Long-Run Real Exchange Rate Determinants in a New Economic Geography Framework

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Abstract

This paper develops a model of long-run real exchange rates based on a New Economic Geography framework that compares three determinants of relative price levels. The first one is a standard Balassa-Samuelson mechanism, that explains relative prices in the non-traded good sector by productivity differentials. The second determinant explains PPP deviations in the traded good sector by the relative cost to produce which deviates from one because of the imperfect substituability of goods. Last, the third determinant, the "Variety Supply effect", also explains PPP deviations in the traded good sector, by the endogenous distribution of firms across countries. Calibrating the model with OECD data, I show that PPP deviations in the traded good sector attributable to the relative producing cost or to the variety supply effect can either play in opposite direction, or strengthen the Balassa-Samuelson effect. This ambiguity is explained in a general equilibrium framework. Indeed, the impact of location decisions on the relative price of traded goods is sensitive to the structure of preferences. When the share of traded good is large enough, the entry of firms leads to a real depreciation because local consumers benefit from a trade cost saving. However, if the share of non-traded goods in consumption is high, this effect is more than compensated by a wage adjustment and the real exchange rate appreciates.

Keywords: Equilibrium Real Exchange Rate, Balassa-Samuelson effect, Home Market effect, New Trade Theory
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1 Introduction

According to Obstfeld & Rogoff (2000), the failure of the Purchasing Power Parity (PPP) relation is one of the main empirical "puzzles" in Open Macroeconomics: despite a strong integration of good markets at the international level, the connection between exchange rates and national price levels is still surprisingly weak and real exchange rates regularly deviate from their PPP level.

A well-accepted explanation of these international price differentials, popularized by Harrod (1933), Balassa (1964) and Samuelson (1964), lies in the existence of cross-country and cross-sector productivity differentials in a perfectly competitive world where labor is immobile and some goods are not traded at the international level. In this framework, an increase in a country's relative productivity in the traded good sector leads to a real exchange rate appreciation because of its positive effect on the equilibrium wage, transmitted to the price of non-traded goods. This Balassa-Samuelson effect has been revisited recently by Bergin, Glick & Taylor (2004), trying to explain the reinforcement of the phenomenon observed in data over the last fifty years. In their model, this tendency is explained by the endogeneity of goods' tradability to productivity shocks : a positive shock pushes the most productive firms of the non-traded good sector to start exporting their production so that the Balassa-Samuelson effect can be magnified, as long as the distribution of productivity shocks is not uniform across all sectors.[1]

Recently however, two papers based on New Trade Theory frameworks have questioned the direction of this link. In both models, productivity gains in a given country can depreciate its real exchange rate thanks to changes in the spatial repartition of firms in response to the technological shock.

The first paper, by Ghironi & Mélitz (2004), is a micro-founded model of trade and macroeconomic dynamics, where PPP deviations come from the existence of a fixed cost to export that endogenously determines the equilibrium share of traded goods. In this model, a positive aggregate productivity shock in the domestic market decreases the relative effective labor cost, and forces the less productive foreign exporters to leave the domestic market. As a consequence, the price of non-traded goods decrease (through a negative wage adjustment) as well as the import price (because only the most price-competitive firms remain in the market) and then the real exchange rate depreciates.[2]

On the other hand, Corsetti, Martin & Pesenti (2005)'s model emphasizes the role of "extensive" margins in a New Economic Geography (NEG) framework. In their model, PPP deviations also come from the existence of trade costs but these trade barriers affect the marginal cost to produce, rather than the fixed cost, so that all goods are traded in equilibrium. The real depreciation that follows a positive productivity shock is then no more attributable to the endogenous tradability of goods. In this model, the depreciation comes from two channels: a cost channel, as productivity gains reduce domestic marginal costs to produce, and a competition channel as some firms enter the market to benefit from the strong productivity, which reduces the general price level when consumers value diversity.

Though the mechanism is quite different, both models show how location decisions of dif-

[1] Note however that, in the case of a global homogeneous productivity shock, the model generates a positive Balassa-Samuelson effect because of the lowering of marginal costs.

[2] Depending on the steady state equilibrium, this effect can be reinforced or mitigated by the impact of productivity shocks on the relative number of foreign exporters with regards to domestic producers in each market.

ferentiated firms can affect i) the marginal costs and ii) the relative supply of domestically produced and imported varieties available to consumers in each country. Both these determinants create deviations from the PPP in the traded good sector, which are consistent with Engel (1999)'s observations. The first "Relative Producing Cost" effect is linked to the assumption of monopolistic competition in the traded good sector and is also present in Bergin et al. (2004)'s model: when goods are imperfectly substitutable and prices are set as a markup over marginal costs, wages do not necessarily fully adjust to productivity shocks, unlike in the standard textbook version of the Balassa-Samuelson model (where arbitrage in international markets make deviations from the law of one price for traded goods impossible). The second "Variety Supply Effect" is newer however. It implies that, as long as international trade is costly, location decisions are important determinants of relative price levels because,*ceteris paribus*, individual good prices are not equalized across countries: in Ghironi & Mélitz (2004), prices set by exporting firms are lower because these firms are more productive whereas in Corsetti et al. (2005), domestically produced goods are cheaper than imported ones because they do not support the variable trade cost. Moreover, an interesting feature of this effect lies in its capacity to counteract the Harrod-Balassa-Samuelson effect working through non-traded good prices.[3]

The objective of this paper is to introduce these effects in a single framework to compare their potential power in explaining PPP deviations. To keep the model as simple as possible, the Balassa-Samuelson effect is generated exogenously by the introduction of a non-traded good sector and productivity differentials across sectors and countries, rather than modelling a complex structure of heterogeneously productive firms as in Bergin et al. (2004) or Ghironi & Mélitz (2004). Like in Corsetti et al.'s model, national supplies of traded good varieties are endogenously determined by i) the relative cost to produce in each country, as in a standard neo-classical model, ii) and the size of national demands through the home market effect.[4] I however depart from Corsetti et al. (2005) insofar as the fixed cost to produce is the same everywhere and productivity gains only influence operational profits.

In partial equilibrium, the real exchange rate is altered by i) the cost-competitiveness of each location in the traded good sector, though the Relative Producing Cost effect, ii) the double productivity ratio through a Balassa-Samuelson effect and iii) the location of firms through the Variety Supply effect. As expected, these determinants interact in a non-trivial way to determine the relative price level: both an increase in a country's relative labor productivity in the traded good sector and a rise in its relative cost to produce the traded good tends to appreciate its real exchange rate whereas a raise in its share in the world supply of traded goods depreciates it. As productivity shocks are likely to affect these three variables, the total effect is unpredictable. Calibrating the model with OECD data for the 1988-2003 period, one shows that the magnitude of the predicted Variety Supply effect is generally too low to counteract the Balassa-Samuelson effect. However, results suggest that neglecting the impact of location decisions can lead to over- or underestimate the Balassa-Samuelson

[3] Note however that both papers emphasize measurement problems that make difficult the confrontation of location decisions effects with the Balssa-Samuelson mechanism in an empirical study. Indeed, the measure of real exchange rates through consumer price indices takes imperfectely into account the apparition of new varieties of a given good in a given market. As a consequence, the Variety Supply effect may be difficult to identify in CPI-based real exchange rates. See details in Corsetti et al. (2005).

[4] In NEG frameworks, the combination of increasing returns to scale and international trade costs makes the size of country (in terms of demand) a crucial determinant of firms location named Home Market Effect (HME hereafter). Indeed, *ceteris paribus*, firms have an incentive to locate in the large country to maximize sales where they are more price-competitive.

mechanism. Moreover, the relative cost to produce the traded good is also an important determinant of PPP deviations in this model: when wages over-react to productivity shocks, the Balassa-Samuelson effect is reinforced whereas moderated wage adjustments mitigate the reaction of non-traded good prices to productivity shocks.

Going further in the analysis and taking into account the endogeneity of location decisions and wages allows to explain this ambiguity. First, one confirms that the three real exchange rate determinants are correlated as productivity gains in the traded good market lead to an entry of firms, which itself affect the labor market equilibrium. When solving the model numerically for reasonable parameter values, one however shows that the magnitude of the correlation is limited so that the Balassa-Samuelson effect is little affected: a 1% change in a country's relative productivity in the traded good sector lead to an appreciation of its real exchange rate which is almost proportional to the share of non-traded goods in consumption. The general equilibrium analysis however put in evidence another structural determinant of the relative price level. Indeed, changes in the relative size of countries, by generating a spatial reallocation of the production of traded goods, have an ambiguous effect on the relative price level. If the share of traded goods in consumption is large enough, the entry of firms in the growing market leads to a real depreciation because local consumers benefit from trade costs savings when goods are domestically produced. However, this effect reverses for a low share of traded goods in consumption because of a dominating, positive wage adjustement when the labor demand increases.[5]

The rest of the paper is organized as follows. Section 2 describes the theoretical framework used to compare the Balassa-Samuelson and the Variety Supply determinants of long-run real exchange rates. These determinants are then studied in Section 3, first in partial equilibrium, then in general equilibrium. Last, Section 4 concludes.

