Expanding Varieties in the Nontraded Goods Sector and the Real Exchange Rate Depreciation

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Abstract This paper studies how the real exchange rate changes with economic growth. Although Devereux (1999) proves that endogenous growth in the distribution sector can cause exchange rate depreciation, MacDonald and Rucci (2005) empirically find that growth in the distribution sector significantly causes the exchange rate to appreciate. To resolve the discrepancy, we replace perfect competition with monopolistic competition in the nontraded goods sector. Although growth of the distribution sector may cause the currency to appreciate, the endogenous growth in the nontraded goods sector tends to cause the currency to depreciate, because the expanding varieties from monopolistic competition drive down the price index of nontraded goods. With reasonable structural parameters, the latter effect dominates, and the real exchange rate depreciates. An economy with a smaller elasticity of substitution between demand for different varieties of the nontraded goods or higher TFP growth in the nontraded goods sector is more likely to have real exchange rate depreciation.

Keywords: Nontraded goods sector, expanding varieties, real exchange rate

JEL Classification: F31, F41, F43

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1. Introduction

Recently there is a widespread view that the global current account imbalance is caused by the undervaluation of the Renminbi (the Chinese currency). As a result, there is growing international pressure on the Renminbi to appreciate. The rationale behind this view is that the Renminbi must have appreciated a lot as the Chinese economy is growing fast[1], therefore, the Renminbi is undervalued (which is good for China's export) given China's fixed exchange rate regime. The main theoretical underpinning behind this rationale is the Balassa-Samuelson hypothesis (Balassa, 1964; Samuelson, 1963)—detailed below. However, Cheung, Chinn and Fujii(2007)conduct an empirical analysis on China's exchange rate, and find that the Renminbi may be undervalued, but it is not statistically significant. They conclude that the undervaluation of the Renminbi may be overvaluated. Therefore, it is desirable for us to deeply investigate the relationship between the real exchange rate and economic growth and reexamine the Balassa-Samuelson hypothesis. In so doing, we may be able to understand why the Chinese currency has not appreciated very much as the Chinese economy grows fast. If it is so, then the exaggerated undervaluation of the Renminbi may not be the culprit for the global current account imbalance. Moreover, we can give suitable policy suggestions to ease the appreciation pressure of the Chinese currency, which helps to maintain the stability of the fixed exchange rate regime of China and thereby the economic growth and stability of the Chinese economy.

The interaction between the long-run exchange rate and economic growth is an old economic issue. According to Obstfeld and Rogoff (1998), the dominant theory in answering this question is the Balassa-Samuelson hypothesis (Balassa, 1964; Samuelson, 1963; Asea and Mendoza, 1994). The Balassa-Samuelson hypothesis is sketched as follows. In a two-country (home and abroad) two-sector (traded and non-traded goods sectors, both of which are perfect competitive) model, the price of traded goods is treated as numeraire and has the same price 1 in both countries. Consumer's logarithmic preference yields that the total price level is a geometric average of the traded goods' prices and the nontraded goods' prices, with weights γ and (1-γ) respectively. As a result, the price indexes of home and abroad are $P = (1)^{\gamma}(p)^{1-\gamma}$, $P^* = (1)^{\gamma}(p^*)^{1-\gamma}$ respectively. Here, p and p^* are the prices of the nontraded goods in home and abroad respectively. Therefore, the ratio of home's price level to that of the abroad (i.e., the real exchange rate) is $P / P^* = (p / p^*)^{1-\gamma}$. Hence, the real exchange rate of home relative to abroad only depends on the relative price of their nontraded goods (see Obstfeld and Rogoff, 1998). According to this hypothesis, in a faster growing economy, the productivity growth of the traded goods is higher, which causes its price of the nontraded goods to increase faster.[2] According to the above equation, the relative faster growth of this country's nontraded goods' prices causes its real exchange rate to appreciate. This theory is supported by some real world examples. As Devereux (1999) points out, Japan grows faster than the U.S. during the period 1973-1997, while the Japanese Yen appreciates 82% against the U.S. dollar.

However, as previous studies have pointed out (e.g., Isard and Symansky, 1995; Engel, 1996; Chinn, 1997; Devereux, 1999), there are also some facts that cast doubts on the Balassa-Samuelson hypothesis. First, it may be better to use the CPI (consumer price index) rather than the price index of the nontraded goods to measure the real exchange rate. This is because statistics show that the price of the traded goods is not equalized across countries (here, it refers to the price of the traded goods faced by consumers or the retail price, instead of the ex-factory (or wholesale) price of the traded goods). Second, there are also some empiric examples that do not support the Balassa-Samuelson hypothesis. As is known to all, the currencies of most fast growing Asian countries before the 1997 financial crisis actually depreciated or did not appreciate much.

