive way.

At the same time, society needs time to realize which are the fields that robots can make a positive contribution to and the ones which might cause problems[577]. That means test runs are needed to see what kind of robot technology is helpful. With an increasing number of test runs done within care facilities, and a steadily growing social interest in finding solutions for the various aspects of the care crisis, this is only a matter of time.

Having said this, even engineers see robotics as a double-edged sword that comes with certain challenges[578]. On the one side, there is work simplification through robot technologies. Technology has the potential to take on tasks that previously had to be done by humans. This in turn releases workers and gives flexibility for other things, such as spending time on interaction. The other side is that there is the risk that people might get used to technology too much, and outsource certain important parts of human interaction. The developer of Muscle Suit verbalizes this risk when saying, *"The more useful robots become, the more dangerous they become too. If people become too used to having robots, they eventually will not be able to control themselves."*[579] Other developers answer the question about where to set limits, and where this might lead to. The developer of OriHime draws a gloomy picture when he illustrates what the future could look like.

> *"I think the worst thing is to lose the communication with people. When the era, where robots do anything comes, it is easy to live without doing anything. However, on the other hand, something can get lost because of this comfort, which is that you don't have to meet people. There will be no caregiver, only robots, who take care of everything around and carry you. In this future, there may be a life without human intervention.*[580]*"*

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576 INR03-IP04 & IP05 (smile baby: Togo Seisakusyo), INR29-IP38 (Tecpo: Shintec Hozumi)
577 INR02-IP03 (SAN Flower: Kato Denki)
578 INR04-IP06 (OriHime: Ory Laboratory), INR06-IP11 (Muscle Suit: INNOPHYS), INR13-IP20 (resyone: Panasonic), INR15-IP22 (palro: Fujisoft)
579 INR06-IP11 (Muscle Suit: INNOPHYS) 00:49:04- 00:49:22 役に立つロボットほど危険。それらによって、人間がロボットに慣れすぎてしまい、自分自身をコントロールできなくなる。
580 INR04-IP06 (OriHime: Ory Laboratory) 00:40:18-00:40:57 一番よくないのは、人とのコミュニケーションをなくしてしまうことじゃないかなと思っています。なんでもロボットがやってくれる時代になっていって、何もしなくても生きていけるっていうのはすごく楽なんですよね。ただ一方で、そうやって楽になってしまったがために失ってしまうものがあって、つまり人と会わなくていいということになってくるんです。介護者もいなくなって、そこにはロボットがいて、自分の身の回りの世話を全部してくれて、自分の体を運んでくれる。未来において、そこに人が介在しない人生があるかもしれない。

The clear risk is the one of outsourcing human communication and leaving it to technology. The high relevance of this issue becomes clear when taking in mind that the developers[581] of communication robots, who are very familiar with this topic, are the ones who are giving these reminders of the importance of human communication. For them, the reason for using robots is not time-saving in general, but the time-saving which connects to being able to spend more time on human interaction in care. Robot technology should never replace humans, only support them.

After the evaluation of robots as a possible solution for Japan's aging society (IQ9.1) and concrete images on the impact of robotics on the field of care (IQ9.2), it is important to get insights on how developers experience the acceptance of robotics within society (IQ9.3). In doing so, there are three groups of experiences (see Figure 6-29): positive, negative and mixed; whereby there is almost a consistent distribution of positive and negative experiences. Only four developers[582] were not able to respond to the question.

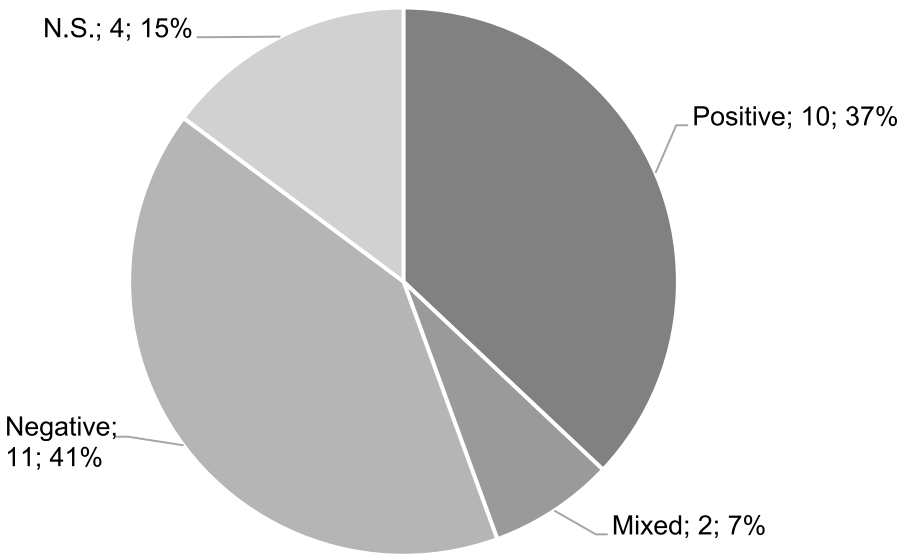

Figure 6-29 Experienced Acceptance among Society towards Care Robots (n=27)

[581] INR04-IP06 (OriHime: Ory Laboratory), INR15-IP22 (palro: Fujisoft)

[582] INR02-IP02 (SAN Flower: Kato Denki), INR04-IP06 (OriHime: Ory Laboratory), INR11-IP18 (Little Keepace: TacaoF), INR39-IP53 (Sasuke: Muscle)

Almost half of the developers[583] experienced average people's view on robotics as positive. This illustrates that robots are slowly entering daily life. The range of opinions for these positive attitudes among society varies from general acceptance over pragmatism to increased points of contact and a positive change of mindset.

In general, developers[584] feel that a basic acceptance to use robots exists. The reason for this is the steadily aging society. Besides the developers, the engineers, even the potential users, average people, are aware of the fact that in the future, the demand for care with all its implications will increase. The developer of resyone believes that, especially among the population over 50 years old, there is high approval of using care robots[585]. The developer of HSR explains this situation further.

> *"In fact, we also take questionnaires, but many people reply much more positively than we expected before. For example, it would be more convenient to have a robot. As I said earlier, there are situations, where you are desperate for any help, because there aren't enough people. Because [robots] they don't have a certain sense of emotion, [robots] they will work silently, so I think people will feel grateful if they do work properly. After that the question is left, what [robots] can do?"*[586]

Omnipresent demographic change, with its connected challenges for Japanese society, such as ensuring a working welfare state and a certain standard of care, might be the motivation behind this way of thinking. This leads to a certain pragmatism and consideration of feasible options to solve care issues in general and on an individual level.

Against this background, there is the experience of developers[587] with the user to consider robots as a possible technical solution for their personal care, because of missing alternatives. This may sound like just an emergency solution, but it might be the necessary motivation for serious consideration by average people. In order to reach the broad diffusion of care robotics within society, taking robots into consideration as a possible option, upcoming care challenges can eventually pave the way for diffusion.

583 INR01-01 (HSR: Toyota Motor), INR03-IP04 & IP05 (smile baby: Togo Seisakusyo), INR06-IP11 (Muscle Suit: INNOPHYS), INR13-IP20 (resyone: Panasonic), INR14-IP21 (Flagship Model: Nabtesco), INR26-IP35 (Dreamer: Santec), INR29-IP38 (Tecpo: Shintec Hozumi), INR39-IP53 (Sasuke: Muscle)

584 INR01-01 (HSR: Toyota Motor), INR29-IP38 (Tecpo: Shintec Hozumi), INR13-IP20 (resyone: Panasonic)

585 INR13-IP20 (resyone: Panasonic)

586 INR01-01 (HSR: Toyota Motor) 00:46:45-00:47:26 実際我々もアンケートをとるんですけど、思っている以上に肯定的なことを言ってくださる方が多いですね。ロボットがあった方が便利と。それは、さっきも言ったとおり、とにかく猫の手も借りたい、人がなかなかいないといった面もあるでしょうし、[ロボットが] ある意味感情もなければ、[ロボットが] 黙々とやってくれるわけですから、ちゃんと働くのであればありがたいという思いを持っていただいているのかなと思います。あとは、どれだけのことができるのかということが問われている状態ですね。

587 INR03-IP04 & IP05 (smile baby: Togo Seisakusyo), INR14-IP21 (Flagship Model: Nabtesco)

Another aspect of a perceived increase of people being positive about care robots might be their high appearance within the media, as well as the higher frequency with points of contact between average people and robots[588]. Robots are not limited to laboratories or the world of the engineers, but have begun entering daily life more and more. The number of test runs is increasing and with this, a habituation effect occurs which causes a reevaluation of previous patterns of thinking. The developer of Sasuke summarizes the change in thinking about robots very clearly.

> *"There is the international welfare equipment exhibition H.C.R. and also the barrier-free exhibition in Osaka and these will be Japan's largest exhibitions for welfare equipment. About 3-4 years ago, when we went out to get feedback on our still under-development Sasuke, nobody stopped by or even passed by our booth. The resistance against robots was so great. That's why I feel a certainty every time I keep presenting at a trade fair. Two years ago, the public response was 'is that a robot?' or 'will there be a time, when robots help within care?'. This year I had the strong feeling that the perspective of people related to the field of care changed on the premise of using robots, such as 'let me test it.', 'let me touch it.' or 'where can I buy this?'."*[589]

It takes time to change ways of thinking. There is no perfect shortcut to influence and change how society thinks about a certain technology. However, a communication strategy that includes the media and brings technology closer to people can improve the situation. This is a point where the government can create a certain output with a certain input. In other words, advertisement and field runs can become a communication tool which can try to influence society into a certain direction.

A trail majority of the developers[590] feels a negative attitude towards care robots. There is a feeling that acceptance is still low, and not enough[591]. In addition to that, acceptance depends on the field of application and the age of the user. Elderly users are more likely to not understand a robot than younger users[592], who grew up with various technologies.

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588 INR26-IP35 (Dreamer: Santec), INR06-IP11 (Muscle Suit: INNOPHYS)

589 INR39-IP54 (Sasuke: Muscle) 00:28:55-00:30:07 国際福祉機器展、H.C.R.とか、大阪ではバリアフリー展っていうのがあって、日本で大きな福祉機器展になるんですね。3-4 年ぐらい前に私達が開発中の Sasuke を見てもらうためにそれらに出たときは、皆さん通りすがりに見ても寄ってきてくれなかったんですね。それぐらいロボットに対する抵抗っていうのはすごく大きかった。それが、見本市に出し続けると、毎回確実に手ごたえを感じるようになってきたんです。「ロボットなの？」「ロボットが介護を手伝ってくれる時代が来るのかなぁ」という反応だったのが 2 年前。今年は「体験させて」「触らせて」「これどうやったら買えるの？」「もう売ってるの？」っていう、使うことを前提に介護に携わる方の視点が変わってきていることをすごく感じたんですね。

590 INR02-IP03 (SAN Flower: Kato Denki), INR07-IP12 (i-me:ma: Kito Seiki Seisakusho), INR08-IP13 (ROBO snail: Ryoei), INR12 (RT.1/ RT.2: RT.Works), INR15-IP22 (palro: Fujisoft), INR21-IP30 (Neruru & Yumeru: T-arts), INR22-IP31 (kyūretto: Aronkasei), INR23-IP32 (KR-1000A: Clarion), INR24-IP33 (aams: bio sync), INR27-IP36 (yorisoi robotto: Sanyo Homes), INR28-IP37 (Hug: Fuji Machine MFG)

591 INR15-IP22 (palro: Fujisoft), INR22-IP31 (kyūretto: Aronkasei), INR24-IP33 (aams: bio sync)

592 INR23-IP32 (KR-1000A: Clarion)

The reasons for this are wrong expectations or a lack of knowledge about robotics itself. People do not want to use robots because they do not see the benefits of robots, and because there is a limited field of application. The developer of SAN Flower talks about their problems during development and what kind of objections they had and still have to face.

> *"I think many people still don't want to use them [robots] now. I believe after all that they are difficult to use. Even if this [SAN Flower] can locate people, but when I say 'please use this', the questions 'how should I attach it?' will return. 'Who will make the elderly use it?', and then the question is 'Isn't it okay to adjust it?', but in the end, there is no adjustment. There are many people, who don't think about their own ideas, and it is good to use them well, when there is a thing, but the majority of people doesn't think about it. That is a bit disappointing. So we think about ourselves, like this, to putting it into shoes or making it smaller, and wanting to proceed with a maker, there are surprisingly many pessimistic people, regarding robots."*[593]

Lack of knowledge on robots combined with low imaginative power leads to a slowly developing application field for robots. Makers are responsible for thinking about the application for their invention and they only get limited input from outside, which makes it difficult to switch thoughts to something completely different and be more user centered. As it is now, development is more or less a guessing game within developers who try to guess what the user might want. These issues could be solved very simply with an open-minded user who is integrated into the development process at an early stage.

