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International Financial Market Integration, Asset Compositions and the Falling Exchange Rate Pass-Through

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Abstract

This paper provides an explanation for the observed decline of the exchange rate pass-through into import prices by modeling the effects of financial market integration on the optimal choice of the pricing currency in the context of rigid nominal goods prices. Contrary to previous literature, the interdependence of this choice with the optimal portfolio choice of internationally traded financial assets is explicitly taken into account. In particular, price setters move towards more local-currency pricing while the debt portfolio includes more foreign assets following increased financial integration. Both predictions are in line with novel empirical evidence.

Keywords: Exchange rate pass-through, financial integration, portfolio home bias, international price setting
JEL-Codes: F41, F36, F31

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1 Introduction

Exchange rate movements have an important impact on economic developments, with two channels standing out as the main transmission mechanisms. The trade channel works via altered export and import prices, while valuations and income from foreign asset positions are affected via the financial channel. The trade channel depends crucially on the exchange rate pass-through and international portfolio compositions determine the effects of the financial channel. Both variables have changed significantly over the recent two decades, a phenomenon we address in this paper. Previous literature has investigated both channels separately, analyzing the determinants of either one of the mentioned variables. We argue that this masks an important part of the picture and take the interdependence of the trade and the financial channel explicitly into account. We find that the currency decomposition of international portfolios has a strong bearing on the value of the exchange rate pass-through, which allows us to explain the observed decline in of the latter over time.[1] Specifically, we show that international financial integration, measured by the number and nature of available assets, affects the international portfolio compositions of domestic relative to foreign bonds and equities, which in turn influences the exchange rate pass-through indirectly but strongly. We present supportive novel empirical observations showing that an increase in equity trade is positively associated with a decline in the holding of domestic relative to foreign net debt positions (that is, a fall in debt home bias) and a falling degree of exchange rate pass-through.

Over the last two decades, an unparalleled expansion in asset trade has indeed taken place. The left panel of Figure 1 shows the sum of portfolio equity assets and liabilities plus the sum of foreign direct investment assets and liabilities over GDP (blue solid line), as reported in the updated and extended version of the data set constructed by Lane and Milesi-Ferretti (2007), over the time period 1990 to 2004 for a broad set of countries.[2] As visible, trade of equity has grown impressively relative to GDP post 1987, the start of the "financial globalization period" (see Kose et al., 2006), as well as relative to total debt assets and liabilities pictured by the black dashed line in the same panel.[3]

At the same time, holdings of net debt positions in domestic relative to foreign currencies have declined internationally. In the right panel of Figure 1, we plot the net debt in domestic currency less net debt in foreign currencies over GDP (blue solid line) and over total debt assets and liabilities (black dashed line), for the same country group as above. Hence, the empirical evidence shows a trend towards holding debt in foreign currency, such that domestic agents benefit from a depreciation of their own currency. Similarly, Bertaut and Griever (2004) document an increase in the portfolio weights of *foreign* long-term debt between 1997 until 2001 for Australia, Denmark, the Euro Area, the United Kingdom, and Sweden.

To explain the shifts in international portfolio composition and the falling exchange rate pass-through

[1] For example, Ihrig et al. (2006) report a statistically significant decline in the average exchange rate pass-through between 1975-1989 and 1990-2004 in the G-7 countries. Marazzi et al. (2005) and Otani et al. (2003) have established similar results concentrating on the U.S. and Japan, respectively. The study of cross-country trade between EMU and non-EMU countries by Campa et al. (2005) also suggests a decline in the exchange rate pass-through in a majority of countries. Furthermore, the International Monetary Fund (2006b) shows a considerable fall of pass-through into import prices for Canada, France, Germany, Italy, Japan, the UK, and the US from the period 1975-89 to 1990-2002. Frankel et al. (2005) and the International Monetary Fund (2006a) document a particular strong decline for emerging economies. HM Customs and Excise (2001) reports a reduction of the share of UK imports priced in pound sterling between 1999 and 2002 by 18 per cent. See also Taylor (2000) and Campa and Goldberg (2002).

[2] We use this time period throughout the paper due to the availability of data on currencies of foreign debt holdings. Appendix C provides a detailed description of the data.

[3] Arguably, falling transaction costs and reduced informational frictions have triggered this development and have increased the possibilities of countries to hedge against idiosyncratic risk by changing relative portfolio weights of domestic to foreign equity. This is particularly relevant for countries that started with less developed financial markets.

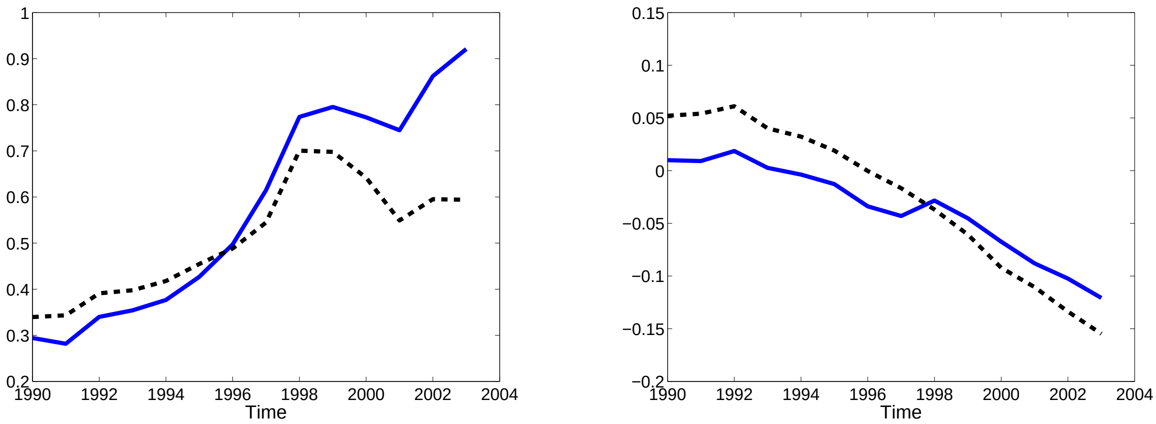

Figure 1: Sum of portfolio equity and FDI assets and liabilities over GDP (left, blue solid line) and divided by sum of debt assets and liabilities (left, black dashed line); average debt home bias over total debt (right, blue solid line) and divided by sum of debt assets and liabilities (right, black dashed line). Country sample: see Table C-3. Sources: Lane and Milesi-Ferretti (2007) and Lane and Shambaugh (2010).

simultaneously, we develop a two-country stochastic general equilibrium model of optimal portfolio choice and endogenous pricing currencies in which we analyze the relationship between the exchange rate pass-through and international financial integration in detail. In particular, starting from a world with trade in nominal bonds only, we add the possibility of trade in equity, representing increased international financial market integration.[4] The expanded set of tradable financial assets allows agents in both countries to hedge more effectively. Using both assets, in turn, frees debt from some of its burden to simultaneously hedge against all shocks present in the economy, such that it can be used more specifically to insure against shocks that trigger a depreciation and reduce consumption. A fall in the home bias of international debt holdings obtains.

The re-balancing of optimal international cross-country asset holdings does not come without an effect on other variables in our general equilibrium model, especially the nominal exchange rate. Since the nominal exchange rate is the key variable for firms deciding to pre-set their export price in their own currency (full exchange rate pass-through) or in the local currency (incomplete exchange rate pass-through), financial market deepening will have a strong bearing on the level of pass-through. One of several influencing effects arises because international trade of equities creates a larger impact of productivity disturbances on the nominal exchange rate, as these shocks impact profits. With trade in equities, higher profits partially leave the country where they accrue, thereby changing relative demand and the exchange rate. Since productivity disturbances also change marginal costs, their correlation with the nominal exchange rate increases. To avoid high production in times of high marginal costs, firms decide to price predominantly in local currency.[5] Consequently, when international finan-

[4]Thus, the degree of international financial integration is measured by the amount of financial instruments available to insure against different types of risk. Kose et al. (2006) argue that this quantity-based measure is best suited to capture financial integration internationally.

[5]The link between the correlation between a higher correlation between marginal costs and the nominal exchange rate on the one side, and more local-currency pricing on the other has been shown by Devereux et al. (2004). In a previous version, Devereux and Engel (2004) find that switching from a bond-only international financial market to a complete set of state-contingent assets increases the importance of relative instead of absolute monetary stability for price setting. As their model features only monetary disturbances as a source of fluctuations and does not endogenize optimal portfolio decisions, we see our paper as complementary. Similarly, our analysis adds to the insights of Engel and Matsumoto (2009), who show

cial markets are more integrated the exchange rate pass-through declines.

Despite the importance of the exchange rate pass-through on welfare and optimal monetary policy, as well as for the creation of a monetary union there have been relatively few explanations put forward in explaining the decline of the exchange rate pass-through.[6] For example, Taylor (2000) argues that in (increasingly prevailing) low-inflation environments the persistence of inflation is lower, which also reduces the persistence of cost changes and the incentives to change prices after exchange-rate movements. Campa and Goldberg (2005) confirm the negative correlation between lower inflation rates and lower pass-through, but attribute this to the shift of imports towards goods that exhibit a lower degree of pass-through. Our explanation that the falling exchange rate-pass-through is affected by the increased international financial integration does not contradict the above hypotheses and is one of several important factors explaining the decline in the exchange rate pass-through.

By modeling the link between the trade and the financial channel, we combine two separate strands of literature. On the one hand, the above mentioned theoretical papers deal with the determinants and effects of local-currency pricing vs. producer-currency pricing, while the optimal international portfolio choice is subject of a distinct body of literature. Most importantly, we use the method developed by Devereux and Sutherland (2011) to solve for the optimal composition of each country's debt and equity portfolio in terms of currency denomination. The insights obtained within this paper might be particularly important for groups of countries that move towards a currency union. The preceding financial market integration can reduce exchange rate pass-through, lowering the costs of giving up the nominal exchange rate as a channel of adjustment after idiosyncratic shocks, see also Engel (2000) and Devereux and Engel (2003). To the best of our knowledge, this aspect of the endogeneity of optimum-currency-area criteria has not been explored so far.

The remainder of this paper is organized as follows. In Section 2 we provide empirical evidence on the link between international financial integration and the increase in debt home bias. Section 3 describes our theoretical framework and lays out the optimal portfolio choice under alternative assumption regarding financial markets. Section 4 describes analytical results regarding the interaction between international financial markets and the pricing currency choice under a simplifying calibration. Section 5 concludes. In Appendix A we solve the model for unrestricted parameter values, with coefficients summarized in Appendix B, while Appendix C lists the sources for all data used throughout the paper.

2 Empirical evidence

In the following we apply regression analyses to empirically identify the importance of international equity trade (relative to trade in debt) for determining the debt home bias and the exchange rate pass-through. The debt home bias (dhb) is defined as net debt holdings in domestic currency minus net debt holdings in foreign currency. Our empirical analysis shows that higher levels of equity trade lead

that an explicit exchange-rate insurance can induce the same allocation as trade in a complete-markets setup. In our model with more shocks, bond and equity holdings serve as imperfect substitutes for such a insurance.

[6] Obstfeld and Rogoff (2000) have shown that with full exchange rate pass-through it is not desirable for monetary policy to target the nominal exchange rate in terms of welfare. A floating exchange rate allows for the adjustment of relative prices and helps to stabilize output and other macroeconomic variables in response of an external shock. However, if exchange rate pass-through is incomplete the exchange rate becomes powerless to alter relative prices and, hence, the shock-absorbing mechanism of a floating exchange rate evaporates (Devereux and Engel, 2003). An important consequence is that under these assumptions countries should adopt a monetary policy oriented at minimizing exchange-rate fluctuations to improve welfare. Other studies showing the importance of pass-through include Betts and Devereux (1996, 2000), Engel (2000), and Obstfeld and Rogoff (2002).

Table 1: Impact of equity trade on debt home bias over GDP

	(1) dhb/gdp	(2) dhb/gdp	(3) dhb/gdp	(4) dhb/gdp	(5) dhb/gdp	(6) dhb/gdp	(7) dhb/gdp	(8) dhb/gdp
(Eq. & FDI)/GDP	0.0714	-0.414***	-0.421***	-0.397***	-0.369***	-0.350***	-0.346***	-0.565***
	(0.122)	(0.114)	(0.101)	(0.101)	(0.102)	(0.109)	(0.106)	(0.0908)
NFA/GDP		-0.763***	-0.586***	-0.554***	-0.553***	-0.554***	-0.543***	-0.738***
		(0.0674)	(0.0624)	(0.0639)	(0.0615)	(0.0612)	(0.0624)	(0.0750)
log(Gross Debt)			0.205***	0.210***	0.214***	0.192***	0.150**	0.0302
			(0.0559)	(0.0553)	(0.0532)	(0.0636)	(0.0656)	(0.0448)
Net Exp.				-0.150	-0.135	-0.130	-0.133	-0.0538
				(0.105)	(0.0818)	(0.0802)	(0.0839)	(0.0719)
Openness					-0.130***	-0.140***	-0.150***	-0.0718*
					(0.0480)	(0.0495)	(0.0436)	(0.0406)
log(GDP/Pop.)						-0.0468	-0.0829	-0.0778**
						(0.0431)	(0.0520)	(0.0309)
Chinn-Ito							-0.0226*	0.00114
							(0.0124)	(0.00354)
log(Pop.)							-0.480**	-0.0698
							(0.187)	(0.134)
Constant	0.354***	0.0787***	0.00424	0.00368	0.0763	0.443	1.952***	0.902**
	(0.0327)	(0.0275)	(0.0405)	(0.0404)	(0.0484)	(0.352)	(0.739)	(0.411)
T & C FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Observations	1414	1414	1414	1375	1375	1375	1351	1099
Adjusted R^2	0.184	0.624	0.657	0.659	0.669	0.671	0.684	
F	5.982	27.90	33.52	28.79	39.10	39.21	44.22	

Robust standard errors (clustered at the country level) in parentheses. $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. dhb/gdp=debt home bias (net debt in domestic currency minus net debt in foreign currencies) over GDP , (Eq. & FDI)/GDP=sum of equity assets and liabilities plus sum of FDI assets and liabilities over GDP, NFA/GDP=net foreign assets over GDP , log(Gross Debt)=log of sum of debt assets and liabilities , Chinn-Ito=index of financial openness from Chinn and Ito (2006) , Openness=Sum of imports and exports over GDP , Net Exp.=net exports over GDP , log(GDP/Pop.)=log of GDP over population, log(Pop.)=log of population, T & C FE=time and country fixed effects. Column (8) displays results from a mean group estimator. Data sources are listed in Appendix C..

to a decline in both, the dhb and the exchange rate pass-through. We thereby confirm two crucial predictions of our theoretical model, which is outlined in the next section. Our results are meant as first steps towards a verification of our model predictions. A full characterization of the data, however, is beyond the scope of this paper.

