International Trade Costs, Home Bias and Europe's Single Market

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Abstract

This chapter incorporates international trade costs in Obstfeld and Rogoff's (1995) model. This extension introduces an endogenous home bias in consumer spending. I show that small trading costs may cause a large home bias. Moreover, tradings costs in the goods market can explain seemingly excessive short-run exchange rate volatility. Finally, the Single Market (declining costs of international trade) will reduce the home bias in consumption. I show that, as a result, monetary policy becomes less powerful in terms of affecting consumption, but better able to influence the general price level.

1 Introduction

Markets for goods and services in the European Union are becoming more and more integrated. This is the result of a variety of developments. In particular, border controls have been abolished, markets are being liberalised, public procurement has been opened to foreign firms and technical standards are being harmonised. More recently, the internet makes it easier and cheaper to order goods and services abroad. Head and Mayer (2000) provide empirical evidence that the bias towards buying domestically-produced products has been on a downward trend since the 1970s.

Despite the trend towards more integration, markets for the same products continue to be segmented. In fact, the home bias in consumer spending is remarkably strong. The aforementioned study by Head and Mayer finds that, in the period 1993-95, Europeans purchased twelve times more from domestic producers than from equally-distant (in a geographic sense) foreign producers.

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The costs of cross-border transactions are still larger than for transactions concluded between parties within the same country. These extra costs may arise from information costs, or from other implicit trade barriers. The importance of information costs was first highlighted by Stigler (1961) and has been explored further by Salop (1977), Bester and Petrakis (1995) and others. Examples are the costs of finding out the quality of foreign goods and foreign counterparties, costs related to differences in distribution channels, costs of cross-border advertisements, etc. Prices are more transparent to buyers from the same country, because they have better access to domestic price information, since newspapers, magazines and tv programmes are distributed largely within national borders. Other implicit trade barriers include different product standards and national regulations which require firms to comply with specific rules in order to enter another national market. In Europe, several steps have been taken to reduce such costs, but many obstacles remain.

This paper analyses the consequences of the remaining barriers to cross-border competition in the context of the Obstfeld and Rogoff (1995) framework. This framework allows for imperfect competition and nominal rigidities. I explicitly incorporate 'transportation costs' for trade between two countries into the model. 'Transportation costs' is a catch-all term: it can be interpreted as any kind of barrier to trade. Hence, the terms transportation costs and trade costs will be used interchangeably in this paper. The introduction of costs for international trade implies that the model deviates from the standard Obstfeld and Rogoff (1995) model. First, the law of one price need not hold. Second, trade costs lead to an endogenous home bias in consumer spending.

A related paper is Warnock (1999), who incorporates a home bias in Obstfeld and Rogoff's model. He imposes an exogenous home bias in preferences: consumers derive more utility from consuming domestically-produced goods than from foreign-produced goods.[1] By contrast, there is no home bias in preferences in this paper: the home bias is endogenous and caused by the interplay of positive costs of international trade and imperfect competition (a finite price-elasticity of demand).

Hau (2000) introduces a home bias in spending by adding non-tradable goods to the model. By contrast, there are only tradable goods in the model in this paper.

Another paper which is related to mine is Obstfeld and Rogoff (2000). They focus on the cost of international trade and its possible implications for several empirical puzzles in international macroeconomics, including the home bias in trade. Their paper studies a number of special cases for a small country, without developing and solving a fully-fledged model which includes costs of international trade, as this paper does. Their two-good model leads to a remarkable discontinuity in prices. This is caused by their assumption that the home country is a small open economy, which may either import or export the good that it is endowed with. Since the world price of the home good is sup-

[1] See Neven, Norman and Thisse (1991) for an earlier, and more extensive modeling of consumer attitude towards foreign products.

posed to be given, the presence of trade costs implies that the home price of this good is below the price on the world market when the home country is a net exporter, whereas it is above the price on the world market when the home country is a net importer. As a result, there is a discrete jump in prices at the point where the home country changes from a net importer to a net exporter. My results, derived in the context of a model with two large countries and a continuum of goods, do not suffer from this peculiarity.

I obtain the following results. First, for realistic values of the price-elasticity parameter, small trading costs lead to a substantial home bias in international trade. I will show numerically that the large decline in the home bias for European countries since the late 1970s found in the literature can be explained by a relatively small reduction in trading costs. The policy implication is the existence of a window of opportunities for the completion of the Single Market.

Second, the Single Market initiative may have important consequences for the transmission of ECB monetary policy. More specifically, in an environment of declining costs of international trade, monetary policy becomes *less* powerful in terms of affecting consumption, but *more* effective in terms of influencing the general price level. The intuition behind this result is that the presence of positive costs of international trade lead to a home bias in spending, which reinforces the usual transmission channels from money to consumption.[2] Therefore, a *decline* in the costs of international trade *reduces* the effectiveness of monetary policy with respect to consumption. The effectiveness of monetary policy with respect to the general price level is the flip-side of its effectiveness with respect to consumption (this follows from the long-run equilibrium conditions in the money market). Therefore, a decline in the costs of international trade implies that monetary policy becomes less able to affect consumption, but better able to influence the general price level.

Third, large short-run exchange rate volatility can be explained by the presence of international trading costs in the goods market. The intuition is as follows. In the presence of wage stickiness and a constant product mark-up (as in the current paper), the short-run relative price level can only adjust as a result of exchange rate changes. Positive costs of international trade lead to a home bias in spending, so only a limited share of goods is affected by exchange-rate movements. As a result, a large short-run exchange rate movement is required to attain short-run money market equilibrium. I will show numerically that when the costs associated with international trade are substantial, short-run exchange rate movements in response to monetary shocks can become extremely large.

The remainder of this paper is organised as follows. Section 2 presents the

[2] In the basic Obstfeld-Rogoff (1995) model (which assumes zero trading costs), the monetary transmission works as follows. In the short run, an expansion of the home money supply leads to a depreciation of the home currency and a surplus on the current account. The expenditure-switching effect associated with the exchange rate depreciation stimulates the consumption of home goods. The short-run current-account surplus implies a permanent improvement in domestic net foreign assets. The resulting positive net investment income flow allows consumption to remain permanently above domestic output. Moreover, the long-run terms of trade improve, which reinforces the possibility for home residents to consume more. This line of reasoning is referred to as the 'usual' channels of transmission in the main text.

basic model and derives the equilibrium conditions assuming optimal behaviour by households and firms. Section 3 discusses money shocks and their impact on consumption, the general price level and the exchange rate. Section 4 concludes.

2 The model

2.1 Market structure and preferences

The world consists of two countries, Home and Foreign, which are completely symmetric. Both countries are inhabited by a continuum of consumer-producers. Producers in the home country are indexed by $z \in [0, \frac{1}{2}]$, producers in the foreign country are indexed by $z \in (\frac{1}{2}, 1]$. Each of them produces a single differentiated good.

Household preferences are defined over an intertemporal utility function which includes a consumption index, real money balances and work effort:

$$U_t = \sum_{s=t}^{\infty} \beta^{s-t}[\log C_s + \chi \log(\frac{M_s}{P_s}) - \frac{\kappa}{2} L_s^2], \tag{1}$$

where U is the lifetime utility of a representative household in the home country, C is real composite consumption index, M is the amount of nominal money balances held by the representative household, P is a consumption-based price deflator, L is the amount of labour used in production, β is the discount factor, χ is a parameter which captures the benefit from holding real money balances and κ captures the disutility from work effort. Finally, s and t denote the moment in time. Time subscripts will be suppressed whenever possible.[3] In the remainder of this paper, foreign variables have an asterisk (*) and a different indexation of producers (f for foreign, against h for home). Apart from that, the mathematical expressions for foreign variables are identical to those found for the home country, unless explicitly stated otherwise.