Another question is, if developed technology has to be a robot, or if it is simply enough to label an invention as a care device instead of a robotic device for care. This change within communication can reduce uncertainties and worries towards technology that might challenge the daily life patterns of elderly people. The developer of RT.1/ RT.2 explains why he thinks that the term "robot" is not paramount for the user.

> *"Now that the term 'care robot' is popular, I am happy to be able to ride that wave, but more than being a robot, it [RT.1/ RT.2] is a mobility aid. This is a little different. I feel a bit iffy about that it [RT.1/ RT.2] will be taken up as a 'robot'. For example, there are a lot people, who bring it to their grandparents, and when they introduce it as a robot, there are many people, who refuse it. Especially RT.1 looks different from the conventional ones [mobility aids]. Some people say that this is good, but after all, when it comes to the elderly,*

[593] INR02-IP03 (SAN Flower: Kato Denki) 00:33:09-00:33:58 [ロボットが] まだ今は使いたくないっていう人が多いと思います。やっぱり使いにくいと思います。これですら、発見できるんですけど、「これ使ってください」って言ったら、「どうやって[タグを]持たせるの？」っていう質問が返ってきちゃうんですよ。「誰が、どうやってお年寄りに持ってもらうんですか？」「それは工夫したらいいんじゃないですか？」っていう話になるんですけど、結局工夫しないんです。アイデアを自分たちで考えない人たちが多くて、物があるときにうまく使えばいいんですが、そこを考えない人が圧倒的に多いんです。それがちょっと残念ですね。なので私たちが自分で考えて、こういう、靴に入れたり、小型化したりと、それはメーカーが進めていくんですが、意外に否定的な人が多いんですよ、ロボットに関しては。

> *they feel strange about a too changed design. Just hearing the word 'robot' gives people the impression, that it is a difficult [or complex] thing."*[594]

This statement includes several aspects. First, the elderly, who have to use the technology, and their relatives, who assume that a technology can help, do not think the same. The relatives' good intentions might remain unanswered. Second, for the elderly, it is irrelevant to use a robot. Elderly people are more likely to accept technology if they can clearly see the benefits, which this technology should bring them. In this context, benefits mean being able to continue the life they are used to living. Robots are only a means to an end, and if another device that is not a robot could fulfill the same function, then that would be fine as well. This is a point not just companies, but also the government has to be aware of and keep in mind when they try to create a market demand or sell their products. A rethinking of the current focus on the terminology 'robot device' might have a positive impact on acceptance within society.

At the same time, developers[595] experience a dominant way of thinking towards care. There is an ideal that care has to be performed by humans and that any care equipment dehumanizes care. The developer of yorisoi robotto makes this clear when pointing out that *"there are still many people, who think that robots shouldn't cross a certain work border. Our staff members are the same. In the field of care, you definitely get in denial towards robots."*[596] Caregivers believe that the use of care equipment takes longer than doing it themselves. The developer of Neruru & Yumeru explains why acceptance of care robots increases only slowly when arguing, *"I feel like robots are still not very well understood. I also think that our culture assigns a strong value to people working hard."*[597] To a certain extent, this is true, and it is undeniable that there is meaning in performing care from human to human. However, in the end, the intentions are not about replacing all caregivers with robots, and there clearly are advantages of technology; people work

[594] INR12 (RT.1/ RT.2: RT.Works) 00:57:51-00:59:03 今は「介護ロボット」って言われてるから、その波に乗れることはうれしいんですけど、でもロボットっていうよりは歩行車なので、そこはちょっと違うなぁと。「ロボット」と言われて取り上げられるのはどうかなぁと思います。というのは、これを実際使うおじいちゃん、おばあちゃんに持っていって、ロボットだと紹介すると引いちゃって、これを敬遠する人が多いんですよ。特にこの RT1 は従来 [の歩行車]と見た目が違うじゃないですか。それがいいという人もいるけど、やっぱり高齢者になるとあまり変わったやつとかは逆にはずかしいと。ロボットって聞いただけで、難しいものだという印象を持たれてしまう。

[595] INR08-IP13 (ROBO snail: Ryoei), INR21-IP30 (Neruru & Yumeru: T-arts), INR27-IP36 (yorisoi robotto: Sanyo Homes), INR28-IP37 (Hug: Fuji Machine MFG)

[596] INR27-IP36 (yorisoi robotto: Sanyo Homes) 00:51:00-00:51:10 ロボットがここからはしない方がいいという考えを持っている人がまだまだ多い。うちの職員もそうです。介護の世界で、どうしてもロボットに対して否定から入るんですね。

[597] INR21-IP30 (Neruru & Yumeru: T-arts) 00:34:49-00:35:04 理解はまだそこまで高くない気はしますね。人の手で苦労してやることに意味を感じる文化もあると思うので。

without being physically exhausted. This in turn connects to lower work fluctuation in the staff and a mitigation of the labor shortage within the field of care.

Two developers[598] experience the acceptance of robots as mixed with positive and negative aspects. This feeling is illustratively summarized by the developer of Little Keepace, when he says that *“after all, people first show interest, when they see a robot. At the beginning is ‘Ah, it can do this. Awesome, robot.’, but when they have to use it, especially elderly, they start to express their worries about the use.”*[599] There is a general interest in robots, and a positive evaluation of this technology and the resulting opportunities. However, when it comes to involvement on the individual level, there exists, in particular for older people, a psychologically excessive demand on technology, and if they have the capabilities to handle it. This might result from low awareness of care robots[600], which comes along with only a blurry image of the possibilities and limitations of robots. The lack of information about robotics (see Chapter 1.2) leads to misconceptions about the state of the art, and this causes worries about if users can handle technology. At the same time, clear communication of the possibilities and limitations contributes to a realistic image on robots, which in turn is the base for higher acceptance and eventual diffusion within society.

On the one side, there is some exceptional acceptance of robots among society (IQ9.3). On the other, there is the question of whether engineers think that there is a likelihood that robots are the one and only solution for Japan’s demographic challenges, or if there are any alternatives (IQ9.4). The responses on this topic, excluding the non-answers[601], are unambiguous (see Figure 6-30); the vast majority of Japanese developers[602] are convinced that robots are the inevitable technical solution for the aging Japanese society.

[598] INR10-IP16 (aijō-kun: Art Plan), INR11-IP18 (Little Keepace: TacaoF)
[599] INR11-IP17 (Little Keepace: TacaoF) 00:40:42 -00:41:00 やはり皆さんロボットっていうのを見て、まず興味は示されるんですよね。「あ、こういうのができたんだ。すごいな、ロボットって。」っていう風にまずは見られるんですが、いざ使うってなると、特に高齢者の方だと、使えるっていうのが不安になるっていう風におっしゃるんですね。
[600] INR10-IP16 (aijō-kun: Art Plan)
[601] INR02-IP02 (SAN Flower: Kato Denki), INR11-IP18 (Little Keepace: TacaoF), INR39-IP53 & IP54 (Sasuke: Muscle)
[602] INR01-01 (HSR: Toyota Motor), INR03-IP04 & IP05 (smile baby: Togo Seisakusyo), INR04-IP06 (Ori-Hime: Ory Laboratory), INR06-IP11 (Muscle Suit: INNOPHYS), INR07-IP12 (i-me:ma: Kito Seiki Seisakusho), INR08-IP13 (ROBO snail: Ryoei), INR10-IP16 (aijō-kun: Art Plan), INR11-IP17 (Little Keepace: TacaoF), INR12-IP19 (RT.1/ RT.2: RT.Works), INR22-IP31 (kyūretto: Aronkasei), INR24-IP33 (aams: bio sync), INR27-IP36 (yorisoi robotto: Sanyo Homes), INR28-IP37 (Hug: Fuji Machine MFG), INR39-IP52 (Sasuke: Muscle)

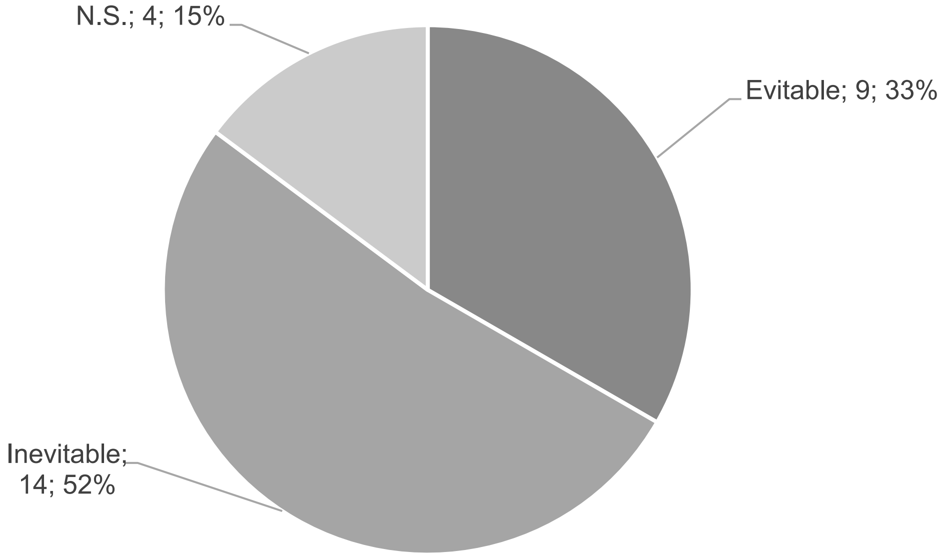

Figure 6-30 Likelihood of Robots as the Technical Solution for Japan's Aging Society (n=27)

There is one main argument why robot technology is inevitable for the future of care in Japan: The urgency and seriousness of the care crisis. Almost all of the developers convinced of care robots believe that there is no other feasible alternative to robotics.

There is a concern of a collapse of the welfare system[603]. Against this background, the labor shortage and the fact that Japan faces problems to integrate and attract foreign labor, developers[604] see migration as no alternative. The developer of aams gives reasons for this lack of alternative when pointing out that, *"People aren't enough anyway. People who care also age, and they have problems with their hips. Therefore I think that it is necessary to accept support through robots or foreign labor. After all, there is a language problem, and for that reason, I think robots will become very important."*[605] The point he made is, even if there would be a sufficient number of migrants coming to Japan, this could not solve the care crisis[606]. It is not only that caregivers are lacking; current

603 INR04-IP06 (OriHime: Ory Laboratory)
604 INR01-01 (HSR: Toyota Motor), INR03-IP04 & IP05 (smile baby: Togo Seisakusyo), INR08-IP13 (ROBO snail: Ryoei), INR28-IP37 (Hug: Fuji Machine MFG)
605 INR24-IP33 (aams: bio sync) 00:33:18-00:34:02 人がとにかく足りない。介護をする人も高齢化しているし、特に腰が悪かったりだとかするので、そういった方々をサポートするには、介護ロボット、あとは海外からの労働移民を認めていくっていうのもあるとは思うんですよ。でもやっぱり言葉の問題とかもあるし、そう考えると、介護ロボットも非常に重要になってくるのではないかと思います。
606 INR27-IP36 (yorisoi robotto: Sanyo Homes), INR39-IP52 (Sasuke: Muscle)

caregivers are getting older[607] as well, and thus there is an urgency to ensure that the limited number of existing laborers can stay as long as possible in their job without any physical complaints.

However, there is still the ideal that humans should do care for humans. The developer of HSR talks openly about this ideal and its related problems.

> *"It would be great to have an environment, where the labor can be completely done by people, but this is, due to costs, human restrictions, difficult. As in the past, only men worked and if they have a big family, they can solve it inside the family. Today there is a change from the own house into facilities and a large number of people, who want to receive care. At the beginning of the long-term care insurance, there were many people, who wanted to become a care worker, but since the salary is low and the work is harsh, there is a big labor shortage in Japan. The ideal is that people want to do, but in reality, it is very difficult to reach this ideal."*[608]

It is the combination of different developments which makes it hard to elaborate effective countermeasures. The change from an extended family system to nuclear families led to higher demands on the welfare system. In addition, there are only limited incentives to becoming a caregiver, because of working conditions such as frequent overwork and low salary. This ultimately suggests the thought of technology, with robotics as a part of it, as an effective solution even in the near future.

There are also a number of developers who think that robots are not the solution to rely on when trying to overcome the care crisis. First, the topic should not be about robots in a narrow sense of a shaped being, the so-called visible robotics[609]. The discourse about problem solving should be opened to robot technology as well, and thus the invisible part of robotics. The latter one is not as media effective as the former, but it is the one which can contribute solutions for care issues, such as monitoring elderly at night to ensure a high standard of medical treatment.