Given these facts, Devereux (1999) theoretically explains why some Asian Countries experienced both fast economic growth and the real exchange rate depreciation. Besides the trade and nontraded goods sectors (these two sectors are still perfect competitive), he introduces a third sector—the distribution sector for the traded goods—and there is monopolistic competition in this sector. His main conclusion is that, the endogenous growth in the distribution sector pushes down the price index of the traded goods (which is fixed at 1 in the Balassa-Samuelson framework). If this effect is large enough, then the CPI (the geometric average of the price indexes of the traded goods and the nontraded goods) would decrease, so would the real exchange rate. However, the recent empirical work of MacDonald and Rucci (2005) finds that the growth of the distribution sector significantly causes the currency to appreciate, contrary to the theoretical prediction of Devereux (1999).

In light of the discrepancy between Devereux (1999) and MacDonald and Rucci (2005), we relax the assumption of the perfect competition in the nontraded goods sector. Specifically, we introduce the expanding varieties in the endogenous growth models (e.g., Romer, 1990) into the nontraded goods sector. In contrast, Devereux (1999) still assumes that the nontraded goods sector is perfectly competitive. Previous studies have shown that the distribution sector is very similar to the nontraded goods sector (see Burstein et al., 2000; Devereux, 1999). Therefore, it is not very convincing to assume that there is monopolistic competition in the distribution sector but not in the nontraded goods sector, as in Devereux (1999). Besides the traded and nontraded goods sectors, we keep the distribution sector as the third sector and assume there is also monopolistic competition in this sector. Moreover, unlike Devereux's (1999) model in which the distribution sector only provides services for the traded goods sector, we allow the distribution sector to distribute both the traded and nontraded goods to consumers. Our assumption that both the nontraded goods sector and the distribution sector have monopolistic competition has theoretical advantages and keeps consistent with the real world.

From the theoretical point of view, given certain structural parameters, on the one hand, the growth of the distribution sector would not cause the CPI to decrease, that is, it may cause the real exchange rate to appreciate. This is consistent with the empirical findings of MacDonald and Rucci (2005). On the other hand, the expanding varieties (i.e., the growth) in the nontraded goods sector would cause the CPI to decrease, and this effect dominates. Therefore, if there were also monopolistic competition in the nontraded goods sector, then as the economy grows fast, its real exchange rate would depreciate or appreciate at a much lower pace. More specifically, although the prices of nontraded goods are increasing, the varieties of the nontraded goods are also expanding. After aggregation, the price index of the nontraded goods (which is the weighted average of the price of the nontraded goods and the varieties of the nontraded goods, with the weight for varieties being negative) decreases, which causes the real exchange rate to depreciate. This theory has two implications for empirics. First, how one country's real exchange rate changes as its economy grows depends on the structural parameters for the nontraded goods sector, such as the elasticity of substitution between the demand for different kinds of the nontraded goods, the capital intensity of the nontraded goods firms, and the total factor productivity (TFP) growth of the nontraded goods sector. Second, it is difficult to measure the real exchange rate (see Cheung, Chinn and Fujii, 2007), but this theory tells us that, in measuring the price index of the nontraded goods, one needs to measure the varieties of the nontraded goods besides the price of each single nontraded good, with the weight of varieties being negative.

As far as the real world is concerned, the nontraded goods sector cannot be simply treated as a perfectly competitive sector. Those sectors such as transportation, insurance, postal services, construction, and health care are treated as nontraded goods sectors because their products are only consumed by the domestic consumers, but they are monopolistic sectors in many countries including China. According to the endogenous growth models (Romer, 1990; Aghion and Howitt, 1992), monopoly is a prerequisite for endogenous growth.[3] Romer (1990) models endogenous growth as the expanding varieties from monopoly. For instance, the real estate developers provide more and more kinds of houses to consumers, while the transportation sector innovates more and more means of transportation for consumers. Modeling the economic growth in the nontraded goods sector as the expanding varieties from monopoly would yield predictions on how the real exchange rate changes with economic growth totally opposite to those from modeling the growth of the nontraded goods sector as an exogenous TFP growth in a perfectly competitive nontraded goods sector (as in previous models such as Balassa, 1964; Samuelson, 1963; Devereux, 1999). After we understand the mechanism via which the endogenous growth (via the expanding varieties) in the nontraded goods sector impacts the real exchange rate, we would have clear policy suggestions.