To analyze the connection between increased trade in equity and a falling debt home bias we conduct a panel regression analysis of 109 countries covering the time period 1990-2004.[7] Table 1 shows a

[7]For this pooled OLS regression, we discard outliers, use robust regressions, and cluster standard errors at the country

Table 2: Impact of equity trade on debt home bias over total debt

	(1) dhb/debt	(2) dhb/debt	(3) dhb/debt	(4) dhb/debt	(5) dhb/debt	(6) dhb/debt	(7) dhb/debt	(8) dhb/debt	(9) dhb/debt
(Eq. & FDI)/GDP	-0.0643	-0.337***	-0.334***	-0.320***	-0.269**	-0.269**	-0.269**	-0.243**	-0.854***
	(0.107)	(0.112)	(0.113)	(0.113)	(0.106)	(0.106)	(0.107)	(0.105)	(0.166)
NFA/GDP		-0.428***	-0.507***	-0.484***	-0.483***	-0.483***	-0.483***	-0.424***	-0.957***
		(0.0674)	(0.111)	(0.109)	(0.106)	(0.106)	(0.106)	(0.0928)	(0.117)
log(Gross Debt)			-0.0919	-0.0853	-0.0796	-0.0796	-0.0792	-0.0572	-0.456***
			(0.0931)	(0.0925)	(0.0881)	(0.0881)	(0.103)	(0.0854)	(0.0950)
Net Exp.				-0.0951	-0.0691	-0.0691	-0.0692	-0.0438	-0.0233
				(0.0952)	(0.0901)	(0.0901)	(0.0910)	(0.0888)	(0.126)
Openness					-0.231**	-0.231**	-0.230**	-0.185**	-0.0887
					(0.0958)	(0.0958)	(0.101)	(0.0707)	(0.0786)
log(GDP/Pop.)							0.000832	-0.0291	-0.117**
							(0.0594)	(0.0632)	(0.0470)
Chinn-Ito								-0.0106	0.00318
								(0.0132)	(0.00528)
log(Pop.)								-0.143	-0.0518
								(0.260)	(0.253)
Constant	0.417***	0.263***	0.296***	0.290***	0.420***	0.420***	0.413	0.969	2.144***
	(0.0245)	(0.0312)	(0.0517)	(0.0519)	(0.0805)	(0.0805)	(0.514)	(1.065)	(0.780)
T & C FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Observations	1414	1414	1414	1375	1375	1375	1375	1351	1099
Adjusted R^2	0.209	0.311	0.316	0.311	0.334	0.334	0.334	0.376	
F	6.975	8.362	8.384	7.793	8.574	8.574	8.194	8.882	

Robust standard errors (clustered at the country level) in parentheses. $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Column (8) displays results from a mean group estimator. dhb/debt=debt home bias over sum of debt assets and liabilities. For description of control variables, see Table 1. Data sources are listed in Appendix C.

significant negative impact of (the log of) the sum of portfolio equity and FDI assets and liabilities on debt home bias over GDP, as defined above. We control for time and country fixed effects and a set of other variables that might impact on the debt home bias. These are log GDP, log Population, the updated Chinn and Ito (2006) index for the capital account openness, net exports over GDP, net foreign assets (NFA) over GDP, and total debt (log of debt assets plus liabilities). We include the index of Chinn and Ito as restriction on debt and equity trade could have an impact on the relative size of these two variables.

Furthermore, Table 2 shows that the negative effect of total equity trade is also present if debt home bias over total debt (sum of debt assets and liabilities) is used as the dependent variable. Regarding

level. See Appendix C for the country list of the 109 countries assessed, a description of all data sources and handling as well as summary statistics and correlations.

Table 3: Impact of equity trade on share of exports in home currency minus that of imports

	(1) PCP	(2) PCP	(3) PCP	(4) PCP	(5) PCP	(6) PCP	(7) PCP	(8) PCP+VCP
(Eq. & FDI)/GDP	0.0959	-0.244*	-0.311***	-0.300***	-0.223**	-0.268***	-0.347***	-0.218**
	(0.143)	(0.128)	(0.0961)	(0.0931)	(0.0939)	(0.0784)	(0.109)	(0.0774)
Inflation Vol.	0.130	0.476**	0.189	0.227	-0.00982	0.259	-0.436	-0.488
	(0.169)	(0.189)	(0.125)	(0.150)	(0.120)	(0.200)	(0.609)	(0.432)
Exch. Rate Vol.	-0.00897	-0.0125***	-0.00766*	-0.00725*	-0.000360	-0.00685*	0.0231	0.00505
	(0.00572)	(0.00390)	(0.00389)	(0.00370)	(0.00468)	(0.00358)	(0.0324)	(0.0230)
year	-0.000354	0.00836*	0.00362	0.00335				
	(0.00522)	(0.00410)	(0.00239)	(0.00243)				
NFA/GDP		-0.376**	-0.195***	-0.192***	-0.134***	-0.0644	0.0849	0.0453
		(0.128)	(0.0572)	(0.0561)	(0.0213)	(0.0509)	(0.168)	(0.119)
log(Gross Debt)			0.210***	0.210***	0.228***	0.232**	0.315***	0.0429
			(0.0616)	(0.0630)	(0.0625)	(0.0786)	(0.0722)	(0.0512)
Net Exp.				0.202	0.274		0.239	-0.0745
				(0.197)	(0.226)		(0.375)	(0.266)
Openness					-0.0968		-0.0526	-0.147
					(0.0627)		(0.176)	(0.125)
Chinn-Ito						0.0146	0.0328	-0.0135
						(0.0136)	(0.0220)	(0.0156)
log(GDP/Pop.)						0.0419	0.0410	0.0189
						(0.0334)	(0.133)	(0.0941)
log(Pop.)						0.127	0.491	-0.324
						(0.677)	(0.784)	(0.556)
Constant	0.956	-16.42*	-7.023	-6.494	0.230***	-0.665	-1.880	1.969
	(10.40)	(8.175)	(4.766)	(4.845)	(0.0278)	(2.175)	(2.772)	(1.966)
T FE	No	No	No	No	No	No	Yes	Yes
Observations	53	53	53	53	53	53	53	53
Adjusted R^2	-0.028	0.448	0.665	0.661	0.661	0.689	0.599	0.410
F	795.4	47.17	442.3	633.1	181.9	9253.4	5.033	3.143

Robust standard errors (clustered at the country level) in parentheses (except for columns (7) and (8)). $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications include country fixed effects. PCP=share of exports set in home currency, PCP+VCP=share of exports set in home currency or US dollar or euro, dhb/debt=debt home bias over sum of debt assets and liabilities, Inflation Vol.=variance of quarterly inflation in the three years before, Exch. Rate Vol.=variance of quarterly nominal effective exchange rate in the three years before. For description of other control variables, see Table 1. Data sources are in Appendix C.

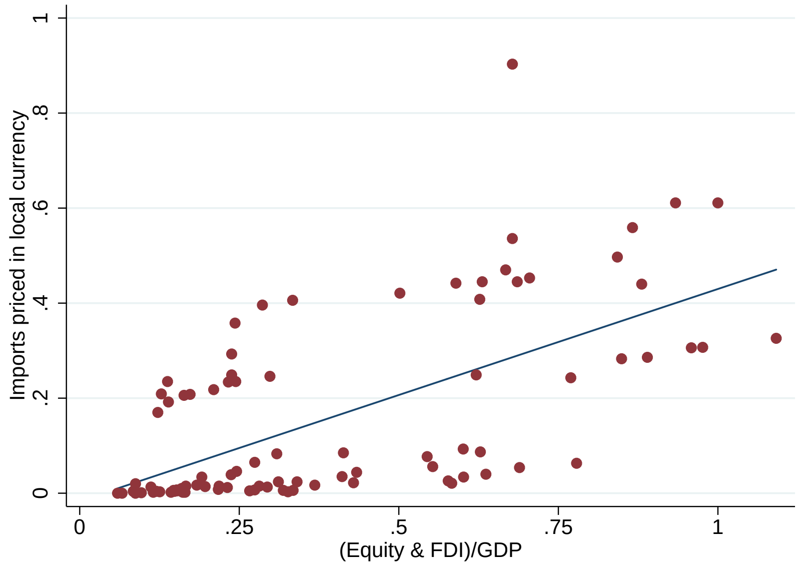

Figure 2: Relation between share of imports priced in local currency, and equity and FDI (assets plus liabilities) over debt (assets plus liabilities). A linear regression line is added. Sources: Lane and Milesi-Ferretti (2007) and Kamps (2006).

the size of the effect, an increase of 1 percentage point in the sum of equity and FDI assets and liabilities over GDP decreases debt home bias over GDP by around .32 percentage points, and debt home bias over total debt by .22 percentage points. Importantly, this effect is also present if we control for total debt in both sets of regressions. Both results are statistically significant at the 1% and 5% level, respectively. Specification (8) in both tables implements a mean group estimator, allowing for heterogenous slope coefficients across countries. This estimation results in even larger and more significant coefficients for both specifications. We can therefore conclude that the more equity is traded internationally, the lower is the debt home bias. This implies that agents choose a debt portfolio from which they benefit more in case of a depreciation of their own currency.

Unfortunately, we lack a similar comprehensive data set on exchange rate pass-through. Our analysis is therefore restricted to a smaller sample, which can give us only indications for the relationship between pass-through and equity trade. Specifically, we use data on how much of the invoicing of imports and exports is done in the local currency, provided in Kamps (2006), an unbalanced panel of 17 countries, ranging from 1994 until 2004.[8] As a first approach, in Figure 2 we plot the share of imports priced in local currency against our measure for financial integration. A clear positive correlation emerges with a correlation of 0.63. This correlation, however, is not directly related to the explanation for falling pass-through presented in this paper because it links the financial integration of the importing (in contrast to the exporting) country to the pricing-currency choice. As we are interested in the impact of financial integration of a given country on the behavior of its domestic firms, we turn to the share of exports priced in the currency of the exporting country which also features less outliers. A lower number shows that less prices react to movements of the countries exchange rate, typically indicating a lower degree of pass-through. As exchange rate and inflation volatility are likely to influence the level of pass-through, they are also included as control variables

[8]Countries and descriptive statistics are listed in Appendix C.

(a preceding three-year window was used for their construction). Again, we control for country and time fixed effects in columns (1)-(7). We find a relatively strong negative impact on producer-currency pricing. A one-percentage point increase of gross trade in equities and FDI decreases the share of exports priced in home currency by around -.34 percentage points, depending on the specification. It is a priori not clear if there are global developments that affect the level of pass-through which we do not control for in the regression. Taking out time fixed effects in column (8), but keeping country fixed effects, increases the degrees of freedom and confirms the results. There are too few observations per country for a group mean group estimator. Export prices that are not set in domestic currency can also be set in vehicle currencies, such as the US dollar or the euro. This case shares some properties from local and producer-currency pricing. Developments in the importing countries that affect its exchange rate relative to the vehicle currency alter its import prices. On the other hand, domestic developments that affect the domestic exchange rate do not change the export good's price in the currency of the importing country. We hence conduct a robustness check in column (9) by using the sum of the shares of export goods priced in home currency, US dollar or euro as the dependent variable. Across specifications we find a clear negative relationship between financial integration and producer-currency pricing.

From our empirical assessment we conclude with two main empirical findings: The higher the financial integration, the more equity is traded internationally, the lower is the debt home bias and the smaller is the degree of exchange-rate pass-through. The next section presents a model that is able to replicate these empirical patterns by allowing for both, an endogenous portfolio choice by households and optimal price-setting behavior by firms.

3 The Model

This section presents a formal analysis of the effects of international asset trade on the exchange rate pass-through. The analysis builds on Devereux and Engel (2003) and similar models. There is a stochastic two-country world. Agents of the home, H, and foreign, F, country produce traded goods. Both countries are of the same size and its inhabitants are indexed by numbers in the interval $[0, 1]$.

Home agents consume a continuum of differentiated home and foreign goods. Each household provides labor to the domestic monopolistic firms. Each firm sets its home and export price prior to the realization of aggregate technology disturbances, monetary policy shocks and demand disturbances, induced by the fiscal authority in each country. Firms meet demand at the pre-set price. Foreign country conditions, indicated by an asterisk, are defined analogously.

There are two periods. In period $t = 0$ no output is produced and no consumption takes place but households trade assets in international financial markets *before* any shocks occur in the economies. Two different international financial asset markets are assessed. Households can either choose the amount of wealth they like to invest in home and foreign nominal bonds, or in home and foreign nominal bonds as well as equities (i.e., claims on the future profits of foreign firms). Moving from an asset market where only nominal bonds are traded towards financial markets where both nominal bonds and equities are held is interpreted as international financial market integration. After asset trade has taken place firms decide whether to set their pre-set price of export goods in their own currency (i.e., producer-currency pricing, PCP) or in the currency of the importing country (i.e., local-currency pricing, LCP). In period $t = 1$ households decide about money balances, consumption, and labor supply, while firms produce and sell goods that consumers demand, once uncertainty is resolved.

3.1 Households, firms and international financial markets

Preferences and demand for goods Expected utility of the representative household is increasing in the aggregate consumption index C, real money balances M/P and decreasing in the disutility of work effort L in period 1:

$$U = E_0 \left[\frac{C^{1-\rho} - 1}{1-\rho} + \chi \ln \frac{M}{P} - K \frac{L^v}{v} \right]. \tag{1}$$

The expectation operator across states of natures in period $t = 1$ given date $t = 0$ information is denoted by E_0. The parameter $\rho > 0$ is the degree of relative risk aversion, $v \geq 1$ is the inverse of the elasticity of labor supply while χ and K are strictly positive parameters. Total labor supply L of the representative household is distributed across monopolistic firms of unit mass, indexed by z, so that $L = \int_0^1 L(z)dz$. The consumption index is a composite of domestic goods and goods produced abroad,

$$C = \left[a^{\frac{1}{\eta}} C_H^{\frac{\eta-1}{\eta}} + (1-a)^{\frac{1}{\eta}} C_F^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \text{ with } P = \left[a P_H^{1-\eta} + (1-a) P_F^{1-\eta} \right]^{\frac{1}{1-\eta}}, \tag{2}$$

being the home consumer price index. The elasticity of substitution between home and foreign goods $\eta > 0$ captures the sensitivity of the allocation between home and foreign goods with respect to relative price changes. For $\eta > 1$, home and foreign goods are substitutes. The parameter $a = 1 - n/2$ measures the overall share of home goods in the home consumption basket (see Sutherland, 2005), where trade openness is measured by the parameter $0 \leq n \leq 1$. This formulation accounts for the empirical consumption bias towards tradable goods produced locally; households give a higher weight to local than to foreign goods. In case of complete trade openness ($n = 1$), there is no home bias in consumption and domestic as well as foreign households consume equal shares of home and foreign goods. In case of $n = 0$, both countries are completely closed. Consumption of home and foreign goods are each a constant-elasticity-of-substitution bundle of differentiated products, with $\sigma > 1$ reflecting the elasticity of substitution between differentiated goods. All home goods sold domestically by local firms are priced in domestic currency, resulting in the bundle $C_H = (\int_0^1 C_H^{\frac{\sigma-1}{\sigma}} dz)^{\frac{\sigma}{\sigma-1}}$, with the corresponding price index $P_H = (\int_0^1 P_H(z)^{1-\sigma} dz)^{\frac{1}{1-\sigma}}$. Imports can be priced either in the consumer's (LCP) or exporting firm's (PCP) currency. It is assumed that the fraction $\tilde{z}^*$ of firms in foreign country exhibit LCP, and the remaining fraction $1 - \tilde{z}^*$ are engaged in PCP, so that

$$P_F = \left(\int_0^{\tilde{z}^*} P_F(z)^{1-\sigma} dz + \int_{\tilde{z}^*}^1 (SP_F^*(z))^{1-\sigma} dz \right)^{\frac{1}{1-\sigma}} \text{ for } C_F = \left(\int_0^1 C_F^{\frac{\sigma-1}{\sigma}} dz \right)^{\frac{\sigma}{\sigma-1}}. \tag{3}$$

The nominal exchange rate S reflects the home currency price of the foreign currency. Analogous conditions hold for the export goods of the home country H, with $\tilde{z}$ reflecting the fraction of home firms deciding on LCP and $1 - \tilde{z}$ of firms following PCP. Domestic demand for home and foreign goods depends on the intra-temporal budget constraint $PC = P_H C_H + P_F C_F$. Maximizing (2) subject to the intra-temporal budget constraint leads to the following demand functions for home and foreign goods

$$C_H = a \left(\frac{P_H}{P} \right)^{-\eta} C \quad \text{and} \quad C_F = (1-a) \left(\frac{P_F}{P} \right)^{-\eta} C, \tag{4}$$

with the following demand functions for individual home, $C_H(z) = (P_H(z)/P_H)^{-\sigma} C_H$, and foreign goods

$$C_F(z) = \left(\frac{P_F^{LCP}(z)}{P_F}\right)^{-\sigma} C_F \qquad \text{for } z = 0, ..., \tilde{z}^*,$$
$$C_F(z) = \left(\frac{SP_F^{PCP}(z)}{P_F}\right)^{-\sigma} C_F \qquad \text{for } z = \tilde{z}^*, ..., 1, \tag{5}$$

showing that $\tilde{z}^*$ foreign firms provide the home country with the foreign good at a price charged in home's currency and $1 - \tilde{z}^*$ at a price of foreign's currency. Analogous demand functions apply for the home good consumed in the foreign country. Our goal will be to derive $\tilde{z}$ and $\tilde{z}^*$ in equilibrium, given the underlying international financial market structure.

