The Link between Economic Growth and the Real Exchange Rate - the Role of the Nontradable Sector -

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Abstract

Underlying assumption of the Harrod-Balassa effect is that productivity improvements in the tradable sector should be fully responsible for economic growth of a country: productivity growth in the nontradable sector was assumed to be stagnant. The productivity hypothesis predicts that real appreciation (depreciation) of exchange rates is a natural consequence of higher productivity growth in the tradable (nontradable) sector relative to that in the nontradable (tradable) sector. Provided that the productivity hypothesis holds, higher GDP growth should always be accompanied by appreciating real exchange rate. However, in episodes of strong economic growth, the real exchange rate seems to have appreciated only about half the time, suggesting that the nontradable sector could equally be responsible for economic growth. The objective of this paper is to demonstrate that productivity growth in the nontradable sector can be higher, sometimes even substantially higher, relative to that in the tradable sector. For this purpose I will directly estimate sectoral productivity growth using the Harberger two-deflator method, a version of growth accounting method for 15 developed countries. In doing so, I will also examine how much the productivity hypothesis holds by regression analysis using both static OLS and dynamic OLS. Whereas the results in the literature have been inconclusive, my findings more or less support the productivity hypothesis.

1 Introduction

The effect of productivity growth on the real exchange rate, in particular in the long run, is a topic that has attracted the attention of researchers in the profession of economics. Theory predicts that TFP improvements in the tradable sector should appreciate the real exchange rate, and that TFP improvements in the nontradable sector should depreciate the real exchange rate. The episode of post-war growth of Japan is believed to be a good example which clearly demonstrates this link between productivity improvements and the real exchange rate. The continuous appreciation of the Japanese yen during this period made observers believe that there should exist a meaningful gap in productivity improvements between the tradable sector and the nontradable sector. My previous work[1] was motivated by this conjecture and did numerically confirm that the tradable sector indeed enjoyed higher productivity improvement relative to the nontradable sector in Japan.

The origin of the productivity hypothesis is often considered to be Harrod (1933), but the credit of making the theory broadly known perhaps goes to Balassa (1964). Cross-country comparisons in Balassa (1964) demonstrated a positive correlation between price levels and income levels. Voluminous works have been written on the productivity hypothesis since then, using different specifications and econometric methods. The main objective of those papers was to examine the existence of systematic link between the real exchange rate and productivity gaps between the tradable sector and the nontradable sector.

Taking the Harrod-Balassa effect strictly, real appreciation in exchange rates can be viewed as a natural result of GDP growth. This is because it is assumed that growth of a country should be fully represented by productivity improvements in the tradable sector. In Isard and Symansky (1997), for example, the authors investigated this line of relationship by sampling APEC countries. The authors examined the link between a country's economic growth and the real exchange rate, but they did not find conclusive support for the Harrod-Balassa effect. Harberger (2003) is another paper that confirmed a weak link between GDP growth and real appreciation of exchange rates. The author sampled large number of countries and concluded against the strict assumption of the Harrod-Balassa effect. Granted that real appreciation of exchange rates is a natural result of gaps in productivity improvements between the tradable sector and the nontradable sector, those results suggest that a county's productivity improvements are not always dominated by those in the tradable sector alone. Actually we seem to know that sectors such as finance and wholesale can achieve important productivity improvements.

I did an excersise similar to the one in Harberger (2003) and confirmed the author's findings. Based on the data from World Development Indicators 2002, I chose episodes of strong and continued real GDP growth by 4% or larger for 8 years or more. I allowed growth rates of real GDP to be lower than 4% if it is only for one period and

[1] See Miyajima (2003a).

if following periods demonstrated strong growth momentum, such as several years of growth by more than 4% or 5%. The criteria are hence less stringent compared to those in Harberger (2003)[2]. I obtained 44 episodes and regressions are run country by country using the following specification:

$$\log(SDR\_RER_t) = \alpha + \beta \log(\text{real}\_GDP_t) + \varepsilon_t \quad (1)$$

where SDR_RER: a version of real exchange rates that I borrowed from papers by Harberger[3]. Because the estimated results may be biased by non-stationarity of data, I added another measure of trend of the real exchange rate: the average of annual rates of change in the real exchange rate. Those numbers should more or less capture long-term trend of the real exchange rate. Column (4) and (5) in table 1 show the estimates of β and rates of change of the real exchange rate respectively. The frequency is summarized in small tables located on the right side of the main table. Looking at the estimates of β, one would notice that the number of positive and negative observations is more or less the same, regardless of either looking at all estimates or only at significant ones. The message remaines the same when I count the number of positives and negatives based on the average of rates of change: 21 positives against 23 negatives. In line with Harberger (2003), those observations suggest that there is no conclusive evidence for the positive link between strong economic growth and real appreciation of exchange rates.

Regarding the link between productivity improvements and the real exchange rate, existing works provide mixed results. Officer (1976) found little evidence supporting the productivity effect, while results from Chinn (1997) and Canzoneri, Cumby and Diba (1996) were inconclusive. On the other hand, somewhat favorable results were found by Hsieh (1982), De Gregorio et al. (1994a), De Gregorio et al. (1994b) and De Gregorio and Wolf (1994).

In the episode of Japan, productivity improvements in the tradable sector were much more important than those in the nontradable sector. As I have just discussed, according to the literatures, however, it appears that the tradable sector does not always seem to represent a large share of a country's productivity improvements. In this paper, I will directly examine the link between a country's growth and productivity gaps between the tradable sector and the nontradable sector. Before going to that point, however, inconclusive results from existing literatures urge me to reexamine the relationship between productivity improvements and the real exchange rate. Establishing this relationship will be the first building block.

There are a couple of issues to be noted as follows. First, many researchers that have examined the productivity hypothesis were concerned about the issue of non-

[2] The author looked for periods in which economic growth exceeded 5% per year over a period of at least a decade in length. So as not to count as secular growth periods of huge spurts in GDP, the author also insisted that the initial and final years of the period should display growth rates of at least 4%. From this exercise there emerged 25 episodes of extended rapid growth, all of them in well-known countries.

[3] See for example Harberger (1989).

stationarity of the data. Some researchers used the data in first-difference in order to purge persistence while others used the cointegrating method. I will briefly discuss this point. Second, my paper differs from existing literatures in the following. Not much attention seems to have been paid to the estimation of TFP. In my project, however, TFP is estimated using the two-deflator method, which takes quality improvements in labor inputs into account. The two-deflator-method is also as powerful as the Jorgenson method in estimating TFP[4]. For the real exchange rate index, I use the SDR-RER, instead of conventionally used symmetric real exchange rate. In this framework, the real exchange rate is not influenced by the prices of nontradable goods in the foreign country.

The structure of this paper is the following. In section 2, I will discuss about the mechanism of the Harrod-Balassa effect and about the choice of the real exchange rate index. Section 3 will explain how the data are constructed and how I estimate productivity using the Harberger two-deflator method. Section 4 consists of estimations of the productivity hypothesis, where I run regressions of the real exchange rate on estimated productivity measures. In section 5 I will show the results of TFP estimation in selected OECD countries. Section 6 concludes.

2 The Harrod-Balassa Effect and the Real Exchange Rate

2.1 The Harrod-Balassa Effect

The origine of the productivity hypothesis goes back to Harrod (1933). In Chapter 4 the author explicitly stated that prices of nontradable goods are affected by the efficiency of its production relative to that of tradable goods. Harrod used three types of goods, A, B and C in his exercise: international, quasi-international and domestic goods. One of the conditions that equalize relative price of C goods in two countries is that the ratio of efficiency in producing C goods to that in producing A goods be the same in two countries. The national level of efficiency in producing each good is affected by the difference in technology or in the endowment of natural resources. The former link is developed by Balassa (1964) and the latter is extended by Bhagwati (1984).

Balassa (1964) examined the relationship between national price levels and efficiency. The author related a country's price level in terms of the ratio of PPP to nominal exchange rates with national income per capita. The underlying assumption was that the tradable sector should represent a large share of the country's productivity improvements because productivity growth in the nontradable sector is supposed be equally stagnant across countries. Hence higher level of national income per capita

[4]See Miyajima (2003b).

should reflect larger productivity difference between the tradable sector and the non-tradable sector, leading to higher price levels. To support his assertions, Balassa showed a couple of sets of data. For instance, based on the data for 12 developed countries, Balassa linked the ratio of PPP to nominal exchange rates and GNP per capita for a point in time and demonstrated they were positively correlated. The author also demonstrated that the price level of service sector was positively related to the country's income level. However, as it will be discussed later, productivity in the nontradable sector does not seem to necessarily lag behind.

Equally renowned is Samuelson (1964). This paper is, however, largely oriented to the discussion about the theory of international trade. The author states that the ratio of PPP to nominal exchange rate increases with higher productivity level, but there is no explicit reference to nontradable goods. The Balassa-Samuelson effect is the name conventionally used. However, given that Samuelson was not explicit about it as much as Harrod and Balassa, I am using the Harrod-Balassa effect in this paper[5].

Mckinnon (1971) was also aware that in countries with high productivity growth the disparity between WPI and CPI tends to grow larger. The most notable case among his samples is Japan, where between 1953 and 1970, CPI increased by 93.3% whereas WPI actually fell by 5.2%. The author, however, did not explicitely relate this story to nontradable goods.

Bhagwati (1984) took a different approach and developed the link between national price level and the endowment of natural resources. His paper is directly motivated by Kravis, Heston and Summers (1982), a work on international comparisons of national incomes and of comparative price structure. The authors confirmed the finding in Balassa (1964) that the price level of services is lower in poor countries, which should be the consequence of smaller differences in productivity gaps between the two sectors. To Bhagwati, having only labor as factor input was excessively limiting and he introduced capital input additionally. In the author's model which consists of two countries, rich and poor, and three final goods, the poor country can produce only two final goods that are relatively labor intensive provided that initial endowment disparities are large such that factor prices do not equalize. This leads to relatively low national price level in the poor country. Samuelson (1994), however, asserted that the Bhagwati's model requires restrictions to reach this conclusion and favors the logic of the productivity hypothesis. In Obstfeld and Rogoff (1999), the authors state that, even though endowment differences should be part of the story, productivity difference is still essential to explain the large inter-county wage differences. In the literature testing the Harrod-Balassa hypothesis, few authors seemed to have included natural resources as an explanatory variable[6]. This papar also focuses

[5]It is called with some variations, but always Samuelson included. For instance, in Obstfeld and Rogoff (1999) the authors call it the Harrod-Balassa-Samuelson effect. The only literature omitting Samuelson is Harberger (2003) which motivated me to do the same thing.

[6]Officer (1976 b) reports that in Clague and Tanzi (1972) the authors include the ratio of natural

only on productivity in the tradable sector and the nontradable sector.

The mechanism of the Harrod-Balassa effct can be demonstrated using the production sector as follows. There are two sectors producing tradable and nontradable goods respectively using capital and labor inputs and Cobb-Douglas technology:

$$Y_T = A_T L_T^{\alpha} K_T^{1-\alpha} \tag{2}$$

$$Y_N = pA_N L_N^{\beta} K_N^{1-\beta} \tag{3}$$

where T and N denote the tradable and the nontradable sector respectively. p represents the relative price of nontradable goods in terms of tradable goods. From profit maximization, it can be shown that the relative price depends on relative growth rates of productivity in the tradable sector and the nontradable sector.

$$d \log p = \frac{\beta}{\alpha} d \log A_T - d \log A_N \tag{4}$$

Note that even if productivity grew at the same rate in two sectors, relative price of nontradable goods can increase if $\frac{\beta}{\alpha} > 1$. It is very likely that the nontradable sector uses more labor intencive technology than the tradable sector does, in which case relative price of nontradable goods would increase even under balanced growth.

2.2 The Real Exchange Rate

This section discusses the choice of the real exchange rate index and contrasts the widely-used CPI real exchange rate with two other indexes. I also explain the index I will use in my research, the SDR real exchange rate.

In his extensive research on the real exchange rate, Edwards (1989) mainteined that there is no consensus how to construct the real exchange rate. The majority of the literature uses national price level or CPI symmetrically for both numerator and denominator, which may be called PPP real exchange rate (PPP-RER). The author prefers to use prices of tradable and nontradable goods, because in the context of tradable-nontradable goods model, the trade account will depend on the domestic relative price of tradable and nontradable goods (T-NT-RER). To summarize:

$$PPP\_RER = E \times \frac{P^*}{P} \tag{5}$$

$$T\_NT\_RER = E \times \frac{P_T^*}{P_N} \tag{6}$$

where P^*: price level in the foreign country; P: price level in the home country; E: nominal exchange rate; P_T^*: the world price level of tradable goods and P_N: the price

resources to other factors of production as one of the principal explanatory variables.

level of nontradable goods in the home country. It is interesting to see the difference between two real exchange rate indexes, PPP RER and T-NT RER. The price levels in the home and in the foreign countries are a composite of the price of tradable and nontradable goods with common weights:

$$P = (P_N)^{\omega} (P_T)^{1-\omega} \tag{7}$$

$$P^* = (P_N^*)^{\omega} (P_T^*)^{1-\omega} \tag{8}$$

Assuming that the law of one price holds for tradable goods:

$$P_T = E \times P_T^* \tag{9}$$

one would finally obtain the following:

$$d \log RER_{T\_N} = \frac{1}{\omega} d \log RER_{PPP} + (d \log P_T^* - d \log P_N^*) \tag{10}$$

Hence changes in foreign price level of tradable and nontradable goods work as a wedge bwtween changes in two real exchange indexes, PPP-RER and T-NT-RER. It is natural to suspect that the choice of the real exchange rate index perhaps affects the result of my analysis. As far as the choice of nominal exchange rate is concerned, the author prefers multilateral exchange rate (effective exchange rate) to bilateral one. He shows that the bilateral and multilateral real exchange rate indexes moved in different directions by plotting many series, and asserts that one needs to construct a broad multilateral index of real exchagne rate. It is perhaps in order to avoid a country specific shock in the foreign country affecting real exchange rate.

