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Abstract

This paper studies how country size affects the role of the exchange rate in external adjustment. First, the impact of country size on the sensitivity of relative prices to external imbalances is explored in a standard two-country neoclassical model. Second, at the empirical level, a significant effect of external imbalances on relative prices is found. In particular, a trade surplus is associated with a deteriorating terms of trade and a declining relative price of non-traded goods, feeding into a depreciation of the real exchange rate. Estimation for G3 and non-G3 sub-samples reveals a systematic pattern in the sensitivity of relative prices to external imbalances, with the transfer effect stronger in larger countries.

Keywords: External imbalances; Relative prices; Transfer effect; Country size
JEL classification: F40; F41

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1. Introduction

Research on the role of the exchange rate in external adjustment has a long established tradition. Following the famous debate between Keynes (1929) and Ohlin (1929) on the effects of German reparations, the transfer problem has become a central issue in international macroeconomics. Two major approaches have been taken: one emphasizing the impact of international payments on the terms of trade, the other highlighting the impact on the relative price of non-traded goods.[1]

The motivation for this paper is to investigate whether country size affects the magnitude of the transfer effect.[2] There are several reasons to believe that the transfer effect is different between large and small countries. First, as emphasized by Keynes (1929), the presence of 'home bias' is necessary for the transfer effect to exist. Second, the contribution of the relative price of non-traded goods to the real exchange rate has proved to be important in both theoretical and empirical literature on external imbalances.[3] Larger countries tend to have both a larger expenditure share on domestic traded goods and a larger non-traded sector. For these reasons, we may expect the scale of the transfer effect to be sensitive to country size. However, we are unaware of any quantitative study of the transfer effect and its dependence on country size.

There is a tremendous amount of literature studying the transfer effect. Samuelson (1952) challenges the 'orthodox' view regarding the implications of transport costs and the deteriorating terms of trade of the transfer paying country. Osbtfeld and Rogoff (1996), building on the Ricardian trade model of Dornbusch et al. (1977), show that a positive home transfer (trade surplus) lowers domestic relative wages and increases the range of domestically produced goods, resulting in a fall of both the real exchange rate and the terms of trade. To emphasize the effect of the terms of trade, Obstfeld and Rogoff (1995) build a small country model endowed with some monopoly power. In this model, a financial transfer to home from the rest of the world decreases domestic labor supply and, consequently, the supply of domestic traded goods, resulting in an increase in the price of domestic relative to foreign traded goods. Lane and Milesi-Ferretti (2004), being more concerned with the possible exogeneity of the terms of trade for many countries, setup a small country model with an exogenous traded and a monopolistically competitive non-traded sector. A transfer to home from the rest of the world decreases labor supply to the non-traded sector, reducing the supply of non-traded goods which is matched by an increase in the relative price of non-traded goods.

At the empirical level, Obstfeld and Rogoff (1995, 1996) estimate cross sectional regressions

[1] For the first approach see Obstfeld and Rogoff (1995), Broner et al. (1997), for the second see Lane and Milesi-Ferretti (2002, 2004).

[2] Since countries come in different sizes, the size of a country may be important in studying a range of issues, including the external adjustment of, say, the USA vs Portugal.

[3] See Obstfeld and Rogoff (2005, 2006), Lane and Milesi-Ferretti (2002, 2004).

of the real exchange rate on the net foreign asset position and find a significant positive coefficient. Broner et al. (1997) study the terms of trade as the main link between relative prices and external imbalances and find a cointegrating relation between the real exchange rate, net foreign asset position and the relative price of non-traded goods. In contrast, Lane and Milesi-Ferretti (2004) study the relative price of non-traded goods as the link between external imbalances and the real exchange rate and find a cointegrating relation between the real exchange rate, net foreign asset position, relative per capita GDPs and the terms of trade. The results also show significant differences in magnitudes of the transfer effect between large and small countries.

We think that these two main strands of the literature are incomplete. First, the data strongly supports the endogeneity of the relative price of non-traded goods to external imbalances.[4] Second, the terms of trade need not be exogenous even for small countries if they specialize in a niche sector of production. This paper fills the gap by (i) endogenizing both the terms of trade and the relative price of non-traded goods to external imbalances simultaneously; and (ii) studying the relation between external adjustment, relative prices and country size at both theoretical and empirical levels.

Our theoretical base follows Obstfeld and Rogoff (2006).[5] These authors study global imbalances in a general equilibrium setup with an adjustment in both the terms of trade and the relative price of non-traded goods. In this model, however, the supply side is exogenous to relative prices. In contrast, we model a general equilibrium with intrinsically differentiated traded goods and allow for an endogenous determination of the terms of trade and the relative price of non-traded goods, feeding into the production decisions. The production side of the economy exhibits constant returns to scale. However, a fixed factor of production is intersectorally immobile, which creates a dependence of the relative price of non-traded goods on external imbalances. These assumptions, combined with a decreasing marginal utility of consumption from the rest of the world and a larger size of non-traded sector for larger economies, generate a positive relation between the country size and the absolute value of the sensitivity of relative prices to external imbalances. For instance, a 1 percentage point reduction in the trade deficit to GDP ratio requires a 3.6 percentage point depreciation of the real exchange rate for a small country with 1 percent population size relative to the world. In contrast, a 1 percentage point reduction in the trade deficit to GDP ratio requires a 6.1 percentage point depreciation of the real exchange rate for a large country with 35 percent population size relative to the world.[6]

[4] Lane and Milesi-Ferretti (2002, 2004) find a strong long-run relationship between the trade balance, net foreign asset position and the relative price of non-traded goods.

[5] Benigno and Thoenissen (2003) paper is qualitatively close to ours since they also endogenize both the terms of trade and the relative price of non-traded goods in their study of the real exchange rate. However, the authors look at the supply side determinants of the real exchange rate and not at the net foreign asset position.

[6] In a sample of 17 industrial countries, Norway, Finland, Denmark, Austria, Sweden, Belgium and Portugal

The empirical part of our paper builds on the research by Lane and Milesi-Ferretti (2002, 2004). Guided by the model, we estimate relative price sensitivities to external imbalances for two different samples of industrial countries: G3 and non-G3. We depart from the Lane and Milesi-Ferretti (2002, 2004) approach, though, by allowing for an endogenous determination of the terms of trade. Our empirical results show a significant transfer effect. A reduction of trade deficit is associated with deteriorating terms of trade and a declining relative price of non-traded goods, feeding into a depreciation of the real exchange rate. Sensitivity of relative prices to external imbalances varies systematically between G3 and non-G3 samples: larger countries tend to have a larger sensitivity. For instance, in a sample of non-G3 industrial countries the estimated transfer coefficient is 1.3, as opposed to the estimated transfer coefficient of 7.7 in the G3 sample.

The rest of the paper is organized as follows. Section two describes the theoretical framework; section three the empirical approach; section four the results; and section five conclusions.

2. Theoretical Framework

We consider a two-country, two-sector world economy. Size differences are introduced via population, with n and $1-n$ agents living in the domestic and foreign countries respectively. Being more concerned with the long-run, uncertainty is ignored. Nominal prices are completely flexible, and labor is free to move between sectors but not internationally.

2.1. Consumer's problem

Home agent j maximizes the objective function

$$U(j)=\sum_{s=t}^{\infty}\beta^{s-t}\left(\frac{C_s^{1-\sigma}(j)}{1-\sigma}-\frac{L_s^2(j)}{2}\right) \tag{1}$$

where $\sigma>0$ is the inverse of the elasticity of intertemporal substitution, $\beta\in(0,1)$ is the discount factor and $L_t(j)$ is work effort. Aggregate consumption $C_t(j)$ depends on both traded $C_{T,t}(j)$ and non-traded $C_{N,t}(j)$ goods

$$C_t(j)=\left(\gamma^{\frac{1}{\theta}}C_{T,t}^{\frac{\theta-1}{\theta}}(j)+(1-\gamma)^{\frac{1}{\theta}}C_{N,t}^{\frac{\theta-1}{\theta}}(j)\right)^{\frac{\theta}{\theta-1}} \tag{2}$$

where $\theta>0$ denotes the elasticity of substitution between traded and non-traded goods. Consumption of traded goods is a constant elasticity of substitution index of domestic $C_{TH,t}(j)$

have a 1 percent population share relative to the aggregate, while the USA has a share of 35 percent.

and foreign $C_{TF,t}(j)$ traded goods

$$C_{T,t}\left(j\right)=\left(\alpha^{\frac{1}{\eta}}C_{TH,t}^{\frac{\eta-1}{\eta}}\left(j\right)+\left(1-\alpha\right)^{\frac{1}{\eta}}C_{TF,t}^{\frac{\eta-1}{\eta}}\left(j\right)\right)^{\frac{\eta}{\eta-1}}\tag{3}$$

where $\eta>0$ captures the elasticity of substitution between domestic and foreign traded goods, while $\alpha>1/2$ represents the 'home bias' in consumption of traded goods. The assumption of 'home bias' in preferences, commonly employed in theoretical research (Warnock, 2003; Obstfeld and Rogoff, 2005, 2006), is an explicit way of modeling frictions in goods market. Under this assumption, purchasing power parity fails, even if the law of one price holds for traded goods. The sub-utility of foreign agent j' has similar functional forms. Preferences are asymmetric, for a foreign consumer attaches weights γ^* and $\alpha^*>1/2$ to the foreign traded good.