For the group of developers who think that there is an alternative to robotics, several solutions, also in combination, are thinkable. One thought is a raise of the retirement age

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[607] INR12-IP19 (RT.1/ RT.2: RT.Works), INR24-IP33 (aams: bio sync)

[608] INR01-01 (HSR: Toyota Motor) 00:48:40-00:49:59 労働力がそこに投入できるような環境があれば、人が全部やればいいということになるけど、なかなかそれはコストの関係や、人的制限などから難しい行為をする、作業をするのもうまくいかない状態だと思いますよね。昔みたいに、男性だけが働いて、大家族制だったら家族の中で済ませてきたのは事実で、今はそれを家の中から施設に場所を移して、たくさんの介護希望者が入ってきている状態。介護保険が始まった当初は、介護を目指す人たちがたくさん入ってくれそうだったけど、思ったよりお金が出せないとか、過酷だとかいろんなことがあって、日本は今本当に人手不足。理想は人でやってあげたいという人は多いですが、じゃあ現実はどうするっていうなかなか厳しいところはあると思います。

[609] INR06-IP11 (Muscle Suit: INNOPHYS)

in combination with more foreign labor and robotics.[610] The developer of resyone explains why it makes sense to raise the retirement age.

> *"The worker will decrease first, but it doesn't mean that elderly people can't work after 60. The average age and life span are extending and thus can be active as a labor force. Once you focus on such things, it isn't simply about the traditional view on productive-age population. There exists a society, where elderly people work well. If that isn't enough, it is just a human thought to consider the use of human resources from abroad. But even if this isn't enough, robots may be used from the viewpoint of reducing the burden of heavy labor."*[611]

For him, the current age of retirement needs to be rethought. The population is steadily getting older, but that does not mean that they cannot contribute to the work force anymore; it is getting older and aging in a healthy way. This has high relevance for the labor market, because the adjustment of the retirement age comes along with two advantages. The first is that the population in general contributes to the work force and thus directly mitigates the labor shortage. Second, every year that the population works longer has a positive impact on the welfare system, because the financial burden of the total amount of pension received during the life span decreases at the same time.

The alternative to attracting foreign labor is one that is also considered by some developers[612], but the discussion about it remains weak. The argumentation against migration is based on two main statements: On the one hand, there are linguistic and cultural barriers that make it difficult to integrate foreign labor. On the other[613], instead of attracting foreigners, the working conditions in general have to change first. The developer of Dreamer expresses his concerns about foreign workers when arguing, *"There's also the option of having foreign workers, but I suppose raising the wages of domestic care workers instead would probably be the best option. It's not that I am denying immigration all together, it's just that it takes a long time living in Japan to understand the different culture and to actually reach a point where one can truly carry out care work."*[614] The point that

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[610] INR13-IP20 (resyone: Panasonic)
[611] INR13-IP20 (resyone: Panasonic) 00:31:11-00:32:04 働き手は一見減りますけれども、高齢者の方が 60 歳になると働かないかというとそうじゃなくて、やっぱり平均年齢とか寿命は延びてますから、そういった方々が労働力として活躍できるわけですね。そういうことに着目したら、単純に今まで通りの生産年齢人口的な見方じゃなくてですね、高齢者の方がしっかり働くという社会はある。それで足りなければ、海外の人材を使うというのも、人的な考え方で言うとある。それでもやっぱり足りないとか、もっと重労働の負担を軽減したいていう観点でロボットは出てくるかもしれません。
[612] INR13-IP20 (resyone: Panasonic), INR29-IP38 (Tecpo: Shintec Hozumi)
[613] INR14-IP21 (Flagship Model: Nabtesco), INR26-IP35 (Dreamer: Santec)
[614] INR26-IP35 (Dreamer: Santec) 00:30:25-00:30:47 外国人に働いてもらうのも一つの選択肢だと思うけど、やはり国内で働いている介護労働者の賃金を上げてやるっていうのが一番確実じゃないかなと。移民をあまり否定するつもりはないんですけど、長く日本に住んで異文化を理解して本当に介護ができるかというと、それは時間がかかると思いますね。

is made here is that raising salaries might be the most effective measure that also has an impact in the short-term. Even the developer of palro believes that it would be nice to have enough young people working in the field of care, but since foreign labor is difficult, robots are a considerable option. He explains that *“there was no thought of immigration, but instead people think that if there were more young people, there wouldn’t be any problems, but if that’s not the case, robots would just be one strategy. I don’t think that they are indispensable, but if considered to be one of other alternatives, I think they could be more effective.”*[615] There is pessimism about foreign labor that is based on Japan’s self-conception as a homogenous nation (Antoni 2002, 264; Tai 2009; Liu-Farrer 2009, 116). According to this understanding, learning the Japanese language and understanding the culture is a challenging task for foreigners. It might be faster to develop robots than to work out a strategy that deals with a systematic integration of foreign labor.

In addition to this, one developer suggests that AI could totally change the situation, because it comes along with wide-scale improvement for the working environment within the field of care.[616] This includes a synchronization of data within a facility, or remembering when medicine has to be used. The further technical progress within the field of AI can lead to a better working environment and thus to a higher care standard.

In any case, the developer of KR-1000A gives a perfectly fitting conclusion for the question about robots as the only alternative for Japan’s aging population. He comes to the heart of this when saying*, “It doesn’t have to be, but I think it would be a better world and society if there was one.”*[617] Robots are not inevitable, but the use of technology in combination with other measures can lead to a better society in total. Robotics is a means to an end to partly support society and overcome related challenges.

Finally, there are the responses on whether developers can imagine suggesting robot technologies for care to their relatives (IQ9.5). As an engineer, dealing with technology and being in the picture about the chances and risks of robotic devices is part of their work duty. For that reason, it does not come as a surprise that all of the developers can imagine recommending care robots for their family and relatives, and on a personal level,

615 INR15-IP22 (palro: Fujisoft) 00:41:14-00:41:45 移民っていう考えは全くなかったんですけど、人の問題は、そのかわり若い人がたくさんいれば、問題はないとは思うんですけど、そうでないならロボットは一つの策ですね。それが不可欠だとは思わないです。ただ一つの選択肢として、より有効になってくるとは思います。

616 INR02-IP03 (SAN Flower: Kato Denki)

617 INR23-IP32 (KR-1000A: Clarion) 00:30:34-00:30:46 なくてもいいけど、あるとよりよい世界、社会になるという風に思います。

for themselves. Besides the developers[618] who simply state that they can imagine robots for the care of their relatives, those who provided reasons and in turn gave insights for their positive determination are more interesting. There are four types of argumentation for a possible use of robots: Self-confident, limitedly, situative and optimistic argumentation.

The first type, the self-confident developer[619] , is not very subtle because they simply emphasize a firm belief in their own inventions. These developers are confident that their invention is the most innovative and helpful one, and that the other robots on the market or in development are less functional. The statement of the developer of aijō-kun makes this very clear when he points out that *“there is nothing to recommend at the moment. If I were forced to saying something, apart from aijō-kun there isn’t much else. So, if your legs are starting to cause you trouble, I would recommend aijō-kun, but that’s about it.[620]”* His transfer aid is the only one on the market that can improve the situation for the elderly. From a theoretical perspective (see Chapter 2.4), this confidence is important, because it shows the persuasive power behind their idea. This is the first requirement on the way to transforming a vague idea into a touchable invention. The second essential requirement needed for successful diffusion within society is whether this enthusiasm sparks into other relevant social groups, namely users, or not.

The second type is the developer that would recommend a care robot for their own family or relatives in a specific situation. The developer of Dreamer touches further upon this when explaining that *“maybe it depends on me. I would recommend it if I couldn’t handle the burden alone. I mean, if I had the time, I would like to be able to do it myself. But, when that’s not possible, I think I would probably feel like using the robot.[621]”* For him, the aspiration is to take care of his own family. The connotation of robot care being only an emergency solution resonates within his statement. Robots are rather a temporary or an emergency solution, rather than the universal approach to solving care issues within

[618] INR03-IP04 & IP05 (smile baby: Togo Seisakusyo), INR04-IP06 (OriHime: Ory Laboratory), INR06-IP11 (Muscle Suit: INNOPHYS), INR07-IP12 (i-me:ma: Kito Seiki Seisakusho), INR08-IP13 (ROBO snail: Ryoei), INR11-IP17 (Little Keepace: TacaoF), INR14-IP21 (Flagship Model: Nabtesco), INR22-IP31 (kyūretto: Aronkasei), INR27-IP36 (yorisoi robotto: Sanyo Homes), INR28-IP37 (Hug: Fuji Machine MFG), INR39-IP52, IP53 & IP54 (Sasuke: Muscle)

[619] INR10-IP16 (aijō-kun: Art Plan), INR24-IP33 (aams: bio sync)

[620] INR10-IP16 (*aijō-kun*: Art Plan) 01:21:04-01:21:22 今勧めてあげられるようなものはない。強いて言えば、自宅で使えるのは今愛移乗くんしかないから。だから、足が悪くなったというなら、うちの愛移乗くんをお勧めできるけど、それ以外にはないです。

[621] INR26-IP35 (Dreamer: Santec) 00:32:13-00:32:33 私次第かな。私が面倒見切れなれば勧めると思います。まだ私の時間が取れる限りは私がやってあげたいなと思います。でも、それができなくなったらロボットを使いましょうとなるという気はします。

the narrowest family circle. This makes one aware of the difference between recommending a solution for other people and for one's own circle. In the latter, it is much more difficult to create distance for an objective decision, because more personal circumstances are taken into account.

The third chain of arguments is in general positive. In the limited case, the developers highlight that it is necessary to play to the strength of robot technology. This means the adoption of a care robot with a convincing concept[622], or the assessment of a specific robot for a certain situation[623]. Thereby the perspective must be on the user's dignity, so on the elderly, rather than on possible improvement through technology. Technology is a means to an end for more independence and the improvement of the quality of life, which relies on the acceptance of its user. The developer of RT.1/ RT.2 explains what this means when saying, *"I think I would recommend it, and I have done before. But, because it can't be used all the time I have regrettably been told 'no thanks, I'll pass'."*[624] Dignity and the acceptance of the actual user of the robot are the keys for a successful and sustainable diffusion. Otherwise, the robot might make it into the facilities or private houses, but will be left in a corner unused.

Finally, there are the technology optimists who are convinced of the benefits of robot technology in general. This has to be seen against the background of an already engineered world, wherein technology makes life easier. The developer of palro argues in the same way when recommending care robots for the care of their own family, *"because I think that we already receive help by technology in our own lives, I really think it's worth a try.*[625]*"* It is about the accomplishment of technology and its influence on daily life that urges the use robotic technology for the field of care. The developer of HSR agrees with this argumentation and further deepens it.

> *"I think that the robots I am working on are still missing functionality, so I want to work on this first. In addition, care robots will diffuse rather as a support for the caregiver than for the care recipients. I am sure that by using them, it [care] will become easier and it is a welcome thing to spend more time on talking and communication. [This leads to] an environment, where you can work more efficiently and use your time in a better way. You still hear scary stories about nursing bullying. For sure, this is because there is a lot of stress. Robots are supposed to help reducing that [stress], though not as much as within a factory, but if you bring machines and IT to the workplace,*

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622 INR29-IP38 (Tecpo: Shintec Hozumi)

623 INR13-IP20 (resyone: Panasonic)

624 INR12-IP19 (RT.1/ RT.2: RT.Works) 01:15:35-01:15:48 勧めると思います、というか勧めたんですけれども。でも、常に使えるわけじゃないんで、いいですと言われてしまいました。

625 INR15-IP22 (palro: Fujisoft) 00:42:27-00:42:37 意外に身の回りで技術に助けられてるものだと思いますので、試してみる価値は非常にあるかなとは思います。

> *the staff becomes happy and in turn the cared people, too. It is scaring to get old and to have to think about what facility we should enter. In order to create such an environment, where everyone can use [care facilities] and live in peace, I think we have to reduce that burden.*[626]*"*

Even if care robotics are not mature yet, they have the potential to improve various environments. They can help to reduce the burden on caregivers, and to increase the quality of life of care recipients. In contrast to the self-confident argumentation, the optimist has a vision and evaluates robotic technology in general as an instrument that can lead to a better society. This vision is needed for the mediation between the user and other engineers, because the user cannot be convinced with technical facts only.