Harberger (1989,2001) extensively discusses about the construction of real exchange rate. The author is also against the use of symmetric real exchane rate indexes. In order to reflect general level of price movements, the author suggests using the GDP deflator or CPI price index in the home country. However, the world price level is represented by the SDR WPI which is constructed by weighted average of WPI in 5 major countries[7], using the weight employed by the IMF in calculating the SDR index. Prices of nontradable goods in foreign countries should not enter into the world price, since those prices should not affect how the home country adjusts itself to shocks. I will call this real exchange rate index as the SDR real exchange rate. As far as nominal exchange rates are concerned, the author uses bilateral exchange rates against the US dollar. Hence the SDR RER is:

$$SDR\_RER = E \times \frac{P_{SDR}}{P_{GDP}} \tag{11}$$

where P_{SDR}: the SDR-WPI and P_{GDP}: the GDP deflator in the home country. I will use the SDR real exchagne rate in my analysis in the remaining part of the paper. The

[7] USA, Germany, Japan, UK and France.

SDR real exchange rate is similar to the tradable-nontradable real exchange rate and hence differes from PPP-RER by the wedge that incorporates prices of nontradable goods in the foreign country.

In order to see which component influence the real exchange rate, I log-decompose the SDR real exchange rate:

$$\log SDR\_RER = \log(\frac{E \times P_{SDR}}{P_T}) + \omega \log(\frac{P_T}{P_N}) \tag{12}$$

Hence log of the SDR real exchange rate is decomposed into two terms, 1) tradable real exchange rate and 2) inverse of the relative price of nontradable goods. If the movements of the SDR real excahgne rate is fully represented by the relative price of nontradable goods, tradable real exchange rate should remain constant. In this particular case, since I normalized all variables to be one in starting year, tradable real exchange rate should stay around zero throughout the period. Figure 1 plots three series for 14 industrial countries. In line with Engel (1999), tradable RER appers to generate the short-run fluctuation of the real exchange rate, but equally remarkable are the idstinct trends of the relative price of nontradable goods.

3 Estimation of Productivity

3.1 Estimation Method

The productivity index is constrcuted based on the concept of the two-deflator method. Detailed description can be found in, for example, Harberger(1998), Robles (1997) or Miyajima (2003a,b). The productivity index here makes the use of the standard labor which is a version of constant quality index for labor input. Quality of capital is captured by rates of return. In this way, the contribution of quality change in labor (capital) inputs is imputed to labor (capital) input itself. The variables are first deflated by the GDP deflator and estimated productivity index is later adjuested by the relative price of value added in order to capture the impact of productivity improvements perceived by final consumers.

I proposed an index of the followingl form in Miyajima (2003a), and will use in this analysis as well:

$$\frac{Q^*_{i,t}}{w^*_0 L^*_{i,t} + (\rho + \delta)_{AVE} K^*_{i,t}} \tag{13}$$

where $Q^*_{i,t}$: real value added of sector i at time t, : $L^*_{i,t}$: the standard labor of sector i at time t; $K^*_{i,t}$: real capital stock of sector i at time t, w^*_0: the standard wage in the starting year; $(\rho + \delta)_{AVE}$: the average of the sum of the rate of return and depreciation in the economy as a whole over the period of estimation.

In what follows I explain how I constructed the index in practice step by step. Nominal value added in the tradable sector and the nontradable sector are deflated by the GDP deflator. Price adjustments are further made by deviding value added by the relative price of value added, P_{VA}/P_{GDP}. This is because part of productivity improvements goes to the final consumer in the form of lower prices.

By using the standard wage:

$$(w_0^*, w_1^*, ..., w_t^*) \tag{14}$$

I can calculate the standard labor in the tradable (T) and the nontradable (N) sectors:

$$\begin{aligned} &(L_{T,0}^*, L_{T,1}^*, ..., L_{T,t}^*) \\ &(L_{N,0}^*, L_{N,1}^*, ..., L_{N,t}) \end{aligned} \tag{15}$$

based on the following relationship:

$$L_t^* = \frac{w_t L_t}{w_t^*} \tag{16}$$

Using w_0^*, I can calculate the following series for the the tradable and the nontradable sectors:

$$\begin{aligned} &(w_0^* L_{T,0}^*, w_0^* L_{T,1}^*, ..., w_0^* L_{T,t}^*) \\ &(w_0^* L_{N,0}^*, w_0^* L_{N,1}^*, ..., w_0^* L_{N,t}^*) \end{aligned} \tag{17}$$

For capital inputs, I estimate $(\rho + \delta)_{AVE}$ by taking the average of the sum of the rate of return and depreciation over the entire period for the economy as a whole. The same $(\rho + \delta)_{AVE}$ is used to multiply the series of real capital in both the tradable sector and the nontradable sector. Hence I would obtain the following series:

$$((\rho + \delta)_{AVE} K_{T,0}^*, (\rho + \delta)_{AVE} K_{T,1}^*, ..., (\rho + \delta)_{AVE} K_{T,t}^*) \tag{18}$$

$$((\rho + \delta)_{AVE} K_{N,0}^*, (\rho + \delta)_{AVE} K_{N,1}^*, ..., (\rho + \delta)_{AVE} K_{N,t}^*) \tag{19}$$

3.2 Data

The availability of data is a major costraint for the choice of sample countries. In this project the data is downloaded from OECD STAN website, which is one of the few complete datasets that contain necessary variables for productivity estimations. Having said that, data for some countreis in the dataset being incompletem I had to narrow down samples to the following countries: Australia (AUS), Austria (AST), Belgium (BEL), Canada (CAN), Finland (FIN), France (FRA), Germany (DEU), Italy (ITA), Japan (JPN), Korea (KOR), the Notherlands (NDL), Sweden (SWE), United Kingdom (UK) and the United States (US). Data for AST and SWE start from 1976 and 1980 respectivily,due to data constraint.

First, I need to classify sectors into the tradable sector and the nontradable sector. The rule of thum might be to classify agriculture, mining and manufacturing sectors into the tradable sector, and the rest into the nontradable sector. There are however exceptional cases such as the agriculture sector in Japan which is completely protected and heavily subsidized. In this case the agriculture sector needs to be classified in the nontradable sector. Instead of trying to familiarize myself with country specific industry struture, I simply consulted the data on exports. When the ratio of exports to sectoral value added turned out to be less than 10%, a cut-off line which appers to be standard in the literature, I classify that sector into the nontradable sector. Consequently, I clategorized the following pairs into the nontradable sector: the agriculture sector in Finland, Japana and Korea, the mining sector in Japan and Korea. Table 2 summerizes estimated ratio. The value of export is measured in terms of output, which is much larger than value added. Even thought some ratio are oddly large because of this, I believe for the purpose of this paper those figures should do.

When it is feasible, I should remove non-productive sectors such as public administration, government and education sectors from the data I used for productivity estimation. This was possible only for AST, DEU, ITA and US. An alternative way to make this adjustment would be to assume that those non-productivie sectors have zero productivity, and adjust estimated productivity for the nontradable sector accordingly. To make sure that public administration, government and education sectors are indeed not productive, I estimated productivity of those sectors in AST, DEU, ITA and US, where complete data were available. Estimated results range from a high of 0.37% in ITA to a low of -1.68% in DEU, and suggest that the assumption of zero productivity improvement could be actually conservative. Table 3 summerizes the reults.

I assume the following relationship to estimate productivity in the "productivie" nontradable sector (time subscript is omitted in this section):

$$RCR_{N+GE}(\%) = \alpha RCR_{GE} + (1-\alpha) RCR_N \tag{20}$$

where RCR: real cost reduction; N: the nontradable sector; GE: government and education sectors; α: share of GE in $N+GE$. Productivity in the nontradable sector net of non-productive sectors is give by:

$$RCR_N = \frac{RCT_{N+GE} - \alpha RCR_{GE}}{1-\alpha} \tag{21}$$

Assuming RCR_{GE} is zero, all I need to estimate is the value of α.

I estimated the share of public administration/government and education sectors relative to total value added. I could not estimate for entire periods. By looking at the trend of α, one would realize that it has been stable for most of the countries throughtout the periods. I hence extraporated α for periods where data were missing and took the average over the periods for each country. Table 4 summerizes estimates, which rage from 11% in JPN to 20% in BEL.

Sectoral prices are estimated by using nominal value and volume of value added. First I estimate prices for the entire economy and for each sector, agriculture (A), mining (MN), manufacturing (MF), public administration/government (G) and education (E) sectors, and normalize them to be 1 in the starting year. Prices for the tradable sector for a country is then estimated as follows:

$$P_T = \gamma_A P_A + \gamma_{MN} P_{MN} + \gamma_{MF} P_{MF} \tag{22}$$

where γ_i: shre of sector i in the tradable sector in terms of value added, hence $\sum \gamma_i = 1$, $i = A, MN, MF$. Note that whether to include all three sector or not depends on country as already discussed. Table 5 shows which sector is classifies to either the tradable or the nontradable sector. In the table, when a cell contains a cross, it means that that sector in that country was classified in the tradable sector when A, MN and MF are concerned. When G and E are concerened, a cross in a cell means that sector was excluded from the nontradable sector based on the data from STAN as opposed to using estimated α as discussed above. Another thing to note is that, some sector are excluded from the tradable sector, such as mining sector in BEL, due to lack of sectoral data.

Using estimated value of P_T, I estimated prices for the nontradable sector:

$$P_{NT} = \frac{P_{GDP} - \phi_T P_T}{1 - \phi_T} \tag{23}$$

where P_{GDP}: the GDP deflator for the economy as a whole; ϕ_T: share of the tradable sector in the economy as a whole. One issue related to estimation of prices would be the fact that what is conventionally classifies as prices of tradable goods actually contain nonnegligeable amount of nontradable component. I this project, however, I do not intend to do any addtional adjustment to account for that issue.

In estimating productivity, capital stock is constructed using the perpetual invertory method:

$$K_{t+1} = (1 - \delta) K_t + I_t \tag{24}$$

where I used 7% for depreciation rate accross the countries and periods. Initial capital stock is estimated by

$$K_0 = \frac{I_0}{(\lambda + \delta)} \tag{25}$$

where λ: growth rate of real GDP. In prectice λ is estimated by taking average of growth rates for perhaps 3 consecutive periods of stedy growth. The stanrard wage is approximated by textile workers wage in each country[8]. An adjustment is required for the fact that the part going to land is not included in investment. I need to reduce value added by some fraction in order to reflect that value added includs return on land whereas capital input does not. I did extensive estimation in this regards in my previous work for the United States. Based on those results and on the literature that uses the two-deflator method, adjustments for land are made as follows: agriculture

[8] An alternative is to use 2/3 of GDP per capita, which I did in my previous work.

sector: reduce sectoral value added by 30%; mining sector: reduce sectoral value added by 10%; manufacturing sector and the nontradable sector: reduce sectoral value added by 5%. No adjustment was made for inventories in this paper.

4 Regression Analysis

Using productivity estimates for each country, I first look at the relationship between the real exchange rate and sectoral productivity in order to examine how much the productivity hypothesis holds in my dataset. I first go over the literature and review how authors have done similar regression analysis. Porductivty measures they have used ranges from GDP per capita, labor productivity to sectoral TFP. Other than productivity measures, some papers include explanatory variables such as government expenditure and terms of trade. Panel data are often employed in order to increase the power, and mostly in the recent literature, the cointegrationg method is used in order to deal with non-stationarity of the data. First I run static OLS (SOLS) regressions using the data both in level and first-difference. After a brief discussion about the non-stationarity, I run dynamic OLS (DOLS) regressions in an aim to imporove the regression results.

4.1 Literature Review

Froot and Rogoff (1991) focused on the EMS countries[9] for the period of 1979-89 and run regressions of CPI RER on government consumption, productivity of manufacturing sector[10] and GNP per capita. The authors found that government consumption significantly affects RER, but found no evidence supporting the productivity hypothesis. Perhaps time series of 10 years may not be long enough for the relative productivity to be a dominant factor. In Ito, Isard and Symansky (1997), the authors focused on the APEC countries and examined the productivity hypothesis. Since growth rates of many of the sampled countries were high, according to the Harrod-Balassa hypothesis the authors should expect appertiation in the real exchange rate. Several tests were conducted, but the results did not quite support the Harrod-Balassa effect. Harberger (2003) confirms the point that the Harrod-Balassa effect is not the rule that should apply to any episode of strong economic growth, hence GDP growth and the real exhcange rate are not systematically related. In his regression analysis, the author found that there was no systematic link between GDP growth and the trend of the real exchange rate[11]. Hence the results did not support

[9] Belgium, Denmark, France, Germany, Ireland, Italy, Luxemburg and Netherlands.

[10] Output per labor in the manufacturing sector.