International financial markets and budget constraints We assume different international financial market structures: in period $t=0$, international asset trade may take place in nominal bonds (NB) or in nominal bonds and equity shares (NBE). Moving from a financial market where only nominal bonds are traded towards financial markets where both bond and equity trade takes place is interpreted as increasing international financial integration and deepening. Thus, the degree of international financial integration is measured by the amount of financial instruments available to insure against different types of risk.

Trade in bonds only (NB economy)
When international financial markets are less integrated it is assumed that only trade in home and foreign nominal bonds in period $t=0$. Bonds are in zero net supply in each period such that

$$B_H + B_H^* = 0 \qquad \text{and} \qquad B_F + B_F^* = 0, \tag{6}$$

where B_H (B_F) are domestic (foreign) nominal bonds held by domestic households and B_H^* (B_F^*) are domestic bonds held by foreign (domestic) consumers. Home bonds are denominated in home currency and foreign bonds in foreign currency. For the given prices of home, p_B, and foreign bonds, p_B^*, at time $t=0$ the home household faces the following budget constraint

$$p_B B_H - p_B^* S_0 B_F = 0. \tag{7}$$

Due to the initial symmetry, the foreign budget constraint at $t = 0$ can be written in terms of the currency of country H as: $p_B B_H^* + p_B^* S_0 B_F^* = -p_B B_H + p_B^* S_0 B_F = 0$. Furthermore, the price for bonds is initially identical and $S_0 = 1$. Consequently, $p_B = p_B^*$ holds. Furthermore, we assume that the initial net foreign asset positions in both countries are zero so that

$$B_H = -S_0 B_F \qquad \text{and} \qquad B_H^* = -S_0 B_F^*,$$

when expressed in country H currency units. If a country goes short in its own bonds, $B_H < 0$ ($B_F^* < 0$), this implies that this country, H (F), holds a positive position of foreign bonds, B_F (B_H^*). Using (6) this can be written as

$$B_H = S_0 B_F^* \qquad \text{and} \qquad B_H^* = S_0 B_F.$$

We can thus express both bonds as $B = B_H = S_0 B_F^*$. Our goal will be to solve for B. $B < 0$ then implies that country H borrows in domestic currency and lends in foreign currency. H would in this case benefit from a depreciation of its currency. After the realization of shocks in period $t = 1$ the representative household derives its income by supplying labor at the nominal wage rate, receiving nominal profits from domestic firms and returns from bond holdings determined in the previous period. Turning to the expenditure side, the household consumes, holds money M, given the initial money stock M_0, and pays lump-sum taxes T. The budget constraints of the representative households in countries H and F in period $t\!=\!1$ are then given by

$$\Pi + B_H - SB_F^* + WL = PC + M - M_0 + T, \quad (8)$$
$$S\Pi^* - B_H + SB_F^* + SW^*L^* = SP^*C^* + S\left(M^* - M_0^* + T^*\right), \quad (9)$$

respectively. Total nominal profits from home and foreign sales of the domestic and foreign firms are Π and Π^*. W and W^* reflect the nominal wage rate at home and abroad. In case of only nominal bonds trade, the Euler equations that characterize the domestic household's optimal portfolio choice decision are given by

$$\lambda_0 p_B = E_0\left(\lambda\right), \qquad \lambda_0 p_B^* = E_0\left(\lambda S\right),$$

where $\lambda = \frac{C^{-\rho}}{P}$ is the Lagrange multiplier associated with the period $t = 1$ budget constraint. Due to the initial symmetry $p_B = p_B^*$; the marginal benefits of both types of assets have to be equal in expected terms, if expressed in the same currency. Hence, the following equation defines the asset market equilibrium conditions at home and abroad,

$$E_0\left(\frac{C^{-\rho}}{P}\right) = E_0\left(\frac{C^{-\rho}}{P}S\right) \quad \text{and} \quad E_0\left(\frac{C^{*-\rho}}{SP^*}\right) = E_0\left(\frac{C^{*-\rho}}{SP^*}S\right). \quad (10)$$

Note that due to the zero net foreign asset positions, either no or both bonds will be held, such that the Euler equations have to hold for both bonds.

Trade in bonds and equity (NBE economy)

If financial markets are integrated, two types of financial assets are traded, bonds and equities. Initially, households fully own their local firms and the net foreign asset position is zero. The relevant budget constraint in the NBE economy at $t\!=\!0$ is then

$$p_B B_H - S_0 p_B^* B_F^* + \phi p_E + \varphi S_0 p_E^* = p_E, \quad (11)$$

where p_E (p_E^*) is the price for a home (foreign) equity share and ϕ (φ) is the amount of home (foreign) shares purchased by domestic consumers. Since the supply of of home and foreign shares is normalized to unity, the equilibrium in the asset market is characterized by $\varphi = 1 - \varphi^*$. Moreover, it follows from symmetry that $\varphi^* = \phi$, which implies that $\varphi = 1 - \phi$. Our goal will be to derive the optimal equity and bond position. In period $t = 1$ the budget constraints of the representative consumers in countries H and F are given by

$$\phi\Pi + \left(1-\phi\right)S\Pi^* + B_H - SB_F^* + WL = PC + M - M_0 + T, \quad (12)$$
$$\phi S\Pi^* + \left(1-\phi\right)\Pi - B_H + SB_F^* + SW^*L^* = SP^*C^* + S\left(M^* - M_0^* + T^*\right),$$

where the households derive their financial income from holding nominal bonds and receiving nominal profits from domestic and foreign firms according to the amounts of shares determined in the previous period. For $\phi > 0.5$ we have a home bias in equity holdings. For trade in equities, the Euler equations with respect to equity shares equalize the marginal costs of buying an additional unit of firms profits in period $t\!=\!0$ to the marginal gains in period $t\!=\!1$. They are given by

$$\lambda_0 p_E = E_0\left(\lambda\Pi\right), \ \lambda_0 p_E = E_0\left(\lambda S\Pi^*\right).$$

Plugging the Lagrange multiplier of the period $t = 1$ budget constraint into the above equation, the Euler equations can be written as

$$E_0\left(\frac{C^{-\rho}}{P}\Pi\right) = E_0\left(\frac{C^{-\rho}}{P}S\Pi^*\right) \text{ and } E_0\left(\frac{C^{*-\rho}}{SP^*}\Pi\right) = E_0\left(\frac{C^{*-\rho}}{SP^*}S\Pi^*\right), \tag{13}$$

which define the asset market equilibrium condition at home and abroad.

Money demand and labor supply In period $t=1$ the representative consumer maximizes her utility (1) with respect to consumption, money balances, and work effort subject to the budget constraint (8) or (12). In particular, as shown above, the consumption Euler equations will depend on the assumed asset market structure, i.e., the number of internationally traded financial assets.The first-order conditions associated with money holdings and the labor supply decision imply

$$\frac{M}{P} = \chi C^{\rho} \qquad \text{and} \qquad \frac{W}{P} = \frac{KL^{\upsilon-1}}{C^{-\rho}}, \tag{14}$$

respectively. The second equation states that the marginal rate of substitution between consumption and leisure is equal to their relative price. As in Devereux and Engel (2004) we assume in the following that $\upsilon = 1$, which implies an infinite wage elasticity of labor supply. The foreign country has similar first-order conditions.

Money market and the nominal exchange rate The first-order conditions associated with money holdings allow us to express the money market conditions as functions of the nominal spending at home and abroad

$$PC = \frac{1}{\chi}\frac{M}{C^{\rho-1}} \quad \text{and} \quad P^*C^* = \frac{1}{\chi}\frac{M^*}{C^{*\rho-1}}. \tag{15}$$

Expressing the two conditions in domestic currency units and solving for the nominal exchange rate yields

$$S = \frac{M}{M^*}\left(\frac{PC}{SP^*C^*}\right)^{-\rho}\left(\frac{SP^*}{P}\right)^{1-\rho}. \tag{16}$$

The nominal exchange rate will be affected by the underlying international financial market integration since differences in nominal spending, $\frac{PC}{SP^*C^*}$, depend on the number of asset types to be traded, as shown by equations (8) and (12).

Monetary and fiscal authorities The money supply in each country has a mean value of zero, i.e., $E_0(M) = E_0(M^*) = 0$ and a finite variance $Var(M)$ and $Var(M^*)$, where the home and foreign monetary disturbances are uncorrelated.
The home government finances its consumption spending by means of taxes and seigniorage. Its budget constraint equals $PG = T + M - M_0$, where T denotes lump-sum taxes. It is assumed that total government expenditure G is a random demand shift with a mean value of $E_0(G) = 0$ and a finite variance $Var(G)$. A similar expression holds for the foreign country. The government in each country consumes the same shares of local and foreign products as the private sector, such that home government demand for differentiated goods takes the same form as the private demand functions (4) and (5), $G_H = a(P_H/P)^{-\eta}G$ and $G_F = (1-a)(P_F/P)^{-\eta}G$. Consequently, the individual government demand function are the same as in (5) and also hold for the foreign country. We assume that home and foreign government spending shocks are uncorrelated.

Profits and firms' price setting decision Firms produce differentiated goods under monopolistic competition and hire labor L at the nominal wage rate W. In $t=0$, firms set their prices by maximizing expected profits from sales in $t=1$ and decide in which currency the prices of the export goods have to be set. The production function of firm z is given by

$$Y(z) = AL(z) = C_H(z) + G_H(z) + C_H^*(z) + G_H^*(z),$$

where A is the productivity parameter that can be seen as a random shift in productivity with a mean value of $E_0(\ln A) = 0$ and a finite variance $Var(\widehat{A})$. A similar expression holds for the foreign country. We assume that both shocks are not correlated. The associated profits for domestic sales are

$$E_0(\pi(z)) = E_0 d(P_H(z) - mc)\left(\frac{P_H(z)}{P_H}\right)^{-\sigma}\left(\frac{P_H}{P}\right)^{-\eta} D.$$

Profits are discounted with the stochastic discount factor $d = C^{-\rho}/P$ since firms are owned initially by domestic households and future profits from production will be evaluated according to the household's marginal utility of consumption. D denotes a home demand variable which consists of private ($(1-a)C$) and state ($(1-a)G$) consumption and is taken as given by firms.[9] Marginal costs are equal to

$$mc = \frac{W}{A}. \tag{17}$$

The profit-maximizing price for domestic sales of an individual home firm equals

$$P_H(z) = \frac{\sigma}{\sigma-1}\frac{E_0(mcC_H d)}{E_0(C_H d)},$$

given the respective individual demand functions. When firms decide whether to set the export price in their own currency (PCP) or in the local currency (LCP), they compare their expected profits from selling in PCP or LCP. The expected profit function of a home firm from sales to the foreign country in local currency can be written as

$$E_0\left(\pi^{LCP}(z)\right) = E_0 d\left(SP_H^{*LCP}(z) - mc\right)\left(\frac{P_H^{*LCP}(z)}{P_H^*}\right)^{-\sigma}\left(\frac{P_H^*}{P^*}\right)^{-\eta} D^*. \tag{18}$$

The profit-maximizing price for local-currency pricing firms is $P_H^{*LCP}(z) = \frac{\sigma}{\sigma-1}E_0(mcZ^*)/E_0(SZ^*)$, for $z = 0, ..., \tilde{z}$, with $Z^* = dP_H^{*\sigma-\eta}P^{*\eta}D^*$. Using this solution, the expected discounted profits from export sales in the local currency are

$$E_0\left(\pi^{LCP}(z)\right) = \tilde{\sigma}\left(E_0 SZ^*\right)^{\sigma}\left(E_0 mcZ^*\right)^{1-\sigma}, \tag{19}$$

where $\tilde{\sigma} = (1/(\sigma-1))(\sigma/(\sigma-1))^{-\sigma}$. The first term of the right-hand side of equation (19) reflects the expected revenues from sales while the second term shows the cost component of expected profits. Thus, revenues and therefore profits under LCP are linear in the nominal exchange rate. This means that under LCP domestic currency revenues increase one-to-one with a nominal exchange rate depreciation. Costs are unaffected by changes in the nominal exchange rate since exchange-rate movements do not induce any demand changes. This can be seen more clearly when taking a second-order approximation of expected profits under LCP

$$E_0\left(\widehat{\pi}^{LCP}(z)\right) \propto \sigma\frac{Var(\widehat{S})}{2} - (\sigma-1)\left[\frac{Var(\widehat{mc})}{2} + \frac{Var(\widehat{Z^*})}{2} + Cov(\widehat{mc},\widehat{Z^*})\right], \tag{20}$$

[9] Given that each firm is a monopolistic producer, profits will be positive for a finite $\sigma > 1$.

where $\widehat{X} = \ln X - \ln \overline{X}$ denotes the percentage deviation of the variable X from its steady state $\overline{X}$. Furthermore, $\widehat{XY} = (\ln X - \ln \overline{X}) + (\ln Y - \ln \overline{Y})$ reflects the sum of the percentage deviations of the variables X and Y from their respective steady states. The variance is denoted by $Var(\widehat{X}) = E_0(\widehat{X}^2)$ and $Cov(\widehat{X}, \widehat{Y}) = E_0(\widehat{X} \cdot \widehat{Y})$ reflects its covariance with variable Y. Equation (20) shows that expected profits under LCP are increasing in nominal exchange-rate volatility via expected revenues. Furthermore, changes in the nominal exchange rate do not affect expected costs. The expected profit function of a home firm from sales to the foreign country in producer currency can be written as

$$E_0\left(\pi^{PCP}(z)\right) = E_0 d\left(P_H^{PCP}(z) - mc\right)\left(\frac{P_H^{PCP}(z)}{SP_H^*}\right)^{-\sigma}\left(\frac{P_H^*}{P^*}\right)^{-\eta} D^*. \tag{21}$$

The corresponding profit-maximizing price for firms that employ producer-currency pricing is then given by $P_H^{PCP}(z) = \frac{\sigma}{\sigma-1} E_0 mcS^\sigma Z^* / E_0(S^\sigma Z^*)$, for $z = \tilde{z}, ..., 1$. Using this solution, the expected discounted profits from export sales in the producer currency are given as

$$E_0\left(\pi^{PCP}(z)\right) = \tilde{\sigma}\left(E_0 S^\sigma Z^*\right)^\sigma \left(E_0 mcS^\sigma Z^*\right)^{1-\sigma}. \tag{22}$$