All goods are tradable and sold in the world market. The elasticity of substitution between goods (whether produced at Home or in Foreign) is θ. The Home consumption index of the composite good is defined by

$$C = \left[\int_0^1 [c(z)]^{\frac{\theta-1}{\theta}} \, dz \right]^{\frac{\theta}{\theta-1}}. \tag{2}$$

The parameter θ is assumed to be larger than one.[4]

The consumption-based price index (defined as the minimum nominal amount of money needed to purchase one unit of composite real consumption, C) is:

$$P = \left[\int_0^1 [p(z)]^{1-\theta} \, dz \right]^{\frac{1}{1-\theta}}, \tag{3}$$

[3] Note that labour enters the utility function with a negative sign, reflecting the household's preference for leisure.

[4] Since the marginal revenue of an additional unity of output is negative when the elasticity of demand is less than one, $\theta > 1$ is required for a positive level of output in equilibrium.

where $p(z)$ is the money price of good z.

As noted before, this paper allows for cross-border trading costs. The presence of cross-border trading costs implies the possibility that the same good sells for a different price in both countries, i.e. the law of one price may not hold. The exact relationships between prices for individual goods will follow from profit maximisation by firms.

There is a single financial asset, an internationally traded riskless real bond denominated in the composite consumption good. There is no capital in the model, hence firms' profits consist entirely of monopoly rents. Firms are entirely domestically owned and profits are immediately handed back to the owners (households). Labour is immobile between countries, so that labour income remains in the own economy. The period budget constraint for a representative household-firm owner of Home can then be written as

$$\begin{aligned} P_t F_t + M_t &= P_t(1+r_{t-1})F_{t-1} + M_{t-1} + \\ &\quad + W_t L_t + \Pi_t - P_t C_t - P_t T_t, \end{aligned} \tag{4}$$

where F_t is the stock of bonds held by the representative household on date t, r_{t-1} is the real interest rate on bonds between $t-1$ and t, W_t is the nominal wage rate, Π_t is its firm's profits and T_t is a lump-sum tax or transfer. Interest rates and taxes are denominated in terms of the composite good.

I assume that the government budget is balanced at all times. Moreover, I assume that there is no government spending. All seigniorage revenues are redistributed in the form of transfers: $0 = T_t + \frac{M_t - M_{t-1}}{P_t}$. The nominal interest rate i_t is defined by $1 + i_t = (1 + r_t)\frac{P_{t+1}}{P_t}$.

2.2 Maximisation of household utility

The household´s maximisation problem is not directly affected by international trading costs. The household´s maximisation problem can be separated in an intratemporal and an intertemporal problem.

Solving the intratemporal problem yields the expression for individual Home consumption of good z [see Obstfeld and Rogoff (1996, p. 664) for a derivation]:

$$c(z) = \left(\frac{p(z)}{P}\right)^{-\theta} C, \tag{5}$$

The demand for good z is decreasing in its relative price, with a price elasticity of θ.

The representative household maximises life-time utility (1), subject to the period budget constraint (4) which must be satisfied in every single period. The first-order conditions of this intertemporal optimisation problem are:

$$C_{t+1} = \beta(1 + r_t)C_t, \tag{6}$$

$$\frac{M_t}{P_t} = \chi C_t \left(\frac{1 + i_t}{i_t}\right), \tag{7}$$

$$L_t^s = \frac{1}{\kappa}\frac{W_t}{P_t}\frac{1}{C_t}. \tag{8}$$

Equation (6) is the standard Euler equation. It indicates how the total consumption of goods is spread over time. Equation (7) is the money demand equation. Equation (8) represents labour supply (the labour-leisure trade-off).

2.3 Maximisation of firm profits

Goods markets are imperfectly competitive. This follows from the fact that the substitutability between different varieties of the single differentiated good in this model is finite ($\theta < \infty$). Imperfect competition is an important ingredient of the model. First, it permits the explicit analysis of pricing decisions. Second, equilibrium prices set above marginal cost rationalise demand-determined output in the short run, since firms do not lose money on a marginal expansion of the output level. Third, imperfect competition means that equilibrium output falls below the social optimum. See Lane (1999).

The representative home-country firm z is a monopolist in the production of a good z. The firm uses only one input: labour. Labour is homogeneous. The production process exhibits constant returns to scale

$$y(z) = \alpha l(z), \tag{9}$$

where α is labour productivity and $y(z)$ is output of good z.

The costs of international trade take the form of a 'melting loss': only a fraction $1-\tau$ of all exported goods reaches its destination.[5] I assume $0 \leq \tau < 1$, i.e. a strictly positive fraction of exports $1-\tau$ reaches its destination and a non-negative fraction τ fails to reach its destination. The goods markets clearing condition, which I will use to solve the firms' optimisation problem below, takes into account this 'melting loss':[6]

$$y(z) = c(z) + \frac{1}{1-\tau}c^*(z), \tag{10}$$

Equation (10) amounts to implicitly assuming that all trading costs are initially incurred by firms, rather than consumers.[7] It will turn out that firms pass on these costs entirely to consumers.

[5] Under alternative specifications (e.g. firms pay an import tariff to the government of the foreign country, or exporting firms need to hire additional workers for ensuring compliance with foreign product rules), I obtain very similar results. However, these specifications require adjustments to the expressions for the household budget constraint and the current account equation, which make the resulting solution more complicated.

[6] The melting loss for Home-produced good z is a fraction τ of Home exports of good z, i.e.: $ml(z) = \tau[y(z) - c(z)]$. Foreign imports are a fraction $1-\tau$ of Home exports: $c^*(z) = (1-\tau)[y(z) - c(z)]$. Therefore, the melting loss for the Home-produced good must be a fraction $\frac{\tau}{1-\tau}$ of Foreign imports: $ml(z) = \frac{\tau}{1-\tau}c^*(z)$. The goods market clearing condition for Home-produced good z is $y(z) = c(z) + c^*(z) + ml(z)$, which can be simplified to equation (10) in the main text.

[7] This assumption may not be too far off from reality, even if the market imperfection originates on the side of consumers (rather than firms). For instance, think of a situation where imperfectly informed consumers receive product information via advertising paid for by firms, as in Stegeman (1991).

The labour market is assumed to be competitive. I assume that labour is immobile internationally, but fully mobile within national borders. It follows directly that, in equilibrium, there will be a single wage rate W (W^*) in each country. Finally, I assume that firms can price-discriminate between countries.

Firm profits are

$$\Pi(z) = p(z)c(z) + Xp^*(z)c^*(z) - Wl(z), \tag{11}$$

where X is the nominal exchange rate, i.e. the price of one unit of foreign currency expressed in the home currency.

The representative Home firm z chooses $p(z)$ and $p^*(z)$ in order to maximise total profits (11), subject to the demand function (5) and its foreign counterpart, the production function (9) and clearing of goods markets (10). I assume that the firm takes Home and Foreign aggregate demand C and C^* as given. International trading costs enter the profit function implicitly: observe that 'melted' exports cause production costs, but do not generate revenues. The first-order conditions are:

$$p(z) = \left(\frac{\theta}{\theta - 1}\right)\frac{W}{\alpha}, \tag{12}$$

$$p^*(z) = \frac{1}{X(1-\tau)}\left(\frac{\theta}{\theta - 1}\right)\frac{W}{\alpha}. \tag{13}$$

These equations represent the optimal pricing rules for the representative Home firm (i.e. for $z \in [0, \frac{1}{2}]$) under monopolistic competition. The prices in equations (12)-(13) are expressed in local currency, i.e. $p^*(z)$ is in Foreign currency. Firms set the Home price equal to unit labour costs plus a mark-up of $\frac{1}{\theta-1}$. They set the Foreign price equal to the Foreign currency equivalent of the Home product price multiplied by $\frac{1}{1-\tau}$. As the goods market moves towards full competition ($\theta \to \infty$) profit margins tend to zero.