We treat the distribution sector as one separate sector: it distributes both the traded goods and nontraded goods to consumers, unlike in Devereux (1999) in which the distribution sector only serves for the traded goods). This sector provides services rather than concrete products. Burstein et al. (2000) point out that over 40% of the final price of U.S. consumer products belongs to the distribution service. The value-added and employment of the distribution sector consist of over 20% of the whole industries (see MacDonald and Rucci, 2005). As in Devereux (1999), our model yields predictions consistent with the fact that the final price of the traded goods faced by consumers is not equalized across countries. However, unlike in Devereux (1999), the endogenous growth of the distribution sector in our model would cause the real exchange rate to appreciate, consistent with the empirical findings of MacDonald and Rucci (2005) and with the view in the previous literature that the distribution sector behaves similarly to the nontraded goods sector (Burstein et al., 2000; Devereux, 1999). In other words, our model shows that it may be arbitrary for MacDonald and Rucci's (2005) to conclude: their empirical results refute the common view that the distribution sector behaves similarly to the nontraded goods sector.

The rest of the paper proceeds as follows. In Section 2, we develop a two-sector (a traded goods sector and a nontraded goods sector) model, which shows that the expanding varieties in the nontraded goods sector may be able to cause the real exchange rate to depreciate. However, we still assume that the final consumer price of the traded goods is equalized across countries. In Section 3 we introduce the distribution sector as the third sector. Then we can further show that the final consumer price of the traded goods is not equalized across countries. Section 4 concludes and provides some policy suggestions.

2. The Expanding Varieties in the Nontraded Goods Sector in a Two-sector Model

In this section, we build a monopolistic competition model for the nontraded goods sector. The monopolistic profit is used as incentives for the expanding varieties in the nontraded goods sector. This would cause the relative price (i.e., the price index) of the nontraded goods in a faster growing economy to decrease, which differs from Devereux (1999) and the Balassa-Samuelson hypothesis.

As in Devereux (1999), we consider a small open economy, where the world interest rate and the price of the traded goods are treated as fixed. In this economy, there are two final products: the traded goods and the nontraded goods. The traded goods are either consumed or exported. The nontraded goods are only consumed by domestic consumers. Financial and physical capitals are mobile for firms and consumers; labor moves freely within the small economy, however, it cannot move out of the economy.

2.1 Consumers

We assume that consumers have the same preference (i.e., one representative agent framework) and maximize the present discounted utility over infinite time horizon. Devereux (1999), based on Barro (1974), points out the rationale for this assumption is that: household can be treated as an overlapping generation that lives forever, and each generation internalizes the welfare of the next generation. Moreover, every consumer faces the same probability of death, denoted by p, which has a Poisson distribution. For simplicity, the total population is normalized to 1. We assume logarithmic preference. The lifetime utility of a representative consumer is (see Devereux, 1999)

$$U = \int_t^{\infty} \log \; c(s, z) \cdot e^{-(p+\rho)(z-t)} dz \tag{1}$$

where c(s, z) is the consumption. s is her birth time. ρ is her time preference. The consumption consists of the traded goods $c_T(s, z)$ and the nontraded goods $c_N(s, z)$:

$$c(s, z) = c_T(s, z)^{\beta} c_N(s, z)^{1-\beta} \tag{2}$$

Given the consumer's preference, the price index of her composite (or total) consumption c(s, z) is

$$P(P_w, P_N) = \phi_\beta P_w^{\beta} P_N^{1-\beta} \tag{3}$$

where P_w is the world price of the traded goods, which is fixed. P_N is the price index of the nontraded goods consumption. Constant $\phi_\beta = \beta^{-\beta}(1-\beta)^{-(1-\beta)}$. The consumer faces two constraints. The first is the budget constraint:

$$P(t)c(s,t) + B(s,t) + K(s,t) = W(t) + (r + p)[B(s,t) + K(s,t)] \tag{4}$$

where B represents her holding of the foreign bond, K is her domestic physical capital investment, and W(t) is the wage rate. Since we study a small open economy, its interest rate is determined by foreign competition (i.e., it is given for the small open economy), denoted as r. The second constraint is the transversality condition: $\lim_{t \to \infty} e^{-(p+\rho)}[B(s,t) + K(s,t)] = 0$ ·