To capture country-size effects on the pattern of consumption, the weight, in our calibration, are implicitly related to country size. The relation, pictured in figure 2, is linear and increasing in country size for both 'home bias' and the weight of non-traded goods in aggregate consumption. These assumptions ensure a larger size of the non-traded sector for larger countries.[7]

The domestic consumer price index, measured in home currency units, is

$$P_t=\left(\gamma P_{T,t}^{1-\theta}+\left(1-\gamma\right)P_{N,t}^{1-\theta}\right)^{\frac{1}{1-\theta}}\tag{4}$$

where $P_{N,t}$ is the domestic price of non-traded goods and $P_{T,t}$ is the price index of traded goods. The latter is determined by the local currency prices of domestic $P_{TH,t}$ and foreign $P_{TF,t}$ traded goods

$$P_{T,t}=\left(\alpha P_{TH,t}^{1-\eta}+\left(1-\alpha\right)\left(\varepsilon_t P_{TF,t}^{*}\right)^{1-\eta}\right)^{\frac{1}{1-\eta}}\tag{5}$$

where ε_t is the nominal exchange rate.[8]

Agents in each country invest in an internationally traded bond B_t that pays interest i_t in domestic currency units, earn labor income $W_tL_t(j)$ and receive dividends $Q_t(j)$ from profits of own country firms. Correspondingly, the flow budget constraint of a domestic agent is

$$B_{t+1}\left(j\right)=\left(1+i_t\right)B_t\left(j\right)+W_tL_t(j)+Q_t(j)-P_tC_t\left(j\right)\tag{6}$$

[7] We choose a linear functional form for its simplicity, while the relation to country size is rationalized by Lane and Milesi-Ferretti (2002).

[8] The presence of the nominal exchange rate is redundant for primary results of the model since it can be rewritten without the nominal exchange rate by assuming that all the transactions are conducted in one global currency. However, indirectly the model's predictions can be used for the policy choice of exchange rate regime. For instance, the real exchange rate adjustment via changes in nominal exchange rate might be more desirable than via large swings in domestic price levels. Thus, countries that have a relatively powerful transfer effect, might be better off by having a relatively flexible exchange rate regime. For this reason we have assumed different currencies in our model economy.

Intertemporal optimality equalizes the marginal utility of consumption in the current period with the discounted marginal utility of consumption of the next period

$$C_t^{-\sigma}(j) = \beta \frac{1+i_t}{P_{t+1}/P_t} C_{t+1}^{-\sigma}(j) \tag{7}$$

The intratemporal optimality condition states that, at the margin, the ratio between marginal utilities of effort and consumption should equal the real wage

$$\frac{L_t(j)}{C_t^{-\sigma}(j)} = \frac{W_t}{P_t} \tag{8}$$

Similar conditions hold for foreign agents.

2.2. Firm's problem

In each country, there are two representative firms: one producing traded goods, the other non-traded goods.[9] Traded goods are produced by a technology given by

$$Y_{TH,t} = \phi_{T,t} L_{TH,t}^{\psi} \tag{9}$$

where $Y_{TH,t}$ represents output, $L_{TH,t}$ labor used in production and $\phi_{T,t}$ is an exogenous productivity shifter in the sector.

Denoting output, labor used in production and the productivity shifter in the non-traded goods sector by $Y_{N,t}$, $L_{TN,t}$ and $\phi_{NT,t}$, we impose the following production function

$$Y_{N,t} = \phi_{N,t} L_{N,t}^{\chi} \tag{10}$$

This type of production function is one possible way to make the relative price of non-traded goods to respond to changes in the net foreign asset position. Of course, these relations could be generalized to a standard Cobb-Douglas function by explicitly incorporating some fixed factor into the production, which, in our framework, is implicitly normalized to one.

Firms in both sectors hire labor until the marginal cost of production equals the marginal product of labor. In the traded goods sector this condition is given by

$$\psi \phi_{T,t} L_{TH,t}^{\psi-1} = \frac{W_t}{P_{TH,t}} \tag{11}$$

[9] An interesting extension of the model would be to deal with endogenous number of goods. Melitz and Ottaviano (2005), for example, in a static model show that, when the price elasticity of demand depends on the number of firms, larger countries export a wider range of goods and have higher average productivity.

while in the non-traded goods sector by

$$\chi \phi_{N,t} L_{N,t}^{\chi-1} = \frac{W_t}{P_{N,t}} \tag{12}$$

Nominal wages W_t between the sectors are equalized due to inter-sectoral labor mobility.

2.3. Equilibrium

To characterize the equilibrium, we define the aggregate variables by $X_t = nX_t(j)$ in domestic and $X_t^* = (1-n)\, X_t^*(j')$ in foreign countries. Using equation (8), average labor supply in the domestic economy is given by

$$\bar{L}_t = \frac{W_t}{P_t} \bar{C}_t^{-\sigma} \tag{13}$$

where $\bar{L}_t$ is average labor supply and $\bar{C}_t$ is average consumption.

The aggregate labor supply in the domestic economy directly depends on the country's size

$$L_t = \frac{W_t}{P_t} n^{1+\sigma} C_t^{-\sigma} \tag{14}$$

Note that, in an equilibrium with a zero net foreign asset position, work effort in domestic relative to foreign economy is a convex function of relative country size.

The market clearing condition in the home produced traded goods market is

$$Y_{TH,t} = \gamma \alpha \left(\frac{P_{TH,t}}{P_{T,t}} \right)^{-\eta} \left(\frac{P_{T,t}}{P_t} \right)^{-\theta} C_t + \gamma^* \left(1 - \alpha^*\right) \left(\frac{P_{TH,t}}{\varepsilon_t P_{T,t}^*} \right)^{-\eta} \left(\frac{P_{T,t}^*}{P_t^*} \right)^{-\theta} C_t^* \tag{15}$$

while the market clearing condition in the home produced non-traded goods market is

$$Y_{N,t} = (1-\gamma) \left(\frac{P_{N,t}}{P_t} \right)^{-\theta} C_t \tag{16}$$

Using aggregate profits, the resource constraint of home country can be written in the following form

$$B_{t+1} = (1+i_t)\, B_t + P_{TH,t} Y_{TH,t} + P_{N,t} Y_{N,t} - P_t C_t \tag{17}$$

By construction, the consumer price based real exchange rate $e_t = P_t / (\varepsilon_t P_t^*)$, which in nested form is given by

$$e_t = \left(\frac{\gamma^* \left(\alpha^* \tau_t^{\eta-1} + (1-\alpha^*) \right)^{\frac{1-\theta}{1-\eta}} + (1-\gamma^*)\, \tau_t^{\theta-1} {\lambda_t^*}^{1-\theta}}{\gamma \left(\alpha + (1-\alpha)\, \tau_t^{\eta-1} \right)^{\frac{1-\theta}{1-\eta}} + (1-\gamma)\, \lambda_t^{1-\theta}} \right)^{\frac{1}{\theta-1}} \tag{18}$$

depends on the terms of trade $\tau_t = P_{TH,t}/(\varepsilon_t P^*_{TF,t})$, as well as domestic $\lambda_t = P_{N,t}/P_{TH,t}$ and foreign $\lambda^*_t = P^*_{N,t}/P^*_{TF,t}$ prices of non-traded relative to traded goods. Our primary interest is the sensitivity of these relative prices to external imbalances.

Denoting steady state variables with tilde, the intertemporal solvency condition in a steady state is given by

$$\frac{\tilde{B}_t}{\tilde{P}_{TH,t}\tilde{Y}_{TH,t} + \tilde{P}_{N,t}\tilde{Y}_{N,t}} = -\frac{\beta}{1-\beta}\frac{\tilde{TB}_t}{\tilde{P}_{TH,t}\tilde{Y}_{TH,t} + \tilde{P}_{N,t}\tilde{Y}_{N,t}} = -\frac{\beta}{1-\beta}\tilde{tby}_t \tag{19}$$

where TB_t is the trade balance, tby_t is the ratio of trade balance to GDP. Needless to say, similar equations hold in the foreign country.

Equations (9)-(12), (14)-(16), (19) with their foreign counterparts and equation (18), combined with the definitions of relative prices, form the steady state system. The equilibrium in goods, labor and asset markets jointly determines the relative prices, wages, consumption and output in both domestic and foreign economies.

2.4. Calibration and the relative price sensitivity

Our benchmark parametrization for the elasticity of substitution between traded and non-traded goods is 0.5, although we report the sensitivities for a relatively large elasticity of 2.[10] Note that the larger the elasticity, the smaller the sensitivity of relative prices to external imbalances. The elasticity of substitution between domestic and foreign traded goods is set to 2.5, which is the value assumed by Faruqee et al. (2005) and is used in the IMF's Global Economic Model.

For the inverse of the intertemporal elasticity of substitution in consumption, a value of 2 is appropriate (Devereux et al., 2006). The share of labor in the traded and non-traded goods sectors is assumed to be 0.8.[11] The full table describing the calibration is provided in Appendix C.

Since our system is highly non-linear, we rely on numerical techniques and proceed in three steps. First, Newton's homotopy is employed to solve the system for the case of symmetric countries around a benchmark steady state with a zero net foreign asset position. Then, using the symmetric equilibrium solution as a point of departure, we utilize the Newton-Raphson procedure and find solutions for the other $n \in (0, 1)$ by continuously updating the

[10] The former is assumed by Faruqee et al. (2005), and is used in the IMF's Global Economic Model. The latter is used by Obstfeld and Rogoff (2006) for comparative purposes to a smaller parametrization of elasticities.

