Biased Productivity Improvement, Terms of Trade and the Equilibrium Real Exchange Rate—a General Equilibrium Approach

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Abstract

We formulate a "two country" model with three sectors in a general equilibrium framework to examine the determination of the equilibrium real exchange rate, allowing for the both substitution between tradable goods produced domestically and abroad and substitution between tradable goods and non-tradable goods. Adopting comparative statics, we find that the productivity improvement in the production of tradable goods will leading to two opposing effects on equilibrium real exchange rate, worsening terms of trade and an increasing relative price of non-tradable goods to tradable goods, ceteris paribus. The net effect on the real exchange rate is theoretically ambiguous. However, on the precondition that the elasticity of substitution among tradable goods is much higher than the elasticity of substitution between tradable goods and non-tradable goods, the net effect of productivity improvement in the tradable sector on the real exchange rate will be positive. That precondition is what makes Harrod-Balassa-Samuelson Hypothesis holds. The empirical evidence is consistent with the prediction of the model using data from 1975-2003 for 18 OECD countries.

Keywords: biased productivity improvement, elasticity of substitution, equilibrium real exchange rate, general equilibrium, structural model

JEL Classification: D24, D11, F31, D50, F1, C5

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1. Introduction

The real exchange rate measures the relative price between countries. Since the real exchange rates are crucial determinant of international competitiveness and balance of payments, it has been one of most interesting, active, and challenging subjects in economics, playing a crucial role in the models of open economy (Chinn, 2006. Taylor, M. P. 1995). The equilibrium real exchange rate is what the real exchange rate will converge to in the long run. It is the real exchange rate under the general equilibrium and balance of trade.

There exist several theories to explain the determination of the equilibrium real exchange rate, based on various assumptions and many empirical studies are developed to test the implications of those theories.

The first line of theory of equilibrium real exchange is the purchasing power parity (PPP) theory. It usually serves as the first approximation; it is simple and dates back centuries. The special terminology of PPP was introduced after World War I and, since then, the idea "has become embedded in how many international economists think about the world" (Taylor and Taylor 2004). It remains influential either explicitly or implicitly (Dornbusch 1976, Rogoff 1996). PPP theory proposes that the law of one price applies to goods across countries; otherwise arbitrage would restore the equality of prices in the two countries. If PPP holds, the equilibrium real exchange rate would be unity. If all goods are tradable, and there are no transportation and transaction costs, arbitrage will ensure that the law of one price holds in equilibrium and thus PPP holds in equilibrium. Even

with the existence of various transaction costs, which may break the law of one price, the price of the same goods in two countries cannot drift too far apart such that relative PPP will still hold. That means the real exchange rate is a stationary variable. The various empirical tests employing co-integration produced mixed results. Some usually cannot reject that real exchange rate follows a nonstationary process, which calls PPP and relative PPP theory into question (see Corbae 1988, Enders 1988, Kim 1990, Strauss, 1995), but the power of these tests is subject to debate (Taylor and Taylor, 2004). Other found support to the stationarity (Froot and Rogoff, 1994).

Another line of this literature distinguishes between tradable and non-tradable goods. It is reasonable to assume that the law of one price applies to tradable goods across countries, but the law of one price may no longer hold true for non-tradable goods. The obvious and often quoted example is a haircut, whose prices differ across countries because it is a non-tradable service. In this case, the real exchange rate will crucially depend on the relative price of the non-tradable. It is usually found that the price of services is higher in rich countries than in poor countries. The reason may lie in the biased productivity improvement between tradable goods and non-tradable goods. If economic growth is driven mainly by productivity improvement in the tradable sector, growth differentials associated with biased productivity change may push the relative price of non-tradable goods ever higher such that the real exchange rate will appreciate even if the prices of tradable goods are the same across countries in equilibrium. This is the Harrod-Balassa-Samuelson Hypothesis (HSB hypothesis) (Harrod, 1973; Balassa, 1964; Samuelson, 1964). The empirical tests of this hypothesis have yielded mixed results. Earlier studies

saw little evidence of HBS hypothesis based on the data in the 1950s and 1960s, but more recent studies based on later data have often found support (Taylor and Taylor, 2004).Evidence in developed countries display more support, but in less developed countries, more contradiction(Bahmani-Oskooee and Niroomand, 1996). The problem with the HBS hypothesis is that it is based on partial equilibrium analysis and may not necessarily be valid theoretically (Zhu and McFarlane, 2005). If the tradable goods produced domestically and those produced abroad are not perfect substitutes then productivity improvement in tradable goods will increase their supply and reduce their prices such that the terms of trade will worsen, ceteris paribus. Therefore, the impact on the real exchange rate is then determined by the combination of opposing Balassa and terms of trade effects such that the net impact on real exchange rate is theoretically unambiguous. There are many extensions to HSB hypothesis which take into consideration a variety of other factors, including demand side and monetary factors, macroeconomic policy, and mobility of capital, usually in the framework of a small open economy or "one country model" (see De Gregorie, 1994, Struss, 1995, Devereux, 1997, Mark 1997, Chinn 2000, Bergin, 2006).

This paper develops a "two country" model of the determination of the equilibrium real exchange rate, combining the biased productivity growth and the equilibrium real exchange rate in a "two country" model (Stock 1980, Lucas 1982). The model considers the effect of substitution among tradable goods and substitution between tradable and non-tradable goods in the context of general equilibrium and the balance of trade. The model will be tested using panel data from 1975-2003 for 18 OECD countries.