In the following and last step, the perspective shifts to the developers themselves and the question of if they can imagine receiving care by a robot (IQ9.6.). The argumentation of the interviewee becomes closer to an actual elderly person. It is no surprise that for this topic also, all of the developers can imagine using a robot or receiving care from a robot. Nevertheless, two types of reasons stand out: One is about independence[627] and one about not bothering others[628]. Both are linked very closely under the key word of dignity. The former is about living a self-decided and independent life in dignity, and the latter is about living in dignity and not having to rely on others for special tasks of everyday life. These special tasks are in particular actions within the private and intimate sphere, such as toileting and bathing. If technology can contribute to daily life, the acceptance will be high and, as a tool that enlarges the self-action radius, it is likely to be preferred instead of relatives or caregivers. The developer of Hug explains the feeling behind this when saying, "*sure, that's possible. That is, you can do what you want to do, if it doesn't bother other people, and you want to use it positively*.[629]" Not only in Japan, but also all over the world, humans prefer to do things by themselves instead of relying

[626] INR01-IP01 (HSR: Toyota Motor) 00:50:11-00:51:46 今自分がやっているロボットは、まだ機能が足りてないなと自分でも思うので、まずそれをやりたいと思います。それに、介護ロボットは介護される人のためというよりは、介護する人をサポートするものから普及していく面があって、それ [介護ロボット] は使っていただいて [介護が] 楽になって、介護する人がより人間らしい対話だったり、話し相手だったりに時間を割けるのはウェルカムなことだと思います。効率的にやっていただいて、余力の時間をもっといい形で使っていけるような環境 [繋がります。] 今も介護いじめだとか、怖い話は聞きますよね。やっぱりストレスが高いということだと思うんですよね。ロボットはそれを減らせる一助になるはずなので、工場というほどではないが、できるだけ機械や IT を入れて、働いている人がハッピーになると、周り回って介護される人もハッピーになれる。我々も年取ったときに [...] 、怖いですよね、どの施設に入ったらいいかなんて考えなければいけないのは。そういった、みんなが安心して利用できるような環境になるためには、そういった負荷を下げてあげないといけないなと思います。

[627] INR01-01 (HSR: Toyota Motor), INR04-IP06 (OriHime: Ory Laboratory), INR11-IP17 (Little Keepace: TacaoF), INR39-IP52 (Sasuke: Muscle)

[628] INR14-IP21 (Flagship Model: Nabtesco), INR23-IP32 (KR-1000A: Clarion)

[629] INR28-IP37 00:35:31-00:35:40 できますね。それによって、自分のやりたいことができる、他の人に迷惑が掛からないということであれば積極的に利用したいですね。

on others. If care robots contribute to an independent life in dignity, they are likely to be accepted and diffuse on a large scale.

In addition, there are two interesting replies. One is on the comparison of the reliance on technology and on humans. The developer of Muscle Suit talks about receiving care, *"It's safe to do it with a machine, but with a person there's always the chance of being dropped. Human mistakes aren't uncommon.*[630]*"* For him, technology is more reliable than humans, because of the lower error rate. Among all of the interviews, he is the only developer with such a strong and optimistic belief in technology. This implies a high motivation for promoting robotics and being able to improve the daily life of the elderly by the use of technology. The other one is about the personification of technology. The developer of SAN Flower dreams of a future with robots as friends when he explains, "*if in my lifetime there was a robot that was equipped with AI, I think people would almost become friends with it. Japanese people, that is. As I mentioned earlier, the robot is anthropomorphic, so you could give it a name and such. Japanese people tend to get on board with these concepts rather easily.*[631]*"* The personification of technology itself is not a new topic and not limited to Japan; even in Western countries people give names to their computers (cp. McDaniel and Gong 1982, Benyon and Mival 2008). Humanoid design is a cultural characteristic in Japan (see Chapter 6.8.). However, the personification of technology itself, whether it is in giving names to a computer or a robot, is a human behavior that is not limited to Japanese Shintoism, and can rather be labeled a human trait.

[630] INR06-IP11 (Muscle Suit: INNOPHYS) 00:54:16-00:54:25 機械でやってもらうと、安心できるけど、人に持ってもらうと落とされるかもしれない[630]。人間のミスは結構起きる。
[631] INR02-IP03 INR02-IP03 (SAN Flower: Kato Denki) 00:35:35-00:35:56 私の時代には、AI 搭載のロボットがいたら、多分友達になるぐらいになると思います、日本人は。さっきの話ですけど、擬人化しちゃいますので、自分たちで勝手に名前を付けたりして。日本人そういうのは受け入れやすいと思いますよ。

7 Conclusion and Outlook

The study at hand assessed the potential and challenges for the adaptation of robot technologies in the care sector in Japan (see Chapter 1). Robots are thought to mitigate care problems. However, the relevant social actors and groups related to robot development have to overcome several challenges before care robots will be widely used within care facilities. The report about the future of employment by Frey and Osborne (2013) caused sensations, because it raised awareness for the implications of steadily proceeding automatization on the working world as we know it. The concerns that robots will take away our jobs (cp. e.g. Ford 2015; Brynjolfsson and McAfee 2014) are unfounded. Care robots are not likely to become a substitute for human caregivers, because the technical state of the art and the field of service robots are still at an early stage. Nevertheless, robot technology can make a contribution to improving the situation within the care industry.

Japan is in some ways a victim of its own success: Economic growth, the availability of medical treatment and ultimately a healthy lifestyle make Japan the leader of the world's life expectancy. The population is not only simply getting older, but it is also getting healthier. Japan became a giant 'laboratory' for avoiding demographic collapse and supporting its aging society without large-scale migration. Technology is the promised panacea (cp. METI 2004c; Prime Minister's Office 2014; RRRC 2015) for decreasing the physical and mental workload of caregivers, for improving quality of life, as well as for filling the labour shortage and keeping the elderly as well-funded consumers on the silver market.

And indeed, it will be interesting if Japan can meet its own requirements, because if the Japanese approach works out, it could be a blueprint for other aging countries. New technologies challenge long-established practices. Mokyr (1990, 12) gets to the heart of this by remarking that *"in every society, there are stabilizing forces that protect the status quo. Some of these forces protect entrenched vested interests that might incur losses if innovations were introduced, others are simply don't-rock-the-boat kind of forces. Technological creativity needs to overcome these forces*." Understanding the Japanese approach to utilizing robot technology as a technical instrument to mitigate the situation within the field of care is valuable input for thinking out of the box in order to solve the challenges of demographic transitions in other countries. It might enable new ways to countermeasure existing challenges.

For these reasons, the verification of the three hypotheses (see Chapter 7.1) gives insights about the current state of care robotics and indicates their future potential. The three working hypotheses (see Chapter 1.2) are the lack of information thesis, the labor replacement thesis and the relevance of environment thesis. They are a part of the quest for the diffusion of care robots not only for Japan, but also for other countries. In addition, their verification makes it possible to derive concrete actions and measures for relevant actors (see Chapter 7.2), especially the coordinating ministries such as METI and MHLW. Finally, at the end of this study, it is time to take stock and raise awareness of the need for further research (see Chapter 7.3).

7.1 Verification of the Working Hypotheses

The first thesis is about the lack of information related to care robots in Japan. There is a lot of information about Japanese robots, in particular industrial robots, available, but only little or even incorrect public information about the true state of art in care robotics.

Several forecasts on Japanese care robots are positive or even enthusiastic, with an expected multiplication of the market volume for care robots (cp. Yano Research Institute 2014; METI 2013b). Also current research on robotics in Japan (cp. Bartneck et al. 2009 Trovato et al. 2013) either highlights the specialty, acceptance, and the enthusiasm for robots or media-effective robot projects, such as Prof. Ishiguro's android research or Honda's ASIMO. This creates the image of Japan as a technologically advanced nation, which can solve its social challenges by making use of robot technology. However, this technology optimism might lead to expectations on care robots that are too high. At the moment, the number of available care robots within care facilities remains low. On the one hand, there are optimistic forecasts about the future of care robotics, and on the other, there is a low degree of diffusion within the field of care. This gap is difficult to explain by only reading literature and market forecasts (see Chapter 3.2). For this reason, it is important to take the mindset of a relevant social group directly involved in the development process into account: The engineers. Their knowledge and experience give disclosure about the reality of care robotics in Japan.

Having said this, above all it is necessary to define the term 'care robot'. In contrast to industrial robots, there exists no official and clear definition of 'care robot' (see Chapter 3.1). Therefore, it is difficult to achieve consensus on what a care robot is and what it should do. In the case of industrial robots, the objective is to automatize industrial production within a clearly defined field of application and environment. Moreover, care robotics is an emerging field, and it is likely that the reality of care robotics now and in several years will change. It is a field that leaves room for interpretation. For this reason, I make use of the concept of interpretative flexibility (see Chapter 2.3), and define care robots flexibly and in a wider sense as devices based on robot technology for the field of care. This includes devices that look like a robot, such as the communication robots OriHime and palro, or the transfer aid ROBEAR, but also inconspicuous devices such as the monitoring system aams or SAN Flower. More important than the appearance is the field of application, because care robots have to contribute to care support, self-dependence or security and communication. The future will push the negotiation process on interpretative flexibility forward, and at some point it will end in a common sense about the necessary essence of a care robot.

Having said this, the missing definition brings along the risk of high expectations such as the prevailing image of humanoid robots, or at least advanced and autonomous robots, which can become an obstacle for the diffusion. Japan sees itself as a robot nation (cp. RRRC 2015; METI 2004c) and foreign media perceives it as the robot kingdom (e.g. Hurst, February 06, 2018; Schodt 1988; Hornyak 2006). Robotics became a national brand for Japan as an advanced technological nation in the world, and robots are their ambassadors (cp. JETRO 2006). There is the widespread image of advanced robotics, in particular humanoids, and to some extent even within research discourse, such as the recommendation for a 'humanoid nurse robot' (cp. Tanioka et al. 2017) as the ideal solution for improving the situation within the field of care. Thereby the prevailing images of robots as humanoid friends (e.g. Astro Boy), or as a way to enable humans to get supernatural power (e.g. Mobil Suit Gundam), are influenced by pop culture.

And of course, autonomous robots and humanoid robots are more impressive than currently technically feasible solutions based on robot technology. It is easier for field-related actors to get attention with advanced robots. This means on the one hand that it is easier for the government to show advantages to the public, and on the other hand, they can also show foreign countries that Japanese technology is a feasible and practicable solution for facing demographic challenges. For companies and research institutes, it is easier to get funding because, through a humanoid as a platform, their research and development is visualized and understandable for most people. For the media, it is easier to get the attention of the reader when using humanoids or other impressive projects.

This however creates misconceptions, especially concerning humanoids, and can even become an obstacle for further development (cp. Mara 2016). When it comes to humanoid robots, aside from the technical possibilities, design becomes key for its success. Acceptance can only be realized when overcoming the uncanny valley (Mori 1970). The design strongly affects the behavior toward a robot. People reject a robot if it looks like a human, but does not act like one. The high technical demands of human design are one reason why some engineers decide on animal designs, which are technically easier to realize. One example is the mental commitment robot paro, whereby a seal shape was selected because people have only a vague idea about it, and thus there is space for interpretation (cp. Shibata 2006).

The interviews with developers showed that there are still many technical issues to be overcome before robots can enter private homes or even care facilities. In other words, there is a gap between the common image of robots and the current state of the art. If technology does not meet expectations, potential users reject it. In Japan, not only for the user but even for the developers (see Chapter 6.8), there is a common sense about the design of a robot: It has to be humanoid. The positive connotation of robots in Japan is a two-sided coin and can become either a catalyst or an obstacle for the success of robotics. The developer of kyūretto explained this very well when he pointed out that *“There is something like Astro Boy and this influence is big. About pressure, for Japanese people Astro Boy is equal to a robot. So even when kyūretto is called a care robot, people question, if it is a robot. [The reason is,] because the image of human-design will clearly come to mind.”*[632] For this reason, I call this the Astro Boy syndrome, when robots do not meet the expectations and images of popular culture. The claim is that humanoid robots are the future of labor in general and for care (cp. Tanioka et al. 2017). However, inconspicuous and probably low-tech technical solutions, namely, robot technologies, which assist caregivers and care receivers or support the daily life of the elderly, will be the future. A few examples are monitoring systems or toilet aids for care facilities, or mobility aids.

Independent from the discourse on humanoid design, there is the challenge of changing the mindset within the field of care. Technology familiar male engineers try to develop

[632] INR22-IP31 (kyūretto: Aronkasei) 00:30:40-00:31:15 鉄腕アトムみたいなものがあって、その影響っていうのは大きいです。プレッシャーというか、日本人にとってロボット＝鉄腕アトムなんですよ。だからキューレットが介護ロボットって言っても、どこがロボットなんですかっていう。ヒューマナイズのイメージが鮮明に入ってきちゃうんで。

technical tools for female caregivers, who are often unfamiliar with technology. The subjective perception of performing and receiving care applies for the acceptance of care robots as well. The developer side tends to evaluate its own inventions and its benefits much more optimistically than caregivers or the elderly do. The reason for this can be a lack of understanding of care.