[11] For instance, when the second real exchange rate index, SDR-RER is regressed on a time trend, the author obtains 18 coefficients with positive signs and 7 with negative signs , the results of other regressions being similar. If one cares about significance (up to 5% level), 13 significant coefficients with positive signs, 4 significant ones with negative signs and 8 not significant coefficients.

the Harrod-Balassa hypothesis.

Some papers used relative productivity to explain the relative price or the real exchange rate, but the results were still mixed. Officer (1976 a) was one of the first work casting doubt to the productivity hypothesis. Officer used three explanatory variables one at a time: 1) GDP per capita, 2) GDP per worker and 3) the ratio of labor productivity in the tradable sector to that in the nontradable sector. Using Germany for the standard country, the author pooled the data for 15 developed countries and run regressions year by year. He useed two PPP indexes from different source to convert variables, and run regression year by year for 24 years (1950-73) for each explanatory variable. It turns out that not a single coefficient on productivity measure is significant at 5% level, and adjusted R-squared was mostly negative. Surprisingly enough, even the relative productivity measure, 3), did not seem to improve the result at all. The author also run regressions in terms of growth in 1973 relative to 1953, but the results turned out to be even worse; when the relative productivity was used, coefficients were negative and insignificant while with the other two productivity measures, some coefficients were positive and significant. Based on those results, Officer asserted that the productivity hypothesis did not hold at all. Officer asserted that Balassa's own findings supporting the productivity hypothesis were invalid based on some points[12]. Hsieh (1982) suspected the results in Officer (1976 a) were the consequence of running cross country regressions by ignore country specific factors. The author fitted time series data for the period of 1954-76 for Japan and Germany separately[13], and found favorable results for the productivity hypothesis.

Chinn (1997) used 9 Asian countries plus US for the period of 1970-92 and regressed the real exchagne rate on a couple of variables using both time series and panel data. The results of this work were not conclusive, and the author suspected substantial persistence in relative prices of tradable goods could be the key.

In Canzoneri, Cumby and Diba (1996), the authors attempted to show that the relative price of nontradable goods could be explained by the relative labor productivity. Basic strategy is to show that nonstationary variables are cointegrated and that the cointegrating slope is one, which implies that one series is influenced by the other. They used time series data for 13 OECD countries for 20 to 30 years and found that country wise regressions could not reject the null of unit root for the series of the relative price nor for that of the relative labor productivity. Even after pooling the data for all countries they could not reject the null, but one might suspect it was due to the lack of power. When they test cointegration, results were mixed for individual countries but once the data were pooled the null of no cointegration

[12] Balassa used conceptually not comparable data for different counties. Also the inclusion of US even thought it is the standard country strongly affected the result, and by dropping it the Balassa's results become quite weak.

[13] Variables were expresed in terms of rates of change. The dependent variable was nominal exchange rate times the ratio of the GDP deflator. The foreign country is a geometric average of the major trading partners of the home country. The tradable sector consists of the manufacturing sector, and productivity is calculated as sectoral GDP per man hour.

was rejected. As the authors suspected the power of the test perhaps increased by pooling the data. Cointegration between nominal exchange rate and tradable goods PPP was also tested in order to check the law of one price for the price of tradable goods. Depending on the specification the results favor the productivity hypothesis, but they are still mixed.

The following three literatures distinguish from others in the use of TFP for productivity measure. De Gregorio, Giovannini and Krueger (1994) fitted relative price of nontradable goods for 5 developed countries for the period of 1971-89. Productivity measure is constructed by Solow residuals, TFP, except for Spain for which they use labor productivity. Explanatory variables are relative productivity in the tradable sector to that in the nontradable sector, government expenditure and private sending share in nontradable goods. They were aware of the non-stationarity of the data. Because the sample was small, instead of testing stationarity they simply used data both in level and in first-difference and compared the results. By running SUR, seemingly unrelated regressions, they found that productivity difference variables had good explanatory power for France, Germany and Italy. The other two regressors had less explanatory power. They also run alternative regressions, the results of which implied that the productivity hypothesis holds for some countries with different degree. Hence the results were not quite conclusive.

In De Gregorio, Giovannini and Wolf (1994) the authors used data for 14 OECD countries and defined goods as tradable if more than 10% of total production was exported. They first testd the PPP and found that inflation rates of tradable goods were highly correlated among core countries while less among non-core countries. Among non-European countries the correlation fell and they found the same pattern with nontradable goods. They suspected that the exchange rates system might have played a role in bringing about the higher correlation of inflation rates. They then test if the Harrod-Balassa hypothesis holds. SURs are run in first-difference in an aim to purge the high persistence, and they found that the difference of TFP between the tradable and nontradable sector significantly affected the price ratio. They also found demand side effects, represented by government expenditure over GDP and per capita income. Changes in relative price seemed to be dominated by supply-side factors in the long-run while equally affected by both demand- and supply-side factors in the short run. Hence this paper appears to provide favorable results to the productivity hypothesis.

De Gregorio and Wolf (1994) does similar experiments as De Gregorio, Giovannini and Wolf (1994), except that this one introduces prices of import and export goods instead of prices of tradable goods. Explanatory variables are hence TFP difference, government expenditure, GDP per capita and terms of trade . They confirm the importance of demand side factor influencing relative price of nontradable goods. The inclusion of terms of trade variable increased the estimated coefficient on relative TFP substantially, which made the authors suspect that focusing solely on the productivity terms could yield excluded variable bias. Regarding the productivity hypothesis, this paper also provides favorable findings.

4.2 Regressions

The literature has been hence incoclusive about the productivity hypothesis. In this section, I run two sets of regressios, static OLS (SOLS) and dynamic OLS (DOLS). The latter is supposed to improve the results by adding leads and lagds of first-differences. I begin with SOLS and show that DOLS improves the regression results in that the signs and significance of coefficients support the productiviy hypothesis better. Overall results in this section appear to support the hypothesis more than those in the literature.

4.2.1 Static OLS

First, I use the following specification:

$$\log(RER) = \alpha + \beta \log(\frac{TFP_T}{TFP_N}) + \varepsilon \tag{26}$$

$$\log(RER) = \alpha + \beta \log(TFP_T) + \gamma \log(TFP_N) + \varepsilon \tag{27}$$

The date are used in terms of both level and first-diference. First-difference is used in an aim to remove the persistence. In equation (26), I expect β to have negative sign because the real exchange should appreciate (its value falls) as a result of relatively higher productivity improvments in the tradable sector. Equation (27) is suposed to capture the idea of the productivity hypothesis even better, by separating TFP into two sectors. Here, I expect β and γ to be negative and positive respectively.

Histograms in figure 2 show the results using the data in level. Detailed results are also availabel in table 6-11. The first histogram reports the results from equation (26) using data in level. In line witht the productivity hypothesis, negative coefficients dominate and are mostly significant at 5% level. The next histogram reports results based on equation (27). For instance, $T, Positvie$ and $T, Negative$ show the frequency of positive and nagative coefficient of TFP of the tradable sector, β respectively. The frequency is more or less in line with what one would expect, but the dominance of signs is weaker.

Next, the same two regressions are run using the data in first-difference. Now the histograms in figure 3 tell opposite story and only few estimates are significant. At this point, my results look inconclusive with respect to the productivity hypothesis. In order to gain better idea, I decomposed the real exchange as already done in the previous section. The real exhcange rate is hence decomposed into two parts: tradable RER and relative price of nontradable goods:

$$\log(RER) = \log(\frac{E \times P_{SDR}}{P_T}) + \omega \log(\frac{P_T}{P_N}) \tag{28}$$

Hence there are four differnet spedicications:

$$\log(\frac{E \times P_{SDR}}{P_T}) = \alpha + \beta \log(\frac{TFP_T}{TFP_N}) + \varepsilon \tag{29}$$

$$\log(\frac{E \times P_{SDR}}{P_T}) = \alpha + \beta \log(TFP_T) + \gamma \log(TFP_N) + \varepsilon \tag{30}$$

$$\omega \log(\frac{P_T}{P_N}) = \alpha + \beta \log(\frac{TFP_T}{TFP_N}) + \varepsilon \tag{31}$$

$$\omega \log(\frac{P_T}{P_N}) = \alpha + \beta \log(TFP_T) + \gamma \log(TFP_N) + \varepsilon \tag{32}$$

I start from looking at equation (29) and (30) where the dependent variable is tradable RER, using data in level. Figure 4 shows that, in either case there is no donminace at all, and productivity improvements appear to affect tradable RER more or less randomely. Figure 5 shows the frequency for the same equations but with the data in first-difference. Relatively higher productivty improvement in the tradable sector turned out to depraiciate tradable RER.

Next, I use equation (31) and (32) where the dependent vatiable is the relative price of nontradable goods. Histograms in figure 6 summarize the results using the data in level. The frequency of signs is in line with what the productivity hypothesis predists. Even thougth the picure becomes slightly blurred in figure 7, where the data are in first-difference, those results suggest that the relative price of nontradable goods is in general moving in a way that the productivity hypothesis predicts.

4.2.2 Dynamic OLS

Almost all the series are non-stationary in level, and some of them still remain so even in first-difference. Table 12 summarizes the results of ADF test for unit root where RER: the real exchange rate; $T-RER$: tradable RER; PR: the relative price of the nontradable goods (hence price ratio); TR: TFP in the tradable sector relative to that in the nontradable sector (hence TFP ratio); TT: TFP in the tradable sector; NT: TFP in the nontradable secttor. When it says "Unit Root", the null of unit root is not rejected, and when percenage is shown the null is rejected at that significance level. The ADF test is based on the following equation:

$$\Delta y_t = \alpha x_t + \beta y_{t-1} + \sum \gamma_i \Delta y_{t-i} + \varepsilon_t \tag{33}$$

where x: a set of exogenous variables. In this paper x consists of trend and intersept and the nuber of lagged dependent variable is one. From table 13, one can see that while the null of unit root cannot be rejected for the data in level, in first-difference the null is mostly rejected. Regressions using the data in level hence may be spurious, due to the lack of stationarity. If the series are cointegrated, however, this is not a problem, since a liner combination of non-starionary series together creates a stationary series.

Words of caution about testing non-stationarity follow. The power of test might be too low to tell a slow convergence from non-stationarity. With a sample of small size such as the data in this paper, one can hardly reject the null of unit root. A sample of large size has a differnect problem. For a series under the test to be unit root, the series needs to have cumulatively increasing variace over time. If the variance of a serie do not increase in a way that the theory require, one tends to reject the null of unit root when the size of a sapmle becomes large[14].

If the series are cointegrated, OLS is valid for estimating the coefficient vector, in other words the cointegrating slope. In this case, DOLS, which introduces leads and lags of first-difference, is supposed to improve the estimated results relative to those of SOLS[15]. DOLS is:

$$q_t = \alpha + \beta z_t + \gamma \Delta z_{t+1} + \delta \Delta z_t + \varepsilon_t \tag{34}$$

where z: independent variables; q: dependent variables; $\Delta z_t = z_t - z_{t-1}$. The cointegration relationship is not tested because regardless of the results, whether the series are cointegrated or not, the best I can do in estimating the relationship is using DOLS.

DOLS is run for all equations, (26), (27), (29)-(32) only using data in level, and estimated results are summarized in figure 8-10. Figure 8 shows that both with equation (27) and (27), estimated results are more favorable to the productivity hypothesis than under SOLS. Productivity ratio has more negative and significant impact on the real exchange rate. When productivity is separately used in the tradable sector and the nontradable sector, negative (positive) link between productivity growth in the tradable (nontradable) sector an the real exchange rate is articulated. When equation (29) and (30) are used, figure 9 shows that there is no dominance in sign in terms of the link between tradable RER and productivity growth. Finally, figure 10 summarizes the results using equation (31) and (32). Under SOLS, the reuslts already favored the productivity hypothesis, and they are similar under DOLS. It apperas that DOLS contributed to improve the overall estimated results in that it better supports the porductivity hypothesis. Detailed resutls are in table 13-15.

5 Growth of Sectoral Productivity

I started this paper by looking at the link between growth of GDP and the real exchagne rate. Lack of predoinance in the relationship between those two variables, either positive or negative, was the observation which made me suspect that productivity improvements in the nontradable sector should be higher relative to those in the tradable sector in perhaps half of the cases. Hence the main objective of this paper was to examine, at least in the sampled countries, whether there is any tendency

[14]See Harberger (2003).

[15]See, for instance, Lee and Tang (2003).

for productivity improvemntes either in the tradable sector or in the nontradable sector to be systematically higher than in the other sector. Even though the results from the regression analysis do not provide clear cut conclusions, the real exchange rate appears to move in a way that the productivity hypothesis predicts. Given this observation, our prior is to suspect that there are equal chance for both sectors to have higher growth of productivity relative the other. In this section, finally, I will show that the data support our prior at lest within the sampled countries.

SInce the estimation strategy was already discussed in the previous section, this section presents the estimated results. For the purpose of productivity estimation, I chose periods where growth of GDP appared to be continuous without any break. This was done in order to make sure that, if the tradable sector is exclusively responsible for economic growth, we should observe its productivty growth to be relatively higher in all countries. Estimated results and period of estiations are summarized in table 16 and figure 11. Note that I included the US. T and NT stand for the tradable and the nontradable sector respectively and rates of growth are in terms of average per annum. In figure 11, the countries are sorted according to the gap in productivity growth bwtween the two sectors, from the largest on the left to the smallest on the right. For instance, in NOR, which is located on the right end, the nontradable sector performed the best relative to the tradable sector in terms of estimated productivity growth. From figure 11, one would notice that both sectors seem to have equal chace of outperforming the other sector in trms of productivity improvements: the tradable sector had higher productivity groth than the nontradable sector did in 8 countries; the opposite was true for 6 countries; both sector had similar productivity growth in one country.