The rest of the paper is arranged as follows. Section 2 will present the basic model. Section 3 will describe the data. Section 4 will provide the econometric model and the empirical results. Section 5 will conclude the paper.

2. The model

Consider a system of two economies that produce three goods and are linked only by trade. Each country produces non-tradable and tradable goods. The tradable goods between the two countries are not perfectly substitutable. Production in both sectors is characterized by constant returns to scale and use of a single factor, labor. Each country is endowed with labor, denoted L in the domestic economy and L^* in the foreign economy. Each country is also endowed with technology for the production of non-tradable and tradable goods. Domestic residents derive utility from the consumption of non-tradable goods and tradable goods produced domestically as well as tradable goods imported from abroad. Trade is balanced. Labor is perfectly mobile within a country and perfectly immobile across countries. There is perfect competition in both the production and labor markets. There are no transaction and transportation costs involving trade between the two economies. Thus, the law of one price applies to tradable goods across the two economies and one wage applies within each economy

2.1 Production and the labor market

The production of non-tradable and tradable goods are given by

$$Y_N = A_N L_N \quad (1)$$

$$Y_T = A_T L_T \quad (2)$$

$$Y^*_N = A^*_N L^*_N \quad (3)$$

$$Y_T^* = A_T^* L_T^* \quad (4)$$

L_i and Y_i correspond to labor and output for each sector, i=N, T, representing non-tradable and domestic tradable goods. The subscript * denotes the foreign country.

The wage in our perfect competitive labor market, is determined by the value of marginal labour product, and is equalized across sectors of the economy such that

$$W = A_T P_T = A_N P_N \quad (5)$$

$$W^* = A_T^* P_T^* = A_N^* P_N^* \quad (6)$$

2.2 Preferences

A typical resident consumes non-tradable goods and tradable goods produced domestically, and tradable goods produced abroad. Preferences are characterized by a Cobb-Douglas utility function involving nontradable goods and composite tradable goods. The composite tradable good is represented by a CES function between tradable goods produced domestically and abroad[1],

$$U = X_N{}^{\alpha}[X_T{}^{\rho} + \phi X_M{}^{\rho}]^{\frac{1-\alpha}{\rho}} \tag{7}$$

$$U^* = X_N{}^{*\alpha^*}[X_M{}^{*\rho} + \phi X_T{}^{*\rho}]^{\frac{1-\alpha^*}{\rho}} \tag{8}$$

The elasticity of substitution between tradable goods is $\sigma = \frac{1}{1-\rho}$ for both economies.

Consumers maximize their utility subject to the budget constraint,

$$P_N X_N + P_T X_T + P_M X_M = I = WL \tag{9}$$

$$P_N{}^* X_N{}^* + P_T{}^* X_T{}^* + P^*{}_M X_M{}^* = I^* = W^* L^* \tag{10}$$

[1] More generally, we can use two tiered embedded CES utility functions. The utility function used here allows us to derive an explicit solution. Also CES function, different expenditure share on non-tradable goods may be related to advancement of the economy. A common elasticity of substitution is assumed to arrive an explicit solution.

Maximization of utility leads to the demand function for each good for each country,

$$X_N = \frac{\alpha WL}{P_N} \tag{11}$$

$$X_T = \frac{(1-\alpha)WL}{P_T[1+\phi^{\sigma}(\frac{P_T}{P_M})^{\sigma-1}]} \tag{12}$$

$$X_M = \frac{(1-\alpha)WL}{P_M[1+\phi^{`-\sigma}(\frac{P_M}{P_T})^{\sigma-1}]} \tag{13}$$

$$X_N{}^* = \frac{\alpha^* W^* L^*}{P_N{}^*} \tag{14}$$

$$X_T{}^* = \frac{(1-\alpha^*)W^* L^*}{P_T{}^*[1+\phi^{`-\sigma}(\frac{P_t^*}{P_M{}^*})^{\sigma-1}]} \tag{15}$$

$$X_M^* = \frac{(1-\alpha^*)W^*L^*}{P_M^*[1+\phi^\sigma(\frac{P_M^*}{P_T^*})^{\sigma-1}]} \quad (16)$$

2.3 Equilibrium

The equilibrium conditions are that there are no excess demands in the labor and non-tradable goods in each economy, and in tradable goods market across economies (Since there is no financial activity across countries, trade balance is automatically maintained across countries.) Thus, for the labor market we have:

$$L = L_N + L_T \quad (17)$$

$$L^* = L_N^* + L_T^* \quad (18)$$

Our equilibrium conditions for the output market are:

$$Y_N = X_N \quad (19)$$

$$Y_N^* = X_N^* \quad (20)$$

$$Y_T = X_T + X_M^* \quad (21)$$

Law of one price applied to tradable goods. Let exchange rate be E, defined as units of foreign currency per unit of domestic currency. Then,

$$P_M^* = P_T E \tag{22}$$

$$P_M = P_T^* / E \tag{23}$$

For a solution, we normalize the price of domestic tradable goods to be one in their currency for each country. That is,

$$P_T = 1 \tag{24}$$

$$P_T^* = 1 \tag{25}$$

2.4 Solution

We have 23 unknown variables and 23 equations including (1)-(6) and (11)-(25), yielding a unique solution:

$$E = \frac{1}{\phi}\left[\frac{(1-\alpha^*)A_T^* L^*}{(1-\alpha)A_T L}\right]^{\frac{1}{\sigma}} \tag{26}$$