2 Theoretical Framework

The general framework used in the following is largely inspired from Baldwin, Forslid, Martin, Ottaviano & Robert-Nicoud (2005)'s "Footlose Capital Model". One considers a static model with two countries (home H and foreign F), two productive factors (labor L and physical capital K) and two sectors, respectively producing a differentiated good T and a homogeneous good N.

Each country is endowed with a stock of factors, that determines the relative size of its demand in general equilibrium, when factor owners cannot move across countries. These endowments are defined as follows: world stocks of labor (L_W) and capital (K_W) are shared in proportions θ and $(1-\theta)$ between H and F. In the following, θ is supposed larger than one half so that the equilibrium home country's demand is "large" in relative terms.

While the ownership of labor and capital is exogenously fixed, services of those factors can be rent to firms against an endogenously determined reward. To simplify, I assume that the supply of both factors is perfectly elastic.

Labor is immobile internationally but perfectly mobile across sectors. Domestic (foreign) firms of both sectors thus compete to share the domestic (foreign) labor stock. As a result, the labor market equilibrium determines a single nominal wage rate by country (W_c, $c = H, F$). Despite these uniform national wage rates however, cross-sectoral and cross-country

[5] MacDonald & Ricci (n.d.) also note that the reaction of real exchange rates to shocks can be sensitive to the structure of preferences between traded and non-traded goods.

productivity differentials lead to labor cost differentials in each country's traded and non-traded good sectors.

In contrast to labor, capital is perfectly mobile internationally so that the (endogenous) share of capital employed in each country does not necessarily match the (exogenous) share of capital owners living there. Namely, capital owners from both countries sell their endowments on an integrated world market against the equilibrium unit price R. This factor is then rent by firms located either in H or in F. Moreover, as capital serves only to cover the fixed costs paid by differentiated good producers, their capital needs determine the world demand.

2.1 Preferences

Assume that, in each country, a representative consumer collectsthe income that factor owners get from the sale of their factors to firms. With this money, the representative consumer buys goods according draws her utility from the consumption, allocated in fix proportions between sectors:

$$C_c = T_c^{\mu} N_c^{1-\mu}, \; c = H, F \tag{1}$$

with μ the share of differentiated goods in the total consumption expenditure[6], N_c the consumption of non-traded good and T_c the consumption basket of all existing varieties of the traded good. Assuming a constant elasticity of substitution between varieties ($\sigma > 1$), T_c can be rewritten in a Dixit-Stiglitz form as :

$$T_c = \left(\int_0^{n_W} x_c(s)^{\frac{\sigma-1}{\sigma}} ds \right)^{\frac{\sigma}{\sigma-1}}$$

with $x_c(s)$ c's consumption of the variety s, and n_W the total number of varieties produced in equilibrium.

In each country, labor and capital supplies (L_c^s and K_c^s) are exogenous. The consumer thus maximizes her consumption (1) under her budget constraint :

$$\int_0^{n_W} p_c(s) x_c(s) ds + P_c^N N_c \quad \leq \quad W_c L_c^s + R\, K_c^s + \Pi_c \equiv E_c$$

with :

- $p_c(s)$ the price of variety s in country c,
- P_c^N the price of non traded goods in country c,
- $W_c L_c^s$ and $R\, K_c^s$ the labor and capital incomes paid to factor owners in c,
- Π_c the residual profit, equal to zero in the free-entry equilibrium,
- E_c the consumer's total income, equal to her consumption expenditure in this static framework.

[6]In the following, I suppose that the share of traded good in the consumption is the same everywhere. However, when solving the model numerically, it will be interesting to authorize preferences to differ in H and F ($\mu_H \neq \mu_F$).

Solving this problem leads to the optimal demands for each type of goods, as a function of income and prices :

$$\begin{aligned} N_c &= (1-\mu)\frac{E_c}{P_c^N} && (2) \\ T_c &= \mu\frac{E_c}{P_c^T} && (3) \\ x_c(s) &= \left(\frac{p_c(s)}{P_c^T}\right)^{-\sigma} T_c && (4) \\ & c = H,\ F \end{aligned}$$

where P_c^T is the expenditure-minimizing price index for traded goods in country c :

$$P_c^T = \left[\int_0^{n_W} p_c(s)^{1-\sigma} ds\right]^{\frac{1}{1-\sigma}}$$

2.2 Technology

The sector N features constant returns and perfect competition and produces a homogeneous good that is not traded in equilibrium (because of its prohibitive trade cost). Labor is the only input in the linear production function. The equilibrium price is then equal to the marginal cost :

$$P_c^N = \frac{W_c}{A_c^N},\ c = H, F \tag{5}$$

with A_c^N the labor productivity in the sector N of country c.

As in the Footlose Capital model, the technology in the traded good sector exhibits increasing returns. The total cost to produce the variety s is separated into a fixed cost of f capital units and a linear cost in labor.[7] Finally, I suppose that international trade of differentiated goods is costly, which I modelize with a "iceberg" cost: to sell one unit abroad, the individual firm has to produce $\tau(>1)$ units because of a real loss occurring during the transport.

In such a framework, a firm located in c that produces a variety s generates the following profit :

$$\Pi_c(s) = p_{cc}(s)x_c(s) + p_{cc'}(s)x_{c'}(s) - \frac{W_c}{A_c^T}\left[x_c(s) + \tau x_{c'}(s)\right] - R\,f, \quad c \neq c'$$

where A_c^T is the labor productivity in the sector T of country c, $p_{cc}(s)$ and $p_{cc'}(s)$ are the chosen prices, for respective sales in the domestic and foreign markets.

Maximizing with the demand functions (4) leads to the optimal prices set by an individual firm from c :

$$\begin{aligned} p_{cc}(s) &= \frac{\sigma}{\sigma-1}\frac{W_c}{A_c^T} && (6) \\ p_{cc'}(s) &= \frac{\sigma}{\sigma-1}\frac{W_c}{A_c^T}\tau && (7) \end{aligned}$$

[7]The fixed cost is supposed to be large enough to ensure that, in equilibrium, each firm produces its own variety in a given location. This implies that the number of existing firms in equilibrium is equal to the number of produced varieties (n_W). Indeed, with CES preferences, the market share when producing a new variety is always higher than the market share that would be obtained by duplicating an existing one. See Dixit & Stiglitz (1977).

$$c = H,\ F \quad c \neq c'$$

One verifies that firms optimally discriminate their domestic and foreign markets by passing the transport cost on to the foreign consumer. This price gap is at the root of the "Home Market Effect", that pushes firms under increasing returns to locate in the largest market to benefit from maximum scale economies where they are more competitive.

As firms in a given location are homogeneous[8], one can suppress the index s in the following. Denoting λ $(1-\lambda)$ the (endogenous) share of firms located in $H(F)$ and $\phi = \tau^{1-\sigma}$ the "freeness" of trade[9], one can rewrite price indices in the traded good sector as :

$$P_H^{T\ 1-\sigma} = \left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} n_W \left[\lambda \left(\frac{W_H}{A_H^T}\right)^{1-\sigma} + (1-\lambda)\phi \left(\frac{W_F}{A_F^T}\right)^{1-\sigma}\right] \tag{8}$$

$$P_F^{T\ 1-\sigma} = \left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} n_W \left[\lambda\phi \left(\frac{W_H}{A_H^T}\right)^{1-\sigma} + (1-\lambda) \left(\frac{W_F}{A_F^T}\right)^{1-\sigma}\right] \tag{9}$$

These price indices are not symmetric because of the presence of trade costs (ϕ) that increases the price of imported goods: the higher are trade barriers (i.e. the lower is ϕ), the higher is the price index for traded goods, especially if the share of imports in the consumption of these goods is large. As in Ghironi & Mélitz (2004) or Corsetti et al. (2005) thus, this model displays no purchasing power parity in the traded good sector. The relative price of traded goods is influenced by two endogenous variables :

- the spatial repartition of firms (λ) that determines the share of imported goods in each country,
- the relative cost to produce the differentiated good ($\rho = \frac{W_H/A_H^T}{W_F/A_F^T}$) that determines the relative competitiveness of domestically produced and foreign traded goods.

2.3 Free Entry and Firms Location

In the long run, firms are free to enter a national market. This drives profits towards zero in equilibrium. For an individual firm, that sells its production at the optimal prices (6) and (7), the zero profit condition implies (respectively for firms located in H and in F):

$$Rf = \frac{1}{\sigma-1}\frac{W_H}{A_H^T} y_H \tag{10}$$

$$Rf = \frac{1}{\sigma-1}\frac{W_F}{A_F^T} y_F \tag{11}$$

with y_c the equilibrium production, including trade costs, of an individual firm located in c :

$$y_c = x_c + \tau x_{c'}, \quad c = H, F, \quad c \neq c'$$

[8] Indeed, productivity gaps are supposed here to be country- rather than firm-specific, as in Ghironi & Mélitz (2004).