The consumer maximizes her utility subject to the two constraints. Solving the Hamiltonian yields the optimal consumption path of the consumer:

$$\frac{\dot{c}(s,t)}{c(s,t)} = r - \rho - \frac{\dot{P}(t)}{P(t)} \tag{5}$$

Aggregating over all consumers (see Blanchard and Fischer, 1989; Devereux, 1999), we get the two conditions that govern the behaviors of the aggregate consumption C(t) and asset holding Q(t) =B(t)+K(t):

$$\dot{C}(t) = \left(r - \rho - \frac{\dot{P}(t)}{P(t)} \right) C(t) - p(p + \rho) \frac{Q(t)}{P(t)} \tag{6}$$

$$P(t)C(t) + \dot{Q}(t) = W(t) + rQ(t) \tag{7}$$

As in Devereux (1999), new consumers are born with no asset. After defining Q(t) =B(t)+K(t) and current total expenditure E=PC, we can rewrite equation (6) as

$$\dot{E}(t) = (r - \rho)E(t) - p(p + \rho)Q(t) \tag{6'}$$

Now equations (6′) and (7) govern the changes in E and Q. Since the wage rate is growing, we de-trend equation (6′) and (7) by dividing by the growth rate of the wage, g_w, and define new variables $e = E / e^{g_w t}$, $q = Q / e^{g_w t}$. Hence equations (6′) and (7) become

$$\dot{e} = (r - \rho - g_w)e - p(p + \rho)q \tag{6''}$$

$$\dot{q} = (r - g_w)q + W_0 - e \tag{7''}$$

Therefore, this economy converges to a balanced growth path along a saddle path (see Devereux, 1999 for details). We are concerned with the decomposition of the consumption. According to equation (2) and the consumer's preference, the consumption can be decomposed as

$$P_w C_T = \frac{\beta}{1 - \beta} P_N C_N \tag{8}$$

Therefore, the total expenditure satisfies

$$E = PC = P_w C_T + P_N C_N = \frac{1}{1 - \beta} P_N C_N \tag{9}$$

2.2 Firms

There are two sectors in this small open economy: a traded goods sector and a nontraded goods sector. Firms in both sectors maximize their profit. For the small open economy, the producers of the traded goods can be treated as perfect competitive ones because they face international competition. In contrast, the nontraded goods sector is immune to international competition. Producers in the nontraded goods sector, therefore, have market power. That is, they can charge a mark-up price for their products. We assume that the nontraded goods sector consists of a continuum of N monopolistic firms. The endogenous growth of the nontraded goods sector can be deemed as the sustained increase in the number of firms, N (see Barro and Sala-i-Martin, 2004, ch. 6).

The production functions for the two sectors are

$$\textit{Traded goods} : Y_T = \theta_T(t) K_T^{\alpha} L_T^{1-\alpha} \tag{10}$$

$$\textit{Nontraded goods} : y(i) + \eta = \theta_N(t) K_N^{\gamma}(i) L_N^{1-\gamma}(i) \tag{11}$$

where we assume that the nontraded goods sector is more labor-intensive, that is, $\alpha>\gamma$. θ denotes the TFP, and $\theta_T(t) = \theta_0 e^{g_T t}$, $\theta_N(t) = \theta_0 e^{g_N t}$. According to the Balassa-Samuelson hypothesis, economic growth is usually concentrated in the traded goods sector, therefore, we assume that $g_T>g_N$ (nevertheless, the productivity growth of the nontraded goods sector should take account of the increase in the varieties of the nontraded goods, that is, the increase in N, which will be discussed later). The production of the nontraded goods needs a fixed set-up cost, η, which can be viewed as the fixed R&D cost for the innovation of new varieties (see Devereux, 1999; Barro and Sala-i-Martin, 2004). The monopolistic profit is used to cover the fixed R&D cost, η (which is the essence of endogenous growth, see Barro and Sala-i-Martin, 2004, ch. 6).

The consumption of the nontraded goods is given by

$$C_N = \left(\int_0^N y(j)^{\lambda} dj \right)^{\frac{1}{\lambda}} \tag{12}$$

where $0\leq\lambda\leq1$. λmeasures the elasticity of substitution between consumer's demand for different types of the nontraded goods. As discussed, the increase in N reflects that the endogenous productivity of the nontraded goods sector is increasing.