[11] Devereux et al. (2006) calibrate the labor share in traded and non-traded sectors to 0.3 and 0.7, with capital considered explicitly. Since the capital is missing in our model, and the fixed factor is implicitly normalized to one, we increase the share of labor to ensure the output is not produced with too little work effort. The equality of weights simplifies the numerical solution.

starting guesses with the solutions from the previous steps.[12] Finally, we take a log-linear approximation of the system around the benchmark and, using equation (19), derive the following equation

$$\ln \tilde{q}_t = \alpha_{q0} + \alpha_{q1} \tilde{tby}_t + \alpha_{q2} \ln \tilde{\phi}_{T,t} + \alpha_{q3} \ln \tilde{\phi}_{N,t} + \alpha_{q4} \ln \tilde{\phi}^*_{T,t} + \alpha_{q5} \ln \tilde{\phi}^*_{N,t} \tag{20}$$

where $\tilde{q}_t \in (\tilde{e}_t, \tilde{\tau}_t, \tilde{\lambda}_t)$, $\tilde{e}_t$ is the real exchange rate, $\tilde{\tau}_t$ the terms of trade, $\tilde{\lambda}_t$ the price of non-traded relative to traded goods, $\tilde{tby}_t$ the ratio of trade balance to GDP, $\tilde{\phi}_{T,t}$ the productivity in domestic traded sector, $\tilde{\phi}_{NT,t}$ the productivity in domestic non-traded sector, $\tilde{\phi}^*_{T,t}$ the productivity in foreign traded sector, $\tilde{\phi}^*_{NT,t}$ the productivity in foreign non-traded sector in a steady state at time t. The coefficients α_{q1} represent the sensitivity of relative prices to external imbalances.

Figure 3 shows how country size affects the sensitivity of aggregate labor supply to the net foreign asset position to GDP ratio in the domestic economy. The negative sign states that a wealth transfer from the rest of the world to domestic consumers reduces the work effort. This transfer, reducing equilibrium amount of labor, also induces an inter-sectoral reallocation of work effort. Figures 4 and 5 show the impact of country size on the sensitivities of domestic labor in traded and non-traded sectors to the net foreign asset position to GDP ratio. A negative sensitivity in the traded goods sector indicates that a transfer of financial wealth to the domestic economy from the rest of the world reduces the level of work effort in traded goods sector. The magnitude of this decrease is quite pronounced for the elasticity of substitution between traded and non-traded goods equal to 0.5. In contrast, the transfer can have either a positive or negative impact on the level of work effort in the non-traded sector. For a relatively large elasticity of substitution between traded and non-traded goods, a transfer of financial wealth to home decreases work effort in the non-traded goods sector. While when the elasticity of substitution is relatively low, the wealth transfer increases work effort. The magnitude of the sensitivity is almost invariant to country size.

Figure 6 plots the impact of country size on the sensitivity of the foreign marginal utility of importable consumption to the domestic net foreign position to GDP ratio. The sensitivity is positive and increasing in country size. A negative net position of the domestic economy implies a trade surplus via the intertemporal solvency condition. The absorption of the domestic trade surplus by the rest of the world is matched by a declining marginal utility of foreign consumers. Since larger countries can run larger surpluses in absolute terms, the associated decline of the marginal utility is larger. Thus, for the rest of the world to absorb domestic trade surplus, the relative price has to decline. The decline is larger, the larger the trade surplus.

Figure 7 shows how country size affects the relation between the sensitivity of the terms

[12]See Judd (1998) for description of these methods.

of trade to external imbalances. Since larger countries generally have larger imbalances in absolute terms, then, given the decreasing marginal utility of consumption of the rest of the world, the associated deterioration of the terms of trade is larger for larger countries.[13] For example, when the elasticity of substitution between traded and non-traded goods is 0.5 and the elasticity of substitution between domestic and foreign traded goods is 2.5, a 1 percentage point reduction in the trade deficit to GDP ratio requires a 3.5 percentage point decline of export prices relative to import prices for a small country with 1 percent population size relative to the world. In contrast, a 1 percentage point reduction in the trade deficit to GDP ratio requires a 5.2 percentage point decline of the terms of trade for a large country with 35 percent population size relative to the world. Though the difference between the sensitivities is not massive, it is still noticeable.

Figure 8 plots the impact of country size on the sensitivity of the relative price of non-traded goods to external imbalances. Since external adjustment partially manifests itself via changes in the relative price of non-traded goods, then, for a given relative productivity differential, running trade surpluses is associated with switching consumption from traded to non-traded goods. This consumption switching is achieved through the decline of the relative price of non-traded goods. The larger the trade surplus and the size of the non-traded sector, the larger the corresponding fall in the relative price of non-traded goods. For instance, when the elasticity of substitution between traded and non-traded goods is 0.5 and the elasticity of substitution between domestic and foreign traded goods is 2.5, a 1 percentage point reduction in the trade deficit to GDP ratio requires a 0.5 percentage point decline of the relative price of non-traded goods for a small country with 1 percent population size relative to the world. In contrast, a 1 percentage point reduction in the trade deficit to GDP ratio requires a 0.9 percentage point decline in the relative price of non-traded goods for a large country with 35 percent population size relative to the world.

The deteriorating terms of trade and the declining relative price of non-traded goods translate into the depreciation of the real exchange rate. The relation between the sensitivity of the real exchange rate to external imbalances and country size is plotted in figure 9. With 0.5 elasticity of substitution between traded and non-traded goods and 2.5 elasticity of substitution between domestic and foreign traded goods, a 1 percentage point reduction in the trade deficit to GDP ratio requires a 3.6 percentage point depreciation of the real exchange rate for a small country with 1 percent population size relative to the world. In contrast, a 1 percentage point reduction in the trade deficit to GDP ratio requires a 6.1 percentage point depreciation of the real exchange rate for a large country with 35 percent population size relative to the world.

Note, that when we set the elasticity of substitution between traded and non-traded goods to 2, the magnitude of the sensitivities generated by the model decreases. Table 1 reports

[13] Observe how the sensitivity of the terms of trade tracks the sensitivity of foreign marginal utility of imports.

the modeled sensitivities in more details. We skip the interpretations of how productivity affects the relative prices, since these have been widely studied already.[14] In particular, Benigno and Thoenisson (2003) paper is qualitatively close to ours. The authors build a two country dynamic stochastic general equilibrium model of the real exchange rate where both the relative price of non-traded goods and the terms of trade are endogenous. The model has a rich structure for studying relative price responses to productivity shocks, but the model does not allow the relative price of non-traded goods to respond to external imbalances - a situation at odds with the data. Guided by these theoretical results, we turn to the empirical assessment of how country size affects the magnitude of transfer effect.

3. Empirical Setup

In this section we empirically study how country size affects the relation between the trade balance and relative prices.

3.1. Data description

The sample, dictated by data availability, includes 17 industrial countries for the period from 1980 to 2003. We use the OECD STAN structural analysis database to construct sectoral price deflators and labor productivities in manufacturing and services to proxy corresponding variables in the traded and non-traded sectors. Data on the trade balance, GDP per capita, GDP (all in 2000 USD) and the real effective exchange rate are taken from World Development Indicators. We construct the terms of trade based on OECD export/import deflators.

The sample is split into G3 and non-G3 groups, proxying large and small countries respectively.[15] Aside from the main countries being defined in G3 and non-G3 groups, twelve additional countries, labeled 'other category', are used to construct the series for the rest of the world. These data are set up with the normalized weights estimated by Bayoumi et al. (2005). Figure 1 presents the relative importance of each of the groups for main countries. The importance of the 'other' group is particularly evident for the United States with an un-adjusted trade share of 31 percent. To construct labor productivity for the rest of the world, we use UN data on sectoral value added and UNIDO (combined with AMECO) data on employment in manufacturing.

[14] See Balassa (1964), Samuelson (1964), Obstfeld and Rogoff (1996), Benigno and Thoenisson (2003), Corsetti et al. (2006a, b).

[15] The G3 are Germany, Japan, United States. The non-G3 sample includes Australia, Austria, Belgium, Canada, Denmark, Finland, France, Italy, Netherlands, Norway, Portugal, Spain, Sweden, United Kingdom. Appendix A lists all of the countries.

3.2. Empirical approach

Although the model generates the dependence of the relative prices on the levels of productivities in traded and non-traded sectors, we choose to follow the established tradition and use relative productivities instead. We define *relative sectoral productivity* as the log productivity differential between non-traded and traded goods sectors within a country; *traded productivity differential* as the log of cross country difference in productivities of traded sectors; *relative sectoral productivity differential* as the difference between the inverted relative sectoral productivities.[16] We relate the real exchange rate to the trade balance, the relative sectoral productivity differential (capturing the Balassa-Samuelson effect), and the traded productivity differential. The same variables explain the terms of trade (but with different coefficients).

$$\ln q_t = \mu_{q0} + \mu_{q1} tby_t + \mu_{q2} \left[\ln(\phi_{T,t}/\phi_{N,t}) - \ln(\phi^*_{T,t}/\phi^*_{N,t})\right] + \mu_{q3} \ln(\phi_{T,t}/\phi^*_{T,t}) \tag{21}$$

where $q_t \in (e_t, \tau_t)$, e_t is the real exchange rate, τ_t the terms of trade, tby_t the ratio of trade balance to GDP, $\phi_{T,t}$ the productivity in domestic traded sector, $\phi_{NT,t}$ the productivity in domestic non-traded sector, $\phi^*_{T,t}$ the productivity in foreign traded sector, $\phi^*_{NT,t}$ the productivity in foreign non-traded sector.

The relative price of non-traded goods is determined by the trade balance, relative sectoral productivity, and the traded productivity differential

$$\ln \lambda_t = \mu_{\lambda 0} + \mu_{\lambda 1} tby_t + \mu_{\lambda 2} \ln(\phi_{N,t}/\phi_{T,t}) + \mu_{\lambda 3} \ln(\phi_{T,t}/\phi^*_{T,t}) \tag{22}$$

where λ_t is the price of non-traded relative to traded goods, tby_t the ratio of trade balance to GDP, $\phi_{T,t}$ the productivity in domestic traded sector, $\phi_{NT,t}$ the productivity in domestic non-traded sector, $\phi^*_{T,t}$ the productivity in foreign traded sector, $\phi^*_{NT,t}$ the productivity in foreign non-traded sector. We expect $\left|\partial\mu_{q1}\right| / \partial n > 0$ for $q \in (e, \tau, \lambda)$.

We proxy the relative productivity differential with GDP per capita relative to the rest of the world; relative sectoral productivity with labor productivity in services relative to manufacturing; traded productivity differential with labor productivity in manufacturing relative to the rest of the world.