Similarly, the optimal pricing rules for the Foreign firm (i.e. for $z \in (\frac{1}{2}, 1]$) are

$$p^*(z) = \left(\frac{\theta}{\theta - 1}\right)\frac{W^*}{\alpha}, \tag{14}$$

$$p(z) = \frac{X}{(1-\tau)}\left(\frac{\theta}{\theta - 1}\right)\frac{W^*}{\alpha}. \tag{15}$$

It follows directly from the optimal pricing rules (12)-(15) that

$$Xp^*(z) = \frac{1}{1-\tau}p(z), \text{ for } z \in [0, \frac{1}{2}], \tag{16}$$

$$p(z) = \frac{1}{1-\tau}Xp^*(z), \text{ for } z \in (\frac{1}{2}, 1]. \tag{17}$$

It is optimal for firms to price-discriminate between markets. Optimal price setting implies that firms fully pass on the costs of international trade to consumers abroad. Thus, even in general equilibrium, the law of one price does not hold.[8]

2.4 The home bias

Combining the consumer demand equation (5) and its foreign counterpart with the price relationships (16)-(17) and assuming symmetry between producers in the same country, it follows that in equilibrium, under international symmetry:

$$\frac{c(h)}{c(f)} = (1-\tau)^{-\theta} > 1. \tag{18}$$

Thus, transportation costs and the price-elasticity of demand together determine the distribution of consumer spending over domestically-produced and imported goods. Let δ be the share of income spent on domestically-produced goods:

$$\delta = \frac{c(h)}{y(h)} = \frac{c(h)}{c(h)+\frac{1}{1-\tau}c(f)} = \frac{1}{1+(1-\tau)^{\theta-1}}, \tag{19}$$

where I have used equations (10), (18) and international symmetry.

The home bias β is defined as the share of income spent on domestically-produced goods in excess of the 'neutral' level, where the 'neutral' level of spending on domestically-produced goods is the share of the home country in world output. In the special case of two countries of equal size, the 'neutral' spending ratio is equal to 1/2. Thus:

$$\beta = \delta - \frac{1}{2}.$$

When markets are fully integrated ($\tau = 0$), both countries consume identical goods baskets ($\delta = \frac{1}{2}$, so that $\beta = 0$). When markets are less than fully integrated ($\tau > 0$), there is a bias towards spending on domestically-produced goods ($\delta > \frac{1}{2}$, so that $\beta > 0$), since firms charge a higher price to foreign customers and since consumers are sensitive to relative prices. Theoretically, when firms would charge a lower price abroad than in their home market, the home bias could actually be negative.

When the price-elasticity of demand is very low ($\theta \to 1$), there is no home bias. The consumers' 'love for variety' is strong enough to overcome even high costs to international trade ($\lim_{\theta\to 1}\beta = 0$). By contrast, when the price-elasticity of demand is very high ($\theta \to \infty$), positive transportation costs ($\tau > 0$) imply that firms are unable to compete in foreign markets. Consumers are very sensitive to prices, so they are unwilling to pay more for the variety that foreign

[8] The firm income per unit produced for the foreign market is the same as per unit produced for the domestic market. In terms of firm revenue, the price charged abroad, which is a fraction τ higher than the price charged in the domestic market, precisely offsets the melting loss, which amounts to a fraction τ of the volume of exports. Only in the special case that these costs tend to zero ($\tau \to \mathbf{0}$), it becomes optimal to sell goods for the same price in both countries and the law of one price holds, as in Obstfeld and Rogoff (1995).

goods bring.[9] They will spend all money on domestically-produced goods and no international trade will take place ($\lim_{\theta\to\infty}\beta = \frac{1}{2}$). Even in less extreme cases, small transportation costs can cause a large home bias, as we will see below.

Table 1 shows the sensitivity of the home bias with respect to the price-elasticity of demand (θ) and the costs of international trade (τ). The literature provides some (implicit) estimates for the price-elasticity of consumption. Obstfeld and Rogoff (2000) cite a number of papers that have estimated product mark-ups. According to their survey, most authors find results that correspond to a price-elasticity of demand (θ) in a range between 3.5 and 6, but some find a price-elasticity as high as 20 for OECD countries. The literature also provides a basis to quantify trade costs (τ). Smith and Venables (1988) estimate the tariff-equivalent of intra-EC trade barriers to be between 23 and 44%. Verwaal and Cnossen (2000) conclude that the compliance costs of new VAT and statistical requirements alone have a lower bound of 5% of the value of intra-EU trade. As stated in the introduction, Rose and Van Wincoop (2001) find that the tariff-equivalent of not using the same currency is 26%. These findings in the literature explain the choice of the parameters in the Table.

Table 1: Transportation costs and home bias

	trade cost τ	home bias β	trade share $1-\delta$	spending ratio $c(h)/c(f)$
$\theta = 3:$				
	5%	3%	47%	1,2
	20%	11%	39%	2,0
	50%	30%	20%	8,0
$\theta = 5:$				
	5%	5%	45%	1,3
	20%	21%	29%	3,1
	50%	44%	6%	32,0
$\theta = 10:$				
	5%	11%	39%	1,7
	20%	38%	12%	9,3
	50%	50%	0%	>200
$\theta = 20:$				
	5%	23%	27%	2,8
	20%	49%	1%	86,7
	50%	50%	0%	>200

[9] Equivalently, when the degree of substitutability (θ) increases, the product variety is lower. Therefore, the additional variety that foreign goods bring is also lower.

From Table 1 it is clear that the higher the price-elasticity of demand and the higher the costs of international trade, the larger the home bias. Small trading costs can cause a large home bias. For the average price-elasticity reported in the literature ($\theta = 5$), a 20% cost is sufficient to lead to a substantial home bias ($\beta = 21\%$). In the case of $\theta = 20$, trading costs of just over five per cent are sufficient to generate a similar home bias.

The quantitative results in Table 1 are relevant only for large economic areas.[10] But even for regions like the euro area and the United States, the quantitative results from a model with two countries of equal size can only give a very rough indication.

Several recent papers focus on the ratio of consumer spending on domestically-produced and imported goods, as defined by equation (18), the 'spending ratio'. The spending ratios reported in the empirical literature vary greatly. McCallum (1995) finds that, after controlling for population size and distance, Canadian consumers are 22 times more likely to buy from a Canadian producer than from a US producer.[11] At the other end of the spectrum, Wei (1996) reports a spending ratio of 2.5 for OECD countries, after controlling for economic size, distance between countries, geographic location and a possible linguistic tie. Wolf (1997) examines whether the home bias is also present at the sub-national level. He concludes affirmatively, but also finds that the international home bias is larger (by a factor five) than the intra-national home bias. A recent study by Head and Mayer (2000) puts the spending ratio for European countries at 12, down from 21 in the late 1970s.

The home bias (β) has a one-to-one relationship with the share of foreign trade in national output ($1 - \delta$). The latter variable is observable from a country's national accounts. For the euro area and the United States, the trade share amounts to 10-15% of GDP.

What reduction in the costs of international trade is required to explain the substantial decline in the home bias for European countries since the late 1970s reported by Head and Mayer? If $\theta = 5$ (the average price-elasticity reported in the literature) is believed to be realistic (it is probably even lower for luxury goods), then Head and Mayer's empirical finding that the spending ratio for European countries has declined from twenty-one to twelve implies that the cost of international trade has declined from 45% to 40% of the value of the traded

[10] In this model, both countries account for half of world output, so that in the absence of trading costs (i.e. when $\tau = \mathbf{0}$), the share of trade in national income is 50%. Small open economies, such as the Netherlands and Belgium, account for only 1-2% of world output. Therefore, in the absence of trading costs, the share of trade in national income should be 98-99% for these countries. Thus, the home bias caused by the costs of international trade needs to be measured against another (higher) baseline value for small countries.