6 Final Remarks

Underlying assumption of the Harrod-Balassa effect is that the tradable sector should be fully responsible for a country's economic gwoth. This paper was motivated by Harberger (2003) where the author had casted doubt on the validity of this assumption. I first confirmed the findings in Harberger (2003) throught my own filter based on a different dataset: even during the episodes of secular and continuous economic growth, the real exchange rate did not have a systematic tendency to appreciate. It appreciated only for about half the time. If the real exchange rate moves in a way that the produtivity hypothesis predicts, it should imply that productivity improvements in the nontradable sector were relatively higher as many times as those in the tradable sector were. The objective of this paper has been to demonstrate this as a fact numerically using productivity estimates.

I first presented the mechanism of the Harrod-Balassa effect and also discussed about the choice of the real exchagne rate index. In doing so I introdeuced the SDR real exchange rate which is perhaps the real world version of tradable-nontradable real exchange rate. Estimation of productivity and data construction were one major building block of this paper. I discussed about estimation methods which owe a gerat deal to the Harberger two-deflator method. Some discussion about data construction followed.

The literature has been inconclusive on the link between productivity improvemtns and the real exchange rate. In order to confirm the validity of the productivity hypothesis, I first run several SOLS regressions both in level and in first-difference. Using the data in level and the aggregate real exchagne rate as dependent vatiable, it appeared that the productivity hypothesis was at work, even thought to lesser extent when sectoral productivity were separated on the right hand side of the equation. When I docomposed the real exchagne rate and used only the relative price of nontradable goods, the results became more supportive to the hypothesis. The other component of the real exchange rate, tradable RER, moved in a way that it blurred the link between sectoral productivity improvments and the real exchange rate. With the data in first-difference, the results became quite weak. Second, DOLS was introduced using the data only in level. Overall the results were improved in that they bacame more favorable to the productivity hypothesis.

FInally, in the last esction, I confirmed the conjecture that productivity growth in the nontradable sector can equally outperform that in the tradable sector, by using productivity estimates. Out of 15 countries, productivity growth was relatively higher in the nontradable sector in 6 countries. It was about the same between tow sectors in one country. Hence I could confirm that rela appreciation of exchange rates is not a natural consequnece of strong GDP growth. As Harberger (2003) concluded, one should not expect own currency to appreciate as a result of economic growth. Such predictions should be made based on the analysis of the situations that each country faces.

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	Countries	(1) Start	(2) End	(3) Average Growth of Real GDP	(4) log (gdp)		(5) Rates of Change of RER
1	Austria	1963	1974	4.61%	-0.5464	**	-0.74%
2	Bahamas, The	1961	1969	9.85%	-0.1674	**	-3.92%
3	Bhutan	1981	2000	6.89%	0.5203	**	0.92%
4	Botswana	1961	1992	10.82%	0.0435	**	-0.18%
5	Brazil	1966	1980	8.23%	-0.1030	*	-0.53%
6	Chile	1984	1998	7.39%	-0.1423		0.10%
7	China	1977	2000	9.01%	0.5389	**	3.21%
8	Colombia	1964	1974	5.91%	0.5457	**	0.37%
9	Congo, Rep.	1968	1975	7.72%	0.0357		0.05%
10	Costa Rica	1962	1979	6.53%	-0.0055		0.08%
11	Cote d'Ivoire	1966	1978	8.57%	-0.1840	*	-0.29%
12	Dominican Republic	1969	1981	7.84%	0.2110	**	0.78%
13	Ecuador	1970	1981	8.28%	-0.1503		-0.31%
14	Equatorial Guinea	1992	2000	22.68%	-0.2155	**	-0.82%
15	France	1961	1974	5.24%	-0.2738	**	-0.45%
16	Gabon	1961	1976	11.76%	-0.3736		-0.53%
17	Greece	1961	1979	6.36%	-0.1538	**	-0.20%
18	Guatemala	1961	1980	5.58%	0.2087	**	0.95%
19	India	1977	2000	5.28%	0.5346	**	0.62%
20	Indonesia	1968	1997	7.39%	0.1197	*	-0.01%
21	Japan	1961	1973	9.65%	-0.4092	**	-0.67%
22	Korea, Rep.	1963	2000	7.80%	-0.3488	**	-0.25%
23	Lao PDR	1989	2000	6.96%	-0.1357		-0.18%
24	Malaysia	1961	1984	7.08%	0.0831	**	0.91%
25	Malaysia	1987	2000	7.41%	-0.0070		0.91%
26	Maldives	1985	2000	8.86%	-0.1238		-0.02%
27	Malta	1965	1981	9.48%	0.4254	**	1.51%
28	Mauritius	1981	2000	5.68%	-0.1489	**	0.10%
29	Mexico	1961	1981	6.80%	-0.1259	**	-0.92%
30	Myanmar	1974	1984	5.67%	0.8926	**	1.45%
31	Pakistan	1961	1970	7.22%	-0.2427	**	-0.67%
32	Pakistan	1973	1992	6.09%	0.3481	**	0.66%
33	Panama	1961	1973	7.58%	0.1006	*	9.45%
34	Papua New Guinea	1961	1973	6.69%	-0.4483		-15.49%
35	Paraguay	1967	1981	7.85%	-0.1127	*	-0.35%
36	Philippines	1961	1981	5.32%	0.4629	**	1.23%
37	Portugal	1961	1973	6.87%	-0.2720	**	-0.26%
38	Saudi Arabia	1961	1980	10.26%	-0.8359	**	-9.69%
39	Singapore	1965	1984	9.95%	-0.0098		-0.41%
40	Spain	1961	1974	7.15%	-0.4985	**	-0.53%
41	Sri Lanka	1973	1986	5.17%	1.1047	**	1.28%
42	Thailand	1961	1996	7.72%	0.0954	**	0.03%
43	Uganda	1987	2000	6.46%	0.2691		0.59%
44	Vietnam	1987	2000	6.83%	0.4423		0.94%

** Significan at 1%
* Significant at 5%

Summery of Column (4)	
Positive	19
Negative	25
Significant	
Positive	16
Negative	15

Summery of Column (5)	
Positive	21
Negative	23

Source: World Development Indicators, the World Bank.

Table 1. Results of regressions and rates of change of the real exchange rate

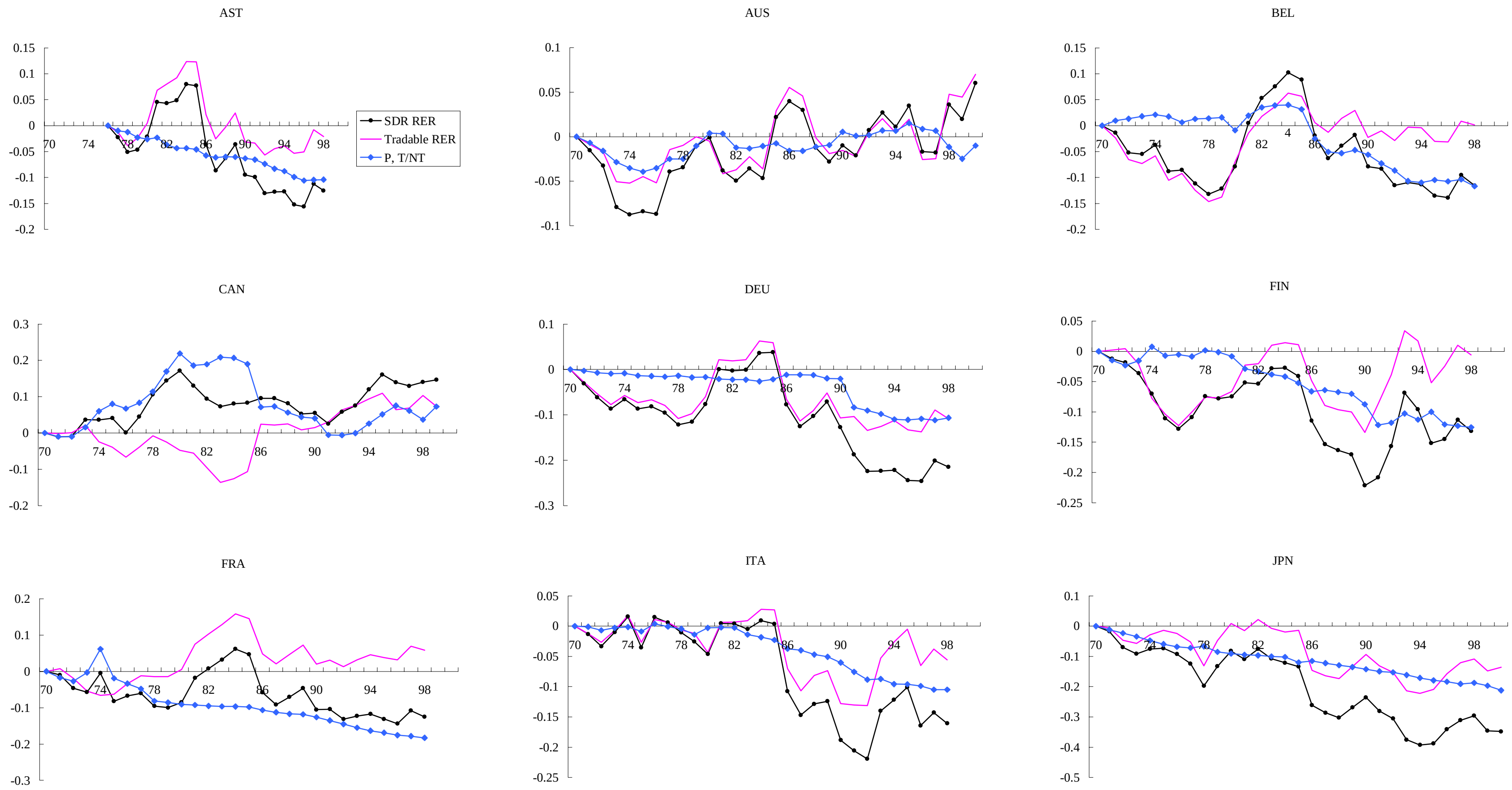


Figure 1. Decomposition of the SDR real exchange rate

The SDR real exchange rate, tradable RER and the relative price of nontradable goods

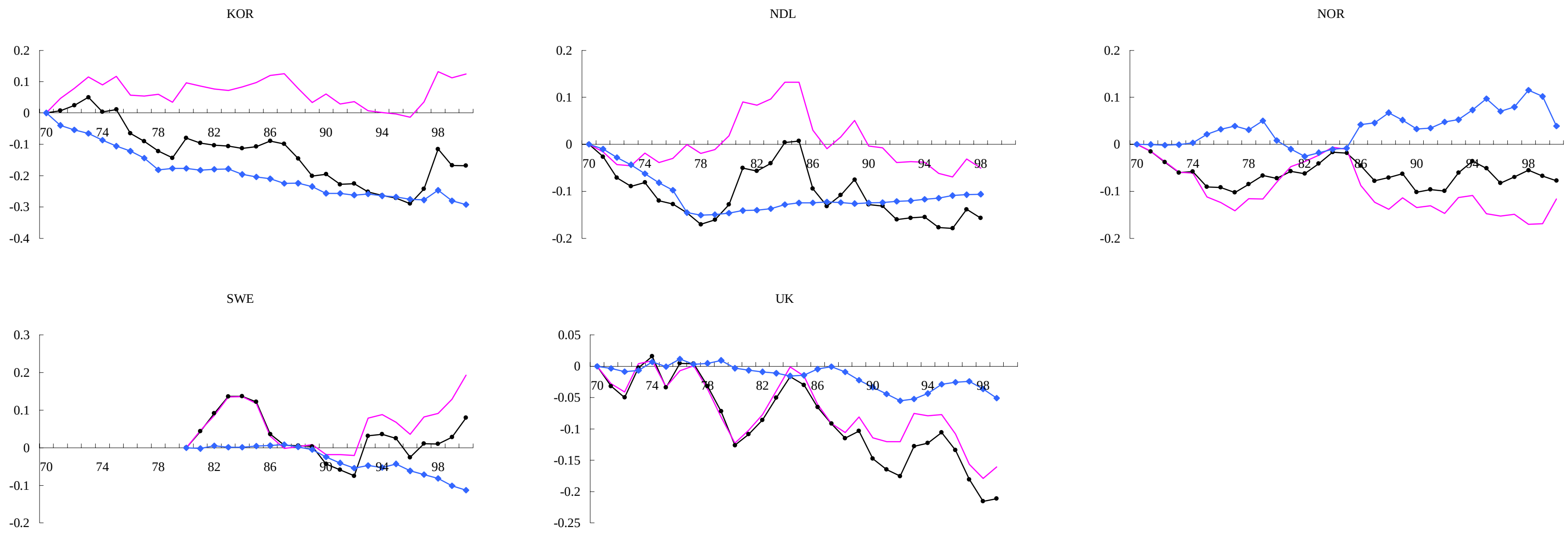


Figure 1. Continued

	Agro	Mining	Manufacturing
Australia	33%	61%	67%
Austria	12%	26%	153%
Belgium	139%	2184%	358%
Canada	53%	78%	163%
Finland	**7%**	40%	147%
France	28%	NA	116%
Germany	22%	21%	119%
Italy	13%	10%	101%
Japan	**1%**	**3%**	41%
Korea	**5%**	**4%**	133%
Netherlands	105%	50%	260%
Norway	36%	97%	135%
Sweden	13%	113%	169%
United Kingdom	15%	55%	99%

Agro: Agriculture, Hunting, Forestry And Fishing
Mining: Mining And Quarrying
Gov.: Public Admin. And Defence; Compulsory Social Security

Table 2. Ratio of export-to-sectoral value added.