Fisher type panel unit root tests, conducted in table 2, point to the non-stationarity of the series, as the tests are unable to reject the unit root in the data. It is well known that a regression with non-stationary series is misleading unless the residuals from this regression are stationary. Having established non-stationarity, we proceed by employing the commonly-used panel dynamic ordinary least squares method (DOLS) and checking for co-integration

[16] Appendix B explains the definitions of variables used in the empirical work.

by applying residual based tests.[17]

The general specification for DOLS(-1,1) is

$$y_{it} = \alpha_i + \theta_t + \boldsymbol{\beta}'\mathbf{x}_{it} + \sum_{j=-1}^{j=1} \Delta\mathbf{x}_{it-j} + \epsilon_{it} \tag{23}$$

where y_{it} is the log of real effective exchange rate, the log of terms of trade or the log services prices relative to manufacturing.[18] Since our measure of relative prices is an index, it is relevant to include cross-section fixed effects α_i. θ_t represent time fixed effects and captures global shocks, $\mathbf{x}_{it}$ is a vector of control variables. In all of the cases the regressions are run for two samples: G3 and non-G3. Our main interest is the significance and relative magnitude of the coefficient on the trade balance to GDP ratio.

4. Results

4.1. Terms of trade

Table 3 reports results for the terms of trade regressions. In columns (1), (2), (5) and (6) we report the results for the specifications consistent with our model. In columns (3), (4), (7) and (8) we extend the empirical model and include two additional regressors: an export diversification index and an import diversification index.

The trade balance is significant in specifications (1), (5) and (6). Once the traded productivity differential is included, a trade surplus is associated with a deterioration of the terms of trade. In the specification without time fixed effects, a 1 percentage point improvement in the trade surplus to GDP ratio is associated with a 4.7 percentage point deterioration of the terms of trade for large countries. In the sample of small countries, a 1 percentage point improvement in the trade surplus to GDP ratio is associated with a 1.6 percentage point deterioration only. The magnitude of the coefficient between large and small countries differs by a factor of three, compared to the factor of two predicted by the model.

The coefficient of the relative manufacturing productivity differential has a negative sign and is almost always significant. In the case of no time fixed effects, this coefficient is equal to -1.1 and -0.2 in G3 and non-G3 samples respectively. The sensitivity of the terms of trade to the traded productivity differential is about six times larger in large countries.[19]

[17] DOLS was proposed by Stock and Watson (1993). Mark and Sul (2003) study the properties of the estimator in the panel context.

[18] The choice of one lead and lag is dictated by the sample length. Given a relatively short sample length, estimations for each country separately provide poor results. Even though these estimations still support the main prediction of the model, pooling the data increases the accuracy of estimates.

[19] Comparison with the model is slightly complicated. There are many possible combinations to generate relative productivity from productivity levels, with, correspondingly, many possible coefficients. This complicates the comparison between modeled and empirical sensitivities of relative prices.

Although not in the model, we acknowledge that the pattern of production has important effects for the determinants of the terms of trade. Krugman (1989) has shown that if the productivity increase transforms into a new range of goods (extensive margin), the terms of trade need not fall. Love for variety is the main force making the rest of the world absorb the excess supply. This, in turn, can potentially affect the sensitivity of the terms of trade to external imbalances. Debaere and Lee (2003) have conducted an extensive empirical study of the terms of trade and the extensive margin and found that fast growing countries can avoid adverse terms of trade effects via expanding the range of traded goods.

Accordingly, we extend the empirical model and include two additional variables: an export diversification index and an import diversification index.[20] The results are reported in columns (3), (4), (7) and (8) of table 3. The trade balance is significant for G3 in a specification with no time fixed effects with a coefficient of -3.8. In a sample of non-G3 countries, the trade balance is always significant. The sensitivity of the terms of trade is -1.1 when there are no time fixed effects. The magnitudes of sensitivities between G3 and non-G3 samples vary with a factor of almost four. Although the productivity differential is no longer significant, export and import diversification indices are significant in two and three cases respectively. Increased variety in the domestic traded sector increases demand from the rest of world due to love of variety, which in turn improves the terms of trade. The reverse argument holds true for the import diversification index. In this specification, multicollinearity between diversification indices and the productivity differential is possible. Nevertheless, the transfer coefficient is still greater for large countries.

In table 3 the 'cointegration' row reports Fisher's Chi-square test for the null of non-stationarity of the residuals from the regressions. The test rejects the non-stationarity of the residuals, providing evidence of a long-run relation between the terms of trade, trade balance and relative productivities (and diversification of exports/imports).

4.2. Relative price of non-traded goods

In this subsection, we estimate the dependence of the relative price of non-traded goods on the trade balance after controlling for relative sectoral productivity and productivity differentials. Although our model is characterized with endogenous terms of trade, and the reduced form equations already include the determinants of the latter, we report some regression results with the terms of trade as an additional control as well. The results are reported in table 4.[21] The trade balance is significant in all cases. After controlling for the relative

[20] The diversification index is constructed by summing the absolute deviations of commodity shares from world shares over all commodities.

[21] An individual time trend is included in the list of regressors to induce stationarity of the residuals. The incorporation of an individual time trend is justifiable however, because the relative price of services shows a secular time trend over the sample period. It should be noted that the conclusions regarding the relative magnitudes of the coefficients are not affected in a specification without the time trend.

sectoral productivity and traded productivity differential, a trade surplus is associated with a decline in the relative price of non-traded goods. When time fixed effects are not considered in columns (1) and (5), the sensitivity of the relative price of non-traded goods to the trade balance is -1.6 in the G3 sample. However, this sensitivity is -0.4 in the non-G3 sample. A 1 percentage point change in the trade balance to GDP ratio has almost a four times larger effect on the relative price of non-traded goods in large countries compared to the factor of almost two predicted by the model.

The coefficient on relative sectoral productivity is significant in all of the cases and has the expected sign. Higher productivity in the non-traded goods sector drives down the marginal cost of production, resulting in a lower relative price of non-traded goods. However, the productivity differential in manufacturing is never statistically significant.

The 'cointegration' row in table 4 indicates that Fisher's Chi Square test rejects the non-stationarity of the residuals, providing evidence of a long-run relation between the relative price of non-traded goods, trade balance, relative productivity differential and traded productivity differential.

4.3. Real exchange rate

Table 5 reports results for the real exchange rate regressions. The trade balance is significant in almost all specifications. After controlling for the relative sectoral productivity differential and traded productivity differential, a trade surplus is associated with a depreciated real exchange rate. In the specification without time fixed effects, a 1 percentage point increase in the trade balance to GDP ratio is associated with a real depreciation of 7.7 percentage points for large countries as opposed to a 1.2 percentage point depreciation in small countries. The magnitude of the coefficient between large and small countries differs by a factor of six, compared to a factor of two predicted by the model. When global shocks are taken into account in specifications (2) and (6), the factor increases up to eight. The sensitivity of the real exchange rate to the trade balance becomes -8.7 and -1.1 respectively.

The coefficient on the GDP per capita differential, capturing the Balassa-Samuelson effect, is significant in almost all cases. In the specifications without the terms of trade, the coefficient on the log GDP per capita differential is positive, statistically significant, and equal to 1.4 and 0.4 for G3 and non-G3 groups respectively.

The coefficient of the relative manufacturing productivity differential has a negative sign and is significant only for the G3 category. A productivity increase in the domestic traded goods sector drives down the marginal cost of production of traded goods resulting in an increase in the supply of traded goods. This increased supply is matched with a depreciation of the real exchange rate.[22]

[22]See Corsetti et al. (2006a) for a theoretical discussion of a positive supply shock resulting in an appreciation

We also report results from regressions with the terms of trade as an additional control. In this case, the terms of trade are assumed to be exogenous, a pattern inconsistent with our model. When the time effects are excluded, the trade balance is insignificant only in the G3 sample. When the time effects are included in the specification, the magnitudes of trade balance coefficients between G3 and non-G3 differ by a factor of seven.

The row 'cointegration' in table 5 reports the results of the co-integration test. Fisher's Chi-square test rejects the non-stationarity of the residuals in three out of four cases, providing evidence of a long-run relationship between the real exchange rate, trade balance and relative productivities.

Overall, the regressions results show that larger countries have a greater sensitivity of relative prices to the trade balance.

It is worth mentioning that a larger elasticity between traded and non-traded goods in the model more closely matches empirical sensitivities of the non-G3 sample. In contrast, sensitivities generated with a lower elasticity more closely match empirical sensitivities of the G3 sample. Thus, incorporating size dependent elasticities could improve predictions of the model for both large and small countries and bring them closer to the data.

5. Conclusions

In this paper we set up a simple two-country model with endogenous terms of trade and relative price of non-traded goods to study the relation between the real exchange rate, relative price of non-traded to traded goods, terms of trade, external imbalances and country size. The model predicts a positive relation between the absolute value of the sensitivity of relative prices to external imbalance and country size. In particular, trade surpluses are associated with deteriorating terms of trade and a declining relative price of non-traded goods, feeding into a depreciation of the real exchange rate.

At the empirical level, after controlling for relative productivity, we find a significant effect of external imbalances on relative prices. Estimation for G3 and non-G3 sub-samples reveals a systematic pattern in the sensitivity of relative prices to external imbalances, with the sensitivity being stronger in larger countries. These results, relevant to the speed and the smoothness of external adjustment, are important to both theoretical and policy issues dealing with relative prices and global imbalances.

Since empirical difference between sensitivities of large and small countries are larger than the differences in sensitivities generated by the model, a study of other mechanisms by which country size may affect the magnitude of the transfer effect could be necessary.

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of the real exchange rate.