[11] The finding of segmented national markets is confirmed by Engel and Rogers (1996) who study price dispersion across the US-Canadian border, rather than the volume of trade. They find that the distance between cities explains a significant amount of the variation in the prices of similar goods in different cities. But the variation of the price is much higher for two cities located in different countries than for two equidistant cities in the same country, even after taking into account such factors as the influence of the nominal exchange rate on the calculation of cross-border prices, the role of sticky prices and the relative homogeneity of labour markets within countries.

products. However, if we believe $\theta = 20$ to be more realistic (as may be the case for commodities, like wheat), the implied decline in the cost of international trade is from 14% to 12%. This suggests that a decline of two to five percentage points in trade costs would be sufficient to explain the observed reduction in the home bias over a twenty-year period. But, again, one should be careful not to overstress the validity of the exact numbers for real-world countries.

Two results emerge from the considerations above. First, for realistic values of the price-elasticity parameter, small trading costs lead to a substantial home bias in international trade. Thus, small trading costs are sufficient to explain the empirical finding that only a very small part of income is spent on foreign-produced goods. Second, the substantial decline in the home bias for European countries since the late 1970s can be explained by a relatively small reduction in trading costs. The policy implication is the existence of a window of opportunities for the completion of the Single Market.

2.5 Loglinearising the model

The model does not yield simple closed-form solutions for general paths of exogenous variables, due to monopoly pricing and the endogeneity of output. Therefore, in order to study the dynamics, the model will be linearised around a symmetric steady state. The first step in this direction is deriving the solution for the initial symmetric steady state.

The model's full steady-state solution is given in Appendix A. Here, I only give the expression for steady state consumption:

$$\overline{C} = \overline{r}\overline{F} + \frac{\overline{P}^p}{\overline{P}}\overline{Y}, \tag{20}$$

where $\overline{P}^p$ is the output deflator and $\overline{P}$ is the consumption-based price index of goods in the Home country. The latter is affected not only by the domestic output deflator $\overline{P}^p$, but also by import prices [which are related to the Foreign output deflator as in equation (17)].

Under international symmetry, and using the starting condition of zero net foreign assets, it follows immediately that:

$$\frac{\overline{P}_0^P}{\overline{P}_0} = \{\frac{1}{2}[1 + (1-\tau)^{\theta-1}]\}^{\frac{1}{\theta-1}} \leq 1.$$

Due to the presence of transportation costs, the consumption-based price index will be larger than the production-based price index in equilibrium: $\overline{P}_0 > \overline{P}_0^p$. An increase in the costs of international trade affects the consumption-based price index ($\overline{P}_0$) via two channels.[12] First, it has an upward impact on the price of imports (as costs are passed on to the consumer). Second, an

[12] The level of the output deflator in the initial steady state ($\overline{P}_0^P$) is not affected by the level of transportation costs. Therefore, the ratio $\overline{P}_0^P/\overline{P}_0$ is affected by transportation costs *only via* their impact on the consumption-based price index $\overline{P}_0$.

increase in trading costs enhances the home bias, thus reducing the import weight in total consumption. Whereas more expensively priced imports push up the consumption-based price index, the increase in the home bias has a moderating impact. The first effect always dominates. Thus, an increase in the costs of international trade unambiguously leads to an increase in the general price level.[13] The implication is that the completion of the European Single Market (i.e. a reduction in trading costs) will lead to a permanent decline in the general price level (and a *temporarily* lower inflation rate).[14]

To allow for asymmetries between the two countries, it is helpful to log-linearise the model around the initial steady state. Define $\widehat{Z}_t = dZ_t/\overline{Z}_0$, that is hatted variables denote percentage changes from the initial steady state. It will be assumed that the costs of international trade (τ) are constant. The full loglinear model is presented in Appendix B.

Trading costs will enter the equations of the log-linear model via δ (which positively depends on both the trading costs and the price-elasticity of demand).

3 Money shocks

This section focuses on monetary shocks, because the role of nominal rigidities is best illustrated in the case of monetary shocks and it is this kind of disturbance that flexible-price models are least well-equipped to handle. See Lane (1999). I will take the case of an unanticipated permanent increase in the Home money supply, i.e. $\widehat{M} = \widehat{\overline{M}}$, which takes place in period $t-1$, when the economy is in the initial steady state. In order to follow the dynamics of the economy after the shock, I will distinguish between the short run and long run. Wages are assumed to be fixed for one period and fully flexible afterwards. After the shock in period $t-1$, the economy arrives at the short-run equilibrium in period t. As in Obstfeld-Rogoff (1995), the economy reaches its long-run equilibrium in $t+1$ and remains in this new steady state thereafter. Thus, there is no staggered price setting as in Calvo (1983). I will first look at this new long-run equilibrium, then turn to the short-run dynamics.

3.1 Long-run impact

The model´s symmetry admits a simple solution approach. I first solve for differences between Home and Foreign variables and then for world aggregates. This approach also provides a better insight in the underlying intuition.

From the linearised versions of equation (20) and its Foreign counterpart:

$$\widehat{\overline{C}}^d = 2\frac{\overline{r}d\overline{F}}{\overline{C}_0} + \widehat{\overline{Y}}^d + (\widehat{\overline{P}}^p)^d - \widehat{\overline{X}}. \tag{21}$$

[13] Neven, Norman and Thisse (1991) obtain a similar result in a different model.

[14] Others have also modeled the completion of the internal market as a reduction in the cost of intra-EU trade. See, for instance, Smith and Venables (1988).

If output were exogenous (i.e. when labour input were fixed), a wealth transfer equal to 1 unit of goods to the Home country would lead to a steady-state international consumption differential of $2\overline{r}$: Home country residents would raise consumption by the interest $\overline{r}$ on the transfer and Foreign residents would reduce consumption by $\overline{r}$. However, output is endogenous in this model: the net wealth transfer leads Home residents to work less and enjoy more leisure. Foreign country residents do the opposite, leading to the following (negative) international output differential:

$$\widehat{\overline{Y}}^d = -\frac{\overline{r}d\overline{F}}{\overline{C}_0}. \tag{22}$$

The endogeneity of output causes the consumption differential between the Home and Foreign country to be smaller than $2\overline{r}d\overline{F}/\overline{C}_0$.

The home country long-run terms of trade, given by

$$\widehat{\overline{TOT}} = (\widehat{\overline{P}}^p)^d - \widehat{\overline{X}} = \frac{\delta}{(1-\delta)[2(\theta-1)\delta+1]}\frac{\overline{r}d\overline{F}}{\overline{C}_0}, \tag{23}$$

improve when the Home country receives a transfer. This improvement is also driven by the labour-leisure decision. The Home country residents' decision to work less reduces Home output and therefore has an upward effect on the terms of trade. In the absence of trading costs ($\tau = 0$ and hence $\delta = \frac{1}{2}$), a wealth transfer of 1 unit of goods would lead to a change in the terms of trade by $\overline{r}/\theta$. For positive trading costs ($\tau > 0$ and hence $\delta > \frac{1}{2}$), the terms of trade improve by more than that. The intuition is that the additional Home demand caused by a wealth transfer falls mainly on Home-produced goods, thus re-inforcing the price increase of Home goods relative to the price of Foreign goods.