[9] This term has been taken from Baldwin et al. (2005). The "freeness" of trade is inversely related to the magnitude of trade barriers that trade costs create. Of course, it depends on the size of trade costs, as higher trade costs make international trade more difficult. But the freeness of trade also depends on the substituability of traded goods. Indeed, when goods become more substituable (when σ increases), trade costs are a stronger barrier to trade as consumers can substitute domestically produced to imported varieties.

At this point, three situations can be distinguished with regards to the spatial repartition of firms in equilibrium:

- two corner equilibria with a total concentration of the production of traded goods, either in H ($\lambda = 1$ and (10) applies), or in F ($\lambda = 0$ and (11) applies),
- an interior equilibrium where some traded good is produced in each country ($\lambda \in]0, 1[$, jointly determined by (10) and (11)).

In the interior equilibrium, long-run operational profits are equalized across countries, at a level that just covers the fixed cost Rf. Using the expressions for profits (10) and (11) and demands (4), one obtains the repartition of firms :

$$\lambda = \frac{s_E}{1 - \phi\rho^{1-\sigma}} - \frac{1 - s_E}{\phi^{-1}\rho^{1-\sigma} - 1} \tag{12}$$

where :

- ρ is the relative cost to produce the traded good : $\rho = \frac{W_H/A_H^T}{W_F/A_F^T}$
- and s_E is H's share in world expenditures : $s_E = \frac{E_H}{E_H+E_F}$

From this, one verifies that, in an interior equilibrium, the concentration of firms in the country H is higher, the higher is H's relative demand and the lower its relative cost to produce.[10] In this model then, two types of comparative advantages emerge :

- an advantage in terms of demand, linked to the Home Market Effect, that makes the "large" country specialize in the production of differentiated goods,
- a comparative advantage *à la* Heckscher-Ohlin, that pushes the country with a high unit labor cost to specialize in capital exports and import the differentiated good.

The spatial equilibrium, and ultimately the relative price of traded goods, is determined by the interaction between these comparative advantages.

This location condition (12) is only valid in the interior equilibrium, i.e. when $\lambda \in]0; 1[$. As detailed in the Appendix, one can verify that this implies the following restriction:

$$\frac{1}{\phi s_E + \phi^{-1}(1 - s_E)} < \rho^{\sigma-1} < \phi^{-1}s_E + \phi(1 - s_E)$$

The interior equilibrium is thus only sustainable for a small enough wage gap. Outside this interval, firms are all located in the low-cost country, the production on the other one being unprofitable. In that case, one country is entirely specialized in capital exports and solely produces non-traded goods, whereas the other one produces its consumption of non-traded

[10] Indeed :

$$\frac{\partial\lambda}{\partial s_E} > 0 \quad and \quad \frac{\partial\lambda}{\partial\rho} < 0$$

goods and the world production of traded goods. The relative price of traded goods then only depends on the size of trade costs.[11]

Having characterized productive patterns, the next step consists in endogeneizing the relative cost to produce (ρ) and H's relative demand (s_E), that both depend on the spatial repartition of firms (λ).

2.4 Market equilibrium, national incomes and the relative wage

In the long-run equilibrium, all the markets clear. From the world capital market equilibrium, one obtains the total number of firms (and produced varieties) in the traded good sector:

$$n_W = \frac{K_W}{f}$$

Moreover, under the zero-profit conditions (10) and (11), the equilibrium price of capital is:

$$R = \frac{\mu}{\sigma} \frac{E_H + E_F}{K_W}$$

The equalization of labor supply with labor demand, on each national market, can be written as :

$$\begin{aligned} W_H \theta L_W &= \lambda n_W (\sigma - 1) R f + (1 - \mu) E_H && (13) \\ W_F (1 - \theta) L_W &= (1 - \lambda) n_W (\sigma - 1) R f + (1 - \mu) E_F && (14) \end{aligned}$$

These equilibrium conditions yield the distribution of world expenditure, that depends on the location of firms :

$$s_E \equiv \frac{E_H}{E_H + E_F} = \frac{\lambda(\sigma - 1) + \theta}{\sigma} \tag{15}$$

The more firms are concentrated in H, the more local workers benefit from the monopolistic rent of the traded good sector and the higher is H's share in the world demand.[12]

Last, (13) and (14) lead to the equilibrium relative labor cost in the traded good sector:

$$\rho = \frac{1 - \theta}{\theta} \frac{A_F^T}{A_H^T} \frac{\lambda(\sigma - 1) + \theta(1 - \mu)}{(1 - \lambda)(\sigma - 1) + (1 - \theta)(1 - \mu)} \tag{16}$$

This relation defines ρ as an increasing function of λ. Indeed, the concentration of firms in H exerts pressures on its relative wage. In comparison with the Footloose Capital Model, this wage adjustment plays as a centripetal force that counterbalances the Home Market Effect,

[11]For instance, if the traded good is entirely produced in country H ($\lambda = 1$), one verifies from (8) and (9) that the relative price of traded goods in country H is :

$$\frac{P_H^T}{P_F^T} = \frac{1}{\tau}$$

[12]This effect only plays through workers' income. Indeed, as the capital market is perfectly integrated, the monopolistic rent paid to capital owners from each country is strictly proportional to relative endowments.

thus explaining why, for reasonable parameter values, the final outcome is always an interior equilibrium.[13]

Together (12), (15) and (16) form a system of 3 equations in 3 unknowns $\{\lambda,\ \rho,\ s_E\}$, that characterizes the long-run interior equilibrium. Because of the non-linearity of these equations, one has to rely on numerical simulations to solve it and infer on the model's determinants of real exchange rates.

3 Determinants of the Real Exchange Rate

3.1 Partial Equilibrium Analysis

In this framework, the long-run real exchange rate, in units of H's consumption per unit of F's, can be written as :

$$RER \equiv \frac{P_H}{P_F} = \left(\frac{P_H^T}{P_F^T}\right)^{\mu}\left(\frac{P_H^N}{P_F^N}\right)^{1-\mu}$$

Calling $BS = \frac{A_H^T/A_H^N}{A_F^T/A_F^N}$ the double productivity ratio, and using the optimal prices (5), (6) and (7), one verifies that, in partial equilibrium :

$$RER = \left(\frac{\lambda\rho^{1-\sigma} + (1-\lambda)\phi}{\lambda\phi\rho^{1-\sigma} + (1-\lambda)}\right)^{\frac{\mu}{1-\sigma}} (\rho\ BS)^{1-\mu} \tag{17}$$

As expected, the Balassa-Samuelson effect measured by BS and the Variety Supply effect reflected in λ alter the real exchange rate in opposite directions.[14] Indeed, a higher concentration of firms in H ($d\lambda > 0$), by increasing the national supply of domestically produced varieties while reducing the share of imported varieties, implies a purchasing power gain for local consumers, that save on trade costs. On the other hand, the real exchange rate is more appreciated, the higher is H's relative productivity in the traded good sector, through the Balassa-Samuelson effect. Last, as wages do not necessarily fully adjust to productivity gains in the traded good sector when traded goods are imperfect substitutes, RER is also sensitive to the relative producing cost in the traded good sector (ρ), through the relative price of both traded and non-traded goods which increase with the relative cost to produce.[15] Thus, the real exchange rate is also increasing in ρ.

This partial equilibrium result is interesting as it underlines new determinants of the real exchange rate, that are likely to interact with the Balassa-Samuelson effect, usually used

[13] This is in sharp contrast with the Footloose Capital model in which the interior equilibrium only exists for similar enough countries (in terms of their size). Indeed, in the Footloose Capital model, the concentration of differentiated firms in a given country does not push up the national wage since their production substitutes itself to the production of homogeneous good to keep the current account balanced. In our model, on the contrary, the centrifugal impact created by a high national demand is counteracted by a wage adjustment, that limits the Home Market Effect.