$$P_N = \frac{A_T}{A_N} \tag{27}$$

$$P_N^* = \frac{A_T^*}{A_N^*} \tag{28}$$

$$P_M = \phi[\frac{(1-\alpha)A_T L}{(1-\alpha^*)A_T^* L^*}]^{\frac{1}{\sigma}} \tag{29}$$

$$P_M^* = \frac{1}{\phi}[\frac{(1-\alpha^*)A_T^* L^*}{(1-\alpha)A_T L}]^{\frac{1}{\sigma}}\} \tag{30}$$

$$W = A_T \tag{31}$$

$$W^* = A_T^* \tag{32}$$

$$Y_N = X_N = \alpha A_N L$$

$$Y_N^* = X_N^* = \alpha^* A_N^* L^* \tag{33}$$

$$Y_T = (1-\alpha)A_T L \tag{34}$$

$$Y_D^* = (1-\alpha^*)A_D^* L^*$$

$$Y_T^* = (1-\alpha^*)A_T^* L^* \tag{35}$$

$$X_T = \frac{(1-\alpha)A_T L}{1+\phi^{\sigma-1}[\frac{(1-\alpha^*)A_T^* L^*}{(1-\alpha)A_T L}]^{\frac{1}{\sigma}}} \tag{36}$$

$$X_T^* = \frac{(1-\alpha^*)A_T^* L^*}{1+\phi^{`1-\sigma}[\frac{(1-\alpha)A_T L}{(1-\alpha^*)A_T^* L^*})^{\frac{1}{\sigma}}} \tag{37}$$

$$X_M = \frac{(1-\alpha^*)A_T^* L^*}{1+\phi^{`\sigma-1}[\frac{(1-\alpha^*)A_T^* L^*}{(1-\alpha)A_T L})^{\frac{1}{\sigma}}} \tag{38}$$

$$X_M^* = \frac{(1-\alpha)A_T L}{1+\phi^{1-\sigma}[\frac{(1-\alpha)A_T L}{(1-\alpha^*)A_T^* L^*}]^{\frac{1}{\sigma}}} \tag{39}$$

$$L_N = \alpha L \tag{40}$$

$$L_T = (1-\alpha)L \tag{41}$$

$$L_N^* = \alpha^* L^* \tag{42}$$

$$L_T^* = (1-\alpha^*)L^* \tag{43}$$

2.5 Real exchange rate

With these solutions we can construct the real exchange rate, R, as follows,

$$R = \frac{EP}{P^*}$$

For a common basket of consumption goods, let the price index be a geometric average of tradable and non-tradable goods (Chinn 2006),

$$P = P_N{}^{\beta} P_T{}^{\gamma} P_M{}^{1-\beta-\gamma}$$

$$P^* = P_N{}^{*\beta} P_M{}^{*\gamma} P_T{}^{*1-\beta-\gamma}$$

If the law of one price applies to the tradable goods, then the real exchange rate becomes,

$$R = (\frac{P_T}{P_M})^{\beta} [\frac{\frac{P_N}{P_T}}{\frac{P_N{}^*}{P_T{}^*}}]^{\beta} = E^{\beta} (\frac{P_N}{P_N{}^*})^{\beta} = \{\frac{1}{\phi}[\frac{(1-\alpha^*)A_T{}^* L^*}{(1-\alpha)A_T L}]^{\frac{1}{\sigma}}\}^{\beta} \left(\frac{A_T / A_N}{A_T{}^* / A_N{}^*} \right)^{\beta} \qquad (44)$$

Terms of trade effect and relative price effect:

Examining the above equation, we can find the first term coincides with the terms of trade effect; and the second term is the relative price effect.

$$\frac{P_T}{P_M} = \frac{1}{\phi}\left[\frac{(1-\alpha^*)A_D{}^* L^*}{(1-\alpha)A_D L}\right]^{\frac{1}{\sigma}} \tag{45}$$

$$\frac{\frac{P_N}{P_T}}{\frac{P_N{}^*}{P_T{}^*}} = \frac{\frac{A_T}{A_N}}{\frac{A_T{}^*}{A_T{}^*}} \tag{46}$$

Adopting a comparative static method of analysis, we have the following propositions:

(1) An improvement of productivity in non-tradable goods would have a negative effect on the relative price and no terms of trade effect, causing a depreciation of the real exchange rate.

(2) An improvement of productivity in tradable goods has two effects, a positive effect on the relative price of non-tradable goods and a negative effect on the terms of trade. Thus, the net effect on the real exchange rate is theoretically ambiguous. In our case, the net effect depends on the elasticity of substitution between domestically produced tradable goods and imported tradable goods. If σ>1, the relative price effect dominates and the net effect is positive. If σ<1, the

terms of trade effect dominates, the net effect is negative.[2] We can also see that, if domestic tradable goods and imported goods are perfect substitutes (that is, σ become infinite), the terms of trade effect will disappear, leaving only the relative price effect. This is the special classic situation associated with the HBS Hypothesis (Gandolfo, 2002, P. 515-516).

(3) Changes of demography and taste also impact the equilibrium real exchange rate. An increase in the number of workers will have an adverse effect on the terms of trade but no effect on the relative price of non-tradables, resulting in a negative effect on the real exchange rate. A change in tastes favoring non-tradable goods will increase α and have improve the terms of trade but have no relative price effect, resulting in a positive effect on the equilibrium real exchange rate.