Under PCP, expected profits are convex in the nominal exchange rate since $\sigma > 1$. Then, due to the expenditure-switching effect a nominal exchange rate depreciation increases foreign demand for domestic goods by more than one-for-one since $\sigma > 1$. This means that ceteris paribus, with an expected rise in nominal exchange rate, revenues from sales under PCP increase relative to LCP. However, in contrast to LCP a change in the nominal exchange rate directly impacts expected costs and hence expected profits negatively. Both points can be illustrated by taking a second-order approximation of expected profits under PCP:

$$E_0\left(\widehat{\pi}^{PCP}(z)\right) \propto \sigma^2 \frac{Var(\widehat{S})}{2} - (\sigma - 1)\left[\frac{Var(\widehat{mc})}{2} + \frac{Var(\widehat{Z^*})}{2} + Cov(\widehat{mc}, \widehat{Z^*}) + \sigma Cov(\widehat{mc}, \widehat{S})\right]. \tag{23}$$

Under PCP, nominal exchange rate variability increases revenues, as $\sigma > 1$, due to the expenditure-switching effect. However, changes in the nominal exchange rate induce demand changes under PCP. As the firm has to meet the demand the given price it has to adjust its labor inputs. A higher variability in production inputs requires adjustments in firms marginal costs which affects expected costs negatively, so that $Cov(\widehat{mc}, \widehat{S}) > 0$. The positive covariance between the nominal exchange rate and marginal costs leads to an increase in expected total costs under PCP relatively to total costs under LCP. This fact will be of importance when assessing the role of international financial market integration on the export price setting behavior of firms. As financial integration affects the behavior of the nominal exchange rate it will influence the price setting decision of firms. Following Devereux et al. (2004) and subtracting (20) from (23), we obtain the decision rule of the home firm whether to set its export price in its own or the local currency. The firm will set its price in PCP (LCP) as long as expected profits under PCP (LCP) are higher than under LCP (PCP), such that a firm's decision rule becomes

$$\frac{Var(\widehat{S})}{2} - Cov(\widehat{mc}, \widehat{S}) > 0, \ \ (< 0). \tag{24}$$

The optimal pricing currency condition (24) holds under the assumption that the discount factor, prices of other firms, foreign total demand and foreign prices are initially exogenous to an individual firm and its pricing currency decision. Analogously, a foreign firm has similar profit structures and will decide to price its exports to the domestic economy in the foreign (home) currency if

$$\frac{Var(\widehat{S})}{2} + Cov(\widehat{mc^*}, \widehat{S}) > 0, \ \ (< 0). \tag{25}$$

The last two equations determine the optimal degree of $\tilde{z}$ and $\tilde{z}^*$ and thereby the equilibrium home (foreign) exchange rate pass-through, $1 - \tilde{z}$ $(1 - \tilde{z}^*)$ conditional on the financial market structure. Before we outline how international financial market conditions interact with the exchange rate pass-through we describe the equilibrium and steady state of the model.

3.2 Equilibrium and steady state

The above described optimality and market clearing conditions are used to determine the endogenous variables in equilibrium – in particular, the equilibrium home exchange rate pass-through, $1-\tilde{z}$ $(1-\tilde{z}^*$ for foreign), as well as the equity, ϕ, and bond portfolios

$$b \equiv \overline{B}/\overline{PC},$$

which corresponds to the negative of the debt home bias. The rational expectations equilibrium is a set of values for consumption, output, labor, real wages, prices and the optimal portfolio shares, given the distribution of shocks to technology, government spending and money supplies at home and abroad, (A, A^*, G, G^*, M, M^*). The model is solved by linearizing around the symmetric non-stochastic steady state where the economic disturbances equal zero.
In steady state a country's sales revenue is given by $\overline{REV} = \overline{YP_H} = \overline{PC}$. It follows that profits and labor income are shares of a country's income, given by $\overline{\Pi} = (1/\sigma)\overline{REV}$ and $\overline{WL} = ((\sigma - 1)/\sigma)\overline{REV}$, respectively. Given the symmetry across countries, purchasing power parity holds in steady state, so that $\overline{SP^*} = \overline{P}$. Furthermore, individual prices are given by $\overline{P_H} = ((\sigma - 1)/\sigma)\overline{W}/\overline{A}$. As the two countries are identical in steady state, the law of one price holds within and across goods, $\overline{P_H} = \overline{SP_H^*} = P_F = \overline{SP_F^*}$. Having described the optimal pricing conditions, the equilibrium and the steady state, we will now show how the integration of international asset markets affect the exchange rate pass-through via the composition of asset trades on financial markets.

4 Financial Markets and the falling exchange rate pass-through

To illustrate the mechanisms at work we first make a set of simplifying assumptions in Section 4.1 and derive an analytical solution. Section 4.2 reports results of numerical simulations of the unrestricted model, whose solution together with additional intuition is presented in Appendix A. In the following we draw on this solution for deriving the simplified version.

4.1 Analytical solution for a simple calibration

As a first step, we assume that there is no home bias in household and government consumption, such that $a = 0.5$. Furthermore, we assume log-utility, i.e., $\rho = 1$ and that the elasticity of substitution between home and foreign traded goods, η, equals unity.[10] This allows us to derive a closed-form solution. With the solution at hand we first discuss the portfolio allocation outcome and then show how it relates to the price-setting behavior of firms.

[10]The assumption of $\eta = 1$ implies Cobb-Douglas preferences. In this case, the terms of trade provide a risk-sharing role, as shown by Cole and Obstfeld (1991), and the asset market structure might not be relevant. However, this is only true when there are only productivity shocks and international asset positions are zero. In the case of demand shocks, such as government spending shocks, risk sharing requires relative income to move asymmetrically, which might also cause non-zero asset positions.

4.1.1 The nominal exchange rate

The money market equilibrium allows to solve for the nominal exchange rate. Expressing (16) in log-linear terms yields

$$\widehat{S} = (\widehat{M} - \widehat{M}^*) - (\widehat{PC} - \widehat{SP^*C^*}). \tag{26}$$

In equilibrium the nominal exchange rate will not only be affected by the relative money supplies but also by the differences in nominal spending, $\widehat{PC} - \widehat{SP^*C^*}$. How this difference reacts to shocks depends on the amount of assets traded. To see this consider in turn the households budget constraint at home and abroad when only nominal bonds or nominal bonds and equities are traded.

4.1.2 Trade in bonds only

Consider first equations (8) and (9), which show that relative nominal spending in the case of trade in bonds equates to

$$\widehat{PC} - \widehat{SP^*C^*} = -2b\widehat{S} + (\widehat{REV} - \widehat{SREV^*}) - (\widehat{G} - \widehat{G}^*). \tag{27}$$

The financial return to the bond holdings b is given by nominal exchange rate movment, $-\widehat{S}$ while relative sales revenues are non-financial income, denoted by REV. We define $b \equiv \overline{B}/(\overline{PC})$, $\widehat{G} = G/\overline{C}$, $\widehat{REV} = \widehat{\Pi} - \widehat{WL}$ and we have used the fact that $B_H = B_F^*$ for $S_0 = 1$. b is the equilibrium amount of bonds we are looking for. Given equation (27), we can express the nominal exchange rate (26) in the economy with trade in bonds only as

$$\widehat{S} = \left(\frac{1}{1-2b}\right)(\widehat{M} - \widehat{M}^*) + \left(\frac{1}{1-2b}\right)(\widehat{G} - \widehat{G}^*), \tag{28}$$

observing that $\widehat{REV} - \widehat{SREV^*} = 0$ in our simple model structure. Given the insurance properties in the economies with nominal bonds only, the exchange rate only transmits two of the three possible economic disturbances across countries. The impact effect of the shocks is affected by the size of the equilibrium portfolio holdings b. The fact that not all disturbances are transmitted via the nominal exchange rate has direct implications for the price setting decision of the firm. To see this more clearly, consider the linearized version of the home marginal costs, equation (17), and its foreign counterpart

$$\widehat{mc} = \widehat{M} - \widehat{A} \qquad \text{and} \qquad \widehat{mc}^* = \widehat{M}^* - \widehat{A}^*, \tag{29}$$

respectively. It follows that the covariance between marginal costs and the nominal exchange rate can be written as

$$Cov(\widehat{mc}, \widehat{S}) = \frac{Var(\widehat{M})}{1-2b} \quad \text{and} \quad Cov(\widehat{mc}^*, \widehat{S}) = -\frac{Var(\widehat{M}^*)}{1-2b}. \tag{30}$$

Note that when nominal bonds are traded only monetary disturbances affect the covariance relationship between marginal costs and the nominal exchange rate. Since all shocks are uncorrelated, the variance of the nominal exchange rate equals

$$Var(\widehat{S}) = \frac{Var(\widehat{M} + \widehat{M}^*)}{(1-2b)^2} + \frac{Var(\widehat{G} + \widehat{G}^*)}{(1-2b)^2}, \tag{31}$$

with $Var(\widehat{G} + \widehat{G}^*)$ and $Var(\widehat{M} + \widehat{M}^*)$ reflecting the sum of domestic and foreign variances of the government spending and monetary policy shocks. The magnitude of the covariance relationship and the variability of the nominal exchange rate also depends on the equilibrium bond holding b.

What will be the amount of equilibrium bonds b held within this financial market structure? Consider the the equilibrium consumption, equation (14), which can be stated for fixed home and foreign prices as

$$\widehat{C} = \widehat{M} - \frac{1-\tilde{z}^*}{2}\widehat{S}. \tag{32}$$

Given the equilibrium evolution of the nominal exchange rate (28) and a value for $\tilde{z}^*$, for which we solve below, it follows that a positive monetary policy shock, i.e., $\widehat{M} > 0$, will increase consumption, despite the depreciation, which corresponds to an increase of the nominal exchange rate.[11] In contrast, a positive disturbance to government spending, i.e., $\widehat{G} > 0$, will also cause a depreciation of the nominal exchange rate but with a simultaneous decline in consumption. A relatively higher domestic government shock also causes a decline in relative nominal spending, which is determined by (27), $\widehat{PC} - \widehat{SP^*C^*} = -2b\widehat{S} - (\widehat{G} - \widehat{G^*})$. Households can hedge against the risk of a decline in consumption by choosing the appropriate equilibrium bond portfolio such that $-2b\widehat{S} > 0$ after a positive shock to $\widehat{G}$. Foreign bond holdings, i.e., $b < 0$, are a good hedge against income risk if a higher domestic government spending causes a depreciation of the nominal exchange rate and, hence, a higher return on foreign bonds. Put differently, the country will receive net financial payments from abroad when its currency is unexpectedly weak. To obtain the equilibrium portfolio choice of b we follow an approximation method for computing the equilibrium portfolio positions developed by Devereux and Sutherland (2011) and take a second-order approximation of the asset market equilibrium condition for the home country (10) and its foreign counterpart. The full details of the derivations are found in the appendix. From (A-8), the solution to the equilibrium bond portfolio is then given by

$$b^{NB} = -\frac{Var(\widehat{G} + \widehat{G}^*)}{2Var(\widehat{M} + \widehat{M}^*)}. \tag{33}$$

The equilibrium bond position implies that the home country lends in the foreign currency and borrows in its own since $b < 0$. Thus, in states when the domestic currency is weak the equilibrium bond positions ensure that the home country will receive net payments from abroad to insure against country specific shocks. This effect is more pronounced the larger are the variances of government spending relative to those of money supply shocks.

Since the home country decides to hold a larger amount of foreign assets, i.e., $b < 0$, the covariance between marginal costs and the nominal exchange rate (30) will be low in absolute value. From (31) it follows that the variance of the nominal exchange rate is decreasing in the home country's foreign asset position, i.e., the smaller is b. This has direct implications for the home firm's pricing decision. For illustrative purposes we consider a symmetrical equilibrium where all home and foreign shock variances are identical and equal unity. The firm's decision rule to either price its exports in its own or local currency can be written as (see equations 24 and 25 with 30 and 31)

$$\mathcal{R}^{NB} \equiv \frac{Var(\widehat{S})}{2} - Cov(\widehat{mc}, \widehat{S}) = \frac{1+2b}{(1-2b)^2} \gtrless 0. \tag{34}$$

Equation (34) shows that the decision of firms to set their export prices either in their own currency (PCP) or in the currency of consumers (LCP) depends on the equilibrium allocation of b. For example, if the equilibrium bond position is $b > -1/2$, it follows from (34) that $\mathcal{R}^{NB} > 0$ and firms will decide to price their export goods in the domestic currency. However, if $b < -1/2$, firms will decide to price

[11] To ensure that consumption increases it needs to be the case that $b < 0.5$, a condition shown below to be satisfied. This also implies that the exchange rate depreciates after a positive monetary shock in the domestic economy.

exports in the foreign currency, as $\mathcal{R}^{NB} < 0$. Given the symmetric equilibrium with home and foreign shock variances being unity, the equilibrium bond position equals $b = -1/2$. This implies that $\mathcal{R}^{NB} = 0$. Consequently, in the NB economy home firms will be indifferent between setting their export prices in PCP or LCP. The same argument applies to the foreign country. Given that $\tilde{z}$ and $\tilde{z}^*$ can hence take any value on the continuum between 0 and 1, the probability that all firms will set their prices the same currency ($\tilde{z}=\tilde{z}^*=0$ or 1) is zero. Consequently, there is neither full nor zero exchange rate pass-through, i.e., $0 < \tilde{z}=\tilde{z}^* < 1$.[12]

4.1.3 Trade in bonds and equities

When financial markets become more integrated, households have the possibility to trade not only nominal bonds internationally but also equities. Since those assets have a different risk profile, the two countries exchange assets to smooth fluctuations in consumption (spending) across different states of natures.
When both nominal bonds and equities are traded we linearize the corresponding period $t=1$ budget constraint for the home country and its foreign counterpart, (12). Taking country differences yields

$$\widehat{PC} - \widehat{SP^*C^*} = \frac{(2\phi-1)}{\sigma}(\widehat{\Pi} - \widehat{S\Pi^*}) - 2b\widehat{S} - (\widehat{G} - \widehat{G^*}) + \frac{\sigma-1}{\sigma}(\widehat{WL} - \widehat{SW^*L^*}). \tag{35}$$

In equilibrium the return on equities, $\widehat{\Pi} - \widehat{S\Pi^*}$, and labour income, $\widehat{WL} - \widehat{SW^*L^*}$, is given by

$$\widehat{\Pi} - \widehat{S\Pi^*} = \frac{(\sigma-1)}{\sigma}\left[(\widehat{A} - \widehat{A}^*) - (\widehat{M} - \widehat{M}^*) + \frac{\tilde{z}+\tilde{z}^*}{2}\widehat{S}\right], \tag{36}$$

and

$$\widehat{WL} - \widehat{SW^*L^*} = \frac{\tilde{z}+\tilde{z}^*}{2(1-\zeta)}\left[2\frac{\phi-1}{\sigma}(\widehat{\Pi} - \widehat{S\Pi^*}) - 2b\widehat{S} + (\widehat{M} - \widehat{M}^*) - (\widehat{G} - \widehat{G^*}) - 2\frac{\widehat{A} - \widehat{A}^*}{\tilde{z}+\tilde{z}^*}\right],$$

with $\zeta = \frac{\sigma-1}{\sigma}\frac{\tilde{z}+\tilde{z}^*}{2}$. In the following we solve for the equilibrium outcome of $\tilde{z}$ and $\tilde{z}^*$. Therefore, we first lay out the nominal exchange rate. Given the above equations we can express the nominal exchange rate (27) in the economy as

$$\widehat{S} = \frac{-[2(\phi-1)\frac{\sigma-1}{\sigma}+1](\widehat{M} - \widehat{M}^*) + (\widehat{G} - \widehat{G}^*) + 2(\phi-1)\frac{\sigma-1}{\sigma}(\widehat{A} - \widehat{A}^*)}{2b - 2(\phi-1)\zeta - 1}. \tag{37}$$

Again, the equilibrium outcome of the nominal exchange rate depends on the equilibrium portfolio allocation of bonds, b, and equities, ϕ. Furthermore, in contrast to the economy where only nominal bonds can be traded, the holding of both, bonds and equities lets the exchange rate transmit all three economic disturbances across countries. From (29) and (37) it follows that the covariance between marginal costs and the nominal exchange rate can now be written as

$$\begin{aligned} Cov(\widehat{mc}, \widehat{S}) &= -\frac{2(\phi-1)\frac{\sigma-1}{\sigma}+1}{2b-2(\phi-1)\zeta-1}Var(\widehat{M}) - \frac{2(\phi-1)\frac{\sigma-1}{\sigma}}{2b-2(\phi-1)\zeta-1}Var(\widehat{A}), \\ Cov(\widehat{mc}^*, \widehat{S}) &= \frac{2(\phi-1)\frac{\sigma-1}{\sigma}+1}{2b-2(\phi-1)\zeta-1}Var(\widehat{M}^*) + \frac{2(\phi-1)\frac{\sigma-1}{\sigma}}{2b-2(\phi-1)\zeta-1}Var(\widehat{A}^*). \end{aligned} \tag{38}$$

[12] Note that lower values for $\tilde{z} = \tilde{z}^*$ imply a lower consumption volatility. This could push firms that are otherwise indifferent between pricing strategies towards choosing PCP. In any case, we obtain at least some pass-through, i.e., $\tilde{z} = \tilde{z}^* < 1$.