[14]
$$\frac{\partial RER}{\partial BS} > 0 \quad whereas \quad \frac{\partial RER}{\partial \lambda} < 0$$

[15] The influence of the relative cost to produce (i.e. of the relative wage and the relative productivity) on the relative price of traded goods is consistent with Zachariadis (2005) that uses a micro-level dataset of absolute prices and finds evidence that productivity affects deviations from the Law of One Price in traded good markets.

to explain PPP deviations. Indeed, both λ and ρ are affected by changes in the relative productivity in the traded and non-traded good sectors. To have a first insight about the likely direction of this interaction, I use OECD data to calibrate the country-specific path of relative productivity gains, relative producing costs in the traded good sector and changes in the spatial distribution of produced traded goods and simulate the theoretical response of the long-run real exchange rate to each of these observed shocks.[16]

All details concerning data sources, the construction of variables and the used method are provided in the appendix of the paper. In outline, I consider successively each country (the country H of the model) with respect to the other ones (the "country" F) and compute the theoretical response of its effective real exchange rate to :

- the observed mean annual growth of its relative productivity in the traded versus non-traded good sector ($\bar{g}^{BS}$)
- the observed mean annual growth of its relative cost to produce the traded good ($\bar{g}^{\rho}$)
- average annual changes in the share of traded goods produced in its own territory ($\bar{g}^{\lambda}$)

This simulation exercise uses a growth equivalent of (17) where μ is authorized to be country-specific.[17] This relation makes it possible to evaluate the expected response of the real exchange rate when BS, λ or ρ varies at the observed pace of growth. This analysis is done *ceteris paribus*, i.e. all other RER determinants being fixed at their initial value, and for arbitrarily chosen parameters.[18]

Simulation results are summarized in Table 1. For each country of the sample, the column named "BS effect" gives the predicted annual growth rate of its effective real exchange rate attributed by the model to the observed evolution of its relative productivity in the traded versus non-traded good sector ($\bar{g}^{BS}$).[19] Similarly, the "VS effect" column gives the theoretical annual growth rate of real exchange rates attributable to observed changes in the repartition of the traded good production ($\bar{g}^{\lambda}$). Last, the "RPC effect" column is the predicted annual growth rate of real exchange rates due to cost differentials in the traded good sector. The fourth column, that just sums the previous three, thus corresponds to the theoretical real exchange rate appreciation (or depreciation if negative) attributed by the model to the combination of the Balassa-Samuelson, the Variety Supply and the Relative Producing Cost effects.[20]

[16] Note that I do not try here to conduct an empirical analysis but content myself with a simulation exercise. Indeed, several difficulties make the conduct of an empirical test of my model tricky: its non-linearity, that makes a separate identification of each effect difficult, its long-run nature, which calls for a cointegration analysis based on a richer model, and measurement problems for real exchange-rate series that take into account the entry of new firms in the market during the estimation period (see Ghironi & Mélitz (2004) and Corsetti et al., 2005).

[17] The justification for using a growth relation is that price levels are generally measured by price indices, in what case the real exchange rate level is uninteresting from an applied perspective. Moreover, the assumption of identical preferences across countries is unrealistic, as shown in Figure 4 that gives estimates of μ for each of the considered countries. The used equation is provided in appendix A.2.5.

[18] Namely, the elasticity of substitution (σ) is supposed to be equal to five and the iceberg cost is set at 1.25, these values being taken from Venables (1996). Results are somewhat sensitive to this choice, as shown in paragraph 3.2.

[19] Note that, with our definition of real exchange rates, a positive value means that, on average, the country's real excahnge rate has appreciated under the effect of productivity shocks.

[20] Of course, this theoretical effect does not exactely match the true movements in real exchange rates provided in the second column of Table 4 at the end of the paper. Indeed, this model solely focuses on the effect of trade on long-run real exchange rates, thus neglecting numerous other determinants, working through

As expected, the model reproduces a strong positive Balassa-Samuelson effect in emerging countries like Poland, Korea or Hungary, attributable to productivity gains in their traded good sector. The BS effect is also strongly positive in the United States but this is because of the high share of non-traded goods in this country's consumption that magnifies moderate productivity gains. The strongest effect is obtained for Poland and implies a real exchange rate appreciation of more than 4% per year. As for the Variety Supply effect, its simulated magnitude is on average lower than that of the BS effect.[21] The strongest effect is obtained for Hungary, whose productive expansion in the traded good sector allows to explain an annual depreciation of its long-run real exchange rate of around 0.5% per year. In the case of this country, the VS effect counteracts the BS effect so that the total predicted appreciation of the Hungarian real exchange rate is half that predicted by the BS effect alone. Last, the Relative Producing Cost effect is large in countries where wage adjustments exceed productivity gains in the traded good sector (as Spain, Hungary, Poland and, above all, Mexico), leading to a real appreciation, or when wages grow less than productivity (as in Austria, Denmark, Finland and the United States), thus pushing relative prices downward.

In eight countries[22], both the Variety Supply and the Relative Producing Cost effects play in opposite direction as the Balassa-Samuelson effect: either the country's relative productivity in the traded good sector vanishes whereas wages only partially adjust, in what case traded good producers have an incentive to leave the domestic market (as in Australia), or on the contrary, the country's relative productivity increases whereas its cost competitiveness improves, explaining the growth of its production of traded goods (as in Austria). Under this configuration, neglecting PPP deviations in the traded good sector would lead to underestimate the Balassa-Samuelson effect, at least if these effects are correlated, as suggested by the model. In three countries, the model suggests that the Balassa-Samuelson, the Variety Supply and the Relative Producing Cost effects reinforce together in influencing the relative price level: in Germany, the three effects tend to appreciate the real exchange rate whereas the opposite is true in New Zealand and Norway. In that case, occurring when productivity gains are more than compensated by wage adjustments, thus detering firms to enter the "productive" countries, neglecting PPP deviations in the traded good sector would lead to overestimate the true Balassa-Samuelson effect. In the remaining countries, the direction of the omission bias when testing the textbook version of the Balassa-Samuelson effect is difficult to anticipate because the Variety Supply effect and the Relative Producing Cost effect play in opposite direction.[23] However, one can still fear the presence of an omission bias in standard estimations of the Balassa-samuelson effect.

monetary or financial markets. For instance, the model underestimates the true real appreciation in East and Central European countries (Czech Republic, Hungary and Poland), as this appreciation is partly due to capital inflows that the model neglects.

[21]This result is consistent with the relatively good fit of models of long-run real exchange rates based on the Balassa-Samuelson hypothesis, that neglects the Variety Supply effect.

[22]Australia, Austria, Belgium, Canada, Denmark, Finland, Korea and New Zealand.

[23]One could infer the direction of the bias by comparing the relative magnitude of effects in columns 2 and 3 of Table 1. I however consider these figures as purely indicative as they are sensitive to the chosen parameters and to my definition of productivity which entirely bears on labor productivity. As a consequence, I only trust the sign of the figures in Table 1.

Table 1: Predicted annual growth rate (in %) of the effective RER, attributable to the Balassa-Samuelson effect, the Variety Supply effect, the Relative Producing Cost effect and a combination of these three effects

	BS effect	VS effect	RPC effect	Total effect
Australia	-1.92	0.02	1.32	-0.58
Austria	0.23	-0.16	-2.65	-2.58
Belgium	0.04	-0.28	-0.58	-0.82
Canada	-0.96	0.00	0.75	-0.21
Czech Republic	0.81	-0.06	0.64	1.39
Denmark	0.51	-0.31	-2.03	-1.83
Finland	0.02	-0.12	-2.05	-2.15
France	0.62	0.01	-1.64	-1.01
Germany	0.35	0.02	1.61	1.98
Greece	-0.75	-0.10	1.39	0.54
Hungary	1.11	-0.58	3.12	3.65
Italy	-0.66	-0.20	0.68	-0.18
Japan	-0.83	0.02	-1.55	-2.36
Korea	1.69	-0.09	-0.26	1.34
Mexico	-0.86	-0.27	14.53	13.40
Netherlands	-0.13	-0.20	-0.35	-0.68
New Zealand	-0.65	0.00	0.24	-0.41
Norway	-1.30	-0.11	-0.33	-1.74
Poland	4.01	-0.13	6.95	10.83
Portugal	0.04	-0.10	1.87	1.81
Spain	-0.61	-0.02	2.76	2.13
Sweden	0.81	0.01	-1.28	-0.46
United Kingdom	-0.70	-0.31	0.27	-0.74
United States	1.22	0.02	-3.09	-1.85

Sources : Simulation of (17) using OECD data

This partial equilibrium analysis thus allows to contrast the partial equilibrium determinants of real exchange rates that we have introduced in the model. It shows that the interaction between the Balassa-Samuelson effect and the Variety Supply effect is a complicated phenomenon that can have various implications for the real exchange rate. However, it is obviously insufficient as location decisions, that determines λ and ρ, have not been taken into account. In the following then, we use numerical simulations to study the structural determinants of the real exchange rate in general equilibrium, with a particular focus on the relative productivity in the traded vs. non-traded good sector (that generates the BS effect) and the relative size of countries (that influence the firms location in our NEG framework).