In reality, the consumer price indices of each country are compiled according to their respective share of non-tradable, domestic tradable and imported tradable goods. Let the share of non-tradable goods be α and the share of imports, δ. Then the share of domestically produced tradable goods is 1- α- δ and the price index is:

$$P = P_N^{\alpha} P_T^{1-\alpha-\delta} P_M^{\delta}$$

$$P^* = P_N^{*\alpha^*} P_T^{*1-\alpha^*-\delta^*} P_M^{*\delta^*}$$

[2] This result seems to help answer the paradox of applicability of BHS hypothesis to developed countries but non-applicability to less developed countries. For developed countries, the trades go on mainly between developed countries, so the exports and imports are more substitutable. But for less developed courtiers, the trades go on mainly between less developed countries and developed countries, so the export and imports are less substitutable

Then the real exchange rate is:

$$R = \frac{EP}{P^*} = \{\frac{1}{\phi}[\frac{(1-\alpha^*){A_T}^*{L^*}}{(1-\alpha)A_T L}]^{\frac{1}{\sigma}}\}^{1-\delta-\delta^*} \frac{(\frac{A_T}{A_N})^{\alpha}}{(\frac{{A_T}^*}{{A_N}^*})^{\alpha^*}} = (\frac{P_D}{P_M})^{1-\delta-\delta^*} \frac{(\frac{P_N}{P_T})^{\alpha}}{(\frac{{P_N}^*}{{P_D}^*})^{\alpha^*}} \qquad (47)$$

The same comparative static features apply as long as $1-\delta-\delta^*$. And when $\sigma > \frac{1-\delta-\delta^*}{\alpha}$, productivity growth in tradable goods has a net positive effect on the real exchange rate, and vice versa.

3. Data

To conduct the empirical work, we formed an unbalanced panel data for 18 countries from 1975 to 2003.[3] Scrotal value added output in current prices and volumes and employment for 9 industries[4] are taken from the OECD STAN database for Industrial Analysis. The real effective exchange rate based on consumer prices and the unit prices of exports and imports is determined from the IMF Financial Statistics. Following De

[3] (1)Australia, (2)Belgium, (3)Canada, (4)Denmark, (5)Finland, (6)France, (7)Germany (West Germany before 1991), (8)Greece, (9)Ireland, (10)Italy, (11)Japan, (12)Netherlands, (13)Norway, (14)Spain, (15)Sweden, (16)Switzerland, (17)United Kingdom, (18)United States of America.

[4] (1)Agriculture, (2) mining,(3)manufacturing, (4)construction, (5)whole sale and retail trade; restaurant and hotel, (6) transportation, storage and communication, (7) finance, insurance, real estate and business services, (8) community, social and personal services, (9) Public administration and defense; compulsory social services. Tradable sectors comprise sectors 1, 2, 3, and 6. The others belong to non-tradable sectors.

Gregorio (1993)'s classification, among the 9 sectors, 4 sectors produce tradable goods and other 5 sectors produce non-tradable goods. Summing up among tradable sectors and non-tradable sectors separately, we construct value added output in terms of current prices and volume and the number of workers in the tradable and non-tradable sectors. Manipulation of those data yields panel data of productivity in the tradable and non-tradable sectors, the prices of tradable goods and non-tradable goods,[5] the total number of workers producing tradables and non-tradables, relative productivity, relative price, and the terms of trade (that is, the ratio of the unit price of exports to the unit price of imports). Because of missing data, our unbalanced panel consists of 236 observations.

The descriptive statistics for the relevant variables are shown in the table 1 in terms of growth rates. Of note are the following basic features:

(1) The average growth rate of productivity for the tradable sectors is much higher than for the non-tradable sectors, which is consistent with our assumption of biased productivity improvement in the tradable sector.

(2) The standard deviation of the growth rate of productivity for the tradable sectors is also much higher than for the non-tradable sectors, which suggest that the difference in economic growth across countries may be clearly associated with differences in productivity improvement in the tradable sectors across countries.

(3) The average number of workers is increasing in the non- tradable sector and overall but decreasing in the tradable sector. That suggests that the elasticity of substitution between the tradable and non-tradable sectors is less than unity. The

[5] We use the implicit price index, that is, the ratio of value added in current prices and volumes, to represent the prices of tradable goods and non-tradable goods.

volatility represented by the standard deviation of the growth rate of the number of workers between tradable sectors and non-tradable sectors is comparable.

Figure 1-6 in the appendix shows the scatter plots between the log price and log productivity ratios of tradable to non-tradable goods, the growth rates of the price and productivity ratios of tradable to non-tradable goods, the log terms of trade and log productivity of tradable goods, the growth rates of terms of trade and the productivity of tradable goods, the log real exchange rate and log productivity ratio of tradable goods to non-tradable goods, and the growth rates of the real exchange rate and the productivity ratio of tradable to non-tradable goods. Casual inspection of those figures suggest that the association between the log price and log productivity ratios of tradable goods to non-tradable goods and the growth rates of the price and productivity ratios of tradable goods to non-tradable goods are obvious, but the association between the log terms of trade and the log productivity of tradable goods, the growth rates of terms of trade and the productivity of tradable goods, the log real exchange rate and the log productivity ratio of tradable to non-tradable goods, the growth rates of the real exchange rate and the productivity ratio of tradable to non-tradable goods are not so obvious and clear. In the next section, we test these associations using econometric analysis and estimation.