AST	0.31%
DEU	-1.68%
ITA	0.37%
US	-1.19%

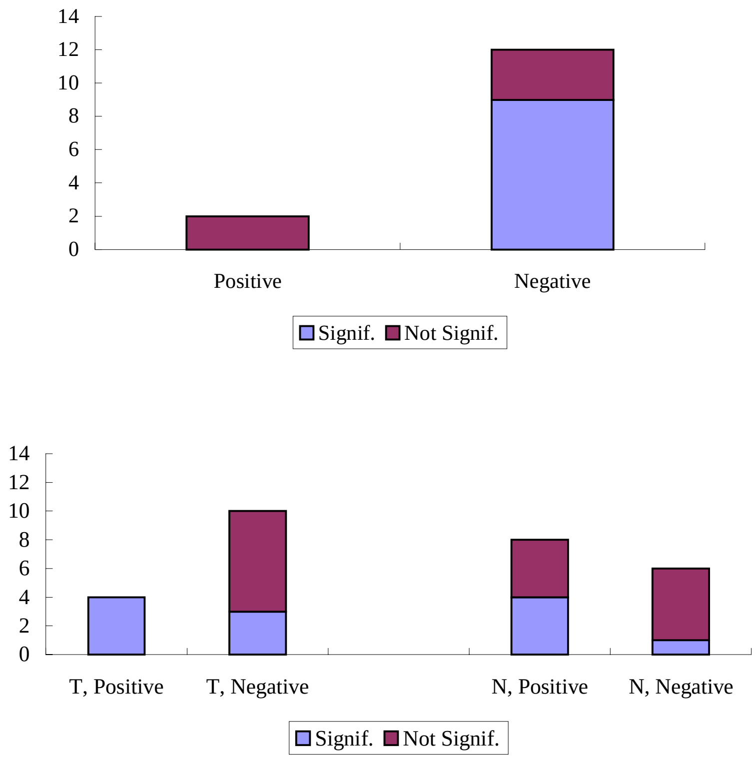
Table 3. Estimated productivity in public administration, government and education sectors.

AUS	14%
BEL	20%
CAN	17%
FIN	13%
FRA	17%
JPN	11%
KOR	12%
NDL	18%
NOR	15%
SWE	14%
UK	16%

Table 4. Estimated value of alpha

		Included in T sector			Excluded from NT sector	
		+ Agro	+ Mining	+ Manufacturing	- Education	- Gov.
Australia	AUS	x	x	x		
Austria	AUT	x	x	x	x	x
Belgium	BEL	x		x		
Canada	CAN	x	x	x		
Finland	FIN		x	x		
France	FRA	x		x		
Germany	DEU	x	x	x	x	x
Italy	ITA	x	x	x	x	x
Japan	JPN			x		
Korea	KOR			x		
Netherlands	NDL	x		x		
Norway	NOR	x	x	x		
Sweden	SWE	x	x	x		
United Kingdom	UK	x	x	x		
United States	US	x	x	x	x	x

Table 5. Sectors which are included or excluded from the tradable sector and the nontradable sector.



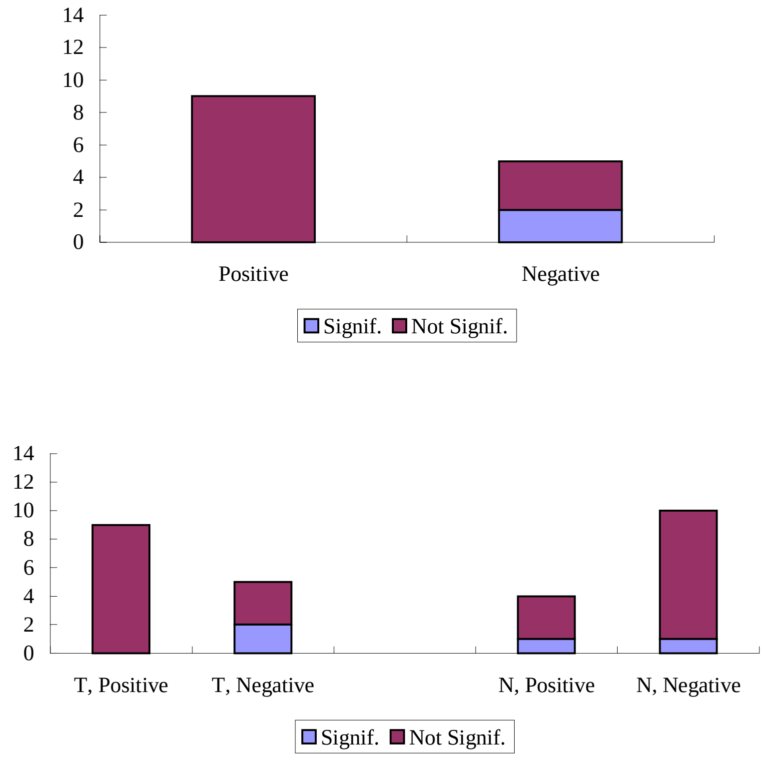


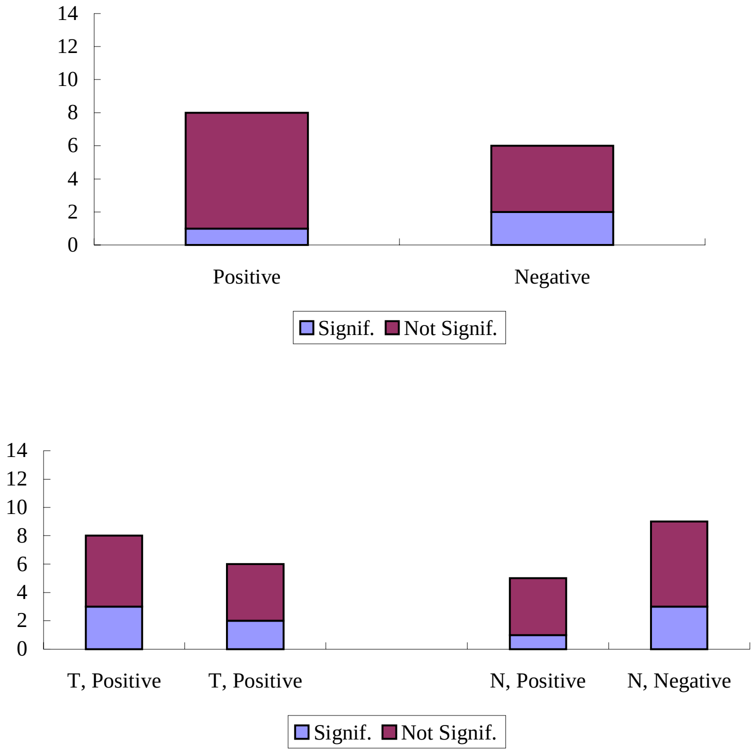
Figure 2. Frequency of signs: data in level

Above: equation (26)
Below: equation (27)

Figure 3. Frequency of signs: data in first-difference

Above: equation (26)
Below: equation (27)

T, positive (negative) indicates the number of positive (negative) coefficients of TFP in the tradable sector.
N, positive (negative) indicates the number of positive (negative) coefficients of TFP in the nontradable sector.



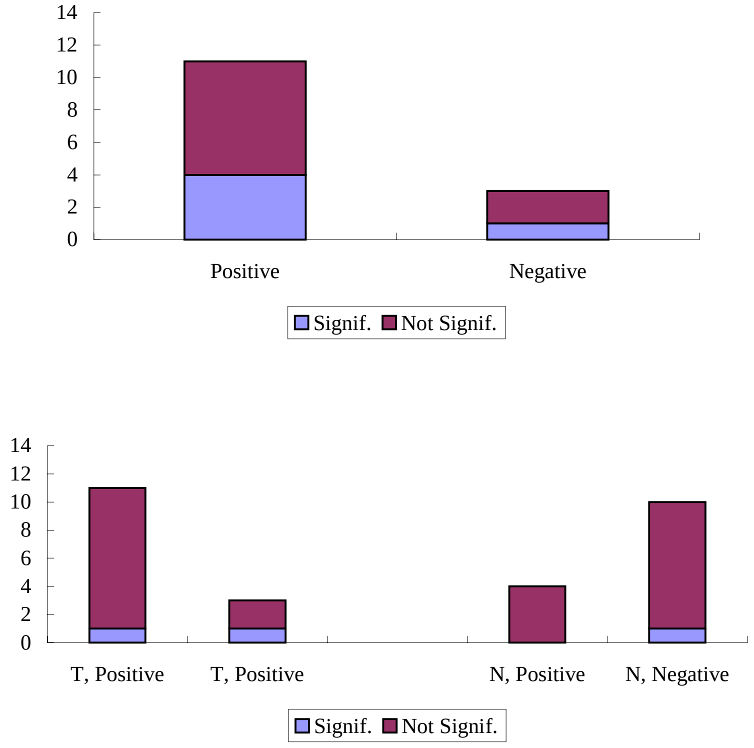
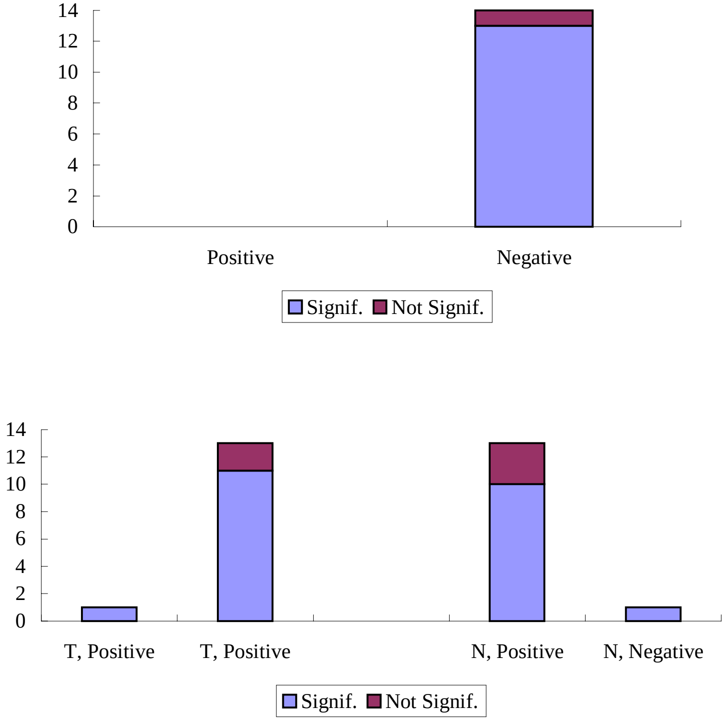


Figure 4. Frequency of signs: data in level

Above: equation (29)
Below: equation (30)

Figure 5. Frequency of signs: data in first-difference

Above: equation (29)
Below: equation (30)



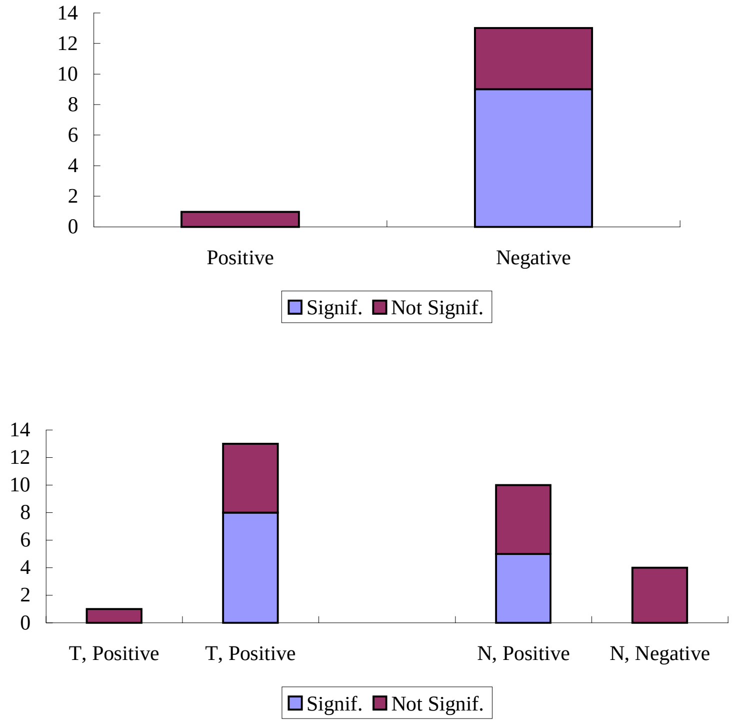


Figure 6. Frequency of signs: data in level

Above: equation (31)
Below: equation (32)

Figure 7. Frequency of signs: data in first-difference

Above: equation (31)
Below: equation (32)