In contrast, the end-user, caregivers or the elderly, might reject the use of care robots for various possible reasons. A care robot can be perceived as an attack on existing practices, even if the advantages might be obvious and outweigh the disadvantages. A few examples are transfer aids such as Hug, aijō-kun or Sasuke, which unmistakably reduce the physical burden on staff. However, existing practices and time-sensitiveness within care can lead to low acceptance and ultimately, a rejection of the robot. This is not only limited to care robots and applies for other care and daily life tools, too. Another example for a positive impact on the life of the elderly can be seen in communication robotic devices which help alleviate loneliness, such as palro, Orihime or Neruru & Yumeru. One group welcomes these new entertainment tools to get variation in daily life, but another group might feel simply pacified and even lonelier. Nevertheless, for the successful diffusion of robots within society, both sides have to be taken seriously.

The point that is important for the user is not that new technology is a robot; it is whether a device is helpful or not. The representative of RT.Works illustrates this with the example of RT.1/ RT.2 when he says that *"I have the feeling that the average people haven't got a lot of expectations on robots. It isn't that they want or don't want to use a robot, it is that they want to go to talk to their neighbors and that RT.1 is only a means to walk and it is understood that it is a robot. They don't want to have the robot RT.1".*[633] Rather than the hardware, the robot itself with its software and how to make use of it will lead to success.

Furthermore, there is a misunderstanding about the potential of care robotics. The fact that the care market is a very specialized market might cut down the market potential of care robotics, not only in Japan. The gold-rush atmosphere, especially among Japanese engineers, forgets that, in contrast to the automatization of production, the potential for the automatization of care is quite limited. The representative of Ryoei experienced this difference between the supplier and demand side when he was told that "*The [care]*

[633] INR12-IP19 (RT.1/ RT.2: RT.Works) 01:05:54- 01:06:41 一般の人たちは、ロボットだからと言ってあんまり期待はしてないという気はします。ロボットが欲しかったり、使いたいというわけではなく、近所の人と話しをしに行きたい、あそこまで行きたいという本当の目的があって、そのために歩く手段としてRT1 っていうのがあって、それはロボットなんだねという理解なんです。RT1 というロボットが欲しいわけではないんです。

industry says that the size [of the market] doesn't ever rise, as the government says. It won't become so big and it isn't such a sweet industry. They [representatives of the industry] told us that if you want to make money there, Ryoei was clearly told that we better stop."[634] The care industry is on the one side a very demanding market and it is difficult for companies to get used to it. On the other side, if a company is able to find its niche within the field of care, it is likely to become a stable business because of limited competition. Nevertheless, a few issues should be mentioned.

First, just because it is technically practicable to automate a certain care task through a robot, it does not mean that it is profitable. Since care robots are at an early stage of diffusion, there is a challenge to overcome high maintenance costs of the robot, training costs for the staff, adjustment costs of the environment to technical requirements, as well as the problem of time for a sector with a constantly high workload, to give just some examples. These factors massively narrow the application potential of robots. In turn, this means that rather than simply placing an existing technology into the field of care, it is necessary to carefully analyze workflows within the field of care and only then to start with development. Additionally, the developers must consult with users, the caregivers and elderly (MHLW 2013a, 6). This is necessary for developing a demand-driven and accepted product and, in this way, successful invention, such as in the case of mobility aid RT.1, the transfer aid Sasuke or toileting aid Dreamer to give only three examples. The chair of RT.1 was moved to the front on the basis of user feedback. In the case of the robohelper Sasuke, the way of transferring people was totally changed, from a moveable head and lifting point under the neck and knees towards a baby sling, because the users suggested this as more secure and comfortable. Users also caused a change of the material of the suction cup on the toileting aid Dreamer. All three inventions have in common that user feedback led to a positive evaluation of the robot, and thus to a successful market entry.

Secondly, not only the state of the art, but also human beings themselves can cause challenges for the application potential of care robots. Physical attributes vary from person to person and make it difficult to develop one robot that fits the needs of all potential users. Transfer aids are a good example for this, because usually they have a weight limit, such as yorisoi robotto with less than 70kg. Moreover, respiratory muscle or bone

[634] INR08-IP13 (ROBO snail: Ryoei) 00:43:07-00:43:33 その [市場] 規模が、国が言っているほど、福祉のニーズが右肩上がりに高くなっていくというようにはならないと、 [介護] 業界の方は言っていますね。そこまで多くはならない、そんなにおいしい業界ではないですよ、と。ここで儲けようとしているなら、リョーエイさんはやめておいた方がいいとはっきり言われました。

problems have to be taken into account, as they might lead to limitations of possible users, e.g. aijō-kun or Hug.

In addition, every human being moves, or at least can move, differently due to the course of aging or disease. The process of rising from a lying to an upright position makes this explicit. One person might lay one elbow from the lateral position and his/her torso and use it to press their body into an upright position. Another might just use his/her hands to support the movement for the transition from lying to the upright position. The same applies for the task of caregivers when they transfer persons. On top of this, the experience of being moved is not perceived the same by every user. What might be perceived as comfortable to one person might at the same time be perceived as a loss of control by another and might even cause anxiety. Therefore, it is difficult to imitate or automate movements, and in turn this narrows the effectiveness and application scope of care robots that support the autonomy of elderly or rehabilitation. In the end, the most practical way of development is to understand and localize a specific potential user group, a niche, rather than trying to design one machine that fits all. It is possible that with the development of technical progress, more flexible robotic devices might emerge, but for the early stages of this technology field, finding a promising niche is the better solution.

In conclusion, the market for care robotics is very specific and challenging. However, according to MIC Research Institute (*Nikkei Shimbun*, May 08, 2017), there are already some more general application fields with a growth forecast and a certain share of the 3 billion market for care robotics in 2016, such as transfer aids (800 million Yen) and communication (580 million Yen) or monitoring systems (370 million Yen). These are application fields with a higher number of potential customers, but in general the care market is a highly segmented, specialized and demand-driven niche market in which certain robots can only satisfy certain segments. In the near future, if at all, there will be no humanoid robotic all-round solution for the field of care as some researchers dream of (cp. e.g. Tanioka et al. 2017; Byford, April 28, 2015; Hurst, February 06, 2018).

The essential element for success in the care robot market is a user-centered robot design approach and the integration of users at an early stage of development. The process of diffusion goes further than just the materialization of an idea into a prototype. It is more important to think about robots as a part of the workflow or daily routine that can increase quality of life and care. In other words, it is about letting go of an often robot-fixed focus and going over to the integration of robots as one part of the overall service and tasks within care.

The second hypothesis is about the wide-scale introduction of robots within the field of care as a uniquely Japanese approach to counter care issues, because care robots are intended to replace human labor. The argumentation behind this is that in Japan, robots are easier to integrate into the relatively homogenous Japanese society than it would with other solutions, for example the integration of foreign migrants (cp. *Canvas8*, March 07, 2017; *The Economist*, November 23, 2017; *CBS News*, July 28, 2017).

Thereby the hypothesis cannot be verified by only analyzing existing publications. In fact, there are several publications about care robotics in Japan (cp. Brucksch and Schultz 2018; Lau et al. 2009) and technology development (cp. Breiner, Cuhls, and Grupp 1994) focusing on Japan. The publications usually have in common that they try to evaluate the market development for care robotics, sometimes with case studies (cp. Brucksch and Schultz 2018), with highlighting pilot projects (cp. Lau et al. 2009) or even through making use of a wide Delphi study to assess the future of technology in Japan (cp. Breiner, Cuhls, and Grupp 1994). The usual outlook for the future of technology within an aging society is positive.

At this point, this study is different, because it tries to disclose the difference between optimistic publications about the future of robotics and the reality of the diffusion of care robotics within society. There must be something that cannot be found in the data. To understand how engineers see the current processes means to gain insights about how realistic forecasts are and how diffusion is developing. For this reason, the fieldwork (see Chapter 5) is reading between the lines. It is collecting knowledge that cannot be obtained by just reading relevant literature.

In doing so, it was possible to gain valuable insights. In the following, I want to summarize the findings from the nine theory-based categories with the 27 engineers and their 22 robot projects. The first category is the personal background of the developers (see Chapter 6.1). The average developer is a male university graduate in engineering and develops robots because it is his work. The non-average developer is a fan of robot manga or anime and a visionary, who is rather convinced of their own invention or wants to contribute to society. In other words, they are not engineers who want to make their childhood dreams come true by creating robots like they are illustrated in manga and anime. The engineers who develop robots are more like technicians who are trying to find solutions for certain issues, and thereby use robots as their platform.

The second category is about the development structure (see Chapter 6.2). The surprising finding is that R&D divisions within companies which focus on robot projects are staffed with only around ten people. The reason for this might be that care robotics is a side business for some companies in order to get a second mainstay in addition to their main business. This applies in particular to companies that want to get more economically independent from the sensitive business cycles of their main business, such as automotive companies.

Moreover, for successful technology development, it is essential to get a broad consensus and thus to exchange information. Perhaps also because the R&D division size is manageable, most information is shared within regular weekly meetings or within a single contact session if necessary. In doing so, weekly meetings ensure certain continuation of the project.

Furthermore, companies evaluate their participation in national programs as a way to not only obtain money for their robot project, but also to gain connections to the field of care. In other words, there is a problem with awareness about technology-driven developments that do not match demands. On the downside, especially for smaller companies, national programs come along with a lot of paperwork which absorbs limited human resources. Additionally, national programs have certain milestones that have to be achieved to get further financial resources. From a theoretical perspective, this creates a major problem which might lead to failure in development because technology development has been put in a rigid corset. Some developers pointed out that if they knew what the outcome would be, there would be no need to participate in national programs and that their rigidity hindered their original schedule.

The next step was to have a closer look on the robot projects themselves (see Chapter 6.3). The developers' replies give insights about how realistic labor replacement through robots in the near future is. The good news is that, in the near, future nobody has to be worried about losing his/her job because most of the robot projects are still in development stages, or have just entered the market. In terms of technological change, this implies that the process is right now located just before the second stage, the materialization of an idea into an invention. The next stage is diffusion within technology and only the future will reveal the speed of this diffusion.

Considering that most robot projects are still in development, it is no surprise that most developers are less specific about their future plans, and prefer to wait and see how everything will work out. So the reason is not only the development stage, but also that most developers see a difference between optimistic market forecasts and experienced reality. The majority of developers want to wait and see how the user will react to increasing number of care robots and then consider further steps, such as going into mass production. Therefore, it is only too understandable that all companies want to focus on the domestic market in Japan, and then with this experience, extend their business into foreign markets. The latter implies that there is a wish for a positive course of diffusion.

The fourth category provides insights on how the developers handle the connection to the field (see Chapter 6.4). For tests of usability within the field of care and in care facilities, an important issue comes to the surface: The problem of getting proper access to the field. If only the responses about the length and frequency of test runs of the robot in care facilities were analyzed, then the conclusion would be that developers seem to be satisfied with only a few short periods of test runs at a later stage in development. This would suggest a technology-driven development approach that ignores the user. However, reality is different, because developers would like to have a closer connection, and longer and more frequent test runs within care facilities. Their initial problem is how to get access to the field. This is in particular difficult for companies which enter care robotics from totally different backgrounds, such as automotive. It might be the fact that test runs are only done at later stages of development, but usually collected feedback has been taken into account only in a few cases.

The fifth category is about the visions behind the robots (see Chapter 6.5). This category is interesting especially from a theoretical perspective because it shows whether an idea can guide and influence the course of development. The vision concept argues that it is impossible to artificially create an idea, and here I found a difference with the theory. A certain number of the robot projects were started on the basis of top-down development with trial-and-error approach than rather a vision. Moreover, for some companies, the robot project simply marks a search for new business fields. The interesting outcome is that even in these cases, the robot project was often able to reach the stage of realization, the prototype stage. This suggests that organization structure might be a factor that shouldn't be underrated for the success of development.

Having said this, the economically-oriented companies tend to be the ones with difficulties in transferring the technology from their main business into the care market. Furthermore, the question on how to evaluate the success of an invention has been left open. For some companies, such as the ones which develop mobility aids, success is simply measured in sold units which is easy to calculate. For other companies, such as the ones who develop monitoring systems, it becomes more difficult to evaluate the impact of their technology. The representative of INNOPHYS suggests focusing on the usability of technology when he points out,

> *"The robot itself isn't useful. 'Useful' means things such as welding robots in a factory or transport robots, but other robots are almost not useful. We aim to design useful things for people's daily lives, not for killing time or entertainment. This machine is not a robot. There is neither a power source nor a controller [in our robot]. So it doesn't have to be a robot if it's useful."*[635]

His statement shows on the one hand the urgency to give highest priority to the usefulness of one's invention. On the other hand, it illustrates the pragmatism behind development, because he believes that a common sense about an invention leads to a marketable product which will be successful.