From equations (21), (22) and (23), the consumption differential is

$$\widehat{\overline{C}}^d = \frac{2\theta\delta+1}{2(\theta-1)\delta+1}\frac{\overline{r}d\overline{F}}{\overline{C}_0} \geq \frac{\theta+1}{\theta}\frac{\overline{r}d\overline{F}}{\overline{C}_0}, \tag{24}$$

where the inequality follows from $\tau \geq 0$ (which implies $\delta \geq \frac{1}{2}$). Thus, for positive trading costs, the consumption differential is larger than the value reported by Obstfeld and Rogoff (1995). The reason is that the home bias induces the additional consumption caused by a wealth transfer to be mainly spent on home goods, which reinforces the terms of trade effect. Thus, any additional Home consumption benefits Foreign producers only to a limited extent and therefore does not generate income abroad to the same extent as when the additional consumption were equally divided over Home and Foreign goods.

The implications for monetary policy follow directly. As will be seen when discussing the short-run dynamics below, an expansion of the Home money supply induces a short-run depreciation of the Home currency and a short-run current account surplus for the Home country, which is balanced by a net transfer of financial assets from Foreign to Home. The accumulation of net foreign assets implies that, in the long run, Home residents can afford themselves to consume more and work less. The long-run terms of trade improve, which reinforces the possibility for home residents to consume more. Thus, equation (24) implies that a money supply shock, via the wealth effect, has an upward effect on the long-run consumption differential. In other words, money can have real effects in the long-run via the intertemporal consumption smoothing channel (Obstfeld and Rogoff, 1996, p. 680).

International trading costs imply that monetary policy becomes better able to influence the international consumption differential. The intuition is as follows. In the first place, positive costs of international trade reduce the share of imported goods in national income. Therefore, a larger short-run exchange rate depreciation is required to reach equilibrium in the money market (the price differential become less responsive to the exchange rate). The larger exchange rate depreciation implies that a larger current account adjustment will take place, i.e. more net foreign assets are accumulated. The additional interest income on net foreign assets facilitates a larger long-run consumption differential. Secondly, the home bias implies that the additional Home consumption caused by the wealth transfer is mainly spent on Home goods, which re-inforces the long-run terms of trade effect, which widens the consumption differential further. Thus, positive costs of international trade enhance the effectiveness of monetary policy with respect to consumption.

Next, look at the international CPI differential. Combining the steady-state version of the linearisation of equation (7) with equation (24) yields:

$$\widehat{\overline{P}}^{d} = \widehat{\overline{M}}^{d} - \frac{2\theta\delta+1}{2(\theta-1)\delta+1}\frac{\overline{r}d\overline{F}}{\overline{C}_0} \leq \widehat{\overline{M}}^{d} - \frac{\theta+1}{\theta}\frac{\overline{r}d\overline{F}}{\overline{C}_0}, \tag{25}$$

where, again, the inequality follows from $\tau \geq 0$ (which implies $\delta \geq \frac{1}{2}$). The wealth effect which causes money to affect long-run real consumption differentials, also implies that the long-run CPI differential changes less than proportionately to a permanent money shock: $\widehat{\overline{P}}^{d} < \widehat{\overline{M}}^{d}$. For positive trading costs, the CPI differential is smaller than the value reported by Obstfeld and Rogoff (1995). Long-term equilibrium in the money market requires that a permanent increase in the money supply is fully reflected in an increase in the *nominal* value of consumption. In other words, equilbrium requires that a money shock is distributed over real consumption and the CPI. From equation (24), trading costs make monetary policy more effective with respect to the international consumption differential. Therefore, positive costs of international trade must reduce the effectiveness of monetary policy with respect to the general price level.

It follows that in an environment of *declining* costs of international trade, monetary policy becomes less able to affect consumption, but better able to affect the general price level.

Next, I turn to world aggregates. It turns out that trading costs do not affect the long-run value of world aggregates.[15] Combining the linearised version

[15] This does *not* imply that trading costs only have distributive effects in this model. Recall

of equations (8), (9) (12)-(13) and (20) with their foreign counterparts yields $\widehat{Y}^w = \widehat{C}^w = 0$. Money is neutral at the world level in the long run. Combining this result with the money demand equation (7) and its foreign counterpart immediately yields $\widehat{P}^w = \widehat{M}^w$. World money shocks will translate one-for-one into price increases at the world level.

3.2 Short-run impact

Next, turn to the short run. Recall that I consider the impact of an unanticipated permanent shock to the Home money supply.

Wages are assumed to be fixed in the short run. Given a constant product mark-up and constant labour productivity, the assumption of short-run nominal wage stickiness directly implies short-run stickiness of output prices [see equation (12)]. Therefore, the short-run world price level is not affected by changes in the money supply: $\widehat{P}^w = 0$. The expressions for world output, world consumption and the world interest rate are: $\widehat{Y}^w = \widehat{C}^w = \widehat{M}^w$ and $\widehat{r} = -\frac{1}{1-\beta}\widehat{M}^w$. In the short run, wages cannot adjust to money shocks. As a result, monetary policy is able to affect output and consumption. In this model, a one percent increase in the world money supply leads to a one percent increase in world output and consumption in the short run.

An increase in the world money supply leads to a decline in the world real interest rate. As a result of the short-run stickiness of nominal wages, the short-run impact of monetary policy on output exceeds its long-run impact. The real interest rate must decline in order to induce a similar time-pattern for world consumption (via lower savings). Note that trading costs do not affect short-run world aggregates.

Next, turn to international differences. The reduced-form solutions are:

$$\widehat{Y}^d = [1 + \frac{2(2\delta\theta - 1)}{2 + \overline{r}(2\delta\theta + 1)}]\widehat{M}^d, \tag{26}$$

$$\widehat{C}^d = \frac{\overline{r}(2\delta\theta - 1)(2\delta\theta + 1)}{[2\delta(\theta - 1) + 1][2 + \overline{r}(2\delta\theta + 1)]}\widehat{M}^d. \tag{27}$$

It is easy to show that $\widehat{Y}^d > \widehat{C}^d$. The intuition is that output becomes demand-determined when wages are rigid. Under monopolistic competition, prices are set above the marginal cost of production. Therefore, at the margin, it is profitable for firms to accommodate additional demand by producing more output.[16] This means that output becomes demand-determined when wages are rigid. As will be seen below, a money expansion in the home country causes a depreciation of the home currency ($\widehat{X} > 0$). This induces net foreign demand for Home goods ($\widehat{Y}^d > \widehat{C}^d$). Both $\widehat{Y}^d$ and $\widehat{C}^d$ are increasing in δ, i.e. the output differential and consumption differential increase in trading costs. The intuition is as

that in this section, I consider small changes in variables. In fact, trading costs *do* have a negative impact on the equilibrium value of consumption.

[16] As stated, this is only true at the margin, i.e. for small increases in demand. See Blanchard and Kiyotaki (1987).

follows. First, we have already seen that the long-run consumption differential is increasing in trading costs. Intertemporal consumption smoothing implies that the short-run consumption differential must also be increasing in trading costs. Secondly, a larger short-run exchange rate depreciation is required to achieve money market equilibrium. The larger exchange-rate depreciation leads to a larger net foreign demand for Home goods, i.e. the net foreign demand for Home goods is also increasing in trading costs. Third, if the short-run consumption differential and the net foreign demand for Home goods are both increasing in trading costs, this must also be the case for the output differential.

The short-run current account (which equals the change in net foreign assets) has the following reduced form:

$$\frac{d\overline{F}}{\overline{C}_0} = \frac{2\delta\theta - 1}{2 + \overline{r}(2\delta\theta + 1)} \widehat{M}^d. \tag{28}$$

An expansion of the Home money supply leads to a short-run surplus on the Home current account.[17] The larger the trading costs (τ), the larger δ, the larger the short-run current account surplus (the coefficient on the right-hand side of equation (28) is increasing in δ). The intuition is that the larger the home bias, the larger the short-run exchange rate depreciation that is required to reach equilibrium in the money market (as the price differential become less responsive to the exchange rate). The larger exchange rate depreciation induces a larger current account surplus.