Given the price of the traded goods (P_w) and the interest rate (r), the perfect competition in the traded goods sector yields that the price of traded goods is equal to its unit cost, that is,

$$P_w = \phi_\alpha \frac{W(t)^{1-\alpha} r^{\alpha}}{\theta_T(t)} \tag{13}$$

where $\phi_\alpha = \alpha^{-\alpha}(1-\alpha)^{-(1-\alpha)}$. W(t)and θ_T(t)denote the domestic wage rate and the productivity of the traded goods sector respectively.

Firms specializing in the producing the nontraded goods have market power, so they charge a mark-up price over the marginal cost for their products. The price mark-up depends on the elasticity of substitution between consumer's demand for different types of the nontraded goods, λ(see equation 12). In a symmetric equilibrium, we have

$$P_y = \frac{1}{\lambda}\phi_\gamma \frac{W(t)^{1-\gamma} r^\gamma}{\theta_N(t)} \tag{14}$$

where $\phi_\gamma = \gamma^{-\gamma}(1-\gamma)^{-(1-\gamma)}$. $1/\lambda > 1$ is the price mark-up. As in the standard endogenous growth models (Romer, 1990; Barro and Sala-i-Martin, 2004, ch. 6), we assume that there is free entry into the production of the nontraded goods, that is, the zero-profit condition. This means that the monopolistic profit from the product sales of the monopolistic producer of each variety just covers the R&D cost, η (see Barro and Sala-i-Martin, 2004, ch. 6). That is, $P_y y\left(\frac{1}{\lambda}-1\right) = P_y \cdot \eta$. Therefore, the sales of the producer of each variety is equal to a constant η/[(1/λ)-1]. Moreover, we have $P_N Y_N = P_y N y$. Using the symmetric equilibrium, equation (12) and $C_N = Y_N$, we have

$$P_N = N^{1-\frac{1}{\lambda}} P_y \tag{15}$$

Furthermore, according to equation (13), in which P_w is fixed, the growth rate of the wage rate is

$$g_w = g_T/(1-\alpha) \tag{16}$$

2.3 The Real Exchange Rate and the General Equilibrium

2.3.1 The Real Exchange Rate

Since there is no nominal currency, the real exchange rate is the ratio of the price level of the small economy to that of the world. Since the price level of the world is fixed, the real exchange rate of the small open economy is equal to its total price level, the CPI. The decrease in the CPI means depreciation. We can further show that, as in the Balassa-Samuelson hypothesis, given the same price of the traded goods, the real exchange rate of the small open economy depends on the price level of its nontraded goods. Therefore, in this section, the decrease in the price index of the nontraded goods implies depreciation.

In the following, we first prove that the change in the total price index is a fixed fraction of that in the price index of the nontraded goods. Therefore, they move in the same direction (i.e., increase together or decrease together). Second, we show that, even if economic growth is concentrated in the traded goods sector, if the endogenous growth of the nontraded good sector (including the increase in TFP and that in the number of varieties, N) is large enough (but still lower than the growth rate of the traded goods sector g_T, as in the Balassa-Samuelson hypothesis), then the growth rate of the price index of the nontraded goods is negative, so is that of the CPI (given the first point proved). One can see that, we get predictions opposite to those of the Balassa-Samuelson hypothesis. The underlying reason is that, the nontraded goods sector in the Balassa-Samuelson hypothesis is perfectly competitive (although this sector has an exogenous growth in TFP), therefore, this sector does not have monopolistic competition and thus endogenous growth (i.e., the increase in the number of N, the expansion in varieties). In contrast, the nontraded goods sector is monopolistic competitive in our model, which also differs from Devereux (1999). The increase in N would decrease the price index of the nontraded goods. This is because although the price of each nontraded good is increasing, the number of varieties is also increasing. The latter would decrease the price index of the nontraded goods, and this effect dominates that of the former in increasing the price index of the nontraded goods. In other words, the price index of the nontraded goods includes not only the price of each single nontraded good, but also the number of varieties. Therefore, our modeling the growth in the nontraded goods sector as endogenously generated by the expanding varieties would yield predictions concerning the real exchange rate different from those in previous works that simply assume growth in the nontraded goods sector is an exogenous TFP growth (Balassa, 1964; Samuelson, 1963; Devereux, 1999).

Lemma 1. The change in the total price index is a fixed fraction of that in the price index of the nontraded goods. Therefore, they change in the same direction.