Now, all shocks that affect marginal costs will also be reflected in the covariance relationship with the nominal exchange rate. Thus, the covariance relationship between marginal costs and the nominal exchange rate is not only affected by monetary disturbances, as in economy where only nominal bonds are traded internationally, but also by productivity shocks. The variance of the nominal exchange rate equals

$$\begin{aligned} Var(\widehat{S}) &= \frac{[2(\phi-1)\frac{\sigma-1}{\sigma}+1]^2 Var(\widehat{M}+\widehat{M}^*)+Var(\widehat{G}+\widehat{G}^*)}{[2b-2(\phi-1)\zeta-1]^2} \\ &\quad +\frac{[2(\phi-1)\frac{\sigma-1}{\sigma}]^2 Var(\widehat{A}+\widehat{A}^*)}{[2b-2(\phi-1)\zeta-1]^2}. \end{aligned} \tag{39}$$

For a given monopolistic markup, $\sigma/(\sigma-1)$, the sign and magnitude of the covariance of the nominal exchange rate with marginal costs and its variance will depend on both the equilibrium amount of bonds and equities held as well as on exchange rate pass-through via ζ.

What determines the equilibrium portfolio within this economy? From the equilibrium consumption (32) it follows that in states of nature when the domestic currency is unexpectedly weak, consumption is low. Households can hedge by choosing a combination of nominal bond and equity holdings that stabilizes nominal consumption. For example, a depreciated currency would cause a decline in consumption but would have a favorable impact on the returns of equities, (36), since profits $\widehat{\Pi}-\widehat{S\Pi^*}$ rises as the nominal exchange rate increases. Thus, if households hold mainly domestic equities and at the same time choose a bond allocation that provides net payments in states when the domestic currency is unexpectedly weak (i.e., $b<0$), they have created a good hedge, visible in equation (35). Again, following the approximation method for computing the equilibrium portfolio positions developed by Devereux and Sutherland (2011), the solution to the equilibrium bond position is

$$\begin{aligned} b^{NBE} &= -\frac{Var(\widehat{G}+\widehat{G}^*)[Var(\widehat{A}+\widehat{A}^*)+\frac{2-\tilde{z}-\tilde{z}^*}{2}Var(\widehat{M}+\widehat{M}^*)]}{2Var(\widehat{A}+\widehat{A}^*)Var(\widehat{M}+\widehat{M}^*)} \\ &= b^{NB}-\frac{2-\tilde{z}-\tilde{z}^*}{2}\frac{Var(\widehat{G}+\widehat{G}^*)}{2Var(\widehat{A}+\widehat{A}^*)}, \end{aligned} \tag{40}$$

demonstrating that $b^{NBE}\leq b^{NB}$, while the equilibrium equity position turns into

$$\phi=\frac{2Var(\widehat{A}+\widehat{A}^*)+\frac{\sigma}{\sigma-1}Var(\widehat{G}+\widehat{G}^*)}{2Var(\widehat{A}+\widehat{A}^*)}. \tag{41}$$

Equations (40) and (41) illustrate that expanding the set of tradable financial assets by equity allows agents in both countries to hedge more effectively since now households can hedge against productivity disturbances, which is not possible in the NB economies. Households decide to hold a higher amount of foreign bond assets, i.e., $b<0$, and a larger amount of domestic equity, $\phi>1$. This ensures them an optimal hedge against fluctuations in spending due to disturbances in government, monetary policy and productivity.

In contrast to the NB economy, the equilibrium bond position is affected by the exchange rate pass-through. Hence, to specify the equilibrium outcome in the NBE economies it is necessary to have a closer look at the firms' price-setting decision rules. Using (38) and (39), in the symmetric equilibrium with equal unit shock variances at home and abroad the home firms' pricing decision rule (24) can be expressed as

$$\mathcal{R}^{NBE}=\frac{2(1-\phi)\zeta\left[1+3(\phi-1)\frac{\sigma-1}{\sigma}\right]+1+2b\left[1+3(\phi-1)\frac{\sigma-1}{\sigma}\right]}{[2b-2(\phi-1)\zeta-1]^2}. \tag{42}$$

Within the symmetric equilibrium we assess the decision rule $\mathcal{R}^{NBE}$ between $\tilde{z} = \tilde{z}^* = 0$ and $\tilde{z} = \tilde{z}^* = 1$, i.e., changing the value of ζ. We show under which conditions of the nominal bond position the firms' decision rule $\mathcal{R}^{NBE}$ is either positive, negative or zero. The equilibrium equity position equals $\phi = 1 + \frac{\sigma}{\sigma-1}\frac{1}{2}$ and is independent of the exchange rate pass-through.[13] In contrast, for the assumption of symmetric shock variances the equilibrium bond position equates to

$$b^{NBE} = -\frac{2 - \frac{\tilde{z}+\tilde{z}^*}{2}}{2}. \tag{43}$$

From this equation we can see that for all $\tilde{z}, \tilde{z}^* = 0, ..., 1$ the nominal bond position will range between $b = -1$ and $b = -1/2$. If we plug in all possible values of b into $\mathcal{R}^{NBE}$, we can solve this fixed point problem for all $\tilde{z}$, given the mark-up $\sigma/(\sigma-1)$. Martins et al. (1996) find markups ranging between 10 and 35 percent, which implies a σ in the range of around 4 to 10. For mark-ups in this range, it holds that the pricing decision rule $\mathcal{R}^{NBE} < 0$ for all $\tilde{z}$. Consequently, LCP is the unique equilibrium in the nominal bond and equity economy and $\tilde{z} = \tilde{z}^* = 1$. When moving towards internationally more integrated financial markets, i.e., moving from the nominal bond economy to an economy where both bonds and equities are traded internationally, the exchange rate pass-through hence declines in both countries.

What explains the decline in exchange rate pass-through? It is the possibility to hedge more effectively against country-specific shocks by balancing the optimal international cross-country asset holdings between equity and bond holdings. By trading equities additionally to bonds, the agents stabilize their consumption fluctuations. To see this, consider equation (28), which holds under both financial market structures. Given the solutions to $0 < \tilde{z}^{NB} = \tilde{z}^{*NB} < 1$ and $\tilde{z}^{NBE} = \tilde{z}^{*NBE} = 1$, it follows that only in the nominal bond economy consumption will be affected by nominal exchange rate movements. Then considering the difference between consumption under the two financial market structures and assuming a unitary variance of all home and foreign shock disturbances, the relative variability of consumption in the nominal bond economy is higher, since

$$Var(\widehat{C}^{NB} - \widehat{C}^{NBE}) = \frac{(1 - \tilde{z}^{NB})^2}{4},$$

for $b^{NB} = -1/2$. Putting it differently, consumption is less volatile under more integrated international financial markets and, consequently, the more integrated financial markets are, the better can households hedge against fluctuation in consumption.

The degree of financial market integration also affects the behavior of the nominal exchange rate. To see this, consider again the solutions to $\tilde{z}$, $\tilde{z}^*$, b and ϕ under the two financial market structures. Assuming a unitary variance of all home and foreign shock disturbances, it holds from (28) in the nominal bond economy that $Var(\widehat{S})^{NB} = 1$ while in more integrated financial markets the variability of the nominal exchange rate is given by (37), $Var(\widehat{S})^{NBE} = 4/3$. It follows that the nominal exchange rate will be more volatile in integrated financial markets. Thus, to allow for a more stable consumption pattern in the NBE economy and a better allocation of goods across countries, the nominal exchange rate has to fluctuate more. This is also mirrored by the fact, that within more integrated financial markets the nominal exchange rate is able to react to all three relative economic disturbances, including also stochastic movements in technology. This enhances the covariance relationship between the nominal exchange rate and marginal costs. Given (30) and (38), it holds that $Cov(\widehat{mc}, \widehat{S})^{NBE} > Cov(\widehat{mc}, \widehat{S})^{NB} > 0$ for $[4(\phi-1)\frac{\sigma-1}{\sigma}+1]/\left\{1 + 2\left[(\phi-1)\zeta - b\right]\right\} > 1/(1-2b)$.

[13] Values of ϕ above unity correspond to an increased usage of complex financial instruments, such as derivatives. See Engel and Matsumoto (2009) for similar outcomes.

To see this more clearly, considering again the solutions to $\tilde{z}$ and $\tilde{z}^*$, b and ϕ under the two financial market structures. Then for a unitary variance of all home and foreign shocks it follows that $Cov(\widehat{mc}, \widehat{S})^{NBE} = 1$, while in less integrated financial markets $Cov(\widehat{mc}, \widehat{S})^{NB} = 1/2$ only. Given the firm's pricing decision rule, in the NBE economy the more accentuated relationship between the nominal exchange rate and marginal costs will outweigh the opposing effect of a higher exchange rate variability. Those aspects will induce firms to switch to local-currency pricing. This then causes a decline in exchange rate pass-through when international financial markets become more integrated. In the following, we show that the analytical conclusions of this section generalize to settings with realistic parameter values. Additionally, we also demonstrate that the debt home bias falls, in line with empirical evidence in Section 2.

4.2 A more general model structure

In the previous section we concentrated on the model's main implication within a simplified framework. The results obtained in this setting are, however, conditional on the simplifying assumption we have made with respect to the preference parameters and the shocks that can hit the two economies. In this section we relax the above made assumptions about the model's structural parameter values and are more general regarding the volatility of shocks. By numerically simulating the model for a variety of parameter values it will be shown that the result of a decline in the exchange rate pass-through remains valid within this more realistic setting. Furthermore, under the more general parameterization we also establish a fall in the home bias of bond portfolio holdings. The simulations use the solution of the full model in Appendix A.

We use baseline parameter values, where applicable, from Devereux et al. (2004). In particular, we set the trade price elasticity between domestically produced and imported goods to $\eta = 1.5$. The coefficient of relative risk aversion is set to $\rho = 1.25$.[14] Trade openness is calibrated to $a = 0.88$, the empirical average for the US over recent decades (see Enders and Müller 2009). The elasticity of substitution between varieties is set to $\sigma = 6$, corresponding to a steady-state markup of 20%. To obtain values for the variances of the shocks, we estimate AR(1)-processes for the HP-filtered logs of M2, Government consumption, and Solow residuals for the US and use identical values for the foreign country.[15] The resulting variances of the error terms result in $\sigma_M^2 = 0.0043\%$, $\sigma_G^2 = \sigma_{G^*}^2 = 0.0045\%$, and $\sigma_A^2 = \sigma_{A^*}^2 = 0.0041\%$. The foreign volatility of the money supply is set 10% higher, $\sigma_{M^*}^2 = 0.0047\%$, such that firms are not indifferent regarding the pricing currency decision in the bonds-only case. The calibration is summarized in Table 4. For all of these volatilities, we conduct robustness checks further below.

4.2.1 Interaction between portfolio home bias and exchange rate pass-through

Before investigating the effects of shifting from a bonds-only economy to a world with bond and equity trade, we first analyze the interdependence of global pass-through (i.e., $1 - (\tilde{z} + \tilde{z}^*)/2$) and bond and equity portfolios for the general case. Specifically, we investigate the influence of one variable on the other by fixing different values for the former and calculating optimal values for the latter. The exogenously fixed variable is hence not set optimally, allowing us to generate a one-directional interdependence. The left panel of Figure 3 shows this interaction for the bonds-only case. The red dashed line depicts the dependence of b on the value of the global pass-through (treated as

[14] Results are robust to changing these parameters. In particular, also very low values of the trade-price elasticity, as reported in Corsetti et al. (2008) and Enders and Müller (2009), do not change the conclusions.

[15] See Appendix C for data sources.

Parameter	Value	Source
ρ	1.25	Devereux et al. (2004)
η	1.5	Devereux et al. (2004)
α	.88	U.S. average
σ	6	Rotemberg & Woodford (1993)
σ_M^2	$.0043\%$	US data
σ_A^2	$.0041\%$	US data
σ_G^2	$.0045\%$	US data
$\sigma_{M^*}^2$	$.0043\% * 1.1$	Symmetry
$\sigma_{A^*}^2$	$.0041\%$	Symmetry
$\sigma_{G^*}^2$	$.0045\%$	Symmetry

Table 4: Baseline parameter values for the numerical simulation of the model.

exogenously), while the blue solid line plots the resulting pass-through if we assume that the debt home bias is exogenous. Technically, we replace equations (24) and (25) with exogenous values for $\tilde{z}$ and $\tilde{z}^*$ in the first case, and equation (A-8) by exogenous values of b in the second case. When varying global pass-through, we start at $\tilde{z} = \tilde{z}^* = 0$ and let first $\tilde{z}$ increase to unity, after which $\tilde{z}^*$ rises from zero to one. In the case of an exogenously set b, we observe that $\tilde{z} = \tilde{z}^* = 1$ for low starting value of b. An increasing b (falling debt home bias) lets $\tilde{z}$ fall to zero, i.e., home switches from LCP to PCP. For intermediate values of b, this remains an equilibrium. Further raising b leads to a falling $\tilde{z}^*$, until the foreign country has switched to PCP too. As visible, both lines are increasing functions of their respective arguments. We obtain a unique solution at their intersection (in this case at a pass-through of 0.5). Also visible is a stronger dependency of the pass-through on the home bias of bond holdings, while the reverse dependence is fairly limited. Specifically, the pass-through changes from absent to complete, depending on the portfolio choice. The debt home bias, in turn, does not reverse sign, independently of the prevailing pass-through. We conclude that financial markets matter quantitatively and qualitatively more for pass-through than vice versa. Investigating the trade channel of exchange-rate movements without simultaneously considering the financial channel thus risks neglecting an important determinant for the former.

Figures 3 (right panel) and Figure 4 depict the same interdependencies for the case of financial integration, i.e., trade in bonds and equities. For these plots, equations (24), (25) and (A-18) were replaced by exogenous values of $\tilde{z}, \tilde{z}^*, b$, and ϕ. As the global pass-through now depends on the home bias in bonds and in equities, Figure 4 is three-dimensional. Because there are unique mappings from pass-through to optimal asset home biases in bonds (blue solid line in the right panel of Figure 3) and equities (red dashed line), and a unique mapping from each combination of these parameter to pass-through (Figure 4), we again obtain a unique solution at their mutual intersection.