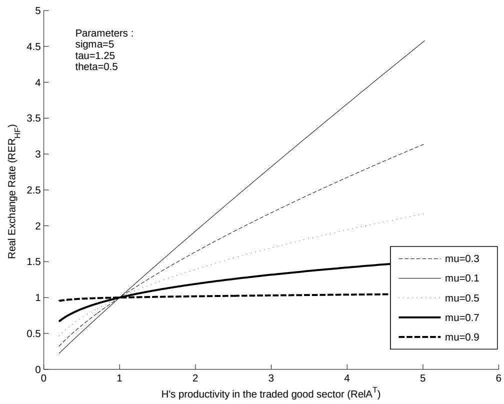
3.2 Structural determinants of the real exchange rate

To see the role of the relative size of countries and the relative productivity in the traded good sector in this non-linear model, one calculates the equilibrium real exchange rate using (17) for different values of θ between 0.5 (symmetric countries) and 1 (strong size asymmetry) and when $RelA^T = A_H^T / A_F^T$ varies between 0.2 and 5. Each of these computations is conducted for different values of i) the transport cost τ, set between 1.05 and 1.45 so as to cover estimates obtained by Hummels (2001), ii) the elasticity of substitution, fixed between 3 and 7 as in Venables (1996), iii) the share of traded goods in consumption.[24]

3.2.1 Productivity gap and the real exchange rate

The theoretical link between the equilibrium real exchange rate and H's relative productivity in the traded good sector is illustrated in Figure 1, for different values of μ. Moreover, Table 2 gives the simulated magnitude of this effect, measured by the elasticity of the real exchange rate to a one percent change in H's relative productivity, for several sets of parameters.[25]

Figure 1: RER influence of productivity gaps and the share of traded goods



As already explained, the real exchange rate appreciates when H's relative productivity in the traded good sector increases because of a wage adjustment. As in a standard Balassa-Samuelson model, the strength of this effect is positively linked to the share of non-traded goods in consumption (Figure 1). Moreover, as H's relative productivity in the traded good sector enters location decisions, the intensity of this effect slightly varies with location determinants, notably H's relative size θ and trade costs τ (see Table 2). As shown in the following paragraph, the direction of these links is sensitive to several parameters as location decisions also influence equilibrium wages. Still however, this sensitivity confirms the importance of taking into account the impact of location decisions when testing the Balassa-Samuelson hypothesis, the correlation between both effects being a potential source of omission bias. With our calibration of parameters, these location effects are quantitatively small and the model globally reproduces the standard Balassa-Samuelson mechanism : a 1% improvement in H's relative productivity in the traded good sector leads to an appreciation of its real exchange rate of around $(1-\mu)$%.

[24]To replicate the multiplicity of situations observed in OECD countrie and illustrated in Figure 4, this parameter is authorized to vary between 0.1 and 0.9.

[25]When the relation is not linear, the table gives the interval in which the elasticity varies for $RelA^T$ between 0.2 and 5.

Table 2: Elasticity of RER with respect to H's relative productivity in the traded good sector($\xi_{RER}^{RelA^T}$)

Parameters		$\xi_{RER}^{RelA^T\,(a)}$
$\sigma = 5,\ \tau = 1.25,$	$\mu = 0.1$	0.94
$\theta = 0.5$	$\mu = 0.3$	0.71
	$\mu = 0.5$	0.48
	$\mu = 0.7$	0.25
	$\mu = 0.9$	0.03
$\sigma = 5,\ \tau = 1.25,$	$\theta = 0.5$	0.25
$\mu = 0.7$	$\theta = 0.7$	[0.25 ; 0.28]$^{(b)}$
	$\theta = 0.9$	[0.25 ; 0.30]
$\sigma = 5,\ \mu = 0.5,$	$\tau = 1.05$	0.50
$\theta = 0.6$	$\tau = 1.15$	0.49
	$\tau = 1.25$	0.48
	$\tau = 1.35$	0.47
	$\tau = 1.45$	0.45

Source : Author's calculations.

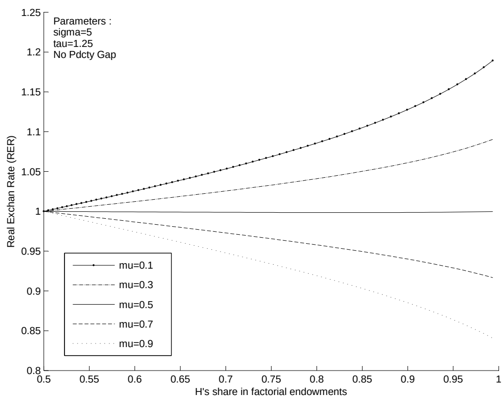
(a) $\xi_{RER}^{RelA^T} = \frac{\partial RER}{\partial RelA^T}\frac{RelA^T}{RER}$ with $RelA^T = A_H^T/A_F^T$. $\xi_{RER}^{RelA^T}$ measures the sensitivity of the real exchange rate to a one percent change of H's relative productivity in the traded good sector.

(b) Interval in which $\xi_{RER}^{RelA^T}$ varies when $RelA^T = A_H^T/A_F^T$ increases from 0.2 to 5.

3.2.2 Relative Size and the real exchange rate

We now turn to the influence of the relative size of countries by making θ vary between 0.5 and 1, thus increasing the firms incentive to enter H through the Home Market Effect. Results concerning the sensitivity of the real exchange rate to this parameter are summarized in Figure 2 and Table 3.

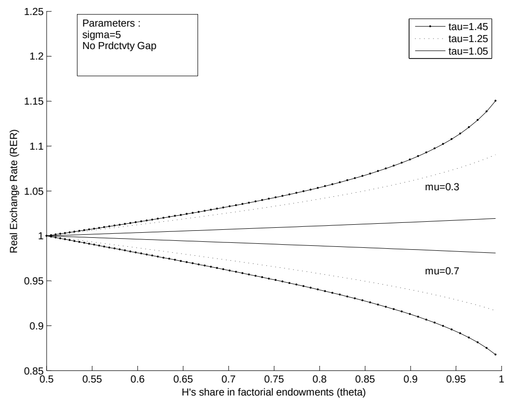
Figure 2: Home Market Effect and the share of traded goods



As illustrated in Figure 2, the direction of the induced exchange-rate effect depends on the share of traded goods in price levels. When the share of traded goods is large enough ($\mu > 0.5$), the size effect is negative : the more firms are concentrated in H to benefit from a large local demand, the lower is H's relative price level because of the trade cost saving implied by the substitution of local products to imported ones. On the other hand, when the consumption of non-traded good is important, this trade cost saving is more than compensated by the pressure that the strong labor demand exerts on H's relative wage. As a consequence, when $\mu < 0.5$, H's relative price level increases with H's share in world factor endowments.

As the influence of θ on the real exchange rate comes from the endogenous repartition of firms (λ), any factor affecting location decisions modifies the intensity of this link. Thus, the magnitude of this effect depends on the size of trade frictions because high trade costs make more crucial the market access, from the firm's viewpoint. As a consequence, the size effect is reinforced by a raise in trade costs (see Figure 3). In the same way, the intensity of this effect is also affected by the substituability between varieties: it is increasing with the elasticity of substitution between goods. Indeed, when the demand is little sensitive to price changes, the agglomeration effect that pushes firms to locate near the largest demand is strong, as shown by Baldwin et al. (2005).

Figure 3: Home Market Effect and the size of trade costs



The quantitative importance of this size effect is measured in Table 3 through the elasticity of RER to θ, for different sets of parameters. This sensitivity increases when countries become more asymmetric. Moreover, the real exchange rate is more sensitive to the relative size of countries as i) preferences between traded and non-traded goods are more biased towards one sector, ii) trade costs are higher, iii) H's relative productivity in the traded good sector is lower, iv) the elasticity of substitution between varieties of the traded good is higher. Depending on the entire set of parameters, the simulated elasticity of the real exchange rate to the relative size of countries varies between -0.85 and 1.04. Comparing this with the elasticity of RER to the Balassa-Samuelson determinant, this implies that the Home Market effect is likely to be an important determinant of real exchange rates.

Confronting results of these two sets of simulations thus highlights a rich variety of situations. By modifying a small number of parameters in a realistic interval, one is indeed able to contrast situations where i) the structural Balassa-Samuelson and Home Market effects reinforce together or play in opposite direction, ii) the Balassa-Samuelson effect dominates or is dominated by the Home Market effect. In particular, when the share of traded goods in consumption is low ($\mu < 0.5$), one can expect the Balassa-Samuelson effect to be strong, and reinforced by a size effect if the country that is relatively more productive also owns a large part of world factor endowments (as China for instance). On the contrary, in large but highly open countries, that consume many imported goods (as the European Union), the Balassa-Samuelson effect should be somewhat compensated by the Home Market Effect.