4. Empirical Results

Equations (45), (46) and (47), show that: (1) relative price of non-tradables to tradables is determined positively by the productivity of tradable goods and negatively by productivity of non-tradable goods; (2) the terms of trade is determined by and the

number of worker in tradables and productivity of tradable sector negatively; and (3) terms of trade and the relative price are positively related to the real exchange rate.

Assuming linearity and country-specific fixed and unobserved heterogeneity, we specify the following econometric equations,

$$\ln\_ pn\_ pt_{it} = c_1 + \beta_{11} \ln\_ pro\_ t_{it} + \beta_{12} \ln\_ pro\_ n + u_{1i} + \varepsilon_{1it}$$

$$\ln\_ pt\_ pm_{it} = c_2 + \beta_{21} \ln\_ pro\_ t_{it} + \beta_{22} \ln\_ l\_ t + \beta_{23} \ln\_ l\_ n + u_{2i} + \varepsilon_{2it}$$

$$\ln\_ re_{it} = c_3 + \beta_{31} \ln\_ pt\_ pm_{it} + \beta_{32} \ln\_ pn\_ pt_{it} + u_{3i} + \varepsilon_{3it}$$

We also specify the real exchange rate equation in reduced form as follows,

$$\ln\_ re_{it} = c_4 + \beta_{41} \ln\_ pro\_ t_{it} + \beta_{42} \ln\_ pro\_ n_{it} + \beta_{43} \ln\_ l\_ t_{it} + \beta_{44} \ln\_ l\_ n_{it} + u_{4i} + \varepsilon_{3it}$$

We use the fixed effect estimator to control for biases arising from unobserved country heterogeneity. The results are summarized in table 2.

The empirical results in the table 2 are consistent with the predictions of our model with either random effect or fixed effect method used. For the regression on the column 2, the

coefficient for the log productivity of tradable goods is positive and significant. The coefficient for the log productivity of non-tradable goods is negative and significant. We test the hypothesis that these two coefficients are equal. The hypothesis is rejected, perhaps because the cost structures of the two sectors differ.

For the regression on terms of trade in column 3, the coefficient for the log productivity of the tradable sector is negative but not significant, the coefficient of the log of the number of workers producing tradable goods is negative and significant, and the coefficient of the log of the number of workers producing non-tradable goods is positive and significant. The hypothesis that the coefficients for the log productivity and the log number of workers in the tradable sector are equal is rejected at the 99% level of significance. Since the coefficient of log productivity in the tradable sector is about 0.08, the elasticity of substitution between tradable goods is about 12 and much greater unity such that the improvement of productivity in tradable goods will lead to equilibrium real exchange rate appreciation ceteris paribus,. In this case, the HBS hypothesis is supported by the empirical evidence.

For the regression of log real exchange rate on the column 4, the coefficients both of log terms of trade and log relative price are positive and significant at the level of 95%. The hypothesis that these two coefficients are equal is rejected at significance level of 95% but not rejected at significance level of 99%.

For the reduced form regression of the log real exchange rate, all the parameters are insignificant and the signs of the important parameters are not consistent with the predictions of the model. This implies that the reduced form regression may be misleading, and structural regression is warranted.

Caveats

Our data consist only of OCED countries, which consist only of developed countries. Real exchange rate may be very persistent, which is not taken into consideration in the regression. Further research should include more countries, especially developing countries

5. Conclusion

Adopting a general equilibrium framework, comparative static analysis in this paper implies that economic growth may bring about two opposing effects, a terms of trade effect and a relative price effect. The productivity improvement in the production of tradable goods will leading to a worsening of terms of trade and an increasing relative price of non-tradable goods to tradable goods, ceteris paribus. The net effect on the real exchange rate is theoretically ambiguous. However, on the precondition that the elasticity of substitution among tradable goods is much higher than the elasticity of substitution between tradable goods and non-tradable goods, the net effect of productivity improvement in the tradable sector on the real exchange rate will be positive. The empirical evidence based on the data of 18 OCED countries here is consistent with these

points. Equilibrium real exchange rate also depends on many other factors, such as population changes, the consumers' demand and etc.

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Appendix

Table 1. Descriptive Statistics

Variables	Mean	Std. Dev.	Min	Max
Real effective exchange rate	3.443511	.3757307	2.870221	4.35978
Terms of trade	.0045781	.0545796	-.284574	.3594012
Relative price	.0149629	.0485081	-.298004	.205627
Productivity in tradable	.0262075	.0325232	-.128590	.205627
Productivity in non-tradable	.0036054	.0131498	-.033127	.0503006
Productivity ratio	.0036054	.0131498	-.144390	.1043537
Total number of workers	.0128522	.0158143	-.059841	.0558863
Number of worker in tradable	-.002470	.0218864	-.077467	0511303
Number of workers in non-tradable	.019323	.0160446	-.060685	.0761833