Proof: According to equation (3): $P(P_w, P_N) = \phi_\beta P_w^\beta P_N^{1-\beta}$, given that the world price of traded goods is fixed, we have $\frac{\dot{P}}{P} = (1-\beta)\frac{\dot{P}_N}{P_N}$, and $\frac{\dot{P}_N}{P_N}$ is just the change the price index of the nontraded goods.

Lemma 2. The change in the CPI (or the price index of the nontraded goods) is a weighted average of the change in the price of each nontraded good and that in the number of the nontraded goods, with the weight of the latter being negative.

Proof: Using equation (15), we have $\frac{\dot{P}_N}{P_N} = \frac{\dot{P}_y}{P_y} + \left(1 - \frac{1}{\lambda}\right)\frac{\dot{N}}{N}$. Using Lemma 1, we have

$$\frac{\dot{P}}{P} = (1-\beta)\frac{\dot{P}_N}{P_N} = (1-\beta)\left[\frac{\dot{P}_y}{P_y} + \left(1 - \frac{1}{\lambda}\right)\frac{\dot{N}}{N}\right] \tag{17}$$

Because 0≤λ≤1, we have (1- $1/\lambda$)<0. Q.E.D.

One can see that, the growth of the traded goods sector would cause the relative price of each nontraded good to increase, that is, $\dot{P}_y / P_y > 0$ (this is because the growth rate of the traded goods sector is higher than that of the nontraded goods sector, which will be proved in Proposition 1). This is the force that causes the real exchange appreciation in the Balassa-Samuelson hypothesis. Here, the varieties of the nontraded goods continue to increase due to monopolistic competition. When consumers have more varieties of the nontraded goods, this effect tends to decrease the price index of the nontraded goods, given its weight is negative: (1- $1/\lambda$)<0. Therefore, the expanding varieties in the nontraded goods sector may cause the real exchange rate depreciation, as proved in Proposition 1.

Proposition 1. The model yields $\frac{\dot{P}_y}{P_y} = \left(\frac{1-\gamma}{1-\alpha}\right) g_T - g_N > 0$; $\frac{\dot{N}}{N} = \left(\frac{\gamma}{1-\alpha} g_T + g_N\right) > 0$**. Moreover,** $\frac{\dot{P}}{P} = (1-\beta)\left(\frac{1-\frac{\gamma}{\lambda}}{1-\alpha} g_T - \frac{1}{\lambda} g_N\right)$**. If g_N=0, then as long as** $\lambda < \gamma$ **, then** $\frac{\dot{P}}{P} < 0$ **. If g_N>0, then it is more likely that** $\frac{\dot{P}}{P} < 0$ **(the real exchange rate decreases or the currency depreciates).**

Proof: We first prove $\frac{\dot{P}_y}{P_y} = \left(\frac{1-\gamma}{1-\alpha}\right) g_T - g_N > 0$.

Combining equations (13) and (14), we eliminate the wage rate to get $P_y = \phi \frac{\theta_T(t)^{\frac{1-\gamma}{1-\alpha}}}{\theta_N(t)} P_w^{\frac{1-\gamma}{1-\alpha}} r^{\frac{\gamma-\alpha}{1-\alpha}}$, where ϕ is a constant. Given fixed price of the traded goods and the interest rate, we have

$$\frac{\dot{P}_y}{P_y} = \left(\frac{1-\gamma}{1-\alpha}\right) g_T - g_N \tag{18}$$

Given that the traded goods sector is more capital-intensive, that is, $\alpha > \gamma$; the economic growth is concentrated in the traded goods sector, that is, $g_T > g_N$, we have $\dot{P}_y / P_y > 0$.

Second, we prove $\frac{\dot{N}}{N} = \left(\frac{\gamma}{1-\alpha} g_T + g_N\right) > 0$.

