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TERMS OF TRADE, PRODUCTIVITY, AND THE REAL EXCHANGE RATE

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ABSTRACT

The paper examines the effects of terms of trade movements and productivity differentials across sectors on the behavior of the real exchange rate. We develop a simple model of a small open economy producing exportable and nontradable goods and consuming importable and nontradable goods and present empirical evidence for a sample of fourteen OECD countries. The evidence broadly supports the predictions of the model, namely that faster productivity growth in the tradable relative to the nontradable sector and an improvement in the terms of trade induce a real appreciation.

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1 Introduction

Sectoral productivity differentials across countries have long been identified as a major determinant of real exchange rate movements (Harrod, 1939; Balassa, 1964; and Samuelson, 1964). In this literature, the price of tradables is pinned down by the law of one price and—through perfect competition—equated with marginal cost. Production relies on internationally perfectly mobile capital and internationally perfectly immobile labor. The small open economy thus takes the world interest rate as given, which determines uniquely the wage rate by the equalization of marginal cost and the given world price. Perfect intersectoral factor mobility ensures factor price equalization across the tradable and the nontradable sector. Given both factor prices, the productivity in the nontradable sector then determines the price of nontradables. *Ceteris paribus*, economies with a higher level of productivity in tradables will thus be characterized by higher wages and hence by higher prices of nontradables, i.e. a more appreciated real exchange rate.

A second strand of literature identifies relative price movements within the tradables sector, specifically, movements in the relative price of exports to imports, as another major determinant of real exchange rate movements (Dornbusch, 1980; Greenwood, 1984; Marion, 1994; Ostry, 1988; Edwards, 1989; Roldos, 1990; and Frenkel and Razin, 1992). The main real exchange rate effect in these models derives from the opposite income effects of export and import price changes interacting with the substitution effect. In addition, terms of trade shocks may display direct supply side effects if imported intermediate inputs are used in domestic production. This literature has developed mainly to understand fluctuations of real exchange rates in developing countries, which are characterized by large fluctuations in the terms of trade. This issues are becoming also relevant in transition economies where trade liberalization will increase the exposure to fluctuation in the terms of trade.

While a substantial body of empirical literature exists on both productivity and terms of trade effects on real exchange rate determination[2], the literature tends to focus on one of the two effects, suggesting the possibility of excluded variable bias. In this paper, we examine the joint effect of productivity differentials and terms of trade movements on the real exchange rate.

In the following section we present a three-goods model of a small open economy.

Section 3 discusses the comparative static characteristics of the model under the extreme assumptions of perfect and zero capital mobility. Section 4 describes the data underlying the empirical evidence reported in section 5. Sections 6 concludes.

2 The Model

We consider a three good economy with two tradable and one nontradable goods. Tradable goods consist of imports, which are produced entirely abroad and consumed domestically, and exports, which are produced but not consumed domestically. Thus, private agents derive utility from the consumption of the nontradable and the imported goods, while the economy produces the nontradable and the exported good.[3] To focus on the long run factors behind real exchange rate movements, we adopt a simple static framework.[4]

2.1 Production

Production of the exportable (y_x) and the nontradable (y_n) good are given by:

$$y_x = a_x L_x^{\alpha} K_x^{1-\alpha}$$

and

$$y_n = a_n L_n$$

where $0 < \alpha \leq 1$, K_x is capital in the exportable sector, and L_i are labor inputs in sector i ($i = x, n$). The nontradable goods sector uses only labor, hence capital is specific to the tradable sector.

2.2 Preferences

We assume that individuals consume an importable good (c_m), available at the given world price p_m and the nontradable good (c_n). Preferences are given by the CES utility function:

$$U = \left\{ \phi c_n^{\frac{\gamma-1}{\gamma}} + (1 - \phi) c_m^{\frac{\gamma-1}{\gamma}} \right\}^{\frac{\gamma}{\gamma-1}} \tag{1}$$

where $\gamma = \frac{1}{(1-\nu)}$, and ν denotes the elasticity of substitution across goods. The consumer maximizes (1) subject to the budget constraint:

$$p_n c_n + p_m c_m = I \tag{2}$$

where I denotes after tax income and the prices of the goods are denoted by p_i $(i = m, n)$. The demand functions for each good are thus given by:

$$c_n = \phi^{\gamma} \frac{I}{p} \left(\frac{p_n}{p} \right)^{-\gamma}$$

and

$$c_m = (1-\phi)^{\gamma} \frac{I}{p} \left(\frac{p_m}{p} \right)^{-\gamma}.$$

where p denotes the utility-based price index:

$$p^{1-\gamma} = \phi^{\gamma} p_n^{1-\gamma} + (1-\phi)^{\gamma} p_m^{1-\gamma}.$$