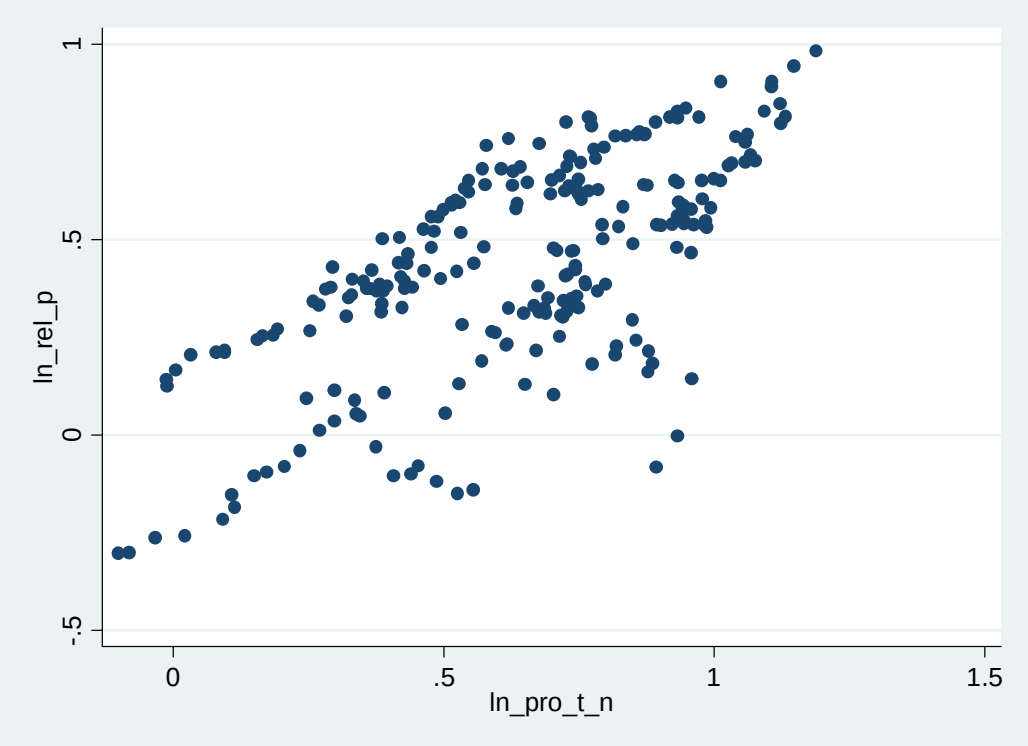
(Note: All numbers are the growth rate in annual average. Real effective exchange rate based on consumer price index; Terms of trade, the ratio of unit value of export to unit vale of import; Relative price, relative price of non-tradable to tradable sector; productivity refers labour productivity. The same below)

Table 2

Dependent	Relative Price		Terms of trade		Real Exchange Rate		Real Exchange Rate
Method	Random	Fixed	Random	Fixed	Random	Fixed	Fixed
Productivity in tradable	.745** (0.0221)	.757** (.024)	-.0618 (.0412)	-.0789 (.041)			-.0154 (.0577)
Productivity in non-tradable	-.885** (0.0735)	-1.015 ** (.0737)					.1905 (.160)
Number of workers in tradable			-.284** (.0978)	-.364** (.105)			-.0998 (.118)
Number of workers in non-tradable			.217** (.0593)	.227** (.062)			.0563 (.078)
Terms of trade					.122* (.0610)	.133 * (.0543)	
Relative Price					.0715* (.0300)	.0838* (.0355)	

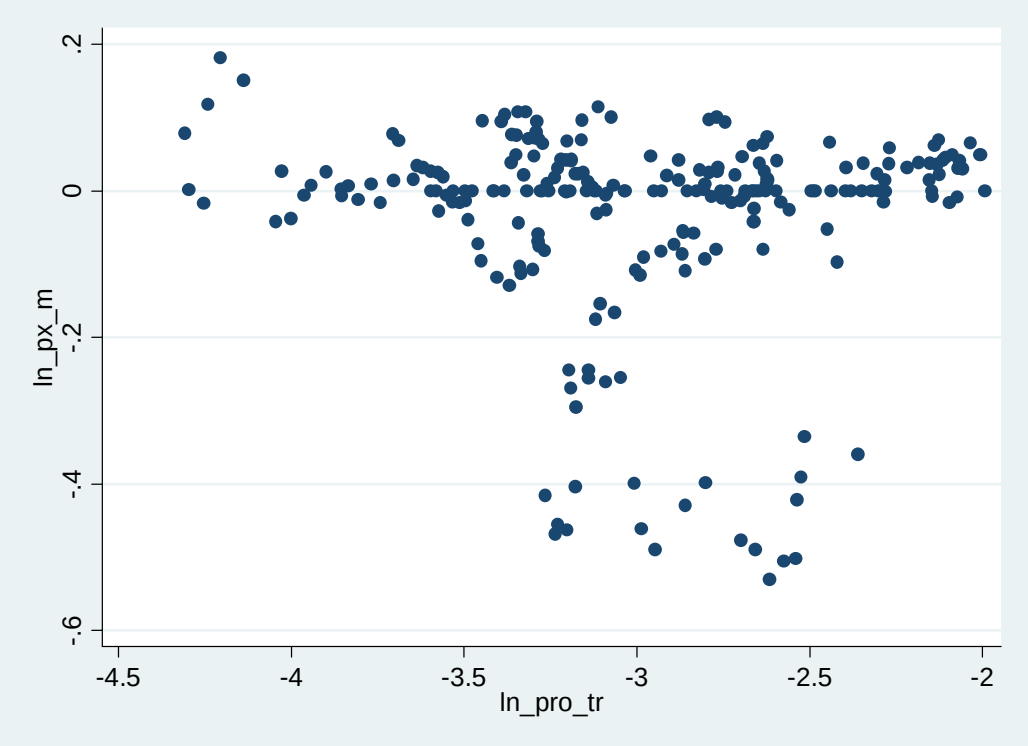
(Note: All regressions are in log form. The numbers in parenthesis are standard deviations, ** means significant at 99% level, * means significant at 95% level)