Table 3: Elasticity of RER with respect to H's relative size (ξ^{θ}_{RER})

Parameters		ξ^{θ}_{RER} $^{(a)}$
$\sigma = 5,\ \tau = 1.25,$	$\mu = 0.1$	[0.12 ; 0.72]
No Prcdvty Gap	$\mu = 0.3$	[0.06 ; 0.37]
	$\mu = 0.5$	$\simeq 0$
	$\mu = 0.7$	[−0.07 ; −0.33]
	$\mu = 0.9$	[−0.13 ; −0.64]
$\sigma = 5,\ \mu = 0.3,$	$\tau = 1.05$	[0.02 ; 0.04]
No Prcdvty Gap	$\tau = 1.25$	[0.06 ; 0.37]
	$\tau = 1.45$	[0.08 ; 1.04]
$\sigma = 5,\ \mu = 0.7,$	$\tau = 1.05$	[−0.02 ; −0.04]
No Prcdvty Gap	$\tau = 1.25$	[−0.07 ; −0.33]
	$\tau = 1.45$	[−0.09 ; −0.85]
$\tau = 1.25,\ \mu = 0.3,$	$RelA^T = 0.5^{(b)}$	[0.06 ; 0.57]
$\sigma = 5$	$RelA^T = 1$	[0.06 ; 0.37]
	$RelA^T = 2$	[0.06 ; 0.25]
$\tau = 1.25,\ \mu = 0.7,$	$RelA^T = 0.5$	[−0.06 ; −0.70]
$\sigma = 5$	$RelA^T = 1$	[−0.07 ; −0.33]
	$RelA^T = 2$	[−0.06 ; −0.12]
	$RelA^T = 5$	[−0.04 ; 0.02]
$\tau = 1.25,\ \mu = 0.3,$	$\sigma = 3$	[0.07 ; 0.25]
No Prcdvty Gap	$\sigma = 5$	[0.06 ; 0.37]
	$\sigma = 7$	[0.05 ; 0.57]
$\tau = 1.25,\ \mu = 0.7,$	$\sigma = 3$	[−0.08 ; −0.20]
No Prcdvty Gap	$\sigma = 5$	[−0.07 ; −0.33]
	$\sigma = 7$	[−0.05 ; −0.52]

Source : Author's calculations.

(a) Interval in which $\xi^{\theta}_{RER} = \frac{\partial RER}{\partial \theta} \frac{\theta}{RER}$ varies when θ increases from 0.5 to 1.

(b) $RelA^T = A^T_H / A^T_F$ is H's relative productivity in the traded good sector.

4 Conclusion

By combining traditional aspects of the real exchange rate modelization with NEG assumptions, the model developed in this paper contrasts two determinants of PPP deviations working through the price of non-traded goods as well as through deviations from the Law of One Price in the traded-good sector. First, as in a standard Harrod-Balassa-Samuelson model, cross-sectoral productivity differentials are introduced, that generate price differentials in the non-traded good sector: the more a country is productive in the traded relative to the non-traded good sector, the more appreciated is its real exchange rate. As traded good prices are not perfectly substitutable, wages however do not fully adjust to productivity gaps in the traded good sector, so that the relative price of traded goods also depends on the relative productivity in the traded good sector. Moreover, the introduction of NEG hypotheses (namely increasing returns and trade costs) allows to generate an additional "Variety Supply" effect explaining discrepancies in national traded-good prices. In such a framework, location decisions indeed affect the relative price of traded goods: *ceteris paribus*, an increase in the share of domestically produced differentiated goods decreases relative prices because of savings on trade costs. This effect can however be counteracted if the pressure on wages exerted by this entry of firms in the market is strong enough. Calibrating these effects with OECD data, one shows that standard tests of the Balassa-Samuelson hypothesis may be biased by the omission of a control for the endogeneity of productive structures. The direction of the bias however depends on general equilibrium effects: if the productivity shock is more than compensated by wage adjustments, firms have no incentive to enter the productive market, which real exchange rate appreciates, as in the textbook Balassa-Samuelson model. However, if wages adjust less than proportionaly, firms find it profitable to enter the productive market, which tends to depreciate the real exchange rate thanks to a decrease in the relative price of traded goods.

Solving the model in general equilibrium allows to study the structural determinants underlying these effects. As expected, a country's real exchange rate increases with its relative productivity in the traded good sector. In this model however, the elasticity of the exchange rate with respect to the relative productivity in the traded good sector is not the share of non-traded goods in consumption, as in the BS framework, because the relative productivity affects location decisions. On the other hand, a country's relative price level also depends on its relative size, an important determinant of location decisions in a model with a Home Market Effect. The direction of this effect is however ambiguous as it depends on the structure of preferences. When the share of traded goods in consumption is large enough, the relation is negative because a size increase leads to a magnified entry of firms, that reduces the share of traded good prices incurring a trade cost. However, when a large share of consumption goods are not traded in equilibrium, the pressure exerted on wages by the entry of firms leads to a dominant cost effect affecting traded and non-traded goods that more than compensates the positive effect linked to the trade cost saving. In that case, the real exchange rate appreciates when a country becomes larger.

These results are interesting for several reasons. First, they show that using a model of trade under imperfect competition can be highly instructive for macroeconomists. Indeed, whereas the impact of location decisions on trade flows has been extensively studied by the New Trade literature, their influence on global variables, such as price levels, has not been much studied. Yet, this simple model emphasizes some structural determinants of long-run real exchange rates that are neglected in neo-classical frameworks. As the New Trade Theory has received strong empirical support, such an approach could be useful to understand some Open Macroeconomic empirical "puzzles" as the PPP puzzle. From an applied perspective, results suggest that neglecting the impact of firms' location decisions when estimating long-run real exchange rates can lead to biased estimates of the Balassa-Samuelson effect. On this point however, the empirical difficulty discussed by Ghironi & Mélitz (2004) or Corsetti et al. (2005) persists. Indeed, building real exchange-rate series from price indices that do not explicitly take into account the endogeneity of national variety supplies amounts to neglect the impact of location decisions, thus introducing a measurement bias that could be embarassing when trying to identify a Variety Supply effect.

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A.1. Productive patterns in partial equilibrium

The geographical distribution of firms in the interior equilibrium is determined by equalizing operational profits, at the previously determined optimal prices and individual demands :

$$\begin{aligned} \frac{1}{\sigma-1}\frac{W_H}{A_H^T}(x_H+\tau x_F) &= \frac{1}{\sigma-1}\frac{W_F}{A_F^T}(x_F+\tau x_H) \\ \Rightarrow \frac{s_E}{\Delta_H}(\rho^{1-\sigma}-\phi) &= \frac{1-s_E}{\Delta_F}(1-\phi\rho^{1-\sigma}) \end{aligned}$$

with :

$$\begin{aligned} \rho &= \frac{W_H/A_H^T}{W_F/A_F^T} \\ \Delta_H &= \lambda\rho^{1-\sigma}+(1-\lambda)\phi \\ \Delta_F &= \lambda\phi\rho^{1-\sigma}+(1-\lambda) \end{aligned}$$

The interval of existence of this interior equilibrium is obtained using a transformation of this condition :

$$\lambda = \frac{s_E}{1-\phi\rho^{1-\sigma}} - \frac{1-s_E}{\phi^{-1}\rho^{1-\sigma}-1}$$

The interior equilibrium is defined as a productive pattern such that some traded good is produced in each country : $\lambda \in]0;1[$. The interval on which this interior equilibrium is defined comes immediately :

$$0<\lambda<1 \;\Rightarrow\; \frac{1}{\phi s_E+\phi^{-1}(1-s_E)} < \rho^{\sigma-1} < \phi^{-1}s_E+\phi(1-s_E)$$

Outside this interval, the traded good is entirely produced in a single country ($\lambda = 0$ or $\lambda = 1$), the external equilibrium being achieved through the compensation of the trade imbalance by the opposite flow paid by firms from the producing country to the foreign capital owners. Which country concentrates the whole production depends on the relative profitability of producing the traded good. For $\lambda = 0$ to be a stable equilibrium, the production in H has to be unprofitable. The profit that an individual firm would obtain when entering H, starting from a situation where all firms are concentrated in F, is:[26]

$$\Pi_{H|\lambda=0} = \frac{\mu}{\sigma}\frac{f(E_H+E_F)}{K_W}\left[\frac{\phi^{-1}s_E+\phi(1-s_E)}{\rho^{\sigma-1}}-1\right]$$

which is negative (thus making this entry unprofitable) as long as :

$$\rho^{\sigma-1} > \phi^{-1}s_E+\phi(1-s_E)$$

[26] Here, we use the standard result featuring the Dixit-Stiglitz model according to which, in equilibrium, the total amount paid to cover the fixed costs is proportional to the world expenditure with a factor μ/σ :

$$RK^W = \frac{\mu}{\sigma}(E_H+E_F)$$

In the same way, one verifies that $\lambda = 1$ is a stable equilibrium if

$$\Pi_{F|\lambda=1} = \frac{\mu}{\sigma} \frac{f(E_H + E_F)}{K_W} \left[\rho^{\sigma-1}(\phi^{-1}(1 - s_E) + \phi s_E) - 1\right] < 0$$

that is to say if

$$\rho^{\sigma-1} < \frac{1}{\phi^{-1}(1 - s_E) + \phi s_E}$$

The following table summarizes patterns of specialization in the traded good sector, as a function of the cost gap :

$\rho^{\sigma-1}$	$\rho_l^{\sigma-1\ (a)}$	$\rho_h^{\sigma-1\ (a)}$	
Productive structure	FS in H[(b)]	IE	FS in F

(a) $\rho_l^{\sigma-1} = (\phi s_E + \phi^{-1}(1 - s_E))^{-1}$ and $\rho_h^{\sigma-1} = \phi^{-1} s_E + \phi(1 - s_E)$

(b) FS = "Full Specialization", IE = "Interior Equilibrium".