Pre-tax income is given by $p_x y_x + p_n y_n$. Individuals pay a lump-sum tax equal to τ, which is used to finance government purchases of nontradable goods of volume g. The government budget constraints is thus given by

$$\tau = p_n g$$

and after-tax income is given by:

$$I = p_x y_x + p_n (y_n - g).$$

2.3 Equilibrium

The model is closed by equilibrium conditions for the labor and nontradable goods markets. We assume that labor is inelastically supplied at L, so in equilibrium:

$$L = L_x + L_n \tag{3}$$

Equilibrium in the nontradable goods market implies that:

$$c_n + g = a_n L_n \tag{4}$$

Combining the equilibrium conditions with the demand function, the joint equilibrium in the markets for labor and nontradable goods is given by

$$\tilde{\phi}\frac{p_x}{p_n}y_x + (1-\tilde{\phi})\left(\frac{y_x}{a_x}\right)^{1/\alpha} = (1-\tilde{\phi})[a_n L - g] \tag{5}$$

where

$$\tilde{\phi} = \phi^\gamma \frac{p_n^{1-\gamma}}{\phi^\gamma p_n^{1-\gamma} + (1-\phi)^\gamma p_m^{1-\gamma}}$$

3 Comparative statics under full and zero capital mobility

We now turn to a discussion of the effects of various shocks, considering separately the cases of perfect and zero capital mobility. We begin with the extreme case of perfect international capital mobility. As various authors have shown[5], the assumption eliminates a role for demand side factors in the determination of relative prices, which depends only on productivity across sectors. We then turn to the opposite case of zero international capital mobility to assess the potential role of demand side factors.

3.1 Perfect Capital Mobility

Denoting wages by w and the interest rate by r, we have by duality:

$$p_x = \frac{\psi}{a_x} w^\alpha r^{1-\alpha} \tag{6}$$

where $\psi = \alpha^{-\alpha}(1-\alpha)^{-(1-\alpha)}$. The law of one price is assumed to hold for exported goods, so p_x is given by the world market price.[6] In like manner, the price of the nontradable good is given by:

$$p_n = \frac{w}{a_n} \tag{7}$$

Combining the price equations, we obtain the following expression for the relative price of the nontradable good in terms of the exportable good:

$$p_n = p_x \left[\frac{a_x}{a_n^\alpha}\frac{1}{\psi \bar{r}^{1-\alpha}}\right]^{\frac{1}{\alpha}} \tag{8}$$

where $\bar{r}$ is the return to capital in terms of the exportable good (r/p_x) and is equal to its world value by the assumption of perfect capital mobility. The relative price of nontradable goods is thus entirely determined by technology (a_x and a_n) and is independent of demand conditions.[7] Equation (8) thus replicates the Harrod- Balassa-Samuelson result that differences in relative prices are caused by differential productivity across sectors.

The intuition is straightforward. Given the price and the return to capital in the exportable goods sector, wages are entirely determined by (6). In turn, wages are the only determinant of the price of nontradables. An increase in productivity in the exportable sector (a_x) increases wages, which increases the price of nontradables. On the other hand an increase in productivity in nontradables does not lower wages and hence decreases the price of nontradables. The strong result relies on a number of equally strong assumptions, including the law of one price, perfect competition in both sectors, perfect domestic mobility of factors, perfect international mobility of capital and constant returns to scale. We next discuss how the results are affected by removing one of the key assumptions, the perfect mobility of capital.

3.2 Zero Capital Mobility

We now assume that capital is internationally as well as intersectorally immobile and normalize the capital stock to one. At a point in time, the exportable good is thus now subject to decreasing returns to scale. For a given level of production the new cost function is given by:

$$C = w\left(\frac{y_x}{a_x}\right)^{1/\alpha},$$

and hence the competitive price, equal to marginal cost, is given by:

$$p_x = \frac{w}{\alpha}\left(\frac{y_x^{1-\alpha}}{a_x}\right)^{\frac{1}{\alpha}}.$$

In contrast to the previous case, the wage is no longer uniquely determined by p_x but depends on the scale of production of exportables. Again, the intuition is straightforward: with a fixed capital stock, the marginal productivity of labor in exportables declines with the level of production. To maintain equality between marginal cost and the given world price, wages—and thus the price of nontradables—have to decline with the level of production of exportables. Using equation (7) to substitute the wage rate by the price of nontradables, we obtain:

$$p_n = \frac{p_x \alpha}{a_n} \left(\frac{y_x^{1-\alpha}}{a_x} \right)^{-\frac{1}{\alpha}}. \tag{9}$$

The relationship is depicted as the downward sloping schedule PP in Figure 1. An increase in p_x or a_x implies that wages increase for a given level of production, and hence that the nontradable good becomes more expensive, leading to an upward shift of PP. In contrast, an increase in a_n reduces p_n for given production of nontradables and wages, resulting in a downward shift of PP.