We have defined the consumer's expenditure $e = E / e^{g_w t}$. Using equations (16) and (9), we have $e = \frac{1}{1-\beta} \frac{P_N C_N}{e^{\left(g_T/_{1-\alpha}\right)t}}$. Using equation (15) to eliminate P_N, and using the market clearing condition

$C_N=Y_N=N^{\frac{1}{\lambda}}y$, we have $e=\frac{1}{1-\beta}\frac{NyP_y}{e^{\left(g_T/1-\alpha\right)t}}$, where e denotes the effective expenditure, which is equal to 1 and has no growth. Therefore, $\frac{\dot{e}}{e}=0\Rightarrow\frac{\dot{N}}{N}+\frac{\dot{P}_y}{P_y}-\frac{g_T}{1-\alpha}=0\Rightarrow\frac{\dot{N}}{N}=-\frac{\dot{P}_y}{P_y}+\frac{g_T}{1-\alpha}$ 。Using equation (18), we have

$$\frac{\dot{N}}{N}=\left(\frac{\gamma}{1-\alpha}g_T+g_N\right)>0\,. \tag{19}$$

Third, inserting equations (18) and (19) into (17), we have $\frac{\dot{P}}{P}=(1-\beta)\left(\frac{1-\frac{\gamma}{\lambda}}{1-\alpha}g_T-\frac{1}{\lambda}g_N\right)$. Therefore, even if $g_N=0$, as long as $\lambda<\gamma$, we have $\dot{P}/P<0$. If $g_N>0$, then it is more likely that $\dot{P}/P<0$. Q.E.D.

For the extreme case $g_N=0$, the growth of the nontraded goods sector totally comes from the expanding varieties of the nontraded goods, that is, the increase in N. Then, according to equation (19), the growth rate of the nontraded goods sector is $\frac{\dot{N}}{N}=\frac{\gamma}{1-\alpha}g_T$. Generally, the α in the Cobb-Douglas production function is around 1/3, and $\gamma<\alpha$ (the nontraded goods sector is more labor intensive), so the growth rate of the nontraded goods sector is far lower than g_T (the growth rate of the traded goods sector). This is consistent with the assumption in the Balassa-Samuelson hypothesis that economic growth is concentrated in the traded goods sector. Nonetheless, as long as $\lambda<\gamma$, we still have $\dot{P}/P<0$ (i.e., the real exchange rate depreciation).

According to Proposition 1, the faster growth in the capital-intensive traded goods sector would cause the price of each nontraded goods to increase. This is because the wage rate is equalized in the two sectors. The faster growth in the traded goods sector causes the faster growth in the wage rate. This would cause the unit cost of the nontraded goods sector to increase, which in turn causes its unit final product price to increase. According to the Balassa-Samuelson hypothesis, the increase in the relative price of the nontraded goods means the real exchange rate appreciation.

However, as long as there is monopolistic competition rather than perfect competition in the nontraded goods sector, then even if the total growth rate (including the TFP growth and the growth in the number of varieties) of the nontraded goods sector is lower than that of the traded goods sector, the effect of the endogenous growth from monopolistic competition in the nontraded goods sector may totally nullify or dominate that from the increase in the price of every single nontraded good. As a result, the price index of the nontraded goods would decrease. More specifically, according to equation (17), the change in the price index of the nontraded goods is a weighted average of that in the price of single nontraded good and that in the number of varieties, with the weight of varieties being negative: (1- $1/\lambda$)<0. A small open economy with a smaller elasticity of substitution of consumer's demand between different kinds of the nontraded goods, or a larger TFP growth of the nontraded goods sector (g_N) is more likely to have the currency depreciation.

2.3.2 The General Equilibrium

Because labor supply is fixed at L, the labor market clearing condition can pin down the output of each sector. The labor market clearing condition is

$$L = L_T + NL_N$$

where L_T and L_N are the labor demand for the traded and the nontraded goods sectors respectively. Inserting in the labor demand of each sector, we have

$$L = (1-\alpha)\phi_\alpha \left(\frac{r}{W_t}\right)^\alpha \frac{Y_T}{\theta_T} + N\frac{1-\gamma}{\lambda}\phi_\gamma \left(\frac{r}{W_t}\right)^\gamma \frac{y+\eta}{\theta_N} 。$$

On a balanced growth path, the employment in each sector is fixed. For the nontraded goods sector, plugging in the growth rates for N, W_t and θ_N, one can confirm that its total labor demand is constant. Therefore, we can derive the output growth of each sector. For the traded goods sector, its output growth rate is $\frac{\dot{Y}_T}{Y_T} = \frac{1}{1-\alpha} g_T$.