The sixth category goes deeper into research issues and challenges (see Chapter 6.6). In doing so, a look into the engineers' mindset reveals a certain lack of understanding with regard to the situation within the care industry. This may be due to the difficulties with getting access to the field of care, but could also be grounded in missing empathy for users' needs. The companies struggle to fulfill the security regulations for being able to do test runs. It is often the case that the test run has to be approved by a certain committee, and this committee only gives permission for test runs if medical evidence exists. This is a chicken-and-egg conundrum, because without tests there is no evidence, and without evidence there are no test runs. Having said this, providing a constructive framework for the development of robots is something the government can have an impact on, through e.g. giving guarantees for the safety of robot projects that participated in national development programs.

The seventh category centered on the robot market itself (see Chapter 6.7), and if and to what extent robots might replace humans, and if robots are the Japanese way to countermeasure the challenges of demographic change. Thereby there is a common sense that the development of the market is unclear. Developers see three major challenges that have to be overcome: To somehow reduce robot costs, to eliminate prejudices against welfare equipment, and to lower the expectations on robots. The short answer to the second hypothesis is no and almost no. In the near future, robots will not be able

[635] INR06-IP11 (Muscle Suit: INNOPHYS) 00:29:24-00:30:18 ロボットそのものだけでは役に立たないんです。役に立つというのは、工場で溶接するロボットや搬送用のロボットのようなものを言っているが、他のロボットはほとんど役に立っていない。暇つぶしや、エンターテインメントではなく、人の生産活動の役に立つものの生産を目指しています。今のこの機械 [ムッスルスーツ] はロボットではないんです。パワーソース635も、コントローラーもないし。だから、役に立つなら、ロボットでなくてもいい。

to replace humans, because the degree of diffusion is too low for wide scale labor replacement.

Moreover, the use of welfare equipment remains low due to the persisting notion that care has to be done manually. Technological change challenges existing mindsets and in order to become successful, such notions have to be overcome. In the concrete case of welfare equipment, there is the initial position that it is not used widely. The Japanese government claims that it is possible to reduce the physical burden on caregivers through care robots, namely transfer and mobility aids. This shows not only high interest, but also high expectations on care robots for solving an urgent issue. The retirement rate among caregivers in Japan compared to other professions is relatively high. Against this background, already in 1994, policy makers, namely MHLW, formulated a guideline on lifting limits for work. For the field of care, this means the limit of lifting for one person is 25 kg (MHLW 2013b, 15). The impact of this guideline, because it is widely unknown as well and because it includes no sanction mechanism or penalty for employers who violate it, is limited. How to implement a legal framework that works could be learned from Australia with its safe patient handling (Australian Nursing & Midwifery Federation 2016), which can serve as a case study for implementing care aids. One actor in Japan that actively promotes a new mindset for the field of care is the Japanese no-lift association (nippon nō rifuto kyōkai n.d.), which bases its knowledge on the Australian system.

Nevertheless, on this point, the activities of the government, such as subsidies or promoting care robotics, are evaluated as positive. There is only the wish that somehow companies could get better access to the field of care, and that probably some kind of regulation for the use of care equipment might have a positive impact on the diffusion of care robotics.

Then there are the high expectations toward robots in general, which are covered by the eighth category (see Chapter 6.8). This chapter gives insights about whether robotics is something that is unique to Japan or not. The interesting finding here is that there seems to be a desired appearance for robots in Japan. They must be humanoid because of the presence of humanoid and advanced robots within manga and anime. On the one hand, pop culture lays the base for positive connotation, and thus acceptance, of robots. On the other, it creates a need to fulfill expectations, because otherwise robots might be rejected. It is the so-called Astro Boy Syndrome, the given duty that a robot in Japan has to be humanoid. Thereby humanoids pictured in manga and anime lead to misconceptions about the state of the art. The developer of palro expresses these expectations on robotics.

> *"In terms of technology, people have the unreasonable expectations that you can talk with humanoids. After all, speech recognition has evolved along with technology, but because there are quite difficult things, cheating is a bad way of saying, but [unreasonable expectations] have to be covered with communication. The old robots speak and do only defined things, but since the mobile phone and Siri came out, people try to start various talks [with robots and machines]. Although, it started to evolve a demand for AI that can respond to this, all companies are still in development."*[636]

For him, these misconceptions about technology are also based on media coverage for which it is more interesting to cover media effective robots such as ASIMO, AIBO or androids, than to highlight monitoring systems for beds, which are rather unspectacular.

At the same time, the limitations of the state of the art lead to two conclusions. The reality of care robotics is low-tech solutions for narrow issues, and high expectations might hinder the diffusion of robots. However, there is also reason for optimism, because automatization is limited to repetitive tasks. Marcus and Davis argue with the example of AI that *"no matter how much data you have and how many patterns you discern, your data will never match the creativity of human beings or the fluidity of the real world."* At the moment, almost no jobs will be lost through robots, and the few that disappear might be balanced through new roles and jobs with less repetitive tasks. The capability of robots and AI is still limited, and thus the feasibility for technology-based labor replacement. Marcus and Davis go to the heart of this when pointing out, "*if machine learning and big data can't get us any further than a restaurant reservation, even in the hands of the world's most capable A.I. company, it is time to reconsider that strategy.*"(Marcus and Davis). As already mentioned, when talking about the images of technology in the media, there is a gap between expectations towards technology and its current state of the art. In the near and far future, there needs to be an operator for every robot. In other words, it is impossible to replace human labor completely.

[636] INR15-IP22 (palro: Fujisoft) 00:18:33-00:19:33 技術面では、人の形をしていてお話ができるというと、過度な期待をされるんです。やっぱり技術と共に、音声認識とかは進化していくんですけど、なかなか難しいところではあるので、ごまかすというと悪い言い方になりますけど、[過度な期待] それをコミュニケーションでカバーしながらやっていくというのが難しいところではありますね。昔のロボットなら決まったことを言って、決まったことをやるような形なんですけど、携帯で Siri とか出てきてから、皆さん[機械と、ロボットと]雑談をするように、いろんな話を投げかけるようになってきてしまったので、それに対応できる人工知能とか AI が求められ始めていますが、まだどこのメーカーも開発中です。

The last category gives significant insights about if and how robots might make a contribution to society (see Chapter 6.9). It is no surprise that engineers evaluate their technologies as being able to contribute to solving the challenges of demographic change. What is more interesting is that there is no sign of an engineer who believes that they are the only option for Japanese aging society. Robot technologies are seen as a partial solution to mitigate the labor shortage and the aging caregiver. However, in fact, robot technologies are evaluated as more practicable than migration, or other changes within the work environment. Having said this, the responses for this vary. One group of developers is convinced that robots are easier to integrate into Japanese society, and another group believes that it might be difficult to attract enough foreigners to balance the labor shortage within the field of care. This leads to the conclusion that robots are not the preferred approach for countermeasuring demographic transition, but are considered as a partial solution in combination with other measurements.

In doing so, the priority areas (see chapter 3.1.2) formulated by the government illustrate how robot technology can make a positive contribution to improve the difficult situation within the field of care. Transfer aids, such as Hug, aijō-Kun, Sasuke or reysone reduce the physical burden on caregivers. Mobility aids such as Little Keepace, Flagship Model, RT.1/RT.2 or Tecpo extend the range of motion for elderly people and enable social participation, or in other words, improve their quality of life. Toilet aids, such as Dreamer or kyuretto, and bathing aids, make it possible to do very intimate tasks alone without being dependent on others. Monitoring systems for private homes or facilities, such as SAN Flower or aams, contribute to a lower psychological burden on the caregiver and relatives, because they can be used to ascertain whether everything is fine or not. This is in particular helpful for night shifts in care facilities, where caregivers sometimes have to work alone and are worried when several nurse calls come in. Monitoring systems help to prioritize and disclose information about the vital status of the elderly. Moreover, communication robots, such as palro, Yumeru & Neruru or OriHime, are a welcome change to repetitive daily life within care facilities, and can partly help to entertain the elderly when caregivers have to do other urgent tasks.

This shows that there is a broad spectrum within areas where robot technologies are very promising, and that it is easy to find new fields for technology. The reason for this might lay in our current daily lives. The developer of palro explains this a bit further, when he explains why he would suggest robots for his own family, *“because I think that we* *already receive help by technology in our own lives, I really think it's worth a try.*[637]*"* This optimistic statement is extended by the developer of KR-1000A who points out whether the future of care has to include robotics when he says that, *"It doesn't have to be, but I think it would be a better world and society if there is one."*[638] It is not that the only available option is robots: it is more that robots can have a positive outcome on future society. Robotics is only a means to an end, and it is up to society how it wants to make use of this emerging technology.

The third and last hypothesis argues that for the successful development of an invention, the institutional and cultural environment which they are embedded in is more important than having a groundbreaking or convincing vision. This sounds obvious, but through the utilization of this study, it can be checked to what extent the theoretical framework of this study fulfills its own ambitions of being able to explain technological change with all its different aspects. Technological change can be illustrated in the following figure (see Figure 7-1).

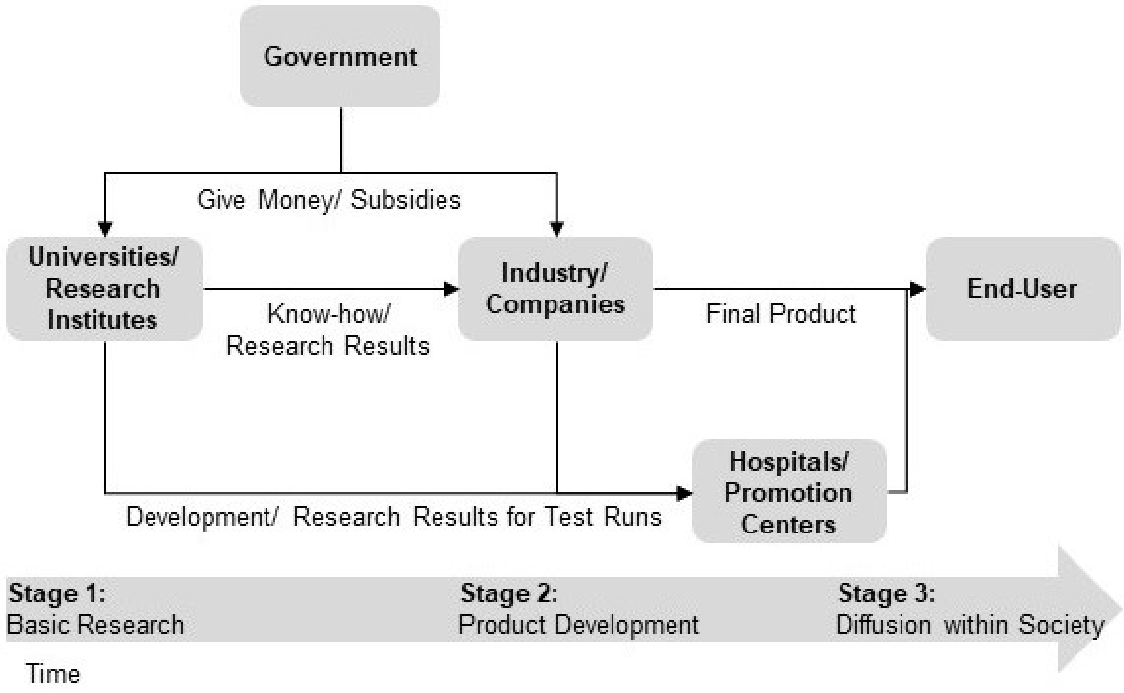

Figure 7-1 Three Step Process of the Development and Diffusion for Care Robotics

[637] INR15-IP22 (palro: Fujisoft) 00:42:27-00:42:37 意外に身の回りで技術に助けられてるものだと思いますので、試してみる価値は非常にあるかなとは思います。
[638] INR23-IP32 (KR-1000A: Clarion) 00:30:34-00:30:46 なくてもいいけど、あるとよりよい世界、社会になるという風に思います。

First of all, the relevant social groups that are involved in the process of change have to be detected. In Japan, the government is represented through METI and MHLW, both of which try to provide an environment for the development of robots. At the same time, the government tries to address challenges within the field of care, such as the labor shortage and to create a new national and international market for further economic growth. From a theoretical perspective, an artificially created vision, which is in this case the care robot as a solution for aging societies, has a tough job because it is difficult for them to obtain the necessary consensus to reach the stage of product development and the stage of diffusion. However, as far as the data from the interviews suggests, this approach is working. For the government, the method of choice is subsidies for the developer and user side in order to promote development and diffusion.