The labor and goods market equilibrium relation (5) is depicted as the upward sloping curve NL (Nontradables and Labor market equilibria). Assuming for the moment that $\tilde{\phi}$ is constant (i.e. that preferences are Cobb-Douglas), the positive slope of NL reflects the need for a higher price of nontradables to reduce demand for nontradables and thus to shift labor to exportables. An increase in productivity in the exportable goods sector shifts NL downward since for a given level of y_x, the price of nontradables must fall to raise demand and shift the released labor to nontradables. An increase in p_x raises income, and hence the demand for nontradables, requiring an increase in the price of nontradables, i.e. an upward shift in NL to restore equilibrium. An increase in government spending likewise shifts NL upward as an increase in p_n is needed to shift labor from the exportables to nontradables. Finally, an increase in the productivity in the nontradables sector requires a reduction in p_n to increase demand, resulting in a downward shift of NL.

Under the assumption of an invariant $\tilde{\phi}$, changes in p_m in contrast have no effect since the substitution effect towards nontradables cancels with the negative income effect. Changes in p_m thus only matter to the extent that they affect $\tilde{\phi}$ which in turn depends on the value of γ. With a low degree of substitutability ($\gamma < 1$)—the empirically relevant case—the negative income effect dominates, inducing a downward shift of NL.

Figure 1 can be used to derive the comparative statics effects of changes in productivities, tradable price changes and government spending. Starting from an original equilibrium E, the resulting equilibrium for a change in the variable z is denoted as

A_x. In terms of the nontradable price, we thus obtain:

$$p_n = f_1(\underset{?}{a_x}, \underset{-}{a_n}, \underset{+}{p_x}, \underset{-}{p_m}, \underset{+}{g}) \tag{10}$$

An increase in the price of the exportable good unambiguously increases both the price of nontradables and the production of tradables. A productivity increase in the nontradable goods sector unambiguously increases the price of nontradables, but has ambiguous effects on the production of exportables. In contrast, an increase in the productivity in the exportable goods sector has ambiguous effects on the price of nontradables and increases the production of exportables. We assume that the income effects dominates for a price increase of the imported good, and hence that the price of nontradables declines. Of course, a change in the price of exportables has a larger (absolute) effect on the price of nontradables compared to an equal price change of the imported good since the income and the substitution effect work in the same direction.

[Insert figure 1]

A sizable body of empirical literature analyzes the effect of supply and demand side shifts on the real exchange rate, defined as the ratio between the domestic price level (p) and the foreign price level (ep^*), expressed in the same currency. To obtain comparability of our results with that literature, we also examine the effects of productivity, government expenditure and terms of trade on conventional measures of the real exchange rate. The price levels, domestic and foreign, are homogeneous functions of degree one in the price of imports and nontradables. Hence, the domestic price can be written as $p = p_m\Psi(p_n/p_m)$. Under the assumption that home exports make up a negligible fraction of world imports, the foreign price level is approximated by $p^* = p_m\Psi^*(p_n^*/ep_m^*)$ (Greenwood, 1984). Therefore, the real exchange rate for a small open economy is given by

$$p/ep^* = \Psi/\Psi^* = f_2(\underset{?}{a_x}, \underset{-}{a_n}, \underset{+}{p_x/p_m}, \underset{+}{g}) \tag{11}$$

4 Data

The empirical work is based on a sample of 14 OECD countries from 1970 to 1985 analyzed in De Gregorio, Giovannini and Wolf (1994).[8] The sample is constrained by the availability of data on sectoral (tradables and nontradables) productivity and prices. To construct these variables we use the international sectoral database of the OECD which includes data on sectoral real and nominal value added, stocks of capital, employment and factor returns for twenty sectors.[9] The ratio between nominal and real value added provides implicit sectoral price deflators.

Most work on productivity and real exchange rates has employed labor productivity rather than the total factor productivity measure suggested by theory.[10] As De Gregorio, Giovannini, and Krueger (1993) show, this substitution is not innocuous since labor shedding may introduce substantial differences between changes in average labor productivity and changes in total factor productivity. The bias may be particularly important in our sample given the rise in unemployment in OECD countries during the sample period, potentially resulting in an increase in average labor productivity far exceeding the growth of total factor productivity. We hence use the data on employment, capital stock and factor returns to compute— in standard fashion—total factor productivity as Solow residuals.