Figure 1



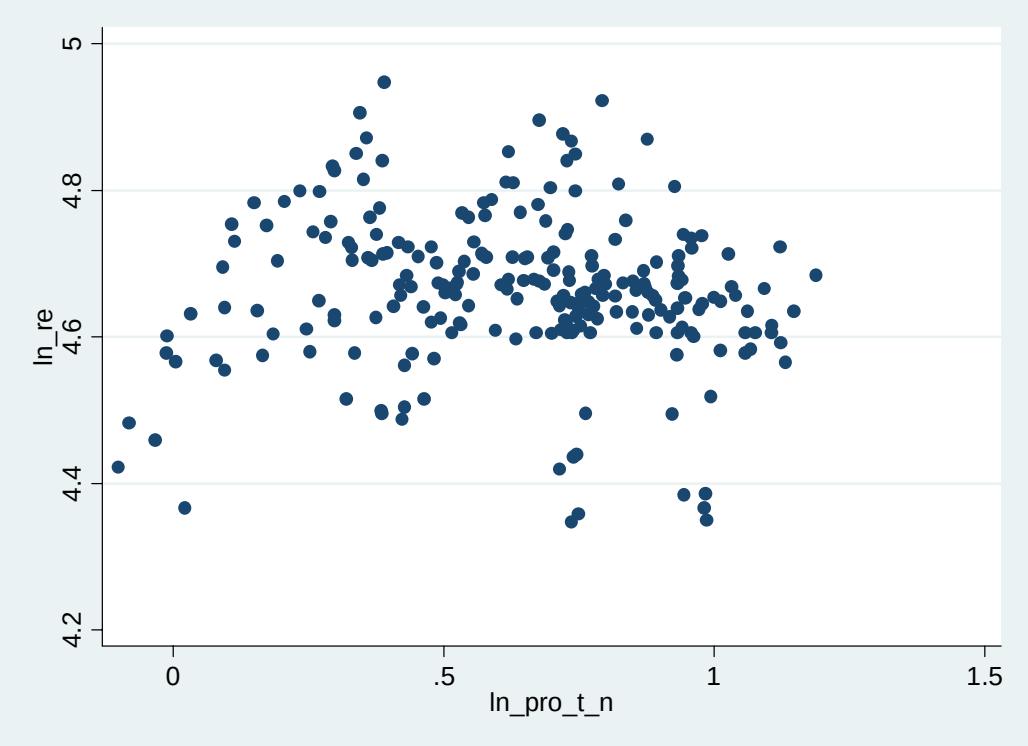
(Note: Ln_pro_t_n is the log ration of labour productivity in tradable sector to the that in non-tradable sector; Ln_rel_p is the log relative price of non-tradable to tradable)

Figure 2



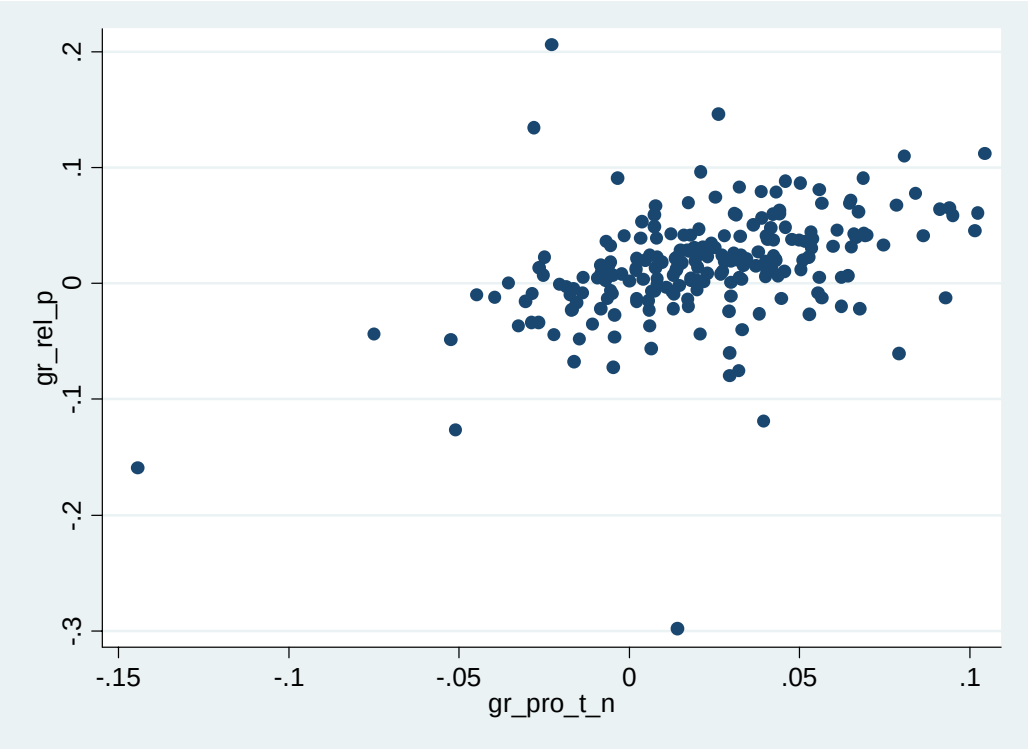
(Note: Ln_pro_tr is the log productivity in tradable; Ln_Px_m is the log terms of trade)