3.3 Exchange rate dynamics

The exchange rate has a substantial role to play in this model. The reason is that the assumptions of short-run nominal wage rigidity and constant mark-ups in this model directly imply short-run price rigidity. Given that wages are all fixed in the short run, short-run relative prices ($\widehat{P}^d$) can only change due to exchange-rate movements. Note that the larger the home bias, the smaller the impact of exchange rate movements on the short-run price differential.

The long-run solution for the exchange rate is:

$$\widehat{\overline{X}} = \widehat{\overline{M}}^d - [1 + \frac{\delta}{(1-\delta)[2(\theta-1)\delta+1]}]\frac{\overline{r}d\overline{F}}{\overline{C}_0} < \widehat{\overline{M}}^d - \frac{1+\theta}{\theta}\frac{\overline{r}d\overline{F}}{\overline{C}_0},$$

where the expression on the right-hand side of the inequality is the solution in the absence of trading costs ($\tau = 0 \Rightarrow \delta = \frac{1}{2}$) and the inequality itself follows from the presence of positive trading costs ($\tau > 0 \Rightarrow \delta > \frac{1}{2}$). Thus, the home bias in consumption reduces the impact of money shocks on the long-run value of the exchange rate. The reduced-form solution is

$$\widehat{\overline{X}} = \frac{1}{2 + \overline{r}(2\delta\theta + 1)} \left\{ 2(1 + \overline{r}) - \frac{\overline{r}\delta(2\delta\theta - 1)}{(1-\delta)[2\delta(\theta-1)+1]} \right\} \widehat{\overline{M}}^d. \tag{29}$$

[17] In the special case $\delta = \frac{1}{2}$ (no trading costs, hence no home bias), the expression reduces to $\frac{d\overline{F}}{\overline{C}_0} = \frac{\theta - 1}{2 + \overline{r}(1+\theta)} \widehat{M}^d$, as found by Obstfeld-Rogoff (1995).

It is straightforward to show that the Home currency will show a long-run depreciation in response to a money shock, unless δ is sufficiently large, that is unless trading costs are above a certain value (see below).

The short-run solution for the exchange rate is

$$\widehat{X} = \frac{1}{2+\overline{r}(2\delta\theta+1)}\left\{\frac{1}{1-\delta}+\frac{\overline{r}(2\delta\theta+1)}{2\delta(\theta-1)+1}\right\}\widehat{\overline{M}}^{d}. \tag{30}$$

It is easy to show that exchange rate overshooting occurs in this model (i.e. $\widehat{\overline{X}} < \widehat{X}$: see Appendix C for a proof). Theoretical explanations for the empirical observation that exchange rate movements are much more volatile than goods prices go back to Dornbusch (1976). He presents an IS-LM model with sticky prices and rational expectations. The intuition behind his exchange rate overshooting result is that, under short-run price stickiness, an expansion of the money supply must be followed by a decline in interest rates in order to restore equilibrium in the money market. The lower level of Home interest rates implies that, under rational expectations, agents must expect an appreciation of the domestic currency. However, long run equilibrium requires a net depreciation. This can only happen if the exchange rate overshoots in the short run. The basic Obstfeld and Rogoff (1995) model has no exchange rate overshooting, but several extensions of this model (which are part of the so-called New Open Macroeconomics) do. As in Dornbusch's paper, the overshooting result in the New Open Macroeconomics literature depends on the assumption that goods prices (or wages) adjust slowly relative to financial asset prices. However, it does not rely on (rational) expectation formation. In Hau (2000) and Cavelaars (2001), overshooting is caused by the presence of non-tradables. Given wage stickiness and a constant mark-up, the relative price of non-tradables cannot adjust in the short run. Thus, the relative price adjustment depends on the exchange rate passthrough and monetary equilibrium requires a relatively large short-run adjustment of the nominal exchange rate. In these papers, exchange rate volatility is inversely related to openness (the share of tradables). The present model contains only tradable goods, as in Warnock (1999). There, a bias in consumer preferences causes a home bias in consumer spending. Here, a home bias in consumer spending is caused by the presence of trading costs. The intuition behind the overshooting in both papers is similar to Hau (2000) and Cavelaars (2001): output prices cannot adjust in the short run, so the relative price level can only change due to short-run exchange rate changes. A larger home bias in spending (caused by either asymmetric preferences or trading costs) implies that a small share of goods are affected by exchange rate movements. Thus, a larger short-run exchange rate movement is required to attain short-run money market equilibrium.

When the costs associated with international trade are substantial, short-run exchange rate movements in response to monetary shocks can become extremely large. Thus, the presence of international trading costs can explain large short-run exchange rate volatility. In fact, when trade costs are sufficiently large ($\delta \rightarrow 1$), the short-run depreciation of the Home currency in response to a Home money shock becomes so large ($\widehat{X} >> 0$) that a long-run appreciation of the Home currency ($\widehat{\overline{X}} < 0$) is required in order to achieve general equilibrium. Thus, the impact of money on the long-run exchange rate is ambiguous in general. It is possible to show that there is a unique admissible value of τ for which $d\widehat{\overline{X}}/d\widehat{\overline{M}}^d = 0$. For lower trading costs, the Home currency shows a long-run depreciation in response to an increase in the Home money supply ($d\widehat{\overline{X}}/d\widehat{\overline{M}}^d > 0$). For higher trading costs, the Home currency shows a long-run appreciation in response to an increase in the Home money supply ($d\widehat{\overline{X}}/d\widehat{\overline{M}}^d < 0$). Table 2 shows some numerical results. In all the results in this Table, I have assumed $\overline{r} = 3\%$ and $d\widehat{\overline{M}}^d = 1\%$.

Table 2: Exchange rate response to a 1% Home money shock, under positive costs to international trade

trade cost τ	short-run XR response $\widehat{X}$	long-run XR response $\widehat{\overline{X}}$
$\theta = 3$:		
5%	1.00%	0.96%
20%	1.22%	0.95%
50%	2.32%	0.90%
70%	5.54%	0.79%
$\theta = 5$:		
5%	1.0%	0.9%
20%	1.6%	0.9%
50%	7.4%	0.7%
70%	53.5%	-0.7%
$\theta = 10$:		
5%	1.1%	0.8%
20%	3.3%	0.7%
50%	>100%	-5.0%
$\theta = 20$:		
5%	1.3%	0.7%
20%	21.9%	-0.0%
50%	>100%	<-100%

From Table 2, the exchange rate response to an increase in the Home money supply is quite sensitive to the elasticity of substitution (θ) and the costs of international trade (τ). Let us take the costs of international trade to be 20% of the value of traded goods. Then, if we regard $\theta = 5$ as plausible, a one percent increase in the Home money supply will lead to a 0.9% increase in the long-run exchange rate. Short-run exchange rate overshooting will occur, but only to a limited degree: the short run exchange rate will increase by 1.6%. If we regard $\theta = 20$ to be more plausible, a one percent increase in the Home money supply will have a negative, but almost negligible impact on the long-run value of the exchange rate. However, the short-run exchange rate will increase by over 20%.

When the costs associated with international trade are substantial, short-run exchange rate movements in response to monetary shocks can become extremely large. Thus, the presence of costs to international trade and imperfect competition can explain quite high short-run exchange rate volatility in response to money shocks.