Log RER		AUS (1)	(2)	AST (1)	(2)	BEL (1)	(2)	CAN (1)	(2)	DEU (1)	(2)
Log, Productivity Ratio	Coef.	-0.508 **		-1.086 **		-0.705 **		-0.211 **		-0.505 **	
	std-dev.	0.158		0.278		0.228		0.075		0.133	
Log, Productivity, T	Coef.		-0.140		-0.053		-1.002 **		0.276 **		-2.663 **
	std-dev.		0.209		0.355		0.340		0.074		0.706
Log, Productivity, NT	Coef.		0.562 **		1.611		1.339 *		0.547 **		1.972 *
	std-dev.		0.149		-0.789		0.592		0.058		0.774
Constant	Coef.	-0.028 **	0.066 **	-0.002	0.034	-0.054 **	-0.092 *	0.040 *	-0.018	-0.093 **	-0.016
	std-dev.	0.008	-0.019	0.018	0.018	0.011	0.035	0.015	0.011	0.013	0.027
Adjusted R-Squared		0.231	0.315	0.393	0.599	0.234	0.244	0.193	0.757	0.325	0.484

Log RER		FIN (1)	(2)	FRA (1)	(2)	ITA (1)	(2)	JPN (1)	(2)	KOR (1)	(2)
Log, Productivity Ratio	Coef.	0.156 **		-3.114		-2.824 **		-1.657 **		-0.779 **	
	std-dev.	0.293		0.746		0.587		0.234		0.108	
Log, Productivity, T	Coef.		-0.481		-0.149		-1.179		0.458		-1.046 **
	std-dev.		0.274		0.258		0.825		0.256		0.234
Log, Productivity, NT	Coef.		0.445		-0.223		0.218		-2.830 **		0.432
	std-dev.		0.654		0.247		1.081		0.498		0.296
Constant	Coef.	-0.059 **	-0.058 *	-0.064 **	-0.008	-0.020	0.049	-0.036	0.042 *	0.044	0.048
	std-dev.	0.014	0.028	0.013	0.019	0.015	0.024	0.028	0.017	0.028	0.028
Adjusted R-Squared		-0.026	0.289	0.370	0.284	0.442	0.601	0.620	0.899	0.632	0.641

Log RER		NDL (1)	(2)	NOR (1)	(2)	SWE (1)	(2)	UK (1)	(2)
Log, Productivity Ratio	Coef.	-0.784		0.107		-0.234		-1.068	
	std-dev.	0.516		0.061		0.339		0.521	
Log, Productivity, T	Coef.		0.899		0.092		-0.575		-0.446
	std-dev.		0.707		0.303		0.397		0.394
Log, Productivity, NT	Coef.		-1.662		-0.111		1.534		-0.315
	std-dev.		0.936		0.064		1.007		0.469
Constant	Coef.	-0.071 *	-0.072 **	-0.051 **	-0.050 **	0.035	0.031	-0.087 **	-0.003
	std-dev.	0.027	0.023	0.008	0.009	0.020	0.021	0.012	0.019
Adjusted R-Squared		0.045	0.236	0.064	0.037	-0.029	0.025	0.099	0.520

Significant at ** 1% and * 5%.

Table 6. Regression results: data in level
Columns (1) and (2) correspond to equation (26) and (27) respectively

D Log RER		AUS (1)	AUS (2)	AST (1)	AST (2)	BEL (1)	BEL (2)	CAN (1)	CAN (2)	DEU (1)	DEU (2)
D Log, Productivity Ratio	Coef.	-0.193		-0.359		-0.707 *		-0.044		0.485	
	std-dev.	0.257		0.632		0.267		0.119		0.597	
D Log, Productivity, T	Coef.		-0.159		-0.542		-0.670 *		0.332		0.506
	std-dev.		0.257		0.578		0.304		0.195		0.755
D Log, Productivity, NT	Coef.		0.341		-1.037		0.797		0.397 *		-0.323
	std-dev.		0.346		0.809		0.502		0.173		0.686
Constant	Coef.										
	std-dev.										
Adjusted R-Squared		0.009	-0.010	-0.009	0.117	0.565	0.130	-0.029	0.137	-0.018	-0.056

D Log RER		FIN (1)	FIN (2)	FRA (1)	FRA (2)	ITA (1)	ITA (2)	JPN (1)	JPN (2)	KOR (1)	KOR (2)
D Log, Productivity Ratio	Coef.	0.104		-0.364 *		0.365		0.443		0.214	
	std-dev.	0.428		0.161		0.617		0.392		0.362	
D Log, Productivity, T	Coef.		0.498		-0.591 *		0.581		0.358		-0.120
	std-dev.		0.467		0.272		0.631		0.361		0.342
D Log, Productivity, NT	Coef.		-0.544		0.153		-0.825		-1.286 *		-0.835
	std-dev.		0.684		0.337		1.008		0.607		0.417
Constant	Coef.										
	std-dev.										
Adjusted R-Squared		-0.019	-0.016	0.145	0.182	-0.011	-0.030	-0.042	0.030	-0.018	0.149

D Log RER		NDL (1)	NDL (2)	NOR (1)	NOR (2)	SWE (1)	SWE (2)	UK (1)	UK (2)
D Log, Productivity Ratio	Coef.	0.273		0.188		0.625		1.000	
	std-dev.	0.476		0.236		0.516		0.503	
D Log, Productivity, T	Coef.		0.309		0.228		0.836		1.033
	std-dev.		0.453		0.291		0.543		0.514
D Log, Productivity, NT	Coef.		-0.526		-0.344		-0.601		-0.352
	std-dev.		0.637		0.255		0.852		0.536
Constant	Coef.								
	std-dev.								
Adjusted R-Squared		-0.015	-0.038	0.001	0.013	0.075	0.074	0.077	0.110

Table 7. Regression results: data in first-difference

Columns (1) and (2) correspond to equation (26) and (27) respectively

Log T-RER		AUS (1)	(2)	AST (1)	(2)	BEL (1)	(2)	CAN (1)	(2)	DEU (1)	(2)
Log, Productivity Ratio	Coef.	-0.253		-0.381		0.328		0.321 **		-1.165	
	std-dev.	0.134		0.258		0.203		0.097		0.587	
Log, Productivity, T	Coef.		0.040		0.395		-0.147		0.983 **		-0.965
	std-dev.		0.180		0.359		0.281		0.087		0.599
Log, Productivity, NT	Coef.		0.313 *		-1.674 *		0.712		0.129		0.645
	std-dev.		0.128		0.797		0.490		0.069		0.657
Constant	Coef.	-0.013	-0.044 *	0.022	0.052 *	-0.029 **	-0.092 **	0.053 **	-0.024	-0.061 **	-0.025
	std-dev.	0.007	0.016	0.017	0.018	0.010	0.029	0.019	0.013	0.010	0.023
Adjusted R-Squared		0.0780	0.1741	0.0508	0.2595	0.0546	0.1880	0.2574	0.8136	0.0953	0.1381

Log T-RER		FIN (1)	(2)	FRA (1)	(2)	ITA (1)	(2)	JPN (1)	(2)	KOR (1)	(2)
Log, Productivity Ratio	Coef.	0.139		0.516		-1.040 *		-0.734 **		0.033	
	std-dev.	0.131		0.271		0.443		0.183		0.074	
Log, Productivity, T	Coef.		0.185		0.666 *		-0.210		0.647 *		-0.121
	std-dev.		0.267		0.253		0.693		0.275		0.162
Log, Productivity, NT	Coef.		-0.254		-0.346		-0.278		-2.191 **		-0.236
	std-dev.		0.638		0.243		0.908		0.536		0.205
Constant	Coef.	-0.054 **	-0.050	0.042 **	-0.010	-0.015	0.020	-0.012	0.037 *	0.058 **	0.060 **
	std-dev.	0.013	0.027	0.012	0.019	0.012	0.020	0.022	0.018	0.019	0.019
Adjusted R-Squared		0.0048	-0.0294	0.0859	0.2820	0.1390	0.2375	0.3338	0.6637	-0.0272	-0.0227

Log T-RER		NDL (1)	(2)	NOR (1)	(2)	SWE (1)	(2)	UK (1)	(2)
Log, Productivity Ratio	Coef.	0.514		0.051		0.507		-0.496	
	std-dev.	0.523		0.137		0.287		0.429	
Log, Productivity, T	Coef.		1.397		-0.605 **		0.235		-0.373 *
	std-dev.		0.783		0.124		0.342		0.139
Log, Productivity, NT	Coef.		-1.865		-0.368 **		0.630		-0.226
	std-dev.		1.037		0.094		0.867		0.184
Constant	Coef.	-0.022	-0.016	-0.091 **	-0.048 **	0.031	0.026	-0.071 **	-0.003
	std-dev.	0.027	0.025	0.017	0.012	0.017	0.018	0.010	0.018
Adjusted R-Squared		-0.0011	0.0424	-0.0296	0.6187	0.1001	0.1187	0.0115	0.4139

Table 8. Regression results: data in level

Columns (1) and (2) correspond to equation (29) and (30) respectively

D Log T-RER		AUS		AST		BEL		CAN		DEU	
		(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
D Log, Productivity Ratio	Coef.	0.012		-0.149		-0.172		0.563 **		1.238 *	
	std-dev.	0.239		0.588		0.242		0.107		0.551	
			0.004		-0.271		-0.110		0.776 **		1.082
D Log, Productivity, T	Coef.		0.238		0.568		0.270		0.196		0.718
	std-dev.										
D Log, Productivity, NT	Coef.		0.130		-0.828		0.257		-0.355		-1.317
	std-dev.		0.333		0.795		0.447		0.174		0.653
Constant	Coef.										
	std-dev.										
Adjusted R-Squared		-0.008	-0.035	0.002	0.0529	0.018	-0.024	0.492	0.470	0.149	0.093

D Log T-RER		FIN		FRA		ITA		JPN		KOR	
		(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
D Log, Productivity Ratio	Coef.	0.006		0.125		0.605		0.664		0.678 *	
	std-dev.	0.423		0.150		0.559		0.390		0.275	
D Log, Productivity, T	Coef.		0.345		0.053		0.634		0.577		0.452
	std-dev.		0.466		0.266		0.568		0.370		0.274
D Log, Productivity, NT	Coef.		-0.260		-0.095		-0.638		-1.209		-1.045 **
	std-dev.		0.682		0.330		0.908		0.622		0.333
Constant	Coef.										
	std-dev.										
Adjusted R-Squared		-0.000	-0.014	0.021	-0.034	0.039	0.006	0.081	0.089	0.161	0.223

D Log T-RER		NDL		NOR		SWE		UK	
		(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
D Log, Productivity Ratio	Coef.	0.250		-0.531 **		0.707		1.215 *	
	std-dev.	0.456		0.148		0.489		0.443	
D Log, Productivity, T	Coef.		0.331		-0.690 **		0.937		0.638
	std-dev.		0.434		0.198		0.506		0.336
D Log, Productivity, NT	Coef.		-0.690		0.190		-0.515		0.180
	std-dev.		0.198		0.319		0.793		0.306
Constant	Coef.								
	std-dev.								
Adjusted R-Squared		0.0081	-0.0140	0.2925	0.3034	0.0776	0.1082	0.1832	0.1291

Table 9. Regression results: data in first-difference

Columns (1) and (2) correspond to equation (29) and (30) respectively

Log Pr		AUS		AST		BEL		CAN		DEU	
		(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Log, Productivity Ratio	Coef.	-0.223 **		-0.651 **		-1.060 **		-0.603 **		-1.935 **	
	std-dev.	0.045		0.044		0.071		0.052		0.246	
Log, Productivity, T	Coef.		-0.260 **		-0.437 **		-0.869 **		-0.815 **		-1.604 **
	std-dev.		0.064		0.037		0.094		0.081		0.199
Log, Productivity, NT	Coef.		0.200 **		0.066		0.645 **		0.466 **		1.252 **
	std-dev.		0.046		0.084		0.161		0.064		0.223
Constant	Coef.	-0.017 **	-0.011	-0.025 **	-0.017 **	-0.025 **	0.000	-0.020	0.005	-0.033 **	0.008
	std-dev.	0.002	0.006	0.003	0.002	0.004	0.009	0.010	0.012	0.005	0.008
Adjusted R-Squared		0.4429	0.4242	0.9046	0.9722	0.8816	0.9146	0.8211	0.8664	0.6694	0.8043

Log Pr		FIN		FRA		ITA		JPN		KOR	
		(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Log, Productivity Ratio	Coef.	-0.613 **		-0.4687		-1.788 **		-0.866 **		-0.714 **	
	std-dev.	0.036		0.3100		0.228		0.079		0.039	
Log, Productivity, T	Coef.		-0.663 **		-0.771 **		-0.935 **		-0.158		-0.794 **
	std-dev.		0.083		0.051		0.295		0.079		0.087
Log, Productivity, NT	Coef.		0.731 **		0.133 *		0.457		-0.639 **		0.611 **
	std-dev.		0.202		0.050		0.387		0.154		0.109
Constant	Coef.	-0.007	-0.010	-0.110 **	-0.000	-0.005	0.029 **	-0.023 *	0.004	-0.021	-0.019
	std-dev.	0.004	0.008	0.013	0.004	0.006	0.009	0.009	0.005	0.010	0.010
Adjusted R-Squared		0.9081	0.9033	0.0411	0.9756	0.6768	0.8114	0.7999	0.9548	0.9168	0.9164