A.2. Confrontation of the theoretical partial equilibrium real exchange rate with OECD data

A.2.1. Data sources

The data used to calibrate the parameters of the model have been obtained from various OECD databases : the STAN Bilateral Trade, the STAN sectorial labor productivity indicators and the Main Economic Indicators.

These databases are constructed on a uniform sectorial classification in 99 industries, that makes data merging easier. Data generally cover the OECD members over a maximum period from 1988 to 2003. In the paper, we only use data concerning 24 countries : Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Japan, Korea, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Sweden, the United Kingdom and the United States.

A.2.2. Traded and non-traded goods

To determine which sectors are exposed to international competition and which can be considered as "non-traded good sectors", one uses a criterium combining data on :

- the import penetration of each sector, i.e. the share of imported goods in the national consumption,
- and the share of exports in the value added.

Using these indicators, an industry is identified as a non-traded good sector if both its import penetration and the share of value added exported abroad are less than 10%.[27] Sectorial

[27] Gregorio, Giovannini & Wolf (1994) use the same type of criteria to separate traded and non-traded goods. They however restrict this criterium to the share of value added that is exported, without taking into account

value added series are drawn from the "STAN International Trade" database. As this database does not cover trade in services, the corresponding sectors are always considered as non-traded. The subsample of non-traded good sectors thus always includes the following activities : "Construction, Wholesale and Retail Trade", "Restaurants and Hotels", "Transport and Storage", "Communication", "Finance, Insurance, Real Estate and Business Services", "Community Social and Personal Services". In addition, the "Electricity, Gas and Water Supply" sector is often included in non-traded good sectors.

A.2.3. Measure of variables

From this classification of sectors into traded and non-traded good industries, one can calculate the share of traded goods in consumption. This is done using data from the "STAN Bilateral Trade" database that gives details on each country's sectorial imports, from each of its partners.[28] Thus, the share of traded goods in country i's consumption at time t is computed as :

$$\mu_{it} = \frac{\sum_{s \in T} \sum_j IMP_{ijt}^s}{\sum_s \sum_j IMP_{ijt}^s}$$

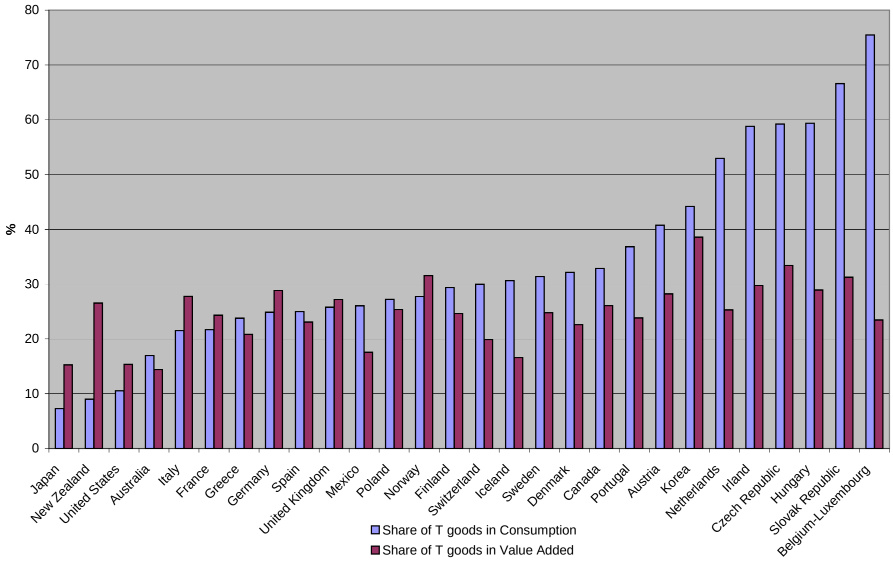
with IMP_{ijt}^s the value of i's imports from j in the sector s at time t (in current international dollars) and T the (country-specific) set of traded good sectors. The time dimension is then dropped by computing the simple mean of $\{\mu_{it}\}$ at the country-level ($\bar{\mu}_i$).

As shown in Figure 4, the share of traded goods in consumption widely varies across countries, much more than the share of traded goods in the total value added : the richest countries (Japan and United States), or the more isolated ones (New Zealand or Australia) appear to consume a higher share of non-traded goods than developing or smaller countries. Note that the time-variance of this indicator is smaller than the cross-country heterogeneity, except in countries like Poland or Mexico, that consumed very few tradable goods at the beginning of the period but opened themselves and reached similar shares of traded goods in their consumption as middle-income countries in 2003. For these countries then, averaging coefficients μ_{it} across time periods is somewhat embarassing as it hides the impact of their opening on the relative weight of the Balassa-Samuelson and the Variety Supply effects in explaining their real exchange rate.

the import penetration. In our model however, in the case of a corner equilibrium, the traded good may be entirely produced in a given country, in which case, in the partner country, the exported share of value added will be zero whereas its import penetration will be unitary. Alternatively, Crucini, Telmer & Zachariadis (2005) measure this by the ratio of exports and imports over output corrected by a measure of local input content.

[28]This database also includes "imports" from the country itself so that the global imports correspond to the country's total consumption.

Figure 4: Share of traded goods in consumption and in value added
Sources : Author's calculations from OECD data



Statistics on the labor productivity by type of goods (A^T or A^N) are obtained using the STAN sectorial labor productivity indicators. In this database, the labor productivity is computed as the value added per worker in each industry. The aggregation in the "traded/non-traded" classification is done by averaging those industry-specific labor productivities, with a weighting scheme based on the share of each sector in the total value added in traded or non-traded sectors :

$$A_{it}^b = \sum_{s \in b} A_{it}^s \frac{VA_{it}^s}{VA_{it}^b}, \quad b = T, N$$

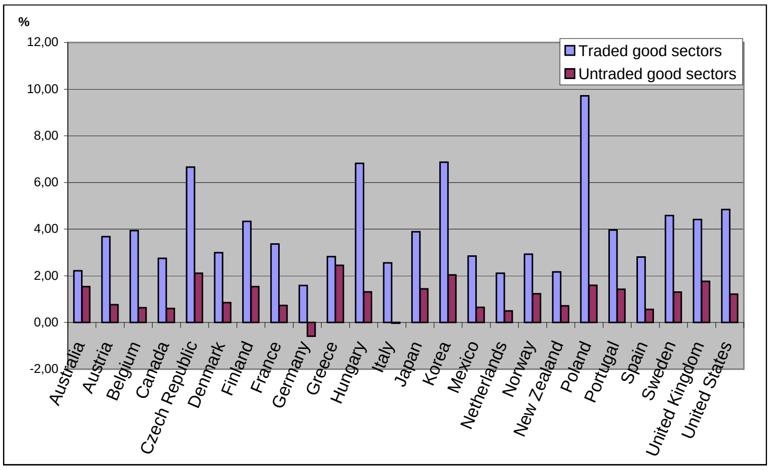
with A_{it}^s the labor productivity in the industry s of country i at time t and VA_{it}^s the value added (at current prices) in the sector s relative to the total value added for all industries. The ratio of A_{it}^T on A_{it}^N is then i's relative productivity in the traded good sector, with respect to the non-traded one. As labor productivity indicators provided by the OECD are indices[29], the level of this variable is not really interesting, unlike its evolution. As expected, the annual growth rate of labor productivity is on average higher in traded than in non-traded good sectors (see Figure 5). This justifies the focus on the relative productivity in the traded good sector in Section 3.1.

From these sectoral productivities, one obtains the Balassa-Samuelson term entering in (17) :

$$BS_{ijt} = \frac{A_{it}^T / A_{it}^N}{A_{jt}^T / A_{jt}^N}$$

[29]The reference year being 1995, as for all indices used in this paper.