4 Conclusions

This paper analyses the consequences of the remaining barriers to cross-border competition in the context of the Obstfeld and Rogoff (1995) framework. This framework allows for imperfect competition and nominal rigidities. I explicitly incorporate 'transportation costs' for trade between two countries into the model. The introduction of costs for international trade implies that the model deviates from the standard Obstfeld and Rogoff (1995) model. First, the law of one price need not hold. Second, trade costs lead to an endogenous home bias in consumer spending.

This approach leads to the following results. First, for realistic values of the price-elasticity parameter, small trading costs lead to a substantial home bias in international trade. This result is in line with the more general finding in the literature that even small transaction costs can have significant economic effects. Numerically, I have shown that the large decline in the home bias for European countries since the late 1970s found in the literature can be explained by a relatively small reduction in trading costs. The policy implication is the existence of a window of opportunities for the completion of the Single Market.

Second, the Single Market initiative may have important consequences for the transmission of ECB monetary policy. More specifically, in an environment of declining costs of international trade, monetary policy becomes *less* powerful in terms of affecting consumption, but *more* effective in terms of influencing the general price level. The intuition behind this result is that the presence of positive costs of international trade lead to a home bias in spending, which reinforces the transmission channels from money to consumption in the basic Obstfeld-Rogoff model. Therefore, a *decline* in the costs of international trade *reduces* the effectiveness of monetary policy with respect to consumption. The effectiveness of monetary policy with respect to the general price level is the flip-side of its effectiveness with respect to consumption (this follows from the long-run equilibrium conditions in the money market). Therefore, a decline in the costs of international trade implies that monetary policy becomes less able to affect consumption, but better able to influence the general price level.

Third, large short-run exchange rate volatility can be explained by the presence of international trading costs in the goods market. The intuition is as follows. Wages are assumed to be sticky. In the current paper, this implies that output prices cannot adjust in the short run either, so in the short run the relative price level can only adjust as a result of exchange rate changes. All goods are tradable, but costs of international trade lead to a home bias in spending, which implies that only a small share of goods is actually affected by exchange-rate movements. As a result, a large short-run exchange rate movement is required to attain short-run money market equilibrium. I have shown numerically that when the costs associated with international trade are substantial, short-run exchange rate movements in response to monetary shocks can become extremely large.

Appendices

A The initial steady state

In the steady state, using the assumption of symmetry among producers in each country, the equations for the Home country are:

$$\begin{aligned}
\overline{P} &= \left[\frac{1}{2}\left[\overline{P}^{p}\right]^{1-\theta} + \frac{1}{2}\left[\frac{\overline{X}}{1-\tau}(\overline{P}^{p})^{*}\right]^{1-\theta}\right]^{\frac{1}{1-\theta}}, \\
\overline{i} &= \overline{r}, \\
\overline{r} &= \frac{1-\beta}{\beta}, \\
\frac{\overline{M}}{\overline{P}} &= \chi\overline{C}\left(\frac{1+\overline{i}}{\overline{i}}\right), \\
\overline{L} &= \frac{1}{\kappa}\frac{\overline{W}}{\overline{P}}\frac{1}{\overline{C}}, \\
\overline{Y} &= \frac{1}{2}\left(\frac{\overline{P}^{p}}{\overline{P}}\right)^{-\theta}\overline{C} + \frac{1}{2}(1-\tau)^{\theta-1}\left(\frac{\overline{P}^{p}}{\overline{X}\overline{P}^{*}}\right)^{-\theta}\overline{C}^{*}, \\
\overline{\Pi} &= \overline{P}^{p}\overline{Y} - \overline{W}\overline{L}, \\
\overline{P}^{p} &= \left(\frac{\theta}{\theta-1}\right)\frac{\overline{W}}{\alpha}, \\
\overline{L} &= \frac{1}{\alpha}\overline{Y}, \\
\overline{C} &= \overline{r}\overline{F} + \frac{\overline{P}^{p}}{\overline{P}}\overline{Y}.
\end{aligned}$$

Therefore, we have a total of (2x10 =) 20 equations. The above system of equations contains 21 endogenous variables: ten for the home country: $\overline{Y}$, $\overline{C}$, $\overline{P}$, $\overline{P}^{p}$, $\overline{W}$, $\overline{L}$, $\overline{\Pi}$, $\overline{F}$, $\overline{r}$, $\overline{i}$, ten for the foreign country: $\overline{Y}^{*}$, $\overline{C}^{*}$, $\overline{P}^{*}$, $(\overline{P}^{p})^{*}$, $\overline{W}^{*}$, $\overline{L}^{*}$, $\overline{\Pi}^{*}$, $\overline{F}^{*}$, $\overline{r}^{*}$, $\overline{i}^{*}$ and one variable that relates to both countries: $\overline{X}$.

As in Obstfeld and Rogoff (1995), the model is closed by imposing the starting condition of zero net foreign assets:

$$\overline{F}_0 = 0.$$

B The loglinearised model

B.1 In terms of equations for each country separately

In the long-run, the level of the net foreign assets $\overline{F}$ is predetermined. There are seven equations for the Home country. Similarly, there are seven corresponding equations for the Foreign country. Denoting long-run steady state changes by hatted overbars, the equations for the Home country are:

$$
\begin{aligned}
\widehat{\overline{P}}^p &= \widehat{\overline{W}}, \\
\widehat{\overline{Y}} &= \delta\{-\theta[\widehat{\overline{P}}^p - \widehat{\overline{P}}] + \widehat{\overline{C}}\} + (1-\delta)\{-\theta[\widehat{\overline{P}}^p - \widehat{\overline{X}} - \widehat{\overline{P}}^*] + \widehat{\overline{C}}^*\} = \\
&= \delta\widehat{C} + (1-\delta)\widehat{C}^* - \theta\left\{\widehat{P}^p - \delta\widehat{P} - (1-\delta)[\widehat{P}^* + \widehat{X}]\right\}, \\
\widehat{\overline{L}} &= \widehat{\overline{W}} - \widehat{\overline{P}} - \widehat{\overline{C}}, \\
\widehat{\overline{L}} &= \widehat{\overline{Y}}, \\
\widehat{\overline{M}} - \widehat{\overline{P}} &= \widehat{\overline{C}}, \\
\widehat{\overline{P}} &= \delta\widehat{\overline{P}}^p + (1-\delta)[\widehat{\overline{X}} + (\widehat{\overline{P}}^p)^*], \\
\widehat{\overline{C}} &= \overline{r}\frac{d\overline{F}}{\overline{C}_0} + \widehat{\overline{P}}^p - \widehat{\overline{P}} + \widehat{\overline{Y}}.
\end{aligned}
$$

Next, turn to the short run. The short-run nominal wage rate is fixed. There are four equations for the home country and four corresponding equations for the foreign country. Denoting short-run changes by hatted variables (no overbars), the short-run equations for the home country are

$$
\begin{aligned}
\widehat{P}^p &= 0, \\
\widehat{L} &= \widehat{Y}, \\
\widehat{P} &= \delta\widehat{P}^p + (1-\delta)[\widehat{X} + (\widehat{P}^p)^*] = \\
&= (1-\delta)\widehat{X}, \\
\widehat{Y} &= \delta\{-\theta[\widehat{P}^p - \widehat{P}] + \widehat{C}\} + (1-\delta)\{-\theta[\widehat{P}^p - \widehat{X} - \widehat{P}^*] + \widehat{C}^*\} = \\
&= \delta\widehat{C} + (1-\delta)\widehat{C}^* + 2\theta\delta(1-\delta)\widehat{X}.
\end{aligned}
$$

Three equations for each country relate the short run to the long run:

$$
\begin{aligned}
\widehat{\overline{C}} - \widehat{C} &= (1-\beta)\widehat{r}, \\
\widehat{M} - \widehat{P} &= \widehat{C} - \beta\widehat{r} - \frac{\beta}{1-\beta}(\widehat{\overline{P}} - \widehat{P}), \\
\frac{d\overline{F}}{\overline{C}_0} &= \widehat{Y} - \widehat{C} - \widehat{P}.
\end{aligned}
$$

B.2 In terms of world aggregates and country differences

It is straightforward to rewrite the equations of the loglinearised model in terms of differences between home and foreign variables and in terms of world aggregates. Define: $x^d = x - x^*$ and $x^w = \frac{1}{2}(x + x^*)$, for any variable x.