Log Pr		NDL		NOR		SWE		UK	
		(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Log, Productivity Ratio	Coef.	-0.347 **		-0.3589 **		-0.702 **		-0.577 **	
	std-dev.	0.037		0.0632		0.110		0.119	
Log, Productivity, T	Coef.		-0.679		-0.356 **		-0.760 **		-1.279 **
	std-dev.		0.452		0.056		0.126		0.049
Log, Productivity, NT	Coef.		0.534		0.343 **		0.834 *		1.457 **
	std-dev.		0.584		0.043		0.318		0.066
Constant	Coef.	0.006	-0.0574 **	-0.007	0.007	0.003	0.004	-0.016 **	0.003
	std-dev.	0.005	0.0151	0.009	0.006	0.007	0.007	0.003	0.006
Adjusted R-Squared		0.7452	0.2848	0.5098	0.7365	0.6781	0.7069	0.4386	0.9613

Table 10. Regression results: data in level

Columns (1) and (2) correspond to equation (31) and (32) respectively

D Log Pr		AUS (1)	(2)	AST (1)	(2)	BEL (1)	(2)	CAN (1)	(2)	DEU (1)	(2)
D Log, Productivity Ratio	Coef.	-0.156 *		-0.190		-0.526 **		-0.721 **		-0.677 **	
	std-dev.	0.073		0.101		0.083		0.060		0.136	
D Log, Productivity, T	Coef.		-0.140		-0.306 **		-0.553 **		-0.505 **		-0.460 *
	std-dev.		0.074		0.080		0.094		0.096		0.169
D Log, Productivity, NT	Coef.		0.091		-0.027		0.560 **		0.916 **		0.831 **
	std-dev.		0.104		0.111		0.155		0.085		0.155
Constant	Coef.										
	std-dev.										
Adjusted R-Squared		0.135	0.081	-0.602	-0.002	0.565	0.535	0.835	0.869	0.421	0.480

D Log Pr		FIN (1)	(2)	FRA (1)	(2)	ITA (1)	(2)	JPN (1)	(2)	KOR (1)	(2)
D Log, Productivity Ratio	Coef.	0.051		-0.503 **		-0.231 *		-0.203 *		-0.428 **	
	std-dev.	0.139		0.045		0.110		0.078		0.127	
D Log, Productivity, T	Coef.		0.070		-0.663 **		-0.086		-0.189 **		-0.509 **
	std-dev.		0.159		0.059		0.117		0.062		0.124
D Log, Productivity, NT	Coef.		-0.167		0.276 **		-0.057		-0.165		0.230
	std-dev.		0.244		0.074		0.187		0.104		0.150
Constant	Coef.										
	std-dev.										
Adjusted R-Squared		-0.171	-0.197	0.790	0.866	-0.163	-0.319	-1.042	-0.420	-0.080	0.048

D Log Pr		NDL (1)	(2)	NOR (1)	(2)	SWE (1)	(2)	UK (1)	(2)
D Log, Productivity Ratio	Coef.	-0.014		-0.266 *		-0.108		-0.397	
	std-dev.	0.160		0.099		0.133		0.504	
D Log, Productivity, T	Coef.		-0.075		-0.239		-0.098		-1.064 **
	std-dev.		0.150		0.136		0.145		0.160
D Log, Productivity, NT	Coef.		0.042		0.326		0.043		1.613 **
	std-dev.		0.202		0.219		0.227		0.146
Constant	Coef.								
	std-dev.								
Adjusted R-Squared		-0.106	-0.135	0.189	0.162	-0.293	-0.376	0.019	0.816

Table 11. Regression results: data in first-difference
Columns (1) and (2) correspond to equation (31) and (32) respectively

	Level						First Difference					
	RER		T-RER		PR		RER		T-RER		PR	
AST	-2.5181	Unit Root	-2.4134	Unit Root	-2.6704	Unit Root	-3.9873	5%	-3.6827	5%	-3.6682	5%
AUS	-3.4471	10%	-3.4625	10%	-3.5615	10%	-3.6923	5%	-3.9888	5%	-3.4733	10%
BEL	-2.0726	Unit Root	-2.3552	Unit Root	-2.2367	Unit Root	-3.1963	Unit Root	-3.3302	10%	-3.2268	10%
CAN	-2.9421	Unit Root	-2.2551	Unit Root	-2.0430	Unit Root	-3.2404	10%	-3.4584	10%	-3.1482	Unit Root
DEU	-2.1834	Unit Root	-2.4599	Unit Root	-1.7762	Unit Root	-4.6206	1%	-4.2897	5%	-2.7846	Unit Root
FIN	-3.1833	Unit Root	-3.2265	Unit Root	-2.7461	Unit Root	-4.3754	1%	-3.7840	5%	-4.5904	1%
FRA	-2.2628	Unit Root	-2.2827	Unit Root	-3.0570	Unit Root	-3.8836	5%	-3.7024	5%	-4.8378	1%
ITA	-2.4194	Unit Root	-2.5059	Unit Root	-1.8780	Unit Root	-4.0279	5%	-3.9764	5%	-3.1313	Unit Root
JPN	-2.9759	Unit Root	-2.8342	Unit Root	-3.5342	10%	-3.6694	5%	-3.9269	5%	-3.9975	5%
KOR	-1.9886	Unit Root	-2.2315	Unit Root	-2.1673	Unit Root	-3.7790	5%	-3.5765	10%	-4.3178	5%
NDL	-2.6948	Unit Root	-1.7141	Unit Root	-3.0235	Unit Root	-4.4543	1%	-4.6653	1%	-2.1484	Unit Root
NOR	-2.4697	Unit Root	-2.5322	Unit Root	-2.2278	Unit Root	-3.5726	10%	-2.8424	Unit Root	-5.3182	1%
SWE	-1.8624	Unit Root	-1.4977	Unit Root	-1.8162	Unit Root	-2.6020	Unit Root	-2.6225	Unit Root	-2.0767	Unit Root
UK	-2.3576	Unit Root	-4.3452	1%	-1.7482	Unit Root	-3.6623	5%	-4.2217	5%	-2.8657	Unit Root
# of Obs.												
Unit Root		13		12		12		2		2		6

	Level						First Difference					
	TR		TT		TN		TR		TT		TN	
AST	-1.1554	Unit Root	-1.9338	Unit Root	-0.0385	Unit Root	-2.2094	Unit Root	-2.2814	Unit Root	-2.5460	Unit Root
AUS	-2.2714	Unit Root	-2.7260	Unit Root	-2.8556	Unit Root	-4.6963	1%	-4.1915	5%	-5.9427	1%
BEL	-2.5911	Unit Root	-1.8682	Unit Root	-2.7331	Unit Root	-3.2700	10%	-3.2087	Unit Root	-3.8165	5%
CAN	-1.7617	Unit Root	-1.6303	Unit Root	-1.9894	Unit Root	-2.6411	Unit Root	-2.7486	Unit Root	-3.0670	Unit Root
DEU	-1.8276	Unit Root	-3.2870	10%	-1.6721	Unit Root	-5.5784	1%	-5.1633	1%	-4.4215	1%
FIN	-2.0756	Unit Root	-2.6392	Unit Root	-2.6792	Unit Root	-3.2066	Unit Root	-4.1845	5%	-3.9034	5%
FRA	-3.0233	Unit Root	-3.1861	Unit Root	-2.6845	Unit Root	-5.3532	1%	-5.2673	1%	-4.5133	1%
ITA	-2.6195	Unit Root	-3.1461	Unit Root	-2.8128	Unit Root	-4.6372	1%	-4.6793	1%	-4.3722	1%
JPN	-1.7881	Unit Root	-2.3653	Unit Root	-3.7359	5%	-5.1681	1%	-5.4890	1%	-4.3690	1%
KOR	-2.5965	Unit Root	-3.8057	5%	-2.3109	Unit Root	-3.1466	Unit Root	-4.1098	5%	-4.2952	5%
NDL	-3.5528	10%	-2.8112	Unit Root	-2.6989	Unit Root	-5.2959	1%	-3.6810	5%	-3.8727	5%
NOR	-1.9218	Unit Root	-1.7058	Unit Root	-3.2525	10%	-3.2681	10%	-2.4556	Unit Root	-5.0577	1%
SWE	-2.4575	Unit Root	-1.2691	Unit Root	-0.7583	Unit Root	-3.3495	10%	-2.9548	Unit Root	-2.8482	Unit Root
UK	-2.0440	Unit Root	-2.1386	Unit Root	-2.1068	Unit Root	-3.6025	5%	-4.0896	5%	-3.5506	10%
# of Obs.												
Unit Root		13		12		12		4		5		3

Table 12. ADF test of unit root

ADF test with trend, intercept and one lagged first-difference.

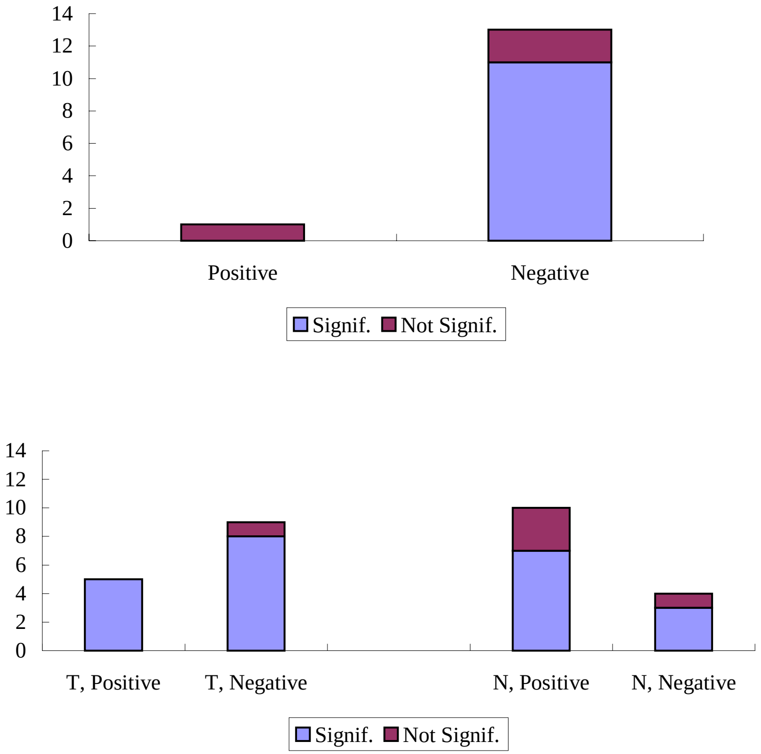


Figure 8. Frequency of signs: dynamic OLS
Above: equation (26)
Below: equation (27)

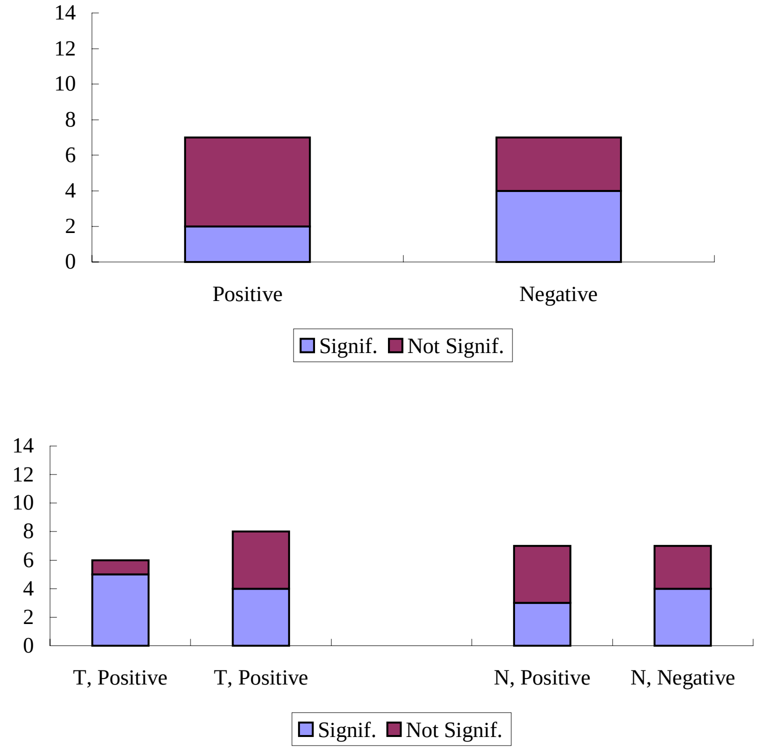
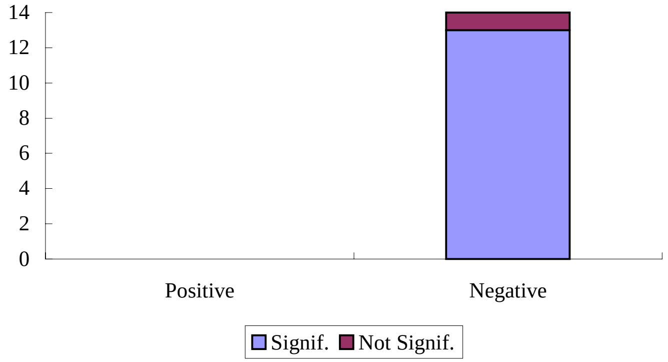


Figure 9. Frequency of signs: dynamic OLS
Above: equation (29)
Below: equation (30)