Regarding the pricing-decisions of firms, the same pattern as above is visible. Increasing the value of b induces first the home country to switch from LCP to PCP, followed by a small region of constant $\tilde{z}$ and $\tilde{z}^*$. Finally, the foreign country also charges according to PCP if b rises further. Regarding the reaction to a changing ϕ, the pattern is quite different. For a given intermediate value of b, a low level of ϕ lets both producers follow PCP rules. For increasing values of ϕ, the optimal $\tilde{z}^*$ rises first. However, some domestic firms switch to LCP already before all foreign firms have done so. It is also domestic firms that are first to go back to PCP for even higher values of ϕ, followed by their foreign counterparts once all home firms use LCP. Furthermore, we can draw similar conclusions as in the

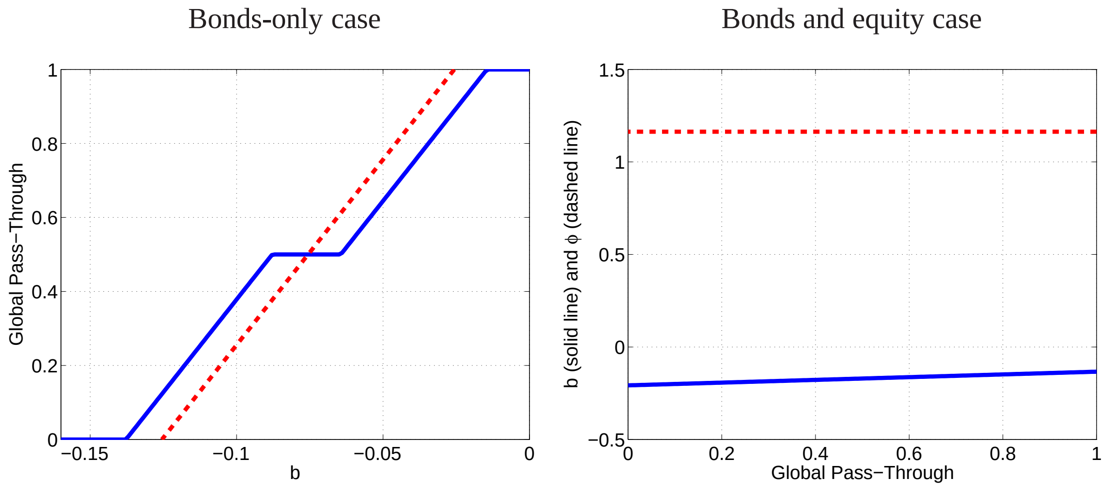

Figure 3: Left: dependence of global pass-through on debt home bias (blue solid line) and vice versa (red dashed line) in bonds-only case. Right: dependence of debt home bias (blue solid line) and equity home bias (red dashed line) on global pass-through in bonds and equity case.

bonds-only case. Financial markets, both in terms of home bias in bonds and in equity, matter highly for pass-through. The reverse is not true, according to Figure 3 (right panel). While the home bias in bonds varies but stays negative if global pass-through changes from zero to one, the home bias in equity is independent of the level of pass-through. Hence, pass-through has only a limited feedback to financial markets. To conclude, when investigating determinants of pass-through, financial markets are crucial.

4.2.2 Effects of financial integration

Table 5 displays the change in the home bias of debt holdings when switching from a bonds-only economy to international financial markets with bonds and equity, for different values of the key parameters of the model. The change in debt home bias corresponds to $b^{NBE} - b^{NB}$ as b denotes the amount of net debt held in domestic currency. As visible, for reasonable ranges of parameter values, the home bias of debt holdings declines after an increase in financial market integration, as empirically found in Section 2. When moving towards trade in bonds and equity, agents can make better use of both instrument to hedge against specific shocks. In particular, equity holdings can be used to hedge against monetary shocks. Since government spending shocks depreciate the exchange rate—in line with evidence in Enders et al. (2011)—and reduce consumption at the same time, increased debt holdings in foreign currency are a good specific hedge. A falling debt home bias results. Put differently, trading equity across countries frees debt from some of its burden to hedge against all shocks present in the economy, and reduces therefore its share in the optimal country portfolio. Similarly, the global exchange rate pass-through for all shown combinations falls by 0.5. This results from the fact that one country always switches from PCP to LCP. As discussed above, trade in equities links developments in total-factor productivity to the exchange rate via financial payments that depend on technology, increasing the correlation between marginal costs and the exchange rate. Hence, firms are induced to switch to local-currency pricing (see also Devereux et al., 2004).
The upper-left panel of Table 5 reports the change in the debt home bias for different values of the

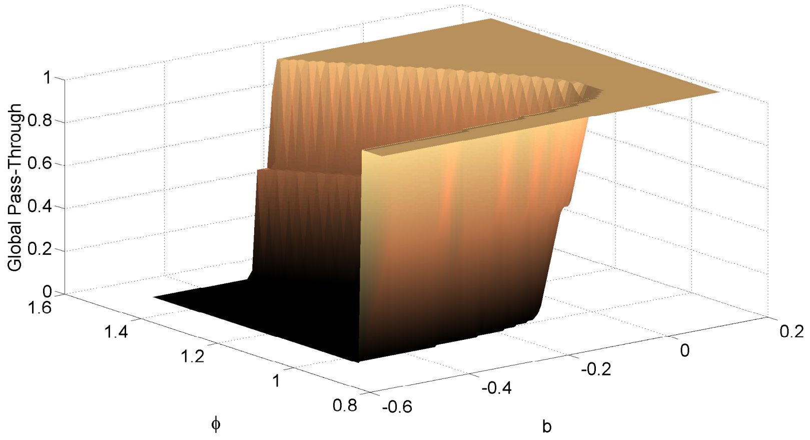

Figure 4: Bonds and equity case: dependence of global pass-through (vertical axis) on home bias in equity (left axis) and debt (right axis).

volatilities of the shocks to the money supplies. The upper-right panel shows the same statistic for different values of the variances of technology shocks, while in the lower-left panel the variances of government expenditure are altered. Finally, in lower-right panel of Table 5 we change the volatility of money shocks, set to the same value in both countries, and technology shocks, also equal across countries.

Summarizing the information of the tables, increased financial integration leads to reductions in pass-through and debt home bias, independently of plausible parameter constellations. We see this in line with empirical evidence, and therefore as an important explanation for the falling exchange rate pass-through.

5 Conclusion

In this paper we have put forward a new explanation for the decline in exchange rate pass-through into import prices. Crucial for our theoretical model is the impact of financial globalization, modeled as an increase in the number and nature of tradable financial assets, on the pricing decision of firms. In the model, we take the mutual interaction between the optimal portfolio and the choice of the invoicing currency into account. The main impact of financial globalization on pass-through works via the reaction of the optimal portfolio, which features more foreign debt assets following the increased availability of international equity. This represents the hedging possibilities that equity takes over from debt. As a reaction to the better hedging opportunities, optimal pass-through falls. We also present empirical evidence supporting the negative effect of gross equity holdings on the home bias of international debt assets. An important policy implication concerns the design of monetary unions: if preceded by financial integration, the effect of the nominal exchange rate on relative prices is reduced because of the reduced exchange rate pass-trough. Moving towards abolishing the nominal exchange rate altogether is therefore likely to have smaller real consequences.

σ^2_M \ $\sigma^2_{M^*}$	0.35	0.43	0.50	0.57	0.64	0.71
0.32	-0.07	-0.07	-0.08	-0.08	-0.08	-0.08
0.39	-0.07	-0.08	-0.08	-0.08	-0.08	-0.09
0.45	-0.08	-0.08	-0.08	-0.08	-0.09	-0.09
0.52	-0.08	-0.08	-0.08	-0.09	-0.09	-0.09
0.58	-0.08	-0.08	-0.09	-0.09	-0.09	-0.09
0.64	-0.08	-0.09	-0.09	-0.09	-0.09	-0.09

σ^2_A \ $\sigma^2_{A^*}$	0.27	0.32	0.38	0.43	0.49	0.54
0.27	-0.13	-0.11	-0.10	-0.09	-0.09	-0.08
0.32	-0.11	-0.10	-0.09	-0.09	-0.08	-0.07
0.38	-0.10	-0.09	-0.09	-0.08	-0.07	-0.07
0.43	-0.09	-0.09	-0.08	-0.07	-0.07	-0.06
0.49	-0.09	-0.08	-0.07	-0.07	-0.06	-0.06
0.54	-0.08	-0.07	-0.07	-0.06	-0.06	-0.05

σ^2_G \ $\sigma^2_{G^*}$	0.39	0.47	0.55	0.62	0.70	0.78
0.39	-0.03	-0.04	-0.04	-0.05	-0.06	-0.06
0.47	-0.04	-0.04	-0.05	-0.06	-0.06	-0.06
0.55	-0.04	-0.05	-0.06	-0.06	-0.06	-0.07
0.62	-0.05	-0.06	-0.06	-0.06	-0.07	-0.07
0.70	-0.06	-0.06	-0.06	-0.07	-0.07	-0.08
0.78	-0.06	-0.06	-0.07	-0.07	-0.08	-0.08

σ^2_{M,M^*} \ σ^2_{A,A^*}	0.40	0.49	0.57	0.65	0.73	0.81
0.48	-0.11	-0.09	-0.07	-0.06	-0.05	-0.04
0.58	-0.11	-0.09	-0.07	-0.06	-0.05	-0.04
0.68	-0.11	-0.09	-0.07	-0.06	-0.05	-0.04
0.77	-0.11	-0.09	-0.07	-0.06	-0.05	-0.04
0.87	-0.11	-0.09	-0.07	-0.06	-0.05	-0.04
0.97	-0.11	-0.09	-0.07	-0.06	-0.05	-0.04

Table 5: Changes in debt home bias ($b^{NBE} - b^{NB}$) for varying σ^2_M and $\sigma^2_{M^*}$ (upper left), σ^2_A and $\sigma^2_{A^*}$ (upper right), σ^2_G and $\sigma^2_{G^*}$ (lower left) or $\sigma^2_M \& \sigma^2_{M^*}$ and $\sigma^2_A \& \sigma^2_{A^*}$ (lower right) due to financial integration. All stated variances are divided by 10^4.

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Appendix

A Equilibrium of the full model

In this section we derive the optimal portfolio solutions under the different degrees of international financial market integration for unrestricted parameter values and show how they influence the equilibrium behavior of the nominal exchange rate and the marginal costs.

Money market equilibrium and the nominal exchange rate First, we use the money market equilibrium to solve for the nominal exchange rate. Expressing (16) in log-linear terms yields

$$\widehat{S} = \frac{(\widehat{M} - \widehat{M^*})}{\rho + (1-\rho)\,(1-a)(2-\tilde{z}-\tilde{z}^*)} - \frac{\rho(\widehat{PC} - \widehat{SP^*C^*})}{\rho + (1-\rho)\,(1-a)(2-\tilde{z}-\tilde{z}^*)}. \tag{A-1}$$

The equilibrium nominal exchange rate will not only be affected by the relative money supplies but also via the differences in nominal spending, $\widehat{PC} - \widehat{SP^*C^*}$, and by the amount of assets traded, as will be now shown.

A.1 Trade in bonds only

We follow an approximation method for computing equilibrium portfolio positions developed by Devereux and Sutherland (2011) and take a second-order approximation of the asset market equilibrium condition for the home country (10) and its foreign counterpart. The differences of these two equations lead to the following arbitrage condition

$$Cov(-\widehat{S}, \widehat{PC} - \widehat{SP^*C^*}) = \frac{1-\rho}{\rho} Cov(-\widehat{S}, \widehat{Q}), \tag{A-2}$$

which relates the covariance between excess returns on domestic nominal bonds (given by nominal exchange rate deviations, $\hat{R}^B_{Fin} = -\widehat{S}$) and relative nominal consumption expenditures, $\widehat{PC} - \widehat{SP^*C^*}$, to the covariance between excess returns on nominal bonds and the real exchange rate, $\widehat{Q} = \widehat{SP^*} - \widehat{P}$. Linearizing the period $t=1$ budget constraints for the home and foreign country (9) and taking country differences, we get an expression for relative nominal consumption expenditures. In doing so we take the government budget constraints into consideration and assume that government expenditures are equal to zero in the deterministic steady state. The relative budget constraint equals

$$\widehat{PC} - \widehat{SP^*C^*} = 2b\hat{R}^B_{Fin} + (\widehat{REV} - \widehat{SREV^*}) - (\widehat{G} - \widehat{G^*}), \tag{A-3}$$

where we have used the fact that $B_H = B^*_F$ for $S_0 = 1$. $\bar{B}$ is the equilibrium amount of bonds we are looking for. Relative sales revenues will be defined as the non-financial return, $\hat{R}^{Non}_{Fin} = \widehat{REV} - \widehat{SREV^*}$.

Optimal nominal bond portfolio Plugging (A-3) into the asset market arbitrage condition (A-2) and rearranging terms we get

$$b = \frac{1}{2}\left(\frac{1-\rho}{\rho}\frac{Cov(\hat{R}^B_{Fin}, \widehat{Q})}{Var(\widehat{S})} - \frac{Cov(\hat{R}^B_{Fin}, \hat{R}^{Non}_{Fin})}{Var(\widehat{S})} + \frac{Cov(\hat{R}^B_{Fin}, \widehat{G} - \widehat{G^*})}{Var(\widehat{S})}\right).$$

This expression states that the optimal equilibrium bond holdings b depend on three components: the covariance between relative nominal bond returns (i.e., the nominal exchange rate) and the real exchange rate, the covariance between the nominal exchange rate and relative sale revenues as well as the covariance between the nominal exchange rate and relative government expenditures, all weighted by the variance of relative nominal bond returns, i.e., the nominal exchange rate.

By making an optimal portfolio choice, the representative household wants to hedge its marginal utility of consumption. A risk averse household ($\rho > 1$) hedges consumption risks stemming from variations in her purchasing power, reflected by movements in the real exchange rate. Domestic bonds are a good hedge against this risk if domestic bond returns are high whenever the domestic price level is high. In the case of $\rho = 1$, a unit increase in real returns of bond assets (domestic or foreign) decreases marginal utility of consumption by one unit, such that bond asset gains evaluated at the marginal utility of consumption vanish and the covariance between relative nominal returns and the real exchange rate becomes irrelevant for the portfolio choice decision.

Furthermore, the representative household wishes to hedge nominal income risks associated with variations in nominal revenues from domestic firms and government expenditures. Domestic bonds are a good hedge if relative domestic bond returns are high whenever domestic revenues are low. For example, an appreciation of the nominal exchange rate causes both, a fall in domestic revenues from foreign sales and a higher relative domestic bond return. Consequently, holding a higher amount of domestic bonds allows to hedge the nominal revenue risk. Government expenditures are fully paid by the seignorage and lump-sum taxes which reduce nominal disposable income. Domestic bonds are a good hedge against taxation risk if domestic bond returns are high whenever the income risk associated with government expenditure is high. Since government spending shocks let the exchange rate depreciate, holding foreign bonds can at least partly offset this negative effect on income.