Then there are the relevant social groups on the implementation side of robotics, the developers. This can be universities or research institutes, which are not dependent on economic profit and thus can do basic research, as well as companies. It is possible that both profit from each other through an exchange of information or research results. One specific form for this is to set up joint ventures. Nevertheless, companies are driven by the interest to develop marketable and profitable products.

Finally, there is the user side, which consists of caregivers and hospitals. The former is the relevant social group that decides whether they accept or reject the inventions. The latter fulfills a dual role, because it can additionally help with test runs, and thus collect evidence for the advantages of a new technology.

Technological change is divided into three stages: Basic research, technology development and the stage of diffusion. In simpler terminology, the stage of the information, the stage of materialization and the stage of diffusion. At the beginning of every technological change, there has to be an innovative idea that is able to challenge the existing system. Even the most brilliant inventor will fail if he is not able to achieve consensus for his idea. Consensus is in the end the important factor that leads to realization of an idea. The first stage ends when the idea becomes an invention.

Innovative ideas have the problem that they are new and cannot rely on existing experience or terminology. Having said this, there is the need of a common vocabulary to be able to communicate and foster exchange about the idea and to achieve consensus. The SCOT approach provides the concept of the technical framework, which is the language for communication. With this language, the idea is able to transform into an invention.

The next step is diffusion within society. At this point, it is not enough to obtain a certain consensus within the groups involved in development. It is necessary to start a discussion about how a new invention should be used by society. This is in other words the negotiation process about various interpretations, which at the beginning of diffusion can be more or less equal. However, during the course of development, the interpretative flexibility, which is the discourse on various interpretations, steadily gets smaller until only one interpretation is left. In the case of care robotics in Japan, the end of the third stage has not been reached yet. Japan is in the middle of the negotiation process about which interpretation should apply for care robotics.

After explaining the basic elements of the process of technological change, I want to explain some characteristics of R&D environment in Japan, too.

First, the ministries in charge of the promotion of care robotics are almost equal. METI has a stronger focus on the maker side and wants to promote possible final products for the economy, and MHLW wants to strengthen the user side. In doing so, problems of responsibility sometimes occur. The reason for this is a missing umbrella organization which could bundle all efforts into overall support from early development on the developer side, to familiarization on the user side. DARPA claims such a position in the United States and concentrates overall robot development.

Second, in Japan, the end of the project period often also marks the end of the robot, because the ministries neither supervise nor monitor after the project period. The AMED program (cp. AMED 2015b) was important to collect first experiences with care robots on a broader scale. It was the chance for facilities to receive care robots with almost no financial risk. On the other hand, this reduced the need to think about what is actually needed. Tax money was invested without the creation of a sustainable market demand. Many of the robots are left unused in a corner.

Third, there are high expectations towards robot technologies. Not only through pop culture, but also through the government that creates false expectations when domestically and internationally advertising Japanese robotics as advanced, and Japan as a robot society. This is not only ignoring the current problems in the landscape of robot development, but also leads to further false expectations and so to an obstacle for reaching their own objectives

Fourth, the system of personal shuffle causes high transaction costs, because the staff on a project might start from an early stage or has only limited knowledge about robotics. Only a strong vision with the necessary consensus can overcome this kind of friction.

This leads to the conclusion that the general model has the main impact on the outcome of technological change and is transferable to other countries. However, culture makes a difference and can support or complicate certain processes within development and diffusion.

Coming to the end of my conclusion, I would like to give an answer to the following question: Is there something special about the approach to utilize technology for solving specific issues? The answer is no. Already after the Second World War, with growing technical progress and a flourishing economy, the Japanese and also other governments made use of the benefits of automatization. This was the robotization of production, in particular in the automotive sector. Since Japan was working at full capacity, robots only mitigated the situation and made it possible for workers to be transferred into other needed fields. For this reason, there is a positive memory concerning the connotation of robots making a contribution to economic growth. Several decades later, the situation changed. Now Japan’s economy is weakening, and society is steadily aging. Against the background of positive connotation, robots should improve the current situation and ensure a working economy for a second time, and additionally should stabilize the welfare system. It is the attempt of the robotization of care.

In this context, it is important to be aware of the gap between the developers’ and the users’ mindset. The former is aware of the potential and challenges of robotics, and the latter is not familiar with the state of the art within the field of care robotics. This leads to high expectations which can become an obstacle for the diffusion of low-tech robots.

There are some points that have to be kept in mind for the future. First, the future of care robotics will be influenced by low-tech solutions rather than high-tech robots. A reason for this is the state of the art and the need to design almost intuitively controllable devices, because caregivers have no time for long technical trainings on just one device. Second, the ministries have to work even closer together. In this context, it might be a good idea to set up an organization to bundle the promotion of care robots, namely AMED. Third, at the moment the user is, for various reasons, almost excluded from the development process. The promotion of better access to the field for the developing companies will have a positive outcome on the speed of diffusion.

Last but not least, there are several things that have to be mentioned. The major difference of the development and promotion of care robotics in Japan is revealed in comparison with other countries. Only when having a look on the priority areas formulated by the government does it become clear that a wide range of possible scenarios for the future of robot technologies within the field of care are considered. This wide range is much more diversified than in other countries, where, if at all, only a few fields are considered for robots.

Moreover, there are fewer constraints about possible application fields for care robots within Japanese society, but also high expectations on robotics. The development of care robotics in Japan is characterized through not excluding any possible options a priori. In doing so, it is pragmatical. This combination is a good basis for fast diffusion within society.

If care robotics works out as a partial solution for demographic challenges, it is likely to work out in other countries as well. In that case, Japan will have a pioneer position and can enter foreign markets almost without any competition. This applies especially for the Asian region with its aging society, which is only waiting for solutions for its demographic challenges, whether these solutions are technical ones or not.

7.2 Recommendations for Further Actions

The study at hand discovered the state of the art in the field of care robotics in Japan. At the end of this study, the question remains how the existing challenges can be overcome in the near future. As a scientist, I am aware of the balancing act which I make when formulating recommendations for further actions. Science has to be neutral as far as possible, and try to avoid being influenced by a personal point of view. At the same time, the collected findings of this study carry relevance because of the nature of care robotics: its changeability. Care robotics is an emerging field with a yet unknown outcome. I do not claim to provide a master plan, but I would like to attempt to contribute to a positive course of development, because I believe that to some extent, technology and aging societies are inseparably interlinked.

Against this background, the following points are made from the perspective of a researcher, and should be understood as ideas for easier diffusion within society, and possible input for involved relevant social groups such as policy makers, robot developers or even caregivers. The central question that remains open is, what has to be done to overcome existing challenges? For this, I suggest the following three instruments: A communication strategy, a robot quota and a participative development design.

Coverage within the media about robotics as the Japanese way (cp. Arillo, December 04, 2019; Byford, April 28, 2015; Dickinson, June 14, 2019) of dealing with social challenges has to be seen critically. On the one hand, there might be some factors that influence the development of care robots in Japan, such as a general interest in technology through the high presence of robots in modern pop culture. On the other hand, when talking about care robots, we are really talking about the needs of elderly people. I claim that the needs of the elderly are almost the same on an international level, because elderly even on the other side of the earth want to live as independently and self-determinedly as possible. Aside from possible cultural differences (e.g. the relevance of the bath culture in Japan), the elderly wants to live without being dependent on someone, and keeping this in mind when developing robots might easily transfer into higher acceptance in the field of care.

The first recommendation is a clear communication strategy. There is a gap between the available information about what robot technology actually can do and of what we expect it to do. For example, there are robotic devices such as thermical floor sensors to locate fallen persons, and then there are pop cultural robots such as Astro Boy or Mobile Suit, or advanced pilot projects such as ASIMO. This inevitably leads to misconceptions, or the Astro Boy Syndrome, which causes an attitude of rejection of care robots. This could be different, because with clear communication within the media, the average person who is not an engineer, could be sensitized for robotics. For this reason, governmental organizations, promotion centers or other relevant actors should make use of public media and use it as a supportive PR tool. Public media (e.g. newspaper, TV) are an easy way to reach many people at the same time.

However, in doing so, it is not just setting up an information campaign, it also has to fit the respective target group. This means creating specific content for specific groups. On the user side, the elderly are likely to be interested in different things compared to other generations. Another relevant user group is female middle-aged caregivers, who are not engineers and are not a group of innovators. The average female caregiver is rarely a robot manga and/or anime fan, and is not attracted by technology. For this reason, a communication strategy which is a clear about the opportunities and challenges of care robotics can have a positive impact on the further course of diffusion within society.

The second recommendation is a quota for robots. The challenge is not to find robotic devices that are useful. At the moment, there are two major challenges with regard to the diffusion of robots: To reduce costs and to get robotic devices used. In this context, a robot quota or making the use of robots obligatory might be an effective instrument to overcome these two obstacles. First, the cost-side, and probably the major benefit, the obligatory use of robots within care facilities is the creation of a higher demand for robots and thus leads to higher production numbers. This in turn leads to lower costs and makes it easier to buy care robots. Second, in regard to the actual use of robots, a general duty to use them causes caregivers to rethink existing patterns. The persisting mindset of doing care by hand might become questioned by the caregiver and pave the way for the integration of not only robotic devices, but also of care equipment into the work routine.

Against the background of high costs as an obstacle for the diffusion of care robots, subsidies, as the Japanese government already uses them, are an instrument to create a demand for robots. It takes a lot of effort to create a new and sustainable market, and especially in the early stages, the product costs are still high and the demand low. At the emerging stage of care robots and without financial support for them, there is no need to use them, because they have many problems and cost a lot of money not only to purchase but also to maintain them. Against this background, subsidies make sense and are an important instrument to give incentives to switch to new technology. These incentives can simply be financial support for development, but also setting incentives through adjusting care insurance towards the inclusion of robots for insurance coverage. Until a certain point, subsidies make sense. However, this situation cannot last forever and there is the omnipresent risk of not creating a demand. The goal of subsidies has to create a market that has healthy market forces with supply and demand, and thus is competitive even internationally.

The third and last recommendation is a participative design approach. The government and also developers are already aware about the gap between R&D and the user side. However, no proper tool has been found to fill this gap. Ways and means for this integration of the user have to be found. There is the need to shift from the maker onto the user towards participative technology development. For this reason, the government must ensure a development-friendly environment e.g. financial support such as coverage by insurance to lower the financial burden and risk on users, easier networking and faster introduction to care facilities. The key for participative development is collaboration. Especially big makers can collaborate with care facilities and provide financial coverage for their robots and know-how to train the staff, but even smaller companies have to have a chance to be able to work together with care facilities.

Another aspect of participative design is for makers to have a chance to understand the field of care. This includes simple things of common sense, such as the work tasks within a given day, and awareness that it is difficult to automatize care in general, but that there are various chances for technology to provide solutions for existing problems. In the case of Japan, the level of technology is not a problem; it is more or less to being able to connect existing technologies to the care field with its very special needs.

7.3 Need for Further Research

With the focus of my study on the developer side of care robots, I especially hope to introduce the state of the art to a wide audience, as well as to highlight the challenges that have to be faced for successful diffusion of new technology, namely care robots, not only for Japan, but also for other countries. Despite all the challenges which lie ahead, I believe that in the future there is an inseparable entanglement of the field of care and technology. Against the background of overaging societies around the world, and thus worsening labor crises within the field of care, robot technology makes a contribution to mitigate the current care crisis and to improve quality of life as well as quality of care.

I hope that I have been able to sensitize for the importance of thinking out of the box, and shed a light on the potential of care robotics as a partial solution for care issues. This study provides the basis for further research and a methodological approach to access this new research topic. The advantage of qualitative methods is that they make it possible to immerse new topics into research with only limited available sources. Since I explored the developer side, ongoing research can go even further into promotion and the user side of care robots to complete the picture.