The long-run equations can be rewritten as six independent equations in world aggregates:

$$
\begin{aligned}
\widehat{\overline{Y}}^w &= \widehat{\overline{L}}^w, \\
(\widehat{\overline{P}}^P)^w &= \widehat{\overline{W}}^w, \\
\widehat{\overline{M}}^w - \widehat{\overline{P}}^w &= \widehat{\overline{C}}^w, \\
\widehat{\overline{L}}^w &= \widehat{\overline{W}}^w - \widehat{\overline{P}}^w - \widehat{\overline{C}}^w, \\
\widehat{\overline{P}}^w &= (\widehat{\overline{P}}^P)^w \\
\widehat{\overline{Y}}^w &= \widehat{\overline{C}}^w.
\end{aligned}
$$

and seven independent equations in country differences:

$$
\begin{aligned}
\widehat{\overline{Y}}^d &= \widehat{\overline{L}}^d, \\
(\widehat{\overline{P}}^p)^d &= \widehat{\overline{W}}^d, \\
\widehat{\overline{M}}^d - \widehat{\overline{P}}^d &= \widehat{\overline{C}}^d, \\
\widehat{\overline{L}}^d &= \widehat{\overline{W}}^d - \widehat{\overline{P}}^d - \widehat{\overline{C}}^d, \\
\widehat{\overline{P}}^d &= (2\delta - 1)(\widehat{\overline{P}}^p)^d + 2(1-\delta)\widehat{\overline{X}}, \\
\widehat{\overline{Y}}^d &= -\theta(\widehat{\overline{P}}^p)^d + \theta(2\delta - 1)\widehat{\overline{P}}^d + 2\theta(1-\delta)\widehat{\overline{X}} + (2\delta - 1)\widehat{\overline{C}}^d, \\
\widehat{\overline{C}}^d &= 2\overline{r}\frac{d\overline{F}}{\overline{C}_0} + (\widehat{\overline{P}}^p)^d - \widehat{\overline{P}}^d + \widehat{\overline{Y}}^d.
\end{aligned}
$$

Note that $d\overline{F}$ is predetermined (in the short run, as will be seen below): the short-run trade balance determines the transfer of net foreign assets ($d\overline{F}$) which, combined with the requirement that the long-run current account must be balanced, determines the long-run trade balance. Thus, there are 13 independent equations in 13 endogenous variables: $\widehat{\overline{Y}}^w$, $\widehat{\overline{C}}^w$, $\widehat{\overline{P}}^w$, $(\widehat{\overline{P}}^p)^w$, $\widehat{\overline{W}}^w$, $\widehat{\overline{L}}^w$, $\widehat{\overline{Y}}^d$, $\widehat{\overline{C}}^d$, $\widehat{\overline{P}}^d$, $(\widehat{\overline{P}}^p)^d$, $\widehat{\overline{W}}^d$, $\widehat{\overline{L}}^d$, $\widehat{\overline{X}}$.

Next, turn to the short run and recall that nominal wages are fixed in the short run. The short-run equations (and the equations relating the short and long run) can be rewritten as six independent equations in world aggregates:

$$
\begin{aligned}
\widehat{Y}^w &= \widehat{L}^w, \\
(\widehat{P}^P)^w &= 0, \\
(\widehat{P})^w &= 0, \\
\widehat{Y}^w &= \widehat{C}^w, \\
\widehat{\overline{C}}^w - \widehat{C}^w &= (1-\beta)\widehat{r}, \\
\widehat{M}^w - \widehat{P}^w &= \widehat{C}^w - \beta\widehat{r} - \frac{\beta}{1-\beta}(\widehat{\overline{P}}^w - \widehat{P}^w),
\end{aligned}
$$

and seven independent equations in terms of country differences:

$$
\begin{aligned}
\widehat{Y}^d &= \widehat{L}^d, \\
(\widehat{P}^P)^d &= 0, \\
\widehat{P}^d &= 2(1-\delta)\widehat{X}, \\
\widehat{Y}^d &= 4\delta(1-\delta)\theta\widehat{X} + (2\delta-1)\widehat{C}^d, \\
\widehat{\overline{C}}^d - \widehat{C}^d &= 0, \\
\widehat{M}^d - \widehat{P}^d &= \widehat{C}^d - \frac{\beta}{1-\beta}(\widehat{\overline{P}}^d - \widehat{P}^d), \\
2\frac{d\overline{F}}{\overline{C}_0} &= \widehat{Y}^d - \widehat{C}^d + (\widehat{P}^P)^d - \widehat{P}^d.
\end{aligned}
$$

Note that $\widehat{\overline{P}}^d$ and $\widehat{\overline{C}}^d$ are determined in the long run (see above). Thus, there are 13 independent equations in 13 endogenous variables: $\widehat{Y}^w$, $\widehat{C}^w$, $\widehat{P}^w$, $(\widehat{P}^p)^w$, $\widehat{L}^w$, $\widehat{Y}^d$, $\widehat{C}^d$, $\widehat{P}^d$, $(\widehat{P}^P)^d$, $\widehat{L}^d$, $\widehat{X}$, $d\overline{F}$, $\widehat{r}$.

C Exchange-rate overshooting

The long-run and short-run money demand equations are:

$$
\begin{aligned}
\widehat{\overline{M}}^d - \widehat{\overline{P}}^d &= \widehat{\overline{C}}^d, \\
\widehat{M}^d - \widehat{P}^d &= \widehat{C}^d - \frac{\beta}{1-\beta}(\widehat{\overline{P}}^d - \widehat{P}^d).
\end{aligned}
$$

Subtract and note that $\widehat{\overline{C}}^d = \widehat{C}^d$ (Appendix B) and that, in the case of permanent money shocks, $\widehat{\overline{M}}^d = \widehat{M}^d$. Then:

$$
\widehat{\overline{P}}^d - \widehat{P}^d = -\frac{\beta}{1-\beta}(\widehat{\overline{P}}^d - \widehat{P}^d).
$$

It follows directly that the long-run price differential must equal the short-run price differential:

$$
\widehat{\overline{P}}^d = \widehat{P}^d.
$$

Recall that

$$
\begin{aligned}
\widehat{\overline{P}}^d &= (2\delta-1)(\widehat{\overline{P}}^p)^d + 2(1-\delta)\widehat{\overline{X}}, \\
\widehat{P}^d &= 2(1-\delta)\widehat{X}.
\end{aligned}
$$

It follows immediately that

$$
\widehat{X} = \widehat{\overline{X}} + \frac{2\delta-1}{2(1-\delta)}(\widehat{\overline{P}}^p)^d.
$$

In the special case $\delta = \frac{1}{2}$, as in Obstfeld and Rogoff (1995), no exchange-rate overshooting will take place ($\widehat{\overline{X}} = \widehat{X}$). However, since the output price differential responds positively to a Home money shock $[d(\widehat{\overline{P}}^p)^d / d\widehat{\overline{M}}^d > 0]$, it follows that in the case of positive trading costs ($\delta > \frac{1}{2}$) exchange rate overshooting ($\widehat{\overline{X}} < \widehat{X}$) is required to ensure that the above equilibrium condition $\widehat{\overline{P}}^d = \widehat{P}^d$ is satisfied.

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