To solve for the optimal portfolio bond holdings we write the nominal exchange rate, nominal consumption spending, and sales revenues as functions of the underlying shocks. We first treat portfolio-based nominal income as exogenous, $\widehat{Ex}_{Fin} = 2b\hat{R}^B_{Fin}$, such that relative domestic bond returns are

$$\hat{R}^B_{Fin} = -\Theta^S_M(\widehat{M} - \widehat{M}^*) + \Theta^S_{PC}(\widehat{Ex}_{Fin} + \hat{R}^{Non}_{Fin}) - \Theta^S_{PC}(\widehat{G} - \widehat{G}^*), \tag{A-4}$$

where the coefficients Θ^S_{PC} and Θ^S_M are given in Appendix B, Table B-1. Furthermore, non-financial income can be written as

$$\hat{R}^{Non}_{Fin} = \Theta^{R^{Non}_{Fin}}_{Ex_{Fin}}\widehat{Ex}_{Fin} + \Theta^{R^{Non}_{Fin}}_{M}(\widehat{M} - \widehat{M}^*) + \Theta^{R^{Non}_{Fin}}_{G}(\widehat{G} - \widehat{G}^*), \tag{A-5}$$

where the structural parameters $\Theta^{R^{Non}_{Fin}}_{Ex_{Fin}}$, $\Theta^{R^{Non}_{Fin}}_{M}$ and $\Theta^{R^{Non}_{Fin}}_{G}$ are provided in Table B-1. Combining (A-4) and (A-5) we get

$$\hat{R}^B_{Fin} = \mathbf{R}_1\widehat{Ex}_{Fin} + \mathbf{R}_2[(\widehat{M} - \widehat{M}^*), (\widehat{G} - \widehat{G}^*)]', \tag{A-6}$$

where $\mathbf{R}_1 = \Theta^S_{PC}\left(1 + \Theta^{R^{Non}_{Fin}}_{Ex_{Fin}}\right)$ is a scalar and $\mathbf{R}_2 = [-(\Theta^S_{\mathsf{M}} - \Theta^S_{PC}\Theta^{R^{Non}_{Fin}}_{M}), -\Theta^S_{PC}(1 - \Theta^{R^{Non}_{Fin}}_{G})]$ is a 1×2 vector. Now we can write the relative discount factor as

$$-\rho(\widehat{PC} - \widehat{SP^*C^*}) + (1-\rho)\,\widehat{Q} = \mathbf{D}_1\widehat{Ex}_{Fin} + \mathbf{D}_2[(\widehat{M} - \widehat{M}^*), (\widehat{G} - \widehat{G}^*)]', \tag{A-7}$$

with $\mathbf{D}_1 = -\Theta^D_{PC}(1 + \Theta^{R^{Non}_{Fin}}_{Ex_{Fin}})$ being a scalar and $\mathbf{D}_2 = [\Theta^D_M - \Theta^D_{PC}\Theta^{R^{Non}_{Fin}}_{M}, \Theta^D_{PC}(1 - \Theta^{R^{Non}_{Fin}}_{G})]$ a 1×2 vector of combinations of structural parameters Θ^D_{M} and Θ^D_{PC}, shown in Table B-1.

Given (A-6) and (A-7), the arbitrage condition (A-2) can be written as $\mathbf{R}\Sigma\mathbf{D}' = 0$, where $\mathbf{R} = \mathbf{R}_1\mathbf{H} + \mathbf{R}_2$, $\mathbf{H} = 2b(1 - 2b\mathbf{R}_1)^{-1}\mathbf{R}_2$, and $\mathbf{D} = \mathbf{D}_1\mathbf{H} + \mathbf{D}_2$ are 1×2 vectors. Σ is the 2×2

covariance matrix of the exogenous disturbances. Even though the economies are hit by monetary policy, demand and productivity shocks, only the first two are insured via bond holding in the NB economies. Thus households cannot insure themselves against relative productivity movements across countries. Solving for b yields

$$b = \frac{1}{2}\left\{\left[\mathbf{R}_2\Sigma\mathbf{D}_2'\mathbf{R}_1' - \mathbf{D}_1\mathbf{R}_2\Sigma\mathbf{R}_2'\right]^{-1}\mathbf{R}_2\Sigma\mathbf{D}_2'\right\}. \tag{A-8}$$

Nominal exchange rate in the NB economy Given the solution to nominal bonds holdings we can express the nominal exchange rate in equation (A-1) as

$$\widehat{S} = \frac{\left(1-\rho\Theta_M^{PC}\right)(\widehat{M}-\widehat{M}^*) + \rho\Theta_G^{PC}(\widehat{G}-\widehat{G}^*)}{\rho + (1-\rho)(1-a)(2-\tilde{z}-\tilde{z}^*)}, \tag{A-9}$$

with Θ_M^{PC} and Θ_G^{PC} provided in Table B-1. Given the insurance properties in the NB economies, the exchange rate only transmits two of the three possible economic disturbances across countries. The impact effect of the shocks is affected by the size of the equilibrium portfolio holding of b since Θ_M^{PC} and Θ_G^{PC} depend on the size of b. The fact that not all disturbances are transmitted via the nominal exchange rate has direct implications for the price-setting decision of the firms since it directly affects the covariance relationship between the nominal exchange rate and marginal costs of the firm. To see this more clearly, consider the log-linearized version of the home marginal costs, equation (17), and its foreign counterpart

$$\widehat{mc} = \widehat{M} - \widehat{A} \qquad \text{and} \qquad \widehat{mc}^* = \widehat{M}^* - \widehat{A}^*, \tag{A-10}$$

respectively, given equation (14). From (A-9) and (A-10) it follows that the covariance between marginal costs and the nominal exchange rate can be written as

$$Cov(\widehat{mc},\widehat{S}) = \frac{\left(1-\rho\Theta_M^{PC}\right)}{\rho + (1-\rho)(1-a)(2-\tilde{z}-\tilde{z}^*)}Var(\widehat{M}), \tag{A-11}$$

$$Cov(\widehat{mc}^*,\widehat{S}) = -\frac{\left(1-\rho\Theta_M^{PC}\right)}{\rho + (1-\rho)(1-a)(2-\tilde{z}-\tilde{z}^*)}Var(\widehat{M}^*), \tag{A-12}$$

respectively. Note that in the NB economies only monetary disturbances affect the covariance relationship between marginal costs and the nominal exchange rate. The magnitude of this covariance relationship, however, will depend on the equilibrium bond holdings b. Since all shocks are uncorrelated, the variance of the nominal exchange rate equals

$$Var(\widehat{S}) = \frac{\left(1-\rho\Theta_M^{PC}\right)^2 Var(\widehat{M}+\widehat{M}^*) + (\rho\Theta_G^{PC})^2 Var(\widehat{G}+\widehat{G}^*)}{\left[\rho + (1-\rho)(1-a)(2-\tilde{z}-\tilde{z}^*)\right]^2}, \tag{A-13}$$

with $Var(\widehat{G}+\widehat{G}^*)$ and $Var(\widehat{M}+\widehat{M}^*)$ reflecting the sum of the variances of the government spending and monetary policy shocks at home and abroad.

A.2 Trade in bonds and equities

Additional to the asset market equilibrium condition for bonds, equation (A-2), we also take a second-order approximation of the home Euler equity equation (13) and its foreign counterpart to obtain

$$Cov(\widehat{\Pi} - \widehat{S\Pi^*}, \widehat{PC} - \widehat{SP^*C^*}) = \frac{1-\rho}{\rho}Cov(\widehat{\Pi} - \widehat{S\Pi^*}, \widehat{Q}). \tag{A-14}$$

As for bonds, we linearize the period $t = 1$ budget constraint for the home country and its foreign counterpart, (12). Taking country differences yields

$$\widehat{PC} - \widehat{SP^*C^*} = \frac{(2\phi - 1)}{\sigma}(\widehat{\Pi} - \widehat{S\Pi^*}) + 2b\hat{R}^B_{Fin} - (\widehat{G} - \widehat{G^*}) + \frac{\sigma - 1}{\sigma}(\widehat{WL} - \widehat{SW^*L^*}).$$

Taking into account that $\hat{R}^E_{Fin} = \frac{1}{\sigma}(\widehat{\Pi} - \widehat{S\Pi^*})$ and $\hat{R}^{Non}_{Fin} = \frac{\sigma-1}{\sigma}(\widehat{WL} - \widehat{SW^*L^*})$, we can rewrite the last equation as

$$\widehat{PC} - \widehat{SP^*C^*} = (2\phi - 1)\hat{R}^E_{Fin} + 2b\hat{R}^B_{Fin} - (\widehat{G} - \widehat{G^*}) + \hat{R}^{Non}_{Fin}. \tag{A-15}$$

Optimal bond and equity portfolio From the expressions above it follows that non-financial returns $\hat{R}^{Non}_{Fin}$ are now determined by the relative labor incomes of households. Given that both bonds and equity are traded, the equilibrium bond position will now depend also on the covariance between the relative returns from equity and bond holdings as well as the equilibrium equity holdings. Following the above solution approach, non financial income equals

$$\hat{R}^{Non}_{Fin} = \Theta^{R^{Non}_{Fin}}_{Ex_{Fin}} \widehat{\mathbf{Ex}}_{Fin} - \Theta^{R^{Non}_{Fin}}_{A}(\widehat{A} - \widehat{A}^*) + \Theta^{R^{Non}_{Fin}}_{M}(\widehat{M} - \widehat{M}^*) - \Theta^{R^{Non}_{Fin}}_{G}(\widehat{G} - \widehat{G}^*), \tag{A-16}$$

with $\widehat{\mathbf{Ex}}_{Fin} = [2b, (2\phi - 1)]\,[\hat{R}^B_{Fin}, \hat{R}^E_{Fin}]'$ and $\Theta^{R^{Non}_{Fin}}_{Ex_{Fin}}$, $\Theta^{R^{Non}_{Fin}}_{A}$, $\Theta^{R^{Non}_{Fin}}_{M}$ and $\Theta^{R^{Non}_{Fin}}_{G}$ defined in the appendix, Table B-2. The structural parameters Θ^S_{PC} and Θ^S_M are also shown in Table B-2. Financial returns can be written as

$$[\hat{R}^B_{Fin}, \hat{R}^E_{Fin}]' = \mathbf{R}_1\widehat{\mathbf{Ex}}_{Fin} + \mathbf{R}_2[(\widehat{A} - \widehat{A}^*), (\widehat{M} - \widehat{M}^*), (\widehat{G} - \widehat{G}^*)]',$$

with $\mathbf{R}_1 = [\Theta^S_{PC}(1 + \Theta^{R^{Non}_{Fin}}_{Ex_{Fin}}), -(\Theta^{R_{Fin}}_{PC} + \Theta^{R_{Fin}}_{S}\Theta^S_{PC})(1 + \Theta^{R^{Non}_{Fin}}_{Ex_{Fin}})]'$ and $\mathbf{R}_2$ being a 3x2 matrix, containing the additional structural parameters $\Theta^{R_{Fin}}_{PC}$ and $\Theta^{R_{Fin}}_{S}$, given in Table B-2. Finally, the relative discount factor equals

$$-\rho(\widehat{PC} - \widehat{SP^*C^*}) + (1 - \rho)\,\widehat{Q} = \mathbf{D}_1\widehat{\mathbf{Ex}}_{Fin} + \mathbf{D}_2[(\widehat{A} - \widehat{A}^*), (\widehat{M} - \widehat{M}^*), (\widehat{G} - \widehat{G}^*)]', \tag{A-17}$$

with $\mathbf{D}_1 = -\Theta^D_{PC}(1 + \Theta^{R^{Non}_{Fin}}_{Ex_{Fin}})$ being a scalar and $\mathbf{D}_2 = [\Theta^D_{PC}\Theta^{R^{Non}_{Fin}}_{A}, \Theta^D_M - \Theta^D_{PC}\Theta^{R^{Non}_{Fin}}_{M}, \Theta^D_{PC}(1 + \Theta^{R^{Non}_{Fin}}_{G})]$ a 1×3 vector of combinations of the structural parameters, where Θ^D_{M} and Θ^D_{PC} are defined in Table B-2. Equations (A-16)-(A-17) allow to write the solution to the bond and equity holding in the NBE economy as

$$\begin{bmatrix} 2b & (2\phi - 1) \end{bmatrix}' = \left[\mathbf{R}_2\Sigma\mathbf{D}_2'\mathbf{R}_1' - \mathbf{D}_1\mathbf{R}_2\Sigma\mathbf{R}_2'\right]^{-1}\mathbf{R}_2\Sigma\mathbf{D}_2'. \tag{A-18}$$

Nominal exchange rate in the NBE economy Given the solution to nominal bonds and equity holdings, the nominal exchange rate in equation (A-1) equals

$$\widehat{S} = \frac{\rho\Theta^{PC}_A(\widehat{A} - \widehat{A}^*) + \left(1 - \rho\Theta^{PC}_M\right)(\widehat{M} - \widehat{M}^*) + \rho\Theta^{PC}_G(\widehat{G} - \widehat{G}^*)}{\rho + (1 - \rho)\,(1 - a)(2 - \tilde{z} - \tilde{z}^*)}, \tag{A-19}$$

with Θ^{PC}_A, Θ^{PC}_M and Θ^{PC}_G displayed in Table B-2. In contrast to the NB economy, the NBE economy allows the exchange rate to transmit all three economic disturbances across countries. Again, the equilibrium outcome of the nominal exchange rate depends on the equilibrium portfolio allocation of bonds, b, and equities, ϕ. From (A-10) and (A-19) it follows that the covariance between marginal costs and the nominal exchange rate in the NBE economies can be written as

$$\begin{aligned} Cov(\widehat{mc},\widehat{S}) &= \frac{\left(1-\rho\Theta_M^{PC}\right)Var(\widehat{M})+\rho\Theta_A^{PC}Var(\widehat{A})}{\rho+(1-\rho)\,(1-a)(2-\tilde{z}-\tilde{z}^*)}, \\ Cov(\widehat{mc}^*,\widehat{S}) &= -\frac{\left(1-\rho\Theta_M^{PC}\right)Var(\widehat{M}^*)+\rho\Theta_A^{PC}Var(\widehat{A}^*)}{\rho+(1-\rho)\,(1-a)(2-\tilde{z}-\tilde{z}^*)}. \end{aligned}$$

Now, all shocks that affect marginal costs will also impact the nominal exchange rate. Thus, the covariance relationship between marginal costs and the nominal exchange rate is not only affected by monetary disturbances, as in the NB economy, but also by productivity disturbances. The sign of this covariance relationship, however, will depend on the equilibrium bond holding b as well as the equilibrium equity position ϕ. Since all shocks are uncorrelated, the variance of the nominal exchange rate in the NBE economy equals

$$\begin{aligned} Var(\widehat{S}) &= \frac{\left(1-\rho\Theta_M^{PC}\right)^2 Var(\widehat{M}+\widehat{M}^*)+(\rho\Theta_G^{PC})^2 Var(\widehat{G}+\widehat{G}^*)}{\left(\rho+(1-\rho)\,(1-a)(2-\tilde{z}-\tilde{z}^*)\right)^2} \\ &\quad +\frac{\left(\rho\Theta_A^{PC}\right)^2 Var(\widehat{A}+\widehat{A}^*)}{\left(\rho+(1-\rho)\,(1-a)(2-\tilde{z}-\tilde{z}^*)\right)^2}. \end{aligned}$$

B Coefficients of the full model

B.1 Trade in bonds only

Table B-1 provides the coefficients used when assessing the nominal bonds economies.