Figure 3



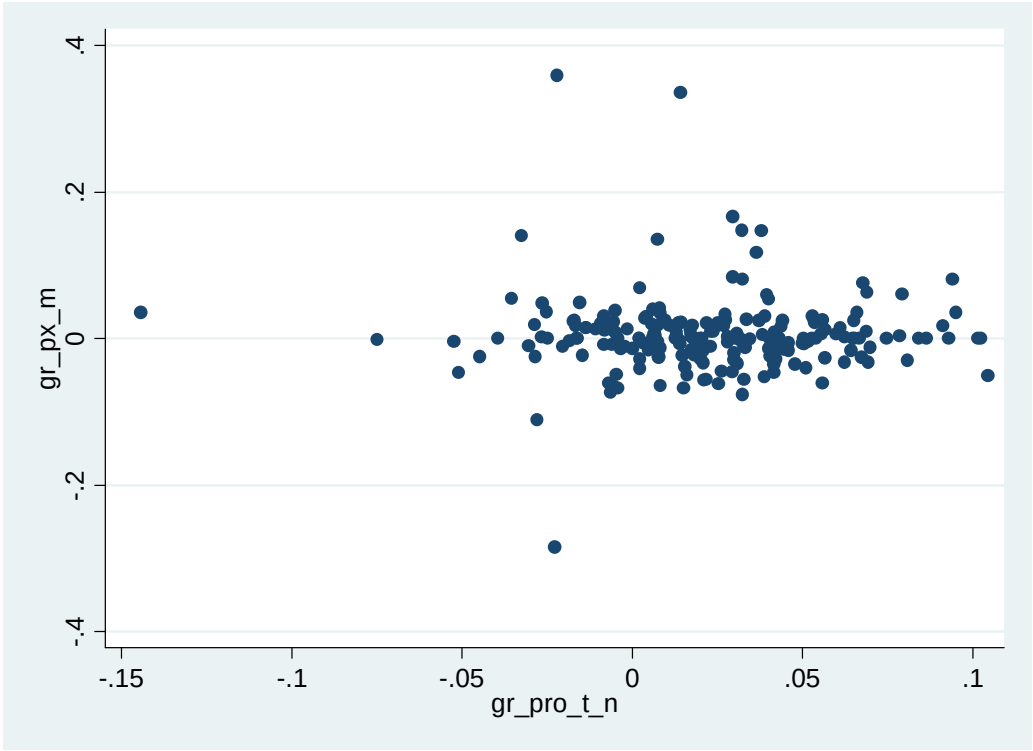
(Note: Ln_pro_tr is the log productivity in tradable; Ln_re is the log real effective exchange rate)

Figure 4



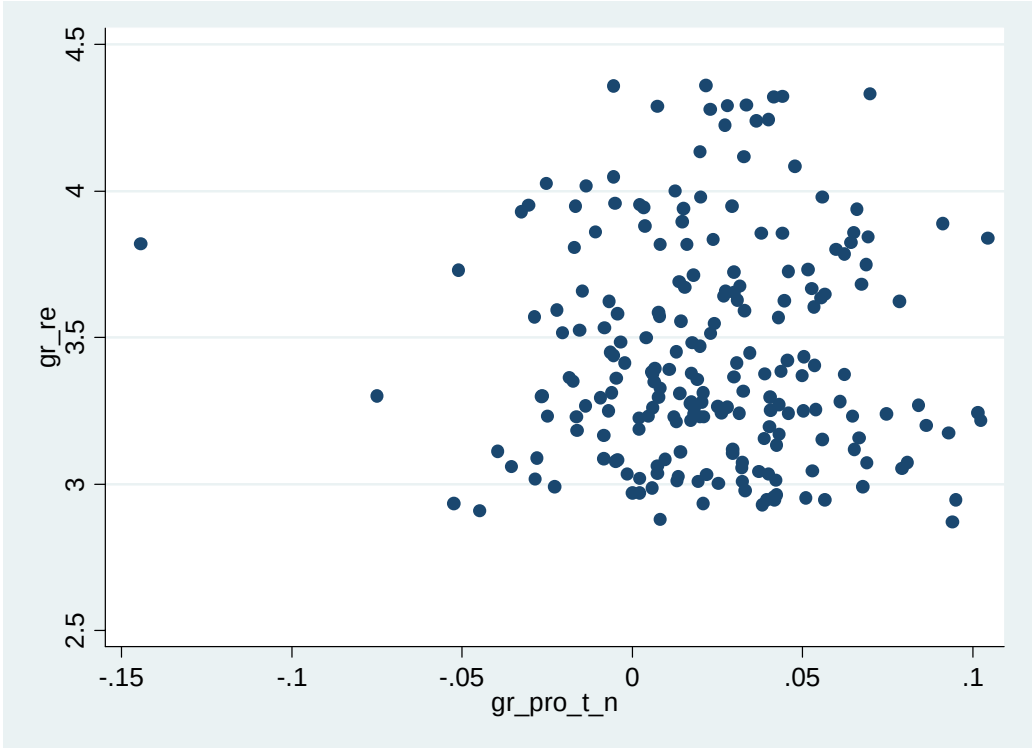
(Note: gr_pro_t_n is the growth rate of ratio of labour productivity in tradable to that in non-tradable; gr_rel_p is the growth rate of relative price)

Figure 5



(Note: gr_pro_t_n is the growth rate of ratio of labour productivity in tradable to that in non-tradable; gr_px_m is the growth rate of terms of trade)

Figure 6



(Note: gr_pro_t_n is the growth rate of ratio of labour productivity in tradable to that in non-tradable; gr_re is the growth rate of real effective exchange)