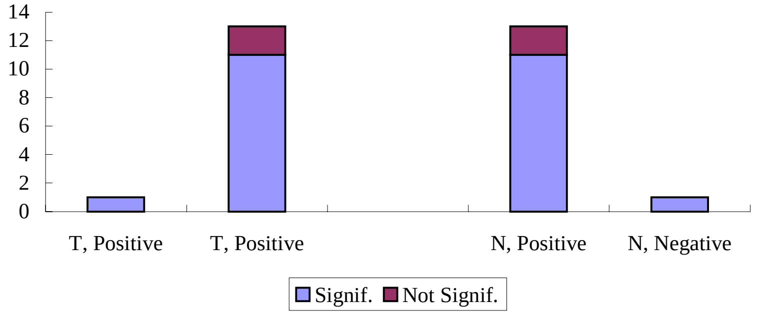


Figure 10. Frequency of signs: dynamic OLS
Above: equation (31)
Below: equation (32)

Log RER		AUS (1)	AUS (2)	AST (1)	AST (2)	BEL (1)	BEL (2)	CAN (1)	CAN (2)	DEU (1)	DEU (2)
Log, Productivity Ratio	Coef.	-0.554 **		-1.104 **		-0.710 *		-0.228 *		-4.077 **	
	std-dev.	0.156		0.327		0.255		0.083		0.795	
Log, Productivity, T	Coef.		-0.058		0.815		-1.631 **		0.334 **		-3.562 **
	std-dev.		0.248		0.510		0.355		0.071		0.808
Log, Productivity, NT	Coef.		0.714 **		-3.614 **		2.609 **		0.609 **		3.011 **
	std-dev.		0.166		1.115		0.654		0.058		0.895
Constant	Coef.	-0.034 **	-0.100 **	0.003	0.020	-0.057 **	-0.201 **	0.034	-0.026 *	-0.093 **	-0.039
	std-dev.	0.008	0.025	0.023	0.021	0.012	0.039	0.017	0.011	0.012	0.038
Adjusted R-Squared		0.249	0.345	0.320	0.641	0.186	0.556	0.157	0.824	0.474	0.498

Log RER		FIN (1)	FIN (2)	FRA (1)	FRA (2)	ITA (1)	ITA (2)	JPN (1)	JPN (2)	KOR (1)	KOR (2)
Log, Productivity Ratio	Coef.	-0.517 **		0.538		-3.528 **		-1.677 **		-0.844 **	
	std-dev.	0.138		0.398		0.621		0.254		0.121	
Log, Productivity, T	Coef.		-0.875 **		0.256		-2.388 *		0.812 **		-1.098 **
	std-dev.		0.263		0.399		1.114		0.237		0.297
Log, Productivity, NT	Coef.		1.494 *		-0.599		1.748		-3.809 **		0.626
	std-dev.		0.676		0.394		1.480		0.474		0.353
Constant	Coef.	-0.0717 **	-0.126 **	-0.058 **	-0.004	-0.007	0.032	-0.036	0.104 **	0.039	0.065
	std-dev.	0.0153	0.031	0.014	0.042	0.016	0.038	0.032	0.019	0.036	0.040
Adjusted R-Squared		0.300	0.565	0.008	0.208	0.520	0.618	0.611	0.940	0.682	0.666

Log RER		NDL (1)	NDL (2)	NOR (1)	NOR (2)	SWE (1)	SWE (2)	UK (1)	UK (2)
Log, Productivity Ratio	Coef.	-0.579		-0.310 *		-0.570		-3.579 **	
	std-dev.	0.680		0.150		0.440		0.537	
Log, Productivity, T	Coef.		3.132 *		-0.971 **		-1.539 **		-1.590 **
	std-dev.		1.177		0.133		0.485		0.167
Log, Productivity, NT	Coef.		-4.430 **		0.017		3.297 *		1.097 **
	std-dev.		1.524		0.108		1.203		0.236
Constant	Coef.	-0.085 *	-0.129 **	-0.085 **	-0.051 **	0.045	0.041	-0.039 **	0.008
	std-dev.	0.036	0.033	0.019	0.016	0.025	0.023	0.011	0.025
Adjusted R-Squared		-0.079	0.223	0.203	0.709	-0.003	0.290	0.615	0.778

Significant at ** 1% and * 5%.

Table 13. Regression results: dynamic OLS
Columns (1) and (2) correspond to equation (26) and (27) respectively

Log T-RER		AUS		AST		BEL		CAN		DEU	
		(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Log, Productivity Ratio	Coef.	-0.309 *		-0.409		0.387		0.322 **		-1.829 *	
	std-dev.	0.149		0.304		0.225		0.110		0.660	
Log, Productivity, T	Coef.		0.217		1.273 *		-0.690 **		1.091 **		-1.645
	std-dev.		0.226		0.508		0.292		0.093		0.717
Log, Productivity, NT	Coef.		0.474 **		-3.711 **		1.845 *		0.215 **		1.470
	std-dev.		0.151		1.111		0.537		0.076		0.794
Constant	Coef.	-0.015	-0.084 **	0.028	0.041	-0.031 **	-0.187 **	0.0534 *	-0.034 *	-0.061 **	-0.049 **
	std-dev.	0.008	0.023	0.021	0.021	0.011	0.032	0.0220	0.014	0.010	0.034
Adjusted R-Squared		0.047	0.237	-0.037	0.370	0.021	0.537	0.259	0.850	0.165	0.089

Log T-RER		FIN		FRA		ITA		JPN		KOR	
		(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Log, Productivity Ratio	Coef.	0.147		0.924 *		-1.387 *		-0.779 **		-0.046	
	std-dev.	0.137		0.378		0.505		0.207		0.084	
Log, Productivity, T	Coef.		-0.105		1.129 **		-0.866		0.929 **		-0.202
	std-dev.		0.267		0.388		0.989		0.286		0.205
Log, Productivity, NT	Coef.		0.551		-0.790 *		0.644		-3.052 **		-0.084
	std-dev.		0.686		0.383		1.314		0.572		0.244
Constant	Coef.	-0.067 **	-0.113 **	0.053 **	0.005	-0.009	-0.007	-0.010	0.102 **	0.069 *	0.085 **
	std-dev.	0.015	0.031	0.014	0.041	0.013	0.033	0.026	0.023	0.025	0.028
Adjusted R-Squared		0.027	0.368	0.102	0.250	0.153	0.195	0.321	0.771	0.031	-0.021

Log T-RER		NDL		NOR		SWE		UK	
		(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Log, Productivity Ratio	Coef.	0.796		0.046		0.219		-0.801	
	std-dev.	0.722		0.146		0.361		0.432	
Log, Productivity, T	Coef.		3.967 **		-0.634 **		-0.575		-0.409 **
	std-dev.		1.343		0.112		0.433		0.140
Log, Productivity, NT	Coef.		-5.177 **		-0.311 **		1.798		-0.246
	std-dev.		1.740		0.091		1.073		0.197
Constant	Coef.	-0.037	-0.051	-0.090 **	-0.064 **	0.034	0.035	-0.069 **	0.002
	std-dev.	0.038	0.037	0.019	0.013	0.021	0.021	0.009	0.021
Adjusted R-Squared		-0.069	0.109	0.038	0.736	0.037	0.194	0.087	0.430

Table 14. Regression results: dynamic OLS

Columns (1) and (2) correspond to equation (29) and (30) respectively

Log Pr		AUS (1)	AUS (2)	AST (1)	AST (2)	BEL (1)	BEL (2)	CAN (1)	CAN (2)	DEU (1)	DEU (2)
Log, Productivity Ratio	Coef.	-0.244 **		-0.670 **		-1.114 **		-0.620 **		-2.192 **	
	std-dev.	0.047		0.042		0.070		0.056		0.259	
Log, Productivity, T	Coef.		-0.288 **		-0.440 **		-0.973 **		-0.870 **		-1.777 **
	std-dev.		0.085		0.041		0.112		0.078		0.188
Log, Productivity, NT	Coef.		0.237 **		0.090		0.825 **		0.426 **		1.424 **
	std-dev.		0.057		0.089		0.205		0.063		0.214
Constant	Coef.	-0.018 **	-0.014	-0.025 **	-0.020 **	-0.025 **	-0.016	-0.025 *	0.010	-0.032 **	0.009
	std-dev.	0.002	0.009	0.003	0.002	0.003	0.012	0.011	0.012	0.004	0.009
Adjusted R-Squared		0.471	0.397	0.929	0.985	0.903	0.935	0.843	0.913	0.721	0.864

Log Pr		FIN (1)	FIN (2)	FRA (1)	FRA (2)	ITA (1)	ITA (2)	JPN (1)	JPN (2)	KOR (1)	KOR (2)
Log, Productivity Ratio	Coef.	-0.638 **		-0.486		-2.065 **		-0.840 **		-0.701 **	
	std-dev.	0.036		0.416		0.223		0.079		0.042	
Log, Productivity, T	Coef.		-0.783 **		-0.856 **		-1.454 **		-0.097		-0.765 **
	std-dev.		0.083		0.056		0.339		0.086		0.107
Log, Productivity, NT	Coef.		1.023 **		0.211 **		1.045 *		-0.731 **		0.649 **
	std-dev.		0.209		0.056		0.450		0.172		0.127
Constant	Coef.	-0.005	-0.019	-0.111 **	-0.013	0.002	0.038 **	-0.026 *	-0.001	-0.034 *	-0.027
	std-dev.	0.004	0.009	0.015	0.006	0.006	0.011	0.010	0.007	0.013	0.014
Adjusted R-Squared		0.927	0.935	0.009	0.986	0.755	0.860	0.803	0.959	0.919	0.910

Log Pr		NDL (1)	NDL (2)	NOR (1)	NOR (2)	SWE (1)	SWE (2)	UK (1)	UK (2)
Log, Productivity Ratio	Coef.	-1.242 **		-0.365 **		-0.748 **		-2.955 **	
	std-dev.	0.366		0.042		0.117		0.363	
Log, Productivity, T	Coef.		-0.800		-0.349 **		-0.892 **		-1.262 **
	std-dev.		0.773		0.060		0.143		0.049
Log, Productivity, NT	Coef.		0.737		0.334 **		1.279 **		1.456 **
	std-dev.		0.993		0.049		0.354		0.070
Constant	Coef.	-0.049 *	-0.078 **	0.004	0.013	0.010	0.006	0.033 **	0.004
	std-dev.	0.020	0.022	0.005	0.007	0.007	0.007	0.008	0.007
Adjusted R-Squared		0.257	0.209	0.735	0.752	0.706	0.747	0.703	0.967

Table 15. Regression results: dynamic OLS

Columns (1) and (2) correspond to equation (31) and (32) respectively

Countries	Productivity Growth		Start	End
AUS	T	1.08%	1970	2001
	NT	1.45%		
AST	T	1.63%	1970	1999
	NT	0.54%		
BEL	T	2.00%	1970	2000
	NT	1.65%		
CAN	T	0.78%	1970	1999
	NT	2.14%		
DEU	T	1.93%	1970	1990
	NT	2.17%		
FIN	T	2.40%	1970	1991
	NT	1.09%		
FRA	T	2.63%	1970	2000
	NT	2.62%		
ITA	T	1.64%	1970	1999
	NT	1.35%		
JPN	T	3.98%	1970	1991
	NT	1.94%		
KOR	T	1.74%	1970	1997
	NT	-1.18%		
NDL	T	2.38%	1970	2000
	NT	1.81%		
NOR	T	0.44%	1970	1998
	NT	1.95%		
SWE	T	2.27%	1980	1999
	NT	0.85%		
UK	T	1.39%	1970	1999
	NT	1.89%		
US	T	0.46%	1970	2000
	NT	0.66%		

Table 16. Growth rates of sectoral productivity

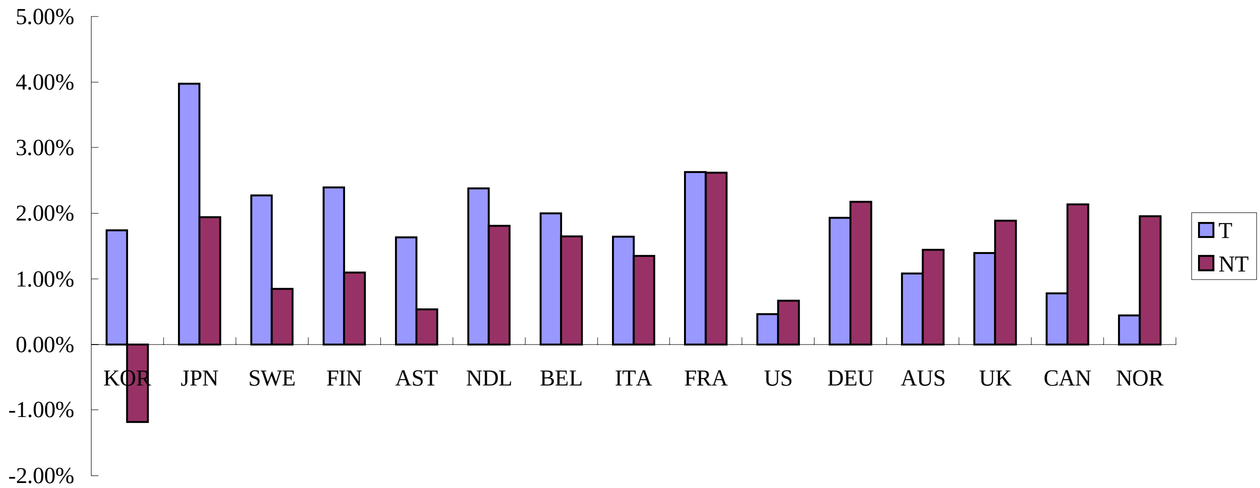


Figure 11. Growth rates of sectoral productivity.