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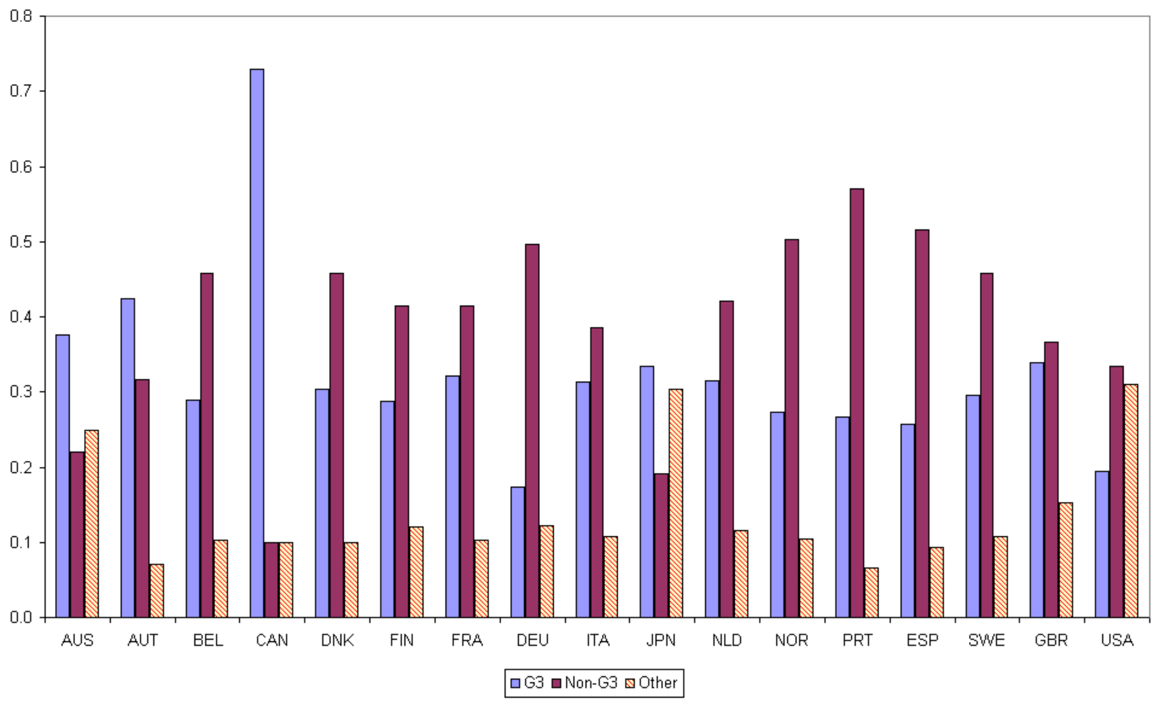
Figure 1: Trade weights



Note: Author's calculations based on Bayoumi et al (2005). G3 and non-G3 refer to industrial countries.

Figure 2: Assumptions of the model

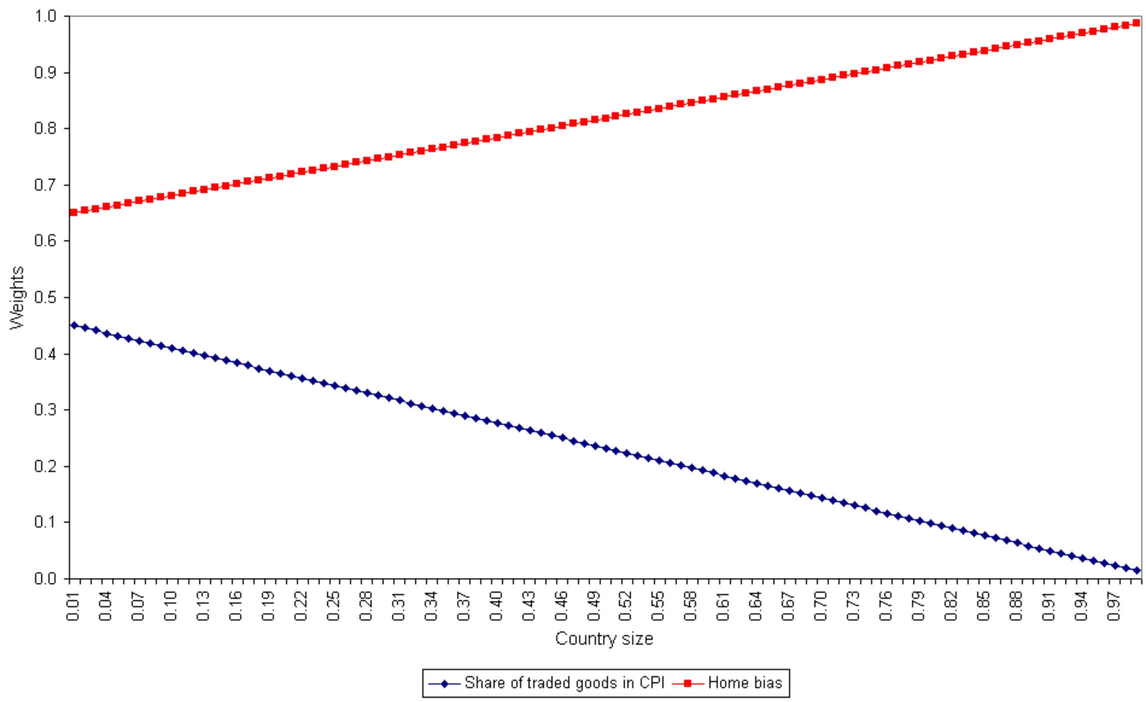
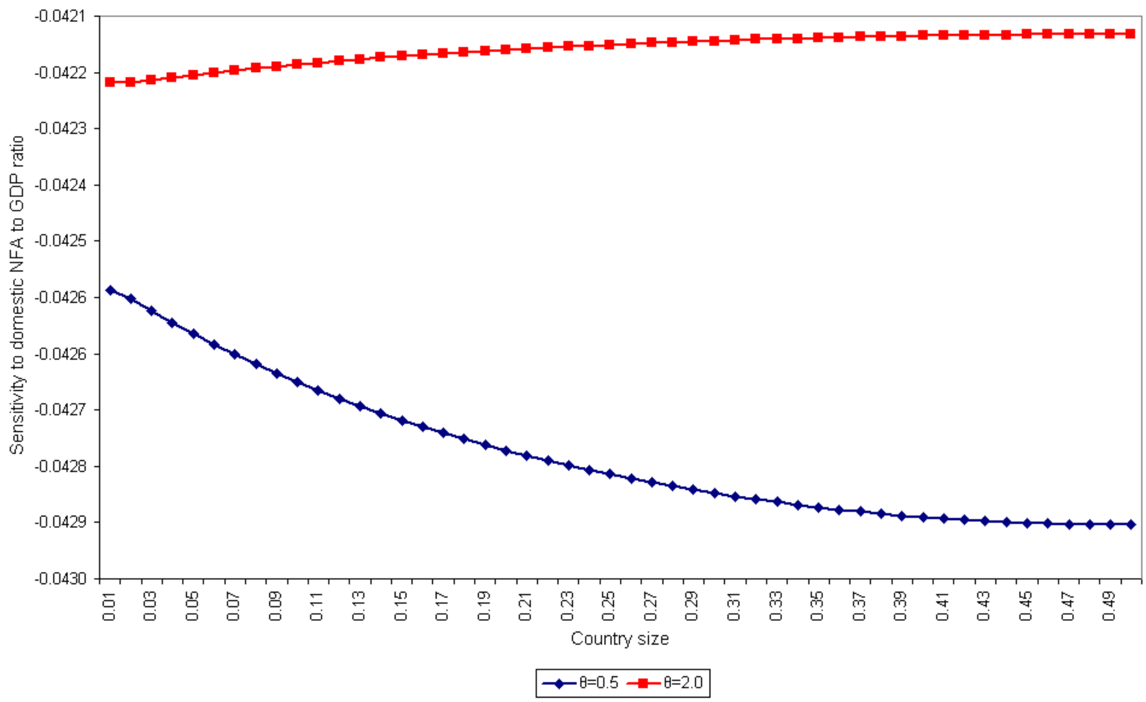
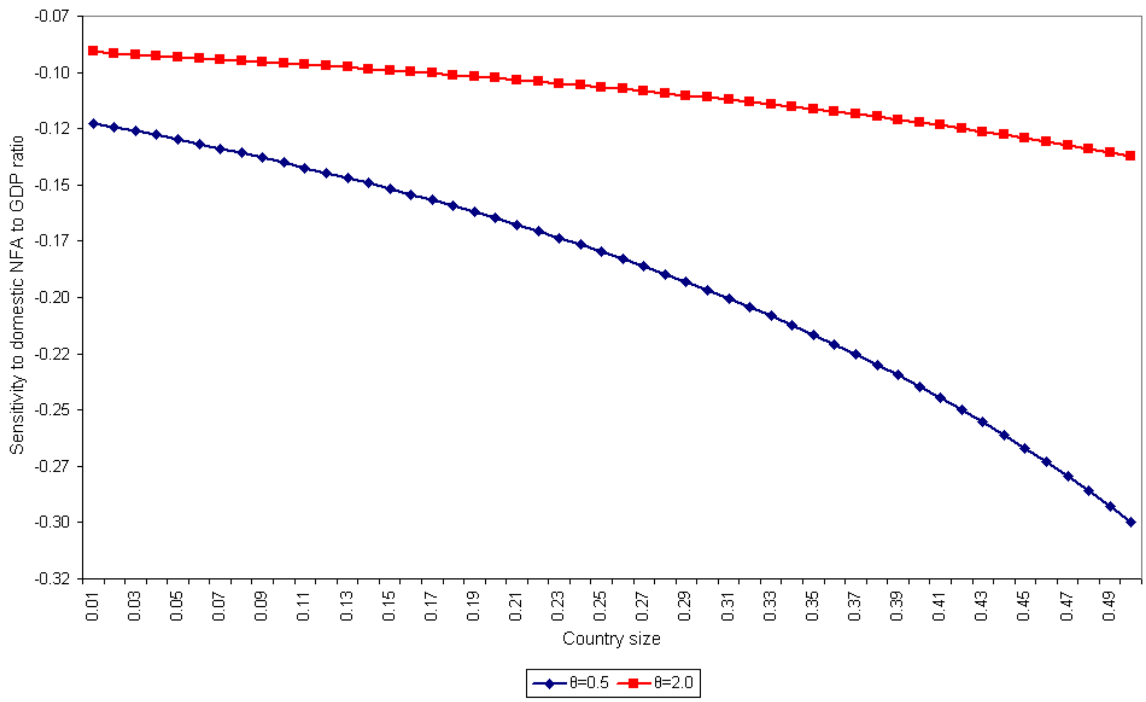