B.2 Trade in bonds and equities

The matrix $\mathbf{R}_2$ is given by

$$\mathbf{R}_2 = \begin{bmatrix} -\Theta_{PC}^S\Theta_A^{R_{Fin}^{Non}}, & (\Theta_{PC}^{R_{Fin}}+\Theta_S^{R_{Fin}}\Theta_{PC}^S)\Theta_A^{R_{Fin}^{Non}}+\frac{\sigma-1}{\sigma} \\ -\Theta_{\mathsf{M}}^S+\Theta_{PC}^S\Theta_M^{R_{Fin}^{Non}}, & \Theta_S^{R_{Fin}}\Theta_{\mathsf{M}}^S-(\Theta_{PC}^{R_{Fin}}+\Theta_S^{R_{Fin}}\Theta_{PC}^S)\Theta_M^{R_{Fin}^{Non}} \\ -\Theta_{PC}^S(1+\Theta_G^{R_{Fin}^{Non}}), & (\Theta_{PC}^{R_{Fin}}+\Theta_S^{R_{Fin}}\Theta_{PC}^S)(1+\Theta_G^{R_{Fin}^{Non}})-\frac{1-2a}{\sigma} \end{bmatrix}'.$$

$\Theta_{PC}^{S} =$	$\rho\Theta_{M}^{S}$
$\Theta_{M}^{S} =$	$\left[\rho + (1-\rho)(1-a)(2-\tilde{z}-\tilde{z}^{*})\right]^{-1}$
$\Theta_{Ex_{Fin}}^{R_{Fin}^{Non}} =$	$-\frac{1-2a-2(1-\eta)(1-a)a(2-\tilde{z}-\tilde{z}^{*})\Theta_{PC}^{S}}{2(1-a)-2(1-\eta)(1-a)a(2-\tilde{z}-\tilde{z}^{*})\Theta_{PC}^{S}}$
$\Theta_{M}^{R_{Fin}^{Non}} =$	$-\frac{2(1-\eta)(1-a)a(2-\tilde{z}-\tilde{z}^{*})\Theta_{\mathsf{M}}^{S}}{2(1-a)-2(1-\eta)(1-a)a(2-\tilde{z}-\tilde{z}^{*})\Theta_{PC}^{S}}$
$\Theta_{G}^{R_{Fin}^{Non}} =$	$\frac{1-2a-2(1-\eta)(1-a)a(2-\tilde{z}-\tilde{z}^{*})\Theta_{PC}^{S}-1+2a}{2(1-a)-2(1-\eta)(1-a)a(2-\tilde{z}-\tilde{z}^{*})\Theta_{PC}^{S}}$
$\Theta_{\mathsf{M}}^{D} =$	$(1-\rho)\left[1-(1-a)(2-\tilde{z}-\tilde{z}^{*})\right]\Theta_{\mathsf{M}}^{S}$
$\Theta_{PC}^{D} =$	$\rho + (1-\rho)\left[1-(1-a)(2-\tilde{z}-\tilde{z}^{*})\right]\Theta_{PC}^{S}$
$\Theta_{M}^{PC} =$	$-\frac{\Theta_{\mathsf{M}}^{S}[2b+(1-\eta)(1-a)a(2-\tilde{z}-\tilde{z}^{*})]}{2(1-a)-[2b+(1-\eta)(1-a)a(2-\tilde{z}-\tilde{z}^{*})]\Theta_{PC}^{S}}$
$\Theta_{G}^{PC} =$	$\frac{2(1-a)}{2(1-a)-[2b+(1-\eta)(1-a)a(2-\tilde{z}-\tilde{z}^{*})]\Theta_{PC}^{S}}$

Table B-1: Structural coefficients of the NB economies.

Table B-2 provides the coefficients used when assessing the nominal bonds and equity economies.

$$\Theta^{R^{Non}_{Fin}}_{Ex_{Fin}} = \frac{\frac{\sigma-1}{\sigma}\left\{2a-1+\rho-\{\rho-(1-a)[\tilde{z}+\tilde{z}^*+(2-\tilde{z}-\tilde{z}^*)(2a(1-\eta)-1+\rho)]\}\Theta^S_{PC}\right\}}{1-\frac{\sigma-1}{\sigma}\left\{2a-1+\rho-\{\rho-(1-a)[\tilde{z}+\tilde{z}^*+(2-\tilde{z}-\tilde{z}^*)(2a(1-\eta)-1+\rho)]\}\Theta^S_{PC}\right\}}$$

$$\Theta^{R^{Non}_{Fin}}_{A} = \left[\frac{\sigma}{\sigma-1} - \left\{2a-1+\rho-\{\rho-(1-a)\left[\tilde{z}+\tilde{z}^*+(2-\tilde{z}-\tilde{z}^*)\left(2a(1-\eta)-1+\rho\right)\right]\}\,\Theta^S_{PC}\right\}\right]^{-1}$$

$$\Theta^{R^{Non}_{Fin}}_{M} = \frac{\frac{\sigma-1}{\sigma}\{\rho-(1-a)[\tilde{z}+\tilde{z}^*+(2-\tilde{z}-\tilde{z}^*)(2a(1-\eta)-(1-\rho))]\}\Theta^S_{\mathsf{M}}}{1-\frac{\sigma-1}{\sigma}\left\{2a-(1-\rho)-\{\rho-(1-a)[\tilde{z}+\tilde{z}^*+(2-\tilde{z}-\tilde{z}^*)(2a(1-\eta)-1+\rho)]\}\Theta^S_{PC}\right\}}$$

$$\Theta^{R^{Non}_{Fin}}_{G} = \frac{\frac{\sigma-1}{\sigma}\left\{\rho-\{\rho-(1-a)[\tilde{z}+\tilde{z}^*+(2-\tilde{z}-\tilde{z}^*)(2a(1-\eta)-1+\rho)]\}\Theta^S_{PC}\right\}}{1-\frac{\sigma-1}{\sigma}\left\{2a-(1-\rho)-\{\rho-(1-a)[\tilde{z}+\tilde{z}^*+(2-\tilde{z}-\tilde{z}^*)(2a(1-\eta)-1+\rho)]\}\Theta^S_{PC}\right\}}$$

$$\Theta^{R_{Fin}}_{PC} = \left[1-2a+(\sigma-1)\rho\right]\sigma^{-1}$$

$$\begin{aligned}\Theta^{R_{Fin}}_{S} = {} & \left[(\sigma-1)\left\{(1-a)\left[\tilde{z}+\tilde{z}^*-(2-\tilde{z}-\tilde{z}^*)\left(1-\rho-2a(1-\eta)\right)\right]-\rho\right\} - \right. \\ & \left. 2\sigma a\,(1-a)\,(1-\eta)\,(2-\tilde{z}-\tilde{z}^*)\right]\sigma^{-1}\end{aligned}$$

$$\Theta^{PC}_{A} = \frac{2(1-\phi)\frac{\sigma-1}{\sigma}}{\begin{array}{c}\left\{1+(2\phi-1)\left(\Theta^{R_{Fin}}_{PC}+\Theta^{R_{Fin}}_{S}\Theta^S_{PC}\right)-2b\Theta^S_{PC}-\frac{\sigma-1}{\sigma}\left(2a-(1-\rho)\right)+\right. \\ \left.\frac{\sigma-1}{\sigma}\left\{\rho-(1-a)\left[\tilde{z}+\tilde{z}^*+(2-\tilde{z}-\tilde{z}^*)\left(2a(1-\eta)-1+\rho\right)\right]\right\}\Theta^S_{PC}\right\}\end{array}}$$

$$\Theta^{PC}_{M} = \frac{\left\{\frac{\sigma-1}{\sigma}\{\rho-(1-a)[\tilde{z}+\tilde{z}^*+(2-\tilde{z}-\tilde{z}^*)(2a(1-\eta)-(1-\rho))]\}-(1-2\phi)\Theta^{R_{Fin}}_{S}-2b\right\}\Theta^S_{M}}{\begin{array}{c}\left\{1+(2\phi-1)\left(\Theta^{R_{Fin}}_{PC}+\Theta^{R_{Fin}}_{S}\Theta^S_{PC}\right)-2b\Theta^S_{PC}-\frac{\sigma-1}{\sigma}\left(2a-1+\rho\right)+\right. \\ \left.\frac{\sigma-1}{\sigma}\left\{\rho-(1-a)\left[\tilde{z}+\tilde{z}^*+(2-\tilde{z}-\tilde{z}^*)\left(2a(1-\eta)-1+\rho\right)\right]\right\}\Theta^S_{PC}\right\}\end{array}}$$

$$\Theta^{PC}_{G} = \frac{(1-2\phi)\frac{1-2a}{\sigma}-\frac{\sigma-1}{\sigma}(1-2a)-1}{\begin{array}{c}\left\{1+(2\phi-1)\left(\Theta^{R_{Fin}}_{PC}+\Theta^{R_{Fin}}_{S}\Theta^S_{PC}\right)-2b\Theta^S_{PC}-\frac{\sigma-1}{\sigma}\left(2a-1+\rho\right)+\right. \\ \left.\frac{\sigma-1}{\sigma}\left\{\rho-(1-a)\left[\tilde{z}+\tilde{z}^*+(2-\tilde{z}-\tilde{z}^*)\left(2a(1-\eta)-1+\rho\right)\right]\right\}\Theta^S_{PC}\right\}\end{array}}$$

Table B-2: Structural coefficients of the NBE economies.

C Data appendix

C.1 Data sources

We use the below variables from the following, freely accessible, data sets:

- Lane and Shambaugh (2010): debt assets in domestic currency % of GDP, debt assets in foreign currency % of GDP, debt liabilities in domestic currency % of GDP, and debt liabilities in foreign currency % of GDP for 109 countries (after eliminating outliers, see Section C.2).
- The updated and extended version of the data set constructed by Lane and Milesi-Ferretti (2007): GDP (US$), Portfolio equity assets (stock), Portfolio equity liabilities (stock), FDI assets (stock), FDI liabilities (stock), Debt assets (stock), Debt liabilities (stock), Portfolio debt assets, Portfolio debt liabilities, and net foreign assets (NFA) for the same countries as in Lane and Shambaugh (2010).

Table C-1: Summary statistics of variables used in Section 2

	count	mean	Var	min	max
dhb/gdp	1414	.2810305	.1478164	-1.045913	2.478
dhb/debt	1414	.3030157	.2434276	-3.608123	3.309734
(Eq. & FDI)/GDP	1421	.2950106	.0652062	.0049113	1.360516
NFA/GDP	1421	-.4650004	.1725927	-2.334387	.8420662
log(Gross Debt)	1421	.7903121	.1686557	.1549832	2.377564
Chinn-Ito	1396	.122579	2.15684	-1.85564	2.45573
Openness	1382	.7002915	.1472087	.1389551	3.49803
Net Exp.	1382	-.0362516	.0118674	-.7324887	.5517565
log(GDP/Pop.)	1421	7.539978	2.297052	4.277153	10.65228
log(Pop.)	1421	2.643276	2.24053	-1.367304	7.170544
Inflation Vol.	889	.01163	.0098052	1.60e-06	2.52893
Exch. Rate Vol.	637	.4034161	16.07405	.0000324	81.6258
PCP	88	.1886023	.0415163	0	.626
PCP+VCP	1421	.1033797	.0827035	0	.9958

- International Financial Statistics from the IMF: exports of goods and services, imports of goods and services (both in national currencies), official or market exchange rates (to convert into US$), nominal effective exchange rate, CPI, and population.
- Chinn and Ito (2006): updated Financial Openness Index.
- OECD Main Economic Indicators: M2. OECD Economic Outlook 92: Government final consumption expenditure, volume; GDPV: Gross domestic product, volume, market prices; ET: Total employment from 1970Q1 until 2012Q4, all for the calculation of the shock variances.
- Kamps (2006): percentage of export and import goods priced in home currency, see her Table A1.

The time period for our regressions in Tables 1 and 2, 1990-2004, is dictated by the length of the series in Lane and Shambaugh (2010).

C.2 Data selection

The financial variables (sum of portfolio equity and FDI assets plus liabilities over GDP, net foreign assets over GDP, total debt over GDP) feature some outliers. These are mainly financial centers such as Hong Kong, Switzerland etc. and some developing countries with extraordinary large and negative net foreign assets. As large parts of the financial centers' assets do most likely not represent asset holdings of their own inhabitants (as assumed in our model), they are not subject of our analysis. In developing countries with large debt, the currency decomposition of net foreign asset reflects most probably choices taken by donor countries instead of optimal portfolio decisions of inhabitants. Using different ways to remove outliers, however, give similar results. We use the multivariate technique to detect outliers proposed in Hadi (1992, 1994) with a significance level of 0.05 (the results are robust to changes in this value, where higher values tend to strengthen the results). Removing observations that are outside of three standard deviations of the final sample for these variables results in very similar estimates. Similarly, manually removing only the largest financial centers (here defined as having values for our financial integration variable plus gross debt over GDP of 7.8 or above, corresponding to the average value for Singapore, Hong Kong, and Switzerland) *gives an impact of equity and FDI trade on debt home bias over GDP of -0.21 (significant at the 5% level) and of -0.13 on the share of producer-currency pricing (also significant at the 5% level), both resulting from the fixed effects regressions including all controls displayed in the tables of Section 2.

Table C-1 summarizes the variables used in the regressions in Section 2, while Table C-2 shows their correlations. Table C-3 displays the countries which were used.

	dhb/gdp	dhb/debt	Eq & FDI	NFA	GD	CI	Open.	NX	gdp/pop	pop	IFV	ERV	PCP
dhb/gdp	1												
dhb/debt	0.775	1											
Eq & FDI	-0.177	-0.207	1										
NFA	-0.842	-0.595	-0.146	1									
GD	0.559	0.205	0.132	-0.570	1								
CI	-0.291	-0.267	0.343	0.220	0.143	1							
Open.	-0.0458	-0.180	0.270	-0.162	0.135	-0.0557	1						
NX	-0.251	-0.235	0.220	0.233	-0.138	0.0314	0.104	1					
gdp/pop	-0.476	-0.396	0.396	0.448	-0.0596	0.563	0.0278	0.391	1				
pop	-0.109	0.0456	-0.145	0.196	-0.161	-0.120	-0.378	0.107	-0.0991	1			
IFV	-0.0157	0.00386	-0.0240	0.0183	-0.0215	0.00889	-0.000985	-0.0281	0.0363	-0.0305	1		
ERV	0.214	0.0927	-0.0340	-0.197	0.157	0.0546	-0.0121	-0.199	-0.0833	-0.0254	0.612	1	
PCP	-0.625	-0.632	0.452	0.408	0.660	0.578	-0.515	-0.182	0.806	0.0321	-0.207	-0.354	1
PCP+VCP	-0.172	-0.108	0.106	0.0939	-0.0522	0.137	0.103	0.0535	0.240	0.0898	0.148	-0.0239	-0.458

Table C-2: Correlations of variables used in Section 2.

United States	El Salvador	Pakistan	Tunisia
Austria	Guatemala	Philippines	Uganda
Denmark	Haiti	*Thailand*	Burkina Faso
France	Honduras	Vietnam	Fiji
Germany	Mexico	Algeria	Papua New Guinea
Italy	Nicaragua	Botswana	Armenia
Netherlands	Paraguay	Cameroon	Azerbaijan
Norway	Peru	Chad	Belarus
Sweden	Uruguay	Congo, Republic of	Albania
Canada	Venezuela, Rep. Bol.	Benin	Georgia
Japan	Jamaica	Equatorial Guinea	Kazakhstan
Finland	Trinidad and Tobago	Ethiopia	Kyrgyz Republic
Greece	Iran, Islamic Republic of	Gabon	Moldova
Iceland	Israel	Ghana	Russia
Ireland	Jordan	Guinea	China,P.R.: Mainland
Portugal	Oman	Côte d’Ivoire	*Ukraine*
Spain	Syrian Arab Republic	Kenya	*Czech Republic*
Turkey	Egypt	Madagascar	Slovak Republic
Australia	Yemen, Republic of	Malawi	Estonia
New Zealand	Bangladesh	Mali	Latvia
South Africa	Cambodia	Morocco	*Hungary*
Argentina	Sri Lanka	Mozambique	*Lithuania*
Bolivia	India	Niger	Croatia
Brazil	*Indonesia*	Nigeria	Slovenia
Chile	Korea	Rwanda	Macedonia
Colombia	*Malaysia*	Senegal	Bosnia and Herzegovina
Dominican Republic	Nepal	Tanzania	*Poland*
		Togo	Romania

Table C-3: Countries used in the regressions in Section 2. Countries for which data on the pricing currency of exports is available and which were hence used in the regressions of Table 3 are written in italics.