A. Appendix

The appendix contains additional information, which makes it easier to understand the previous chapters. The following contents are included

- Questionnaire (see Table A-1)
- Matrix's of the Interviews (see Figure A-2)

Questionnaire

Table A-1 Questionnaire for the Interviews

IQ		
	インタビューの日時	Interview Date
	ロボット名	Robot
	重点分野	Priority Area
	組織名	Company Name
	設立	Founded
	本社	Head Office
	従業員数	Employees
	本業（商品構成）	Main Business (Product Range)
	ウェブサイト（URL）	Website
	ロボット写真	Robot Picture (URL)
IC01：自己紹介・経歴		
1.	お名前、所属の機関をお願いします。	Name、 Position
2.	差し支えなければ、生まれた年をお聞かせください。	Age、 Gender
3.	はじめに、経歴とその当時の活動など、ご自身についてお聞かせください。	Background
3.1.	現在の仕事の内容をご説明していただきないでしょうか？	
4.	ロボットに関して興味を持ったのはいつ頃でしょうか。また、昔からロボットの開発者になりたいと思っていましたか?	Interest in Robot
4.1.	【Y】そのためにどういった努力をされましたか?	Effort for Carrier
IC02：組織構造・研究目的・協力関係・資金提供		

1.	ロボットに関する開発組織又は構造について簡単にご説明ください。誰が開発に加わり、研究目的はどのように構成されていますか？	Development Background (Organization Structure, Objective)
1.1.	直接に開発に関わる方々は何人でしたか？	Involved Persons
2.	研究・開発の情報はどのように交換されていますか?情報交換には規則（例：毎週、毎月）がありますか?それとも、話し合いはどちらかというと非公式なものでしょうか？	Information Exchange
3.	国内・国際の組織（例：介護施設、企業、政府、研究機関）と協力すること又は、共同研究事業（例：国・県・市町村の推進事業）に関わることはありますか？	Participation in (national/ other) Projects
3.1.	【Y】具体的にどの事業ですか？	Which
3.2.	【Y】その協力活動は研究にどのような利点・欠点を与えていますか？	Cooperation (Dis-) Advantages
3.3.	【Y】援助を受けるため、何か条件（例：中間報告等）がありましたか？	Cooperation Conditions
IC03：研究焦点及び特定のロボットプロジェクト		
1.	ロボットの開発の経緯についてお聞かせください。	development history, reason for development
X.	ロボットの発端又は動機は何でしょうか？	
1.1.	ロボットの開発は、外部からの働きかけ（例：政府からの要請等）があって始められたものですか？それとも内部で決定され始められたものですか？	internal/ external started project
1.2.	どの特徴はありますか?又は目新しいものは何でしょうか？（例：特別なデザイン・機能）	Uniqueness/ outstanding/ convinced about the own work
1.3.	ロボットの機能を簡単にご説明していただけないでしょうか？	
2.	ロボットはどの開発段階にありますか?	Current state of development
2.1.	これ以降の開発計画にはどういったものがありますか?	Future development/ general plan
2.2.	【商品段階】あれば、ロボットの生産・販売数を教えていただけないでしょうか?	Sold units (if marketable)
2.3.	【商品段階】どのようなビジネスモデル（いわゆる通常販売、レンタル等）で販売されますか?何故このビジネスモデルを選びましたか?	Future business model

2.4.1.	【過去】いつ市場に売り出されましたか?	Market maturity
2.4.2.	【将来】市場に売り出される段階にいつ頃達する見通しでしょうか?	Plan for market maturity
3.	中長期的大量生産の計画はありますか?	Mass production
3.1.	どのマーケット（国内・国際）のために開発をなさっていますか? 何故でしょうか?	Japan/ Global
IC04：ユーザビリティテスト		
X.	技術シーズと現場・ユーザーニーズはどう製品化に繋がれると思いますか？	(Only for Promotion/ Care)
1.	ロボットは、人間とのインタラクションについて実験されましたか？	Human-Robot-Interaction
1.1.	【Y】企業、介護施設又は利用者との協力関係はありますか? 何故でしょうか？	Cooperation & test
1.2.	【Y】どういった相手との実験でしたか？	Target group
1.3.	【Y】相互作用試験に対するフィードバック又は反応 はどうでしょうか？	Feedback
1.4.	【Y】そのあとで（相互作用試験後）何か改善された部分はありましたか？	(Y) Improvement
1.5.	【N】何故でしょうか?何かの理由はありますでしょうか？	(N) Improvement
1.6.	現在どこかに使われていますか？	(Only for Care)
IC05：ビジョンと理想		
1.	ロボットに対する開発・研究の動機・モティベーションを教えていただけないでしょうか？開発の目的は何でしょうか？	Development Goal
1.1.	ロボットによって社会的な価値はありますか?有用性はどのようにして計測（数字化・データ化）出来るとお考えですか？	Evaluation of the Robots Value
2.	ロボットのデザインは、何か特別な影響を受けていますか?何故でしょうか？	Design
2.1.	誰がそのデザインを決めましたか？	Design Decision
X.	誰か・何かがこのロボットにきっかけをしていますか？	Occasion for the Development
3.	ロボットの名称の由来について教えていただけますか？	Origin of the Name
4.	開発について他の関係者の方々はどうお考えですか？共通の概念又はビジョンをお持ちですか？	Consensus about the Development

4.1.	【Y】共通のビジョンは書面に記録されていますか？	Official Vision
4.2.	【N】非公式的には今後の開発に関して一致している意見はありますか？	Unofficial Vision
IC06：研究・開発に関連する問題とその解決		
X.	団体側にとって、どういったことがロボットの開発に良い （悪い） 影響を与えますか？	Influencing Factors for the Development
1.	ロボットの開発に関する問題点 （例： 資金、技術、法規制） についてお聞かせ頂けますか？	Development Obstacles
2.	開発にあった具体的な失敗はありましたか? 一例を挙げていただけますか？	Examples
2.1.	【Y】どの失敗でしょうか？解決はどうでしたか？	Mistakes and Solutions
X.	【Y】個人的な観点と団体的な観点からどのように取り扱われましたか？	Individual and Organizational Perspective
IC07：市場潜在力・問題点・政策		
1.	国内外のサービスロボット、特に介護ロボットの市場潜在力と市場規模についてはどう思いますか? 何故でしょうか?	Market Potential
2.	サービス、特に介護ロボットの普及をする問題点はあると思いますか?	Problem for Diffusion
2.1.	【Y】どのような問題点でしょうか?（例：技術、社会、政治、法的な問題）	Definition of Issues
2.2.	ロボット開発・普及の環境（例：安全規格、技術的実現可能性、介護保険制度）を改善するには何が必要でしょうか?	Suggestions for Improvement
2.3.	サービスロボット開発・普及に対する主務省（経済産業省、厚生労働省、総務庁）の役割と活動をどのように評価なさっていますか?	Evaluation of the Governmental Efforts
3.	ユーザー・ロボット・インタラクションから生じる事故の法的責任についてはどう思いますか?責任はロボット、ユーザー又はメーカーに置くべきでしょうか?	Responsibility for Human-Robot-Accidents
IC08：介護ロボットと技術に対する期待		
1.	海外でもロボットが開発されていますが、これについてはどう思いますか?	Foreign Robots
1.1.	海外（特に欧米）に比べると日本における開発とは何か違いがありますか?	Japans Characteristics (1: Development)

1.2.	産業ロボット又はサービスロボットと介護ロボットの分野における日本の国際的な競争力についてはどう思いますか?	International Competitiveness
2.	日本のロボットの特徴は何だと思いますか?	Japans Characteristics (2: Culture)
2.1.	神道、ポップカルチャー（アニメ、漫画）、からくり人形をはじめとする特異な文化によってロボットが広く親しまれるとよく言われています。これに関してどう思いますか?	Cultural Factors
2.2.	これらはご自分自身のお仕事に与える影響・外圧・プレッシャーはありますか?どのところでしょうか?	Cultural Impact (1)
3.	政府と国民にはサービス、特に介護ロボットに対する期待はあると思いますか?	Expectations of the Government & Society
3.1.	【Y】どの期待だと思いますか?	
3.2.	【Y】特に介護分野の利用を考えると技術的実現可能性はありますか?	Technical Feasibility
3.3.	これら（文化的かつ社会的な期待）は開発或いは仕事に与える影響はありますか?どの程度まででしょうか?	Cultural Impact (2)
IC09：ロボットによる社会貢献		
1.	ロボットの利用は高齢化社会における問題の解決策として考えられていますが、これについてどのように考えますか? その理由もお聞かせください。	Robotics as Solution (Overaging Society)
2.	介護ロボットによって介護業界の作業・仕事の流れはどのように改善されてくると思いますか?	Robotics Influence on Workflow (Care)
2.1.	介護ロボットはどのように利用すれば良いと思いますか? どんな可能性、逆に危険性がありますか?	Chances and Dangers of Robotics
2.2.	介護ロボットにさせたほうがいい行動、させないほうがいい行動は何だと思われますか?	(Un-) Desired Field of Application (Robot)
3.	社会の中に幅広い介護ロボットの利用に関する理解・反抗はあると思いますか?その理由は何でしょうか? （例： 論理かつ社会的な問題）	Social Acceptance of Robotics
4.	今後に幅広く介護ロボット導入になると思いますか?	Diffusion Scale (Future)
4.1.	【Y】何故でしょうか? 介護ロボットの利用は不可欠でしょうか?	(Yes) Inevitability of the Use of Robots
4.2.	【N】何故でしょうか? 他の選択肢はありますか?	(No) Alternatives to Robots

5.	○○さんの家族又は親戚の介護のためにも介護ロボットを勧めると思いますか?	Care Robots for own Relatives
5.1.	【N】勧められない理由を教えてください。	
6.	ご自身がロボットを利用することは想像できますか?	Care Robots for personal Use

Matrix's of the Interviews

The heart of this study is the interview matrix. The interview matrix brings all together and is the base for the analysis of the collected data. On the left the interview categories (IC) with their related categorical interview questions (IQ) provide the framework. From the left to the right, the interviews are lined up in chronological order. Thereby, a summary of each interviewee's respond for each of the IC's and its IQs is given. The structure is simple, but enables to keep an overview over the vast amount of information.

A digital version of the interview matrix is attached to this study in form of an electronic media.

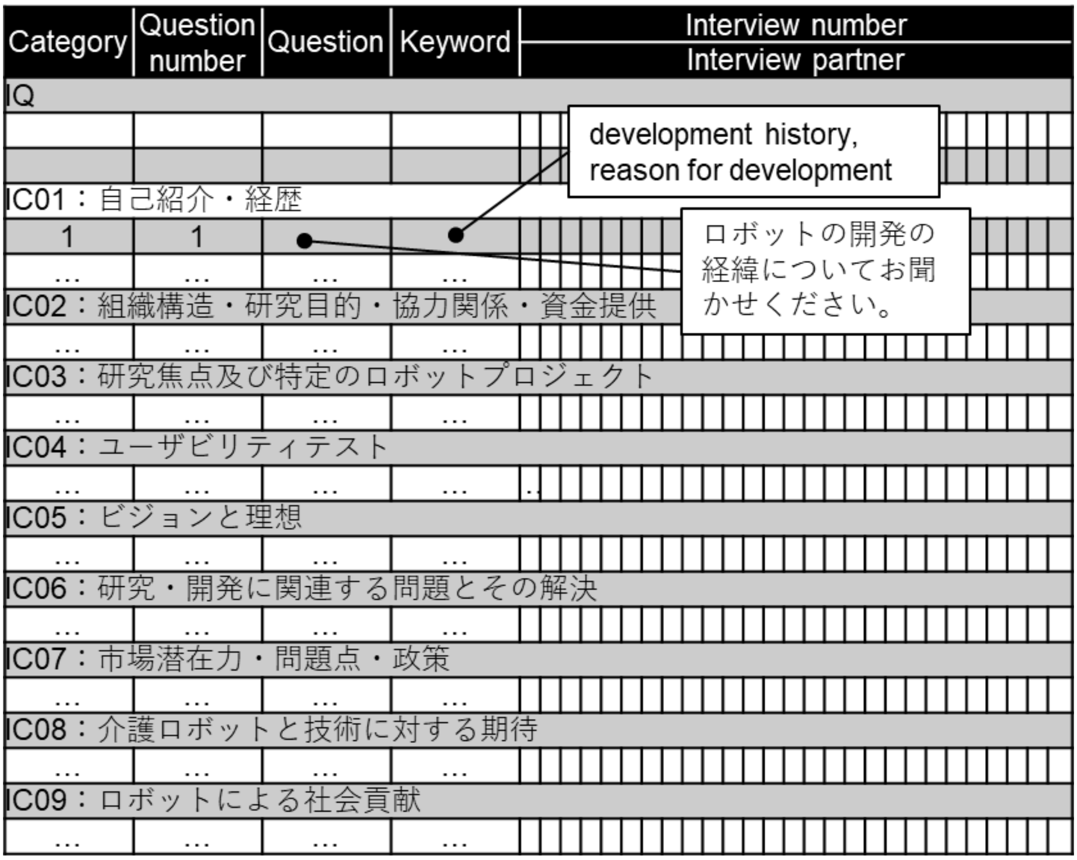

Figure A-2 Interview Matrix

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