Lacking information that would enable us to distinguish between exported goods and import substitutes, we classify sectors into one of two groups, tradables and nontradables. The classification is based on the export shares in output for the whole sample of countries, using a cutoff point of 10 percent to delineate nontradables.[11] The criterion classifies agriculture, mining, all of manufacturing and transportation as tradables. The remaining sectors, accounting for about 50–60 percent of GDP, are treated as nontradables.

We use the indices of unit export and import values from the IMF *International Financial Statistics* as measures of the export and import prices. The same source also provides the nominal exchange rate, a real exchange rate series based on trade weighted CPI's, and an index of the world price level based on the implicit GDP deflator of industrial countries. The IMF *World Economic Outlook* provides data on the share of real government expenditure in real GDP and on per capita GDP.

5 Empirical Evidence

We estimate equations (10)–(11) for the sample of OECD countries. All variables are expressed in logs, and because of the high autocorrelation in the level regressions, the equations were estimated in first differences. The results for the real exchange rate and for the relative price of nontradables are reported in tables 1 and 2. The regressions either use the sectoral total factor productivities as separate variables, or use the weighted average defined in (8). The real exchange rate regressions also include GDP per capita to permit comparisons with previous work and to allow for additional demand side effects, arising, for example, from non-homothetic preferences linking demand shares—and hence the real exchange rate—to the level of income.

Regressions 1.1 and 1.2 in table 1 estimate the standard productivity model with the real exchange rate as the dependent variable. In line with the previous literature the differential in total factor productivity across sectors, per capita GDP and the share of government expenditure in total GDP enter highly significantly with the expected sign. The positive coefficient on the relative productivity term supports the Harrod- Balassa-Samuelson conjecture, while the significant effects of government spending and income suggest that the demand side factors do play an important role, casting doubt on the empirical support for the perfect capital mobility case.

Regressions 1.3 and 1.4 report regressions with only the terms of trade as regressors. Both the terms of trade themselves and the export and import prices separately enter highly significantly with the correct sign and the predicted difference in the absolute magnitude of the coefficients on the export and import price.

[Insert table 1]

The inclusion of relative price shifts in the tradables sector— either in the aggregate (regressions 1.5 and 1.6) or separately (regressions 1.7 and 1.8)—does not change the sign or significance of the productivity and government variables. Indeed, the estimated coefficient on relative productivity increases substantially, suggesting a possible excluded variable bias in regressions focusing solely on the productivity terms. The income variable in contrast becomes insignificant, suggesting that it may have played a proxy role for terms of trade shocks in the previous regressions. The terms of trade themselves come in highly significantly with the predicted sign. Regressions 1.5 and 1.6 also correspond to the theoretical prediction on the relative size of the coefficients on import and export prices.

Table 2 reports the results using the relative price of nontradables rather than the real exchange rate as the dependent variable. We try out three different deflators, the price of imports, the price of exports and a worldwide GDP deflator. In all three cases, changes in the terms of trade are highly significant, signed in accordance to the theoretical prediction. In line with the results from table 1 and the predictions of the model the coefficient on the price of exports is greater, in absolute value, than the coefficient on the price of imports.

[Insert table 2]

In contrast to the results obtained for the real exchange rate, the support for the Harrod-Balassa-Samuelson conjecture is weaker. The coefficient on productivity growth in tradables becomes generally insignificant from zero while productivity growth in nontradables enters with a significant positive sign in contradiction to the theory. A possible explanation for this finding could be the simultaneous effect of a nominal depreciation on the price of final good import prices—lowering the relative price—and on the cost of imported intermediate goods, reducing measured Solow residuals.

6 Concluding Remarks

Two sizable but separate empirical literatures examine the linkage between relative price movements on the one hand and relative sectoral productivities and terms of trade shock on the other. This paper aimed to merge the two strands, presenting a model that allows for both productivity and terms of trade shocks and assessing the role of both factors in the determination of exchange rates. We find that both terms of trade fluctuations and differential productivity growth across sectors are highly significant determinants of real exchange rate movements as well as important factors behind changes in changes in the relative price of nontradables. The evidence furthermore suggests that the terms of trade affect the real exchange rate mainly through an income effect.

Notes

[1] We are grateful to Patrick Asea, Jonathan Ostry, and Jorge Roldos for valuable comments, but remain responsible for any errors.