Figure 3: Sensitivity of labor supply in domestic economy



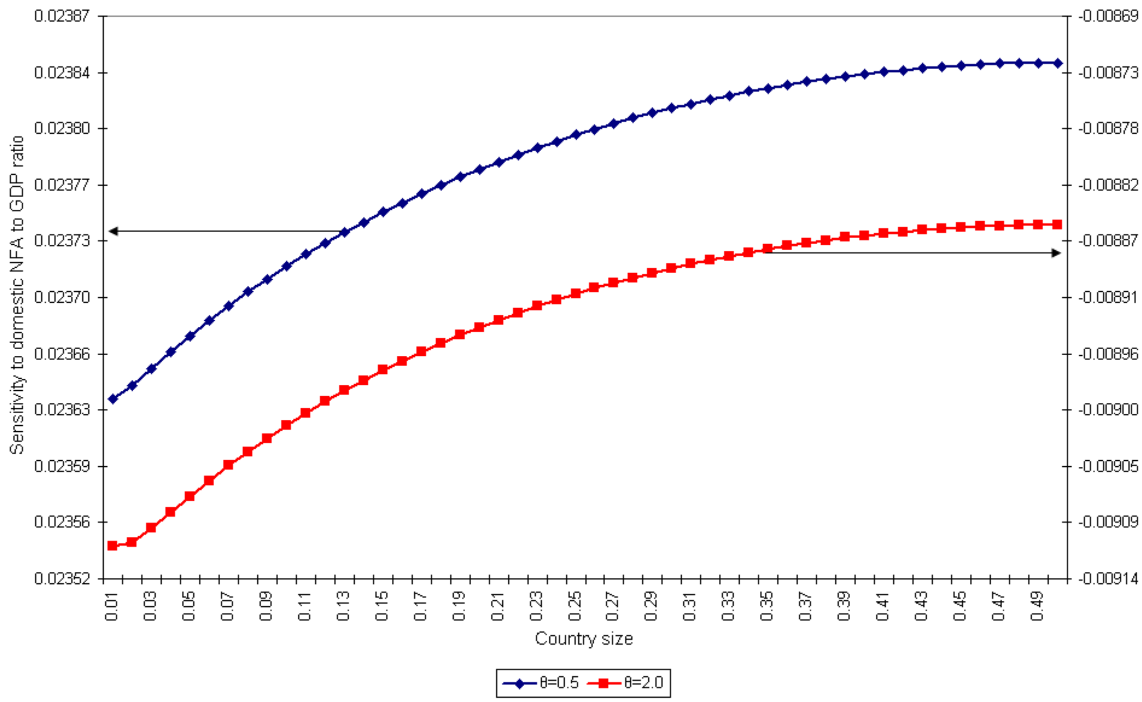
Note: θ is the elasticity of substitution between non-traded and traded goods.

Figure 4: Sensitivity of labor supply in domestic traded goods sector



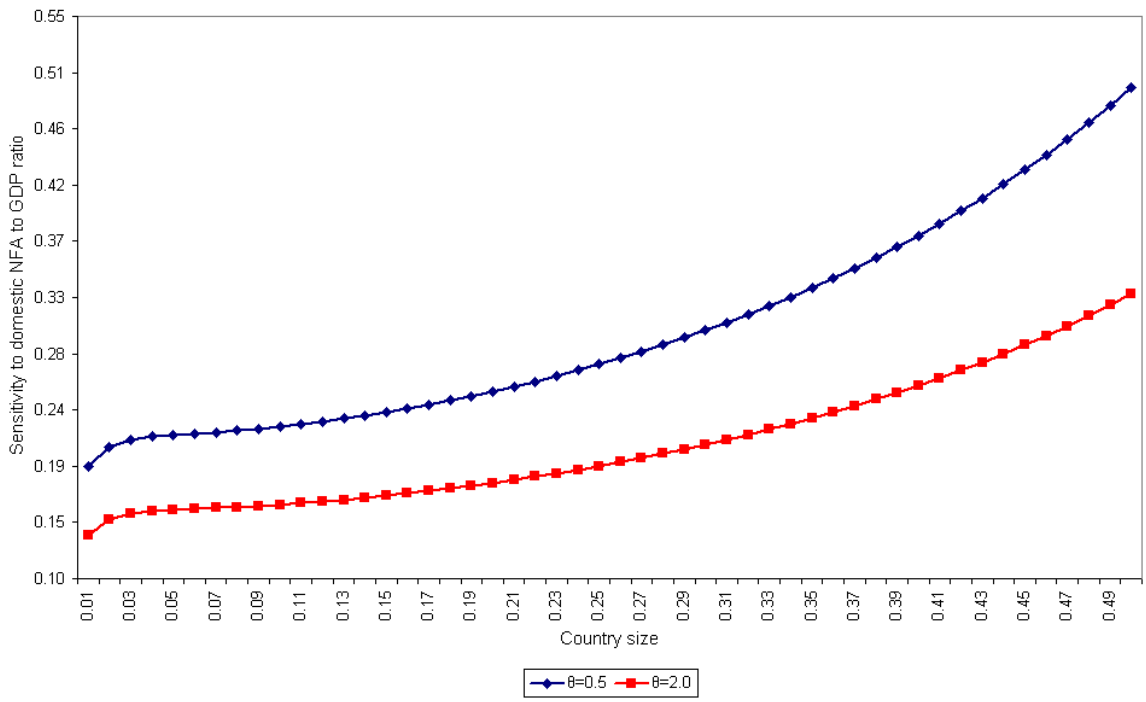
Note: θ is the elasticity of substitution between non-traded and traded goods.

Figure 5: Sensitivity of labor supply in domestic non-traded goods sector



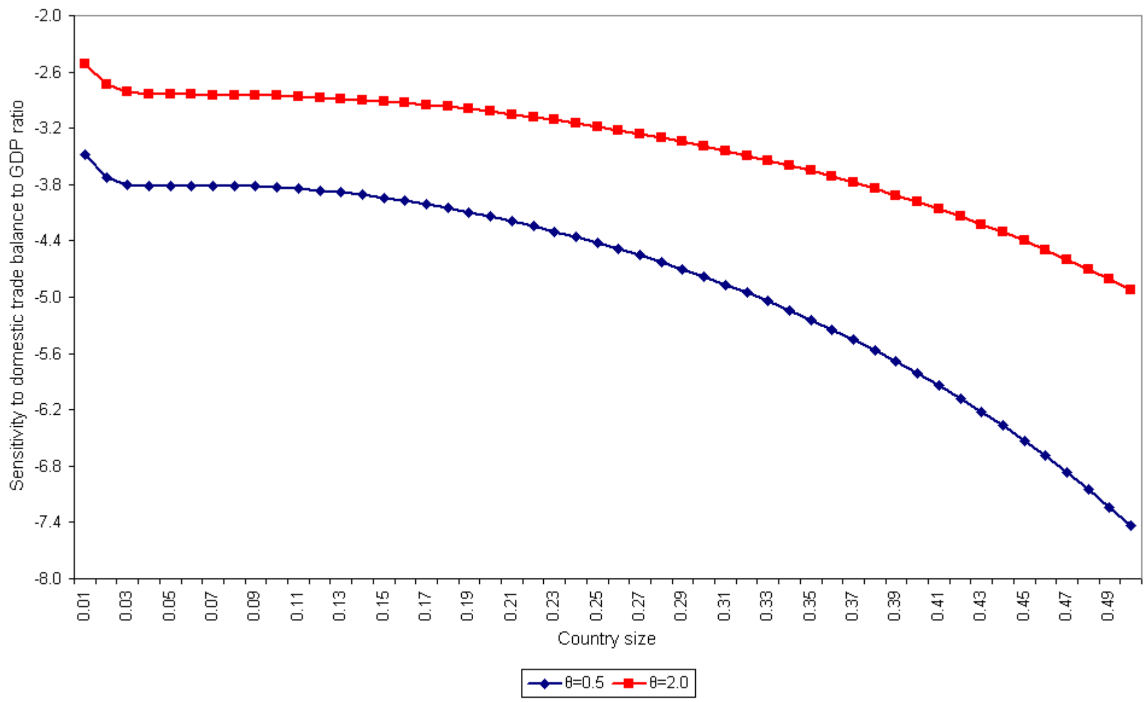
Note: θ is the elasticity of substitution between non-traded and traded goods.