Figure 5: Mean annual labor productivity growth in traded and non-traded sectors



Wages are measured by the unit labor cost indice in the whole economy, also provided in the STAN database.[30] Using these labor cost data and the labor productivity series, one can calibrate the relative cost to produce in the traded good sector (ρ_{ijt}) as :

$$\rho_{ijt} = \frac{w_{it}/A_{it}^T}{w_{jt}/A_{jt}^T}$$

The spatial repartition of traded good producers (λ) is measured indirectly through the ratio of the nominal traded good productions in the considered countries :

$$\nu_{ijt} = \frac{n_{it}p_{it}^T y_{it}^T}{n_{jt}p_{jt}^T y_{jt}^T}, \quad \lambda_{ijt} = \frac{\nu_{ijt}}{1+\nu_{ijt}}$$

To measure each country's nominal production of traded goods, one uses the series of GDP at current prices provided by the OECD's "Main Economic Indicators", multiplied by the share of value added in traded good sectors :

$$n_{it}p_{it}^T y_{it}^T = GDP_{it} * VA_{it}^T$$

A.2.4. Aggregation into "effective" statistics

When simulating (17) to evaluate the potential impact of the Balassa-Samuelson and the Variety Supply effects on real exchange rates (see Section 3.1), it is convenient to work in effective terms, i.e. to consider each country with respect to all its OECD partners.

Thus, when simulating (17) for a given country i, one needs a measure of its partners's relative productivity in the traded good sector relative to the non-traded sector (A_{-it}^T/A_{-it}^N

[30]The unit labor cost relative to the whole economy is prefered to the unit labor cost in the traded good sector in order to match our assumption of a perfect labor mobility between sectors driving wages to equality in each country.

where $-i$ is the set of i's partners). One calculates it through a trade-weighted geometric average of its partners' relative productivity :

$$\frac{A^T_{-it}}{A^N_{-it}} = \prod_{j\in -i}\left(\frac{A^T_{jt}}{A^N_{jt}}\right)^{\omega_j}$$

In this expression, ω_j is the share of country j in i's total trade during the base year (1995) :

$$\omega_j = \frac{X_{j1995} + M_{j1995}}{\sum_{j\in -i}(X_{j1995} + M_{j1995})}$$

where X_{j1995} is the value of i's exports to j in 1995 and M_{j1995} the value of its imports from j.

The Balassa-Samuelson variable, in effective terms, is then :

$$BS_{i-it} = \frac{A^T_{it}/A^N_{it}}{A^T_{-it}/A^N_{-it}}$$

An equivalent weighting scheme is used in the simulations to average :

- the country's relative cost to produce in the traded good sector :

$$\begin{aligned} W_{-it} &= \prod_{j\in -i} W_{jt}^{\omega_j} \\ A^T_{-it} &= \prod_{j\in -i} A_{jt}^{T\ \omega_j} \\ \rho_{it} &= \frac{W_{it}/A^T_{it}}{W_{-it}/A^T_{-it}} \end{aligned}$$

- and its relative share in the production of traded goods :

$$\begin{aligned} n_{-it}p^T_{-it}y^T_{-it} &= \prod_{j\in -i} n_{jt}p^T_{jt}y_{jt}^{T\ \omega_j} \\ \nu_{i-it} &= \frac{n_{it}p^T_{it}y^T_{it}}{n_{-it}p^T_{-it}y^T_{-it}} \\ \lambda_{it} &= \frac{\nu_{i-it}}{1+\nu_{i-it}} \end{aligned}$$

A.2.5. Methodology

These series being constructed, one can simulate the theoretical relation (17) to infer each country's long-run effective real exchange rate (as predicted by the model). As some of the series are based on indices, it is however convenient to switch from the relation in levels to a growth equivalent of (17). Moreover, as shown by Figure 4, assuming μ to be the same in all countries is obviously unrealistic. As a consequence, the simulation is done on a growth relation where the coefficient μ is authorized to vary across countries ($\mu_H \neq \mu_F$). The exact used relation is :

$$g_t^{RER} = (\mu_F - \mu_H)g_t^{A^T_F/A^T_H} + \mathbf{A}g_t^{\lambda} + \mathbf{B}g_t^{\rho} + (1-\mu_H)g_t^{BS} \tag{18}$$

where

$g_t^i = di/i$ is the annual growth rate of variable i between $t-1$ and t,

$$\mathbf{A} = \frac{\lambda}{\sigma - 1}\left(\frac{\mu_F(\phi\rho^{1-\sigma} - 1)}{\lambda\phi\rho^{1-\sigma} + (1-\lambda)} - \frac{\mu_H(\rho^{1-\sigma} - \phi)}{\lambda\rho^{1-\sigma} + (1-\lambda)\phi}\right)$$

$$\mathbf{B} = \frac{\mu_H\rho^{1-\sigma}\lambda}{\lambda\rho^{1-\sigma} + (1-\lambda)\phi} - \frac{\mu_F\lambda\phi\rho^{1-\sigma}}{\lambda\phi\rho^{1-\sigma} + (1-\lambda)} + (1-\mu_H)$$

More precisely, in section 3.1, we simulate, for each country, the predicted average growth of RER ($g^{RER} = T^{-1}\sum_t g_t^{RER}$) induced by :

i) the observed mean growth of the double productivity ratio ($g^{BS} = T^{-1}\sum_t g_t^{BS}$)

ii) the observed mean growth of the traded good production in the domestic market ($g^{\lambda} = T^{-1}\sum_t g_t^{\lambda}$),

iii) the observed mean growth of the relative cost to produce the traded good ($g^{\rho} = T^{-1}\sum_t g_t^{\rho}$).

This simulation exercise is a *ceteris paribus* analysis, i.e. all other variables entering in (18) are maintained constant at their initial value.

Table 4: Descriptive Statistics of the Variables of Interest in a sample of OECD countries

	Period	$\bar{g}_{RER}(\%)^{(a)}$	$\bar{\mu}_H(\%)$ $^{(b)}$	$\bar{\mu}_F(\%)$ $^{(c)}$	$\bar{g}_{BS}(\%)$ $^{(d)}$	$\bar{g}_\lambda(\%)$ $^{(e)}$	$\bar{g}_\rho(\%)$ $^{(f)}$
Australia	88-01	0.68	17	14	-2.31	-2.16	1.54
Austria	88-02	-0.87	41	26	0.39	9.31	-3.75
Belgium	88-02	-0.54	75	26	0.15	5.55	-1.16
Canada	88-00	-0.80	33	12	-1.42	-0.01	1.00
Czech Republic	95-00	4.37	59	27	1.99	4.05	1.37
Denmark	88-02	-4.00	32	22	0.75	10.30	-2.62
Finland	88-02	-0.47	29	25	0.03	7.62	-2.64
France	88-01	-1.24	22	27	0.79	-0.25	-1.91
Germany	88-01	-0.83	25	27	0.47	-0.37	1.98
Greece	95-02	2.30	24	27	-0.99	7.76	1.75
Hungary	92-02	12.98	59	27	2.75	15.62	7.19
Italy	88-02	0.95	22	25	-0.84	3.41	0.79
Japan	88-01	-2.28	7	18	-0.89	-0.59	-1.68
Korea	89-99	2.97	44	12	3.04	1.91	-0.34
Mexico	88-01	14.94	26	12	-1.16	7.26	18.49
Netherlands	88-02	-0.30	53	27	-0.28	5.82	-0.58
New Zealand	89-98	-0.52	9	15	-0.72	-1.13	0.26
Norway	88-02	-0.35	28	27	-1.79	7.46	-0.44
Poland	92-01	15.58	27	28	5.56	4.17	8.85
Portugal	88-99	3.20	37	24	0.06	3.17	2.64
Spain	88-01	1.07	25	25	-0.82	0.50	3.30
Sweden	88-01	0.56	31	24	1.18	-0.74	-1.64
United Kingdom	88-02	0.83	23	28	-0.94	4.41	0.31
United States	88-01	-1.04	11	21	1.37	-0.18	-3.63

Sources : Author's calculations

For each country, calculations are done considering the rest of the sample as its partners, with a weighting scheme based on the share of each partner in the country's total trade (exports plus imports).

(a) Mean annual growth rate of the effective real exchange rate (CPI based). A positive value means that, on average, the country's relative price level has increased, i.e. its real exchange rate has appreciated.

(b)(c) Mean share of traded goods in the nominal consumption of the considered country (b) and of its partners (c).

(d) Mean annual growth of the double productivity ratio : $BS = \frac{A^T_{tH}/A^N_{tH}}{A^T_{tF}/A^N_{tF}}$. Used to measure of the Balassa-Samuelson effect.

(e) Mean annual growth of the country's relative production of traded growth : $\lambda = \frac{GDP^T_{tH}}{GDP^T_{tH}+GDP^T_{tF}}$. Used to measure of the Variety Supply Effect.

(f) Mean annual growth of the country's relative cost to produce the traded good : $\rho = \frac{W_{tH}/A^T_{tH}}{W_{tF}/A^T_{tF}}$. Used to measure the Relative Producing Cost effect.