[2] For the effects of productivity on the real exchange rate see Hsieh (1982), Marston (1987), Froot and Rogoff (1991a, b), Bergstrand (1991), De Gregorio, Giovannini and Krueger (1994) and De Gregorio, Giovannini and Wolf (1994), and for the effects of the terms of trade see Edwards (1989) and Roldos (1990).

[3] See Dornbusch (1980), Greenwood (1984), Neary (1988), Ostry (1988), Edwards (1989), and Roldos (1990).

[4] See Backus and Smith (1992) and Backus et al. (1992) for dynamic treatments of international relative prices.

[5] See Froot and Rogoff (1991a), Rogoff (1992), De Gregorio, Giovannini and Wolf (1994), and Obstfeld (1993).

[6] For simplicity, we fix the nominal exchange rate at one and also normalize K_x to one. This last assumption has no effects on the ensuing discussion since we do not analyze capital accumulation.

[7] While we treat $\bar{r}$ as given, it is interesting to note that according to (8) a decline in $\bar{r}$ will prompt capital to flow to the exportable sector, increasing wages and the relative price of nontradable goods.

[8] Australia (AUS), Belgium (BEL), Canada (CAN), Denmark (DNK), Finland (FIN), France (FRA), Germany (GER) , Italy (ITA), Japan (JPN), the Netherlands (NLD), Norway (NOR), Sweden (SWE), the United Kingdom (GBR) and the United States (USA).

[9] (1) Agriculture, (2) mining, (3) food, beverages, tobacco, (4) textiles, (5) wood and wood products, (6) paper, printing, publishing, (7) chemicals, (8) non-metallic mineral products, (9) basic metal products, (10) machinery, equipment, (11) other manufactured products, (12) electricity, gas, water, (13) construction, (14) wholesale and retail trade, (15) restaurants, hotels, (16) transport, storage, communication, (17) finance, insurance, (18) real estate, (19)community, social and personal services

and (20) government services. For further details on this database see Meyer-zu-Schlochtern (1988).

[10] See, for example, Hsieh (1982), Bergstrand (1991), and Froot and Rogoff (1991a).

[11] This classification does not change qualitatively when a different cutoff is used, see De Gregorio, Giovannini and Wolf (1994).

Table 1: Regression Results: Real Exchange Rate

Reg. No.	TFP[a] Different.	Price of Exports	Price of Imports	Terms of Trade	Government Expenditure	GDP per-capita
1.1	0.098				4.070	0.385
	(0.038)				(0.374)	(0.109)
1.2	0.156				2.912	
	(0.033)				(0.159)	
1.3				0.473		
				(0.014)		
1.4		0.538	-0.442			
		(0.006)	(0.012)			
1.5	0.182			0.489	3.851	0.126
	(0.012)			(0.024)	(0.280)	(0.096)
1.6	0.197			0.495	3.458	
	(0.055)			(0.023)	(0.215)	
1.7	0.259	0.593	-0.458		2.903	-0.156
	(0.053)	(0.025)	(0.030)		(0.293)	(0.093)
1.8	0.238	0.578	-0.448		3.348	
	(0.050)	(0.022)	(0.030)		(0.207)	

Notes. Standard deviations in parenthesis. All regressions were estimated using SUR in first differences, including a country- specific constant, and a total of 210 observations.

[a] Total factor productivity.

Table 2: Regression Results: Relative Price of Nontradables

Reg. No.	TFP[a] Tradab.	TFP[a] Nontrad.	TFP[a] Different.	Price of Exports	Price of Imports	Terms of Trade	Govern. Expend.
Deflator: GDP deflator industrial countries							
2.1	0.035	1.667		0.969	-0.176		4.760
	(0.034)	(0.088)		(0.017)	(0.014)		(0.183)
2.2	-0.053	2.398				0.370	5.441
	(0.053)	(0.155)				(0.026)	(0.347)
2.3			-0.086	1.018	-0.187		1.834
			(0.024)	(0.011)	(0.011)		(0.124)
Deflator: Price of imports							
2.4	-0.053	2.398		0.370			5.441
	(0.053)	(0.155)		(0.026)			(0.347)
2.5			-0.021	1.157			1.971
			(0.010)	(0.005)			(0.049)
Deflator: Price of exports							
2.6	0.063	1.504			-0.116		4.508
	(0.023)	(0.074)			(0.015)		(0.147)
2.7			-0.046		-0.155		1.924
			(0.011)		(0.005)		(0.050)

Notes. Standard deviations in parenthesis. All regressions were estimated using SUR in first differences, including a country- specific constant, and a total of 210 observations.

[a] Total factor productivity.

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Figure 1
Comparative Statics