Figure 6: Sensitivity of foreign marginal utility of importable consumption



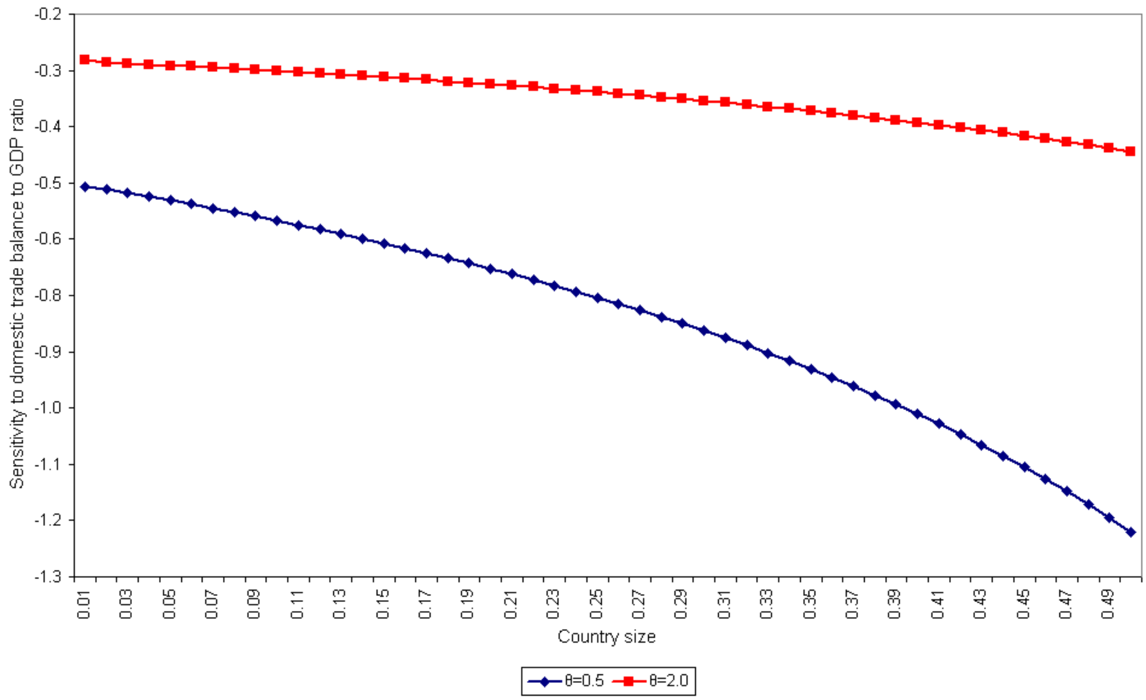
Note: θ is the elasticity of substitution between non-traded and traded goods.

Figure 7: Sensitivity of the terms of trade, $\ln(P_{TH}/\varepsilon P^*_{TF})$



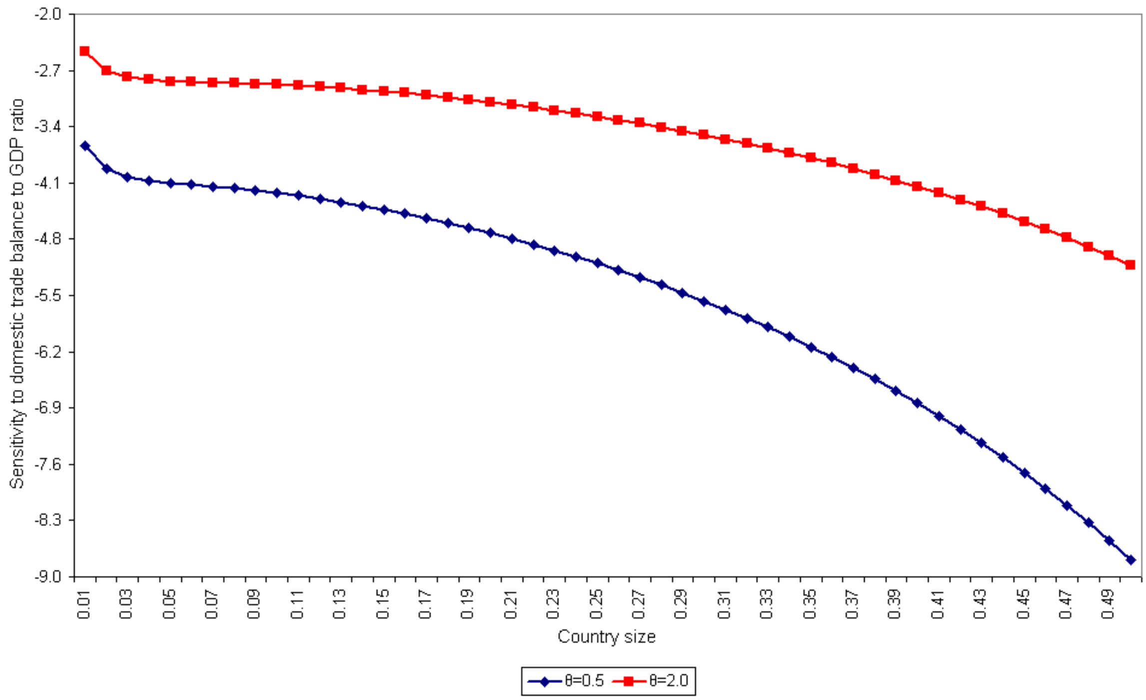
Note: θ is the elasticity of substitution between non-traded and traded goods.

Figure 8: Sensitivity of relative non-traded prices, $\ln(P_N/P_{TH})$



Note: θ is the elasticity of substitution between non-traded and traded goods.

Figure 9: Sensitivity of the real exchange rate, $\ln(P/\varepsilon P^*)$



Note: θ is the elasticity of substitution between non-traded and traded goods.

Table 1: Modeled sensitivities

Country size, n	(1) 0.01	(2) 0.03	(3) 0.20	(4) 0.35
Part A: $\theta = 0.5$				
Terms of trade				
Trade balance	-3.49	-3.80	-4.14	-5.24
Productivity in domestic traded goods sector	-0.17	-0.17	-0.18	-0.18
Productivity in domestic non-traded goods sector	-0.02	-0.02	-0.03	-0.03
Productivity in foreign traded goods sector	0.15	0.16	0.17	0.17
Productivity in foreign non-traded goods sector	0.04	0.04	0.04	0.04
Relative price of non-traded goods				
Trade balance	-0.54	-0.55	-0.70	-0.89
Productivity in domestic traded goods sector	1.11	1.11	1.11	1.11
Productivity in domestic non-traded goods sector	-1.11	-1.11	-1.11	-1.11
Productivity in foreign traded goods sector	0.003	0.003	0.003	0.004
Productivity in foreign non-traded goods sector	0.001	0.001	0.001	0.001
Real exchange rate				
Trade balance	-3.63	-4.03	-4.72	-6.14
Productivity in domestic traded goods sector	0.43	0.44	0.54	0.62
Productivity in domestic non-traded goods sector	-0.61	-0.63	-0.74	-0.83
Productivity in foreign traded goods sector	-0.96	-0.95	-0.87	-0.79
Productivity in foreign non-traded goods sector	1.14	1.14	1.07	0.99
	(5)	(6)	(7)	(8)
Part B: $\theta = 2$				
Terms of trade				
Trade balance	-2.52	-2.81	-3.02	-3.65
Productivity in domestic traded goods sector	-0.34	-0.34	-0.36	-0.38
Productivity in domestic non-traded goods sector	0.15	0.15	0.16	0.18
Productivity in foreign traded goods sector	0.44	0.44	0.42	0.41
Productivity in foreign non-traded goods sector	-0.25	-0.25	-0.23	-0.21
Relative price of non-traded goods				
Trade balance	-0.29	-0.30	-0.34	-0.39
Productivity in domestic traded goods sector	0.85	0.85	0.85	0.85
Productivity in domestic non-traded goods sector	-0.84	-0.84	-0.84	-0.84
Productivity in foreign traded goods sector	-0.02	-0.02	-0.02	-0.01
Productivity in foreign non-traded goods sector	0.01	0.01	0.01	0.01
Real exchange rate				
Trade balance	-2.47	-2.78	-3.09	-3.79
Productivity in domestic traded goods sector	0.18	0.18	0.21	0.24
Productivity in domestic non-traded goods sector	-0.34	-0.35	-0.38	-0.41
Productivity in foreign traded goods sector	-0.42	-0.41	-0.35	-0.31
Productivity in foreign non-traded goods sector	0.59	0.58	0.52	0.48

Note: θ is the elasticity of substitution between non-traded and traded goods. n=0.01 corresponds to the population share of Norway, Finland, Denmark, Austria, Sweden, Belgium, Portugal in a sample of 17 industrial countries; n=0.35 to the population share of USA; n=0.03 to non-G3 average population share; n=0.20 to G3 average population share.

Table 2: Panel unit root test

	(1) G3 level	(2) G3 difference	(3) Non-G3 level	(4) Non-G3 difference
ln(rprod_dif)	0.37	45.48	21.98	154.8
	(0.99)	(0.001)	(0.78)	(0.001)
ln(prdmanf_dif)	1.41	32.89	35.61	134.9
	(0.97)	(0.001)	(0.15)	(0.001)
ln(reer)	11.76	31.64	31.77	129.5
	(0.07)	(0.001)	(0.28)	(0.001)
ln(rnp)	1.21	39.65	14.78	135.6
	(0.98)	(0.001)	(0.98)	(0.001)
ln(tot)	9.39	25.53	39.02	178.0
	(0.15)	(0.001)	(0.08)	(0.001)
ln(tot_manf)	6.09	29.86	29.20	141.5
	(0.41)	(0.001)	(0.40)	(0.001)
tby	4.60	24.15	30.23	134.7
	(0.60)	(0.001)	(0.35)	(0.001)
ln(gdppc_dif)	7.82	21.63	33.02	113.0
	(0.25)	(0.001)	(0.24)	(0.001)

Note: ADF Fisher Chi-square. P-values in parenthesis.
The definitions of the variables are as follows: tby is the trade balance to GDP ratio; ln(gdppc_dif) the log of GDP per capita relative to the rest of the world; ln(rprod_dif) the log of labor productivity in services relative to manufacturing; ln(prdmanf_dif) the log of labor productivity in manufacturing relative to the rest of the world; ln(tot) the log of terms of trade based on export/import deflators; ln(tot_manf) the log of terms of trade based on manufacturing prices; ln(rnp) the log of services prices relative to manufacturing prices; ln(reer) the log of real effective exchange rates; di_exp the export diversification index; di_imp the import diversification index.

Table 3: Terms of trade regressions

Part A: G3	**(1)**	**(2)**	**(3)**	**(4)**
tby	-4.67	-0.75	-3.77	2.56
	(1.54)***	(1.66)	(1.80)**	(1.84)
ln(prdmanf_dif)	-1.06	-0.56	-0.59	0.65
	(0.12)***	(0.21)**	(0.39)	(0.49)
ln(gdppc_dif)	1.33	1.83	0.85	0.42
	(0.33)***	(0.40)***	(0.42)*	(0.59)
di_exp			0.29	2.77
			(0.54)	(0.99)**
di_imp			-0.61	-1.90
			(0.58)	(0.63)***
Time effect	No	Yes	No	Yes
Observations	63	63	63	63
Countries	3	3	3	3
Adjusted R^2	0.58	0.69	0.56	0.75
Cointegration	11.56	18.92	15.09	40.25
	(0.07)	(0.004)	(0.02)	(0.001)
Part B: Non-G3	**(5)**	**(6)**	**(7)**	**(8)**
tby	-1.62	-1.72	-1.13	-1.86
	(0.36)***	(0.36)***	(0.29)***	(0.27)***
ln(prdmanf_dif)	-0.18	-0.03	-0.04	-0.01
	(0.08)**	(0.07)	(0.07)	(0.06)
ln(gdppc_dif)	-0.07	0.18	-0.01	-0.08
	(0.20)	(0.21)	(0.18)	(0.18)
di_exp			0.11	0.88
			(0.19)	(0.26)***
di_imp			-1.65	-1.20
			(0.26)***	(0.29)***
Time effect	No	Yes	No	Yes
Observations	294	294	294	294
Countries	14	14	14	14
Adjusted R^2	0.55	0.66	0.69	0.74
Cointegration	44.13	47.98	41.37	48.83
	(0.03)	(0.01)	(0.05)	(0.01)

Note: Estimated with DOLS. Standard errors in parenthesis. Cointegration is checked with residual based ADF Fisher Chi-square test, where residuals are obtained from DOLS regressions. P-values in parenthesis.
***,**,* significant at 1, 5 and 10 percent respectively.
The definitions of the variables are as follows: tby is the trade balance to GDP ratio; ln(prdmanf_dif) the log of labor productivity in manufacturing relative to the rest of the world; ln(gdppc_dif) the log of GDP per capita relative to the rest of the world; di_exp the export diversification index; di_imp the import diversification index.

Table 4: Relative non-traded price regressions

Part A: G3	**(1)**	**(2)**	**(3)**	**(4)**
tby	-1.63	-2.05	-1.87	-2.00
	(0.56)***	(0.61)***	(0.58)***	(0.62)***
ln(rprod_dif)	-0.26	-0.65	-0.03	-0.37
	(0.13)*	(0.15)***	(0.19)	(0.29)
ln(prdmanf_dif)	0.22	0.08	0.36	0.30
	(0.18)	(0.17)	(0.22)	(0.25)
ln(tot)			-0.11	-0.17
			(0.09)	(0.15)
Time effect	No	Yes	No	Yes
Observations	63	63	63	63
Countries	3	3	3	3
Adjusted R^2	0.99	0.99	0.99	0.99
Cointegration	19.56	17.37	26.11	24.21
	(0.003)	(0.01)	(0.001)	(0.001)
Part B: Non-G3	**(5)**	**(6)**	**(7)**	**(8)**
tby	-0.39	-0.24	-0.59	-0.48
	(0.19)**	(0.19)	(0.23)**	(0.22)**
ln(rprod_dif)	-0.30	-0.50	-0.25	-0.45
	(0.16)*	(0.18)***	(0.16)	(0.19)**
ln(prdmanf_dif)	0.22	0.05	0.26	0.09
	(0.17)	(0.19)	(0.17)	(0.20)
ln(tot)			-0.13	-0.16
			(0.06)**	(0.05)***
Time effect	No	Yes	No	Yes
Observations	294	294	294	294
Countries	14	14	14	14
Adjusted R^2	0.95	0.96	0.95	0.96
Cointegration	64.16	60.38	68.8	60.06
	(0.001)	(0.001)	(0.001)	(0.001)

Note: Estimated with DOLS. Standard errors in parenthesis. Individual time trend is included to induce stationarity of the residuals. Cointegration is checked with residual based ADF Fisher Chi-square test, where residuals are obtained from DOLS regressions. P-values in parenthesis.
***,**,* significant at 1, 5 and 10 percent respectively.
The definitions of the variables are as follows: tby is the trade balance to GDP ratio; ln(rprod_dif) the log of labor productivity in services relative to manufacturing; ln(prdmanf_dif) the log of labor productivity in manufacturing relative to the rest of the world; ln(tot) the log of terms of trade based on export/import deflators.

Table 5: Real exchange rate regressions

Part A: G3	**(1)**	**(2)**	**(3)**	**(4)**
tby	-7.72	-8.69	-2.91	-4.87
	(2.20)***	(3.16)**	(2.94)	(2.53)*
ln(gdppc_dif)	1.40	1.67	0.48	-1.30
	(0.55)**	(0.76)**	(0.59)	(0.47)**
ln(prdmanf_dif)	-0.97	-1.23	-0.09	-0.04
	(0.42)**	(0.47)**	(0.59)	(0.30)
ln(tot)			0.70	1.70
			(0.28)**	(0.20)***
Time effect	No	Yes	No	Yes
Observations	63	63	63	63
Countries	3	3	3	3
Adjusted R^2	0.78	0.69	0.82	0.93
Cointegration	16.96	22.06	14.78	16.29
	(0.01)	(0.001)	(0.02)	(0.01)
Part B: Non-G3	**(5)**	**(6)**	**(7)**	**(8)**
tby	-1.25	-1.06	-0.75	-0.73
	(0.21)***	(0.19)***	(0.28)***	(0.33)**
ln(gdppc_dif)	0.37	0.67	0.41	0.64
	(0.19)*	(0.17)***	(0.19)**	(0.16)***
ln(prdmanf_dif)	0.04	0.11	0.08	0.11
	(0.08)	(0.08)	(0.08)	(0.07)
ln(tot)			0.28	0.18
			(0.08)***	(0.11)*
Time effect	No	Yes	No	Yes
Observations	294	294	294	294
Countries	14	14	14	14
Adjusted R^2	0.65	0.73	0.68	0.75
Cointegration	40.36	45.60	34.02	40.15
	(0.06)	(0.02)	(0.20)	(0.06)

Note: Estimated with DOLS. Standard errors in parenthesis. Cointegration is checked with residual based ADF Fisher Chi-square test, where residuals are obtained from DOLS regressions. P-values in parenthesis.
***,**,* significant at 1, 5 and 10 percent respectively.
The definitions of the variables are as follows: tby is the trade balance to GDP ratio; ln(gdppc_dif) the log of GDP per capita relative to the rest of the world; ln(prdmanf_dif) the log of labor productivity in manufacturing relative to the rest of the world; ln(tot) the log of terms of trade based on export/import deflators.

Appendix A: Country list

G3: Germany, Japan, United States

Non-G3: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Italy, Netherlands, Norway, Portugal, Spain, Sweden, United Kingdom

Other: China, Greece, Hong Kong, Ireland, Israel, Korea, Malaysia, Mexico, New Zealand, Singapore, Thailand, Turkey

Appendix B: Data sources and definitions

tby: The ratio of trade balance to GDP in constant 2000 USD. Trade balance is computed as the difference between exports and imports of goods and services in constant 2000 USD. *Source:* World Bank's World Development Indicators.
ln(gdppc_dif): Log of GDP per capita in constant 2000 USD relative to the rest of the world. Proxies the relative productivity differential (classic Balassa-Samuelson effect). *Source:* World Bank's World Development Indicators.
ln(rprod_dif): Log of labor productivity in services in constant 2000 USD relative to manufacturing in constant 2000 USD. Captures the relative productivity. *Source:* Author's calculation based on the OECD STAN value added in national currency, period average exchange rates from IMF's IFS, and employment from OECD STAN.
ln(prdmanf_dif): Log of labor productivity in manufacturing in constant 2000 USD relative to the rest of the world. Captures traded productivity differential. *Source:* Author's calculation based OECD STAN value added in national currency, period average exchange rates from IMF's IFS, UN data on sectoral value added in constant 1990 USD (re-based to 2000) and UNIDO (suplemented with AMECO) data on employment in manufacturing.
ln(tot): Log of the terms of trade based on export/import deflators. *Source:* Author's calculation based on export/import deflators from OECD Economic Outlook.
ln(tot_manf): Log of the terms of trade based on manufacturing prices. *Source:* Author's calculation based on implicit deflators from OECD STAN and UN data on sectoral value added.
ln(rnp): Log of services relative to manufacturing prices. Captures the log of non-traded relative to traded goods price. *Source:* Author's calculation based on implicit deflators from OECD STAN.
di_exp: Export diversification index. *Source:* UNCTAD.
di_imp: Import diversification index. *Source:* UNCTAD.

Appendix C: Calibration table

Parameters and values	Description
$\beta = 0.95$	Discount factor
$\theta = 0.5; 2$	Elasticity of substitution between non-traded and traded goods
$\eta = 2.5$	Elasticity of substitution between home and foreign traded goods
$\sigma = 2$	Inverse of elasticity of substitution in consumption
$\psi = 0.8$	Share of labor in traded sector
$\chi = 0.8$	Share of labor in non-traded sector
$\gamma = 0.45 - \frac{0.44}{99}(100n - 1)$	Share of traded goods in domestic CPI
$\gamma^* = 0.45 - \frac{0.44}{99}(100(1-n) - 1)$	Share of traded goods in foreign CPI
$\alpha = 0.65 + \frac{0.34}{99}(100n - 1)$	Coefficient of domestic "home bias"
$\alpha^* = 0.65 + \frac{0.34}{99}(100(1-n) - 1)$	Coefficient of foreign "home bias"

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