3. The Expanding Varieties in Both the Nontraded Goods Sector and the Distribution Sector in a Three-Sector Model

This model is just an expansion of the model in section 2, which further considers the distribution sector. Unlike Devereux (1999) who assumes that the distribution sector only serves the traded goods sector, we assume that the distribution sector serves both the traded goods and the nontraded goods sectors, which is more consistent with the real world.[4]

Devereux (1999) introduces the distribution sector that serves the traded goods to explain why East Asian countries experienced the real exchange rate depreciation or littler appreciation along with their faster growth. However, as discussed, the recent empirical work of MacDonald and Rucci (2005) finds that the growth of the distribution sector actually significantly causes the currency to appreciate, contrary to the prediction of Devereux. Therefore, we need extra forces to explain the East Asian experience, which is the motivation of section 2. Nevertheless, it is still necessary to include the distribution sector, as discussed in the introduction. First, empirically, this sector is very important and cannot be overlooked (see Burstein et al., 2000; MacDonald and Rucci, 2005). Second, it helps to explain the fact that the retail price of the traded goods is different across countries. Although the ex-factory (wholesale) price of the traded goods is equalized across countries, when the traded goods reach the hand of consumers, their prices become different, which is caused by the endogenous growth of the distribution sector. We can prove that, under certain structural parameters, the growth in the distribution sector still causes the currency to appreciate, consistent with the empirical findings of MacDonald and Rucci (2005). However, the mechanism of section 2 still exists, which causes the currency to depreciate. Therefore, we can still explain the East Asian experience.

The Lemma 1 in section 2 tells us that the CPI is a fixed fraction of the price index of the nontraded goods. The reason is that, the price of the traded goods is fixed for the small open economy due to international competition, hence $\dot{P}_T / P_T = 0$. In contrast, here (section 3), the price index of the traded goods becomes a composite index for the consumer, which includes the ex-factory (wholesale) price of the traded goods as wells as the price and varieties of the distribution services. The expanding varieties in the distribution sector cause the price index of the traded goods to change: $\dot{P}_T / P_T \neq 0$. P_T is a weighted average of the ex-factory price of the traded goods (P_w) and the price index of the distribution sector. Even if the ex-factory price of the traded goods (P_w) is fixed for the small open economy due to international competition, that is, $\dot{P}_w / P_w = 0$, as long as the change in the price index of the distribution sector is not zero, we have $\dot{P}_T / P_T \neq 0$. Devereux (1999) introduces the distribution sector that serves the traded goods to prove that $\dot{P}_T / P_T < 0$, which would decrease the CPI (i.e., cause the currency to depreciate). In light of the empirical findings of MacDonald and Rucci (2005), the growth in the distribution sector actually causes $\dot{P}_T / P_T > 0$. Then Devereux (1999) cannot explain the East Asian experience. This is the reason why we introduce monopolistic competition into the nontraded goods sector. In so doing, we have $\dot{P}_N / P_N < 0$. Therefore, as long as this effect dominates that of the distribution sector in increasing the price index of the traded goods (that is its effect in causing $\dot{P}_T / P_T > 0$), then the total CPI still decreases. This still can explain why it is possible that a fast growing small economy can have the real exchange rate depreciation, and keep consistent with the empirics of MacDonald and Rucci (2005).

3.1 Consumers

The consumer's problem is the same as that in section 2. The consumer's consumption consists of the traded goods and the nontraded goods:

$$c(s,z) = c_T(s,z)^{\beta} c_N(s,z)^{1-\beta} \tag{3.1}$$

Here, the consumption of the traded goods consists of two parts: the amount of v_T purchased at the world price P_w; the amount of the distribution service d_T purchased at the price P_d:

$$c_T(s,z) = v_T(s,z)^{\mu} d_T(s,z)^{1-\mu} \tag{3.2}$$

Since unlike Devereux's (1999), we allow the distribution sector to distribute both the traded and the nontraded goods to consumers. The consumption of the nontraded goods consists of two parts: the amount of v_N purchased at the price P_N; the amount of the distribution service d_N purchased at the price P_d:

$$c_N(s,z) = v_N(s,z)^{\mu} d_N(s,z)^{1-\mu} \tag{3.3}$$

Given the consumer's preference, the total price index (i.e., CPI) can be expressed as

$$P(P_T, \hat{P}_N) = \phi_{\beta} P_T^{\beta} \hat{P}_N^{1-\beta} \tag{3.4}$$

The price index of the traded goods is

$$P_T(P_w, P_d) = \phi_{\mu} P_w^{\mu} P_d^{1-\mu} \tag{3.5}$$

The price index of the nontraded goods is

$$\hat{P}_N(P_N, P_d) = \phi_{\mu} P_N^{\mu} P_d^{1-\mu} \tag{3.6}$$

where $\phi_{\mu} = \mu^{-\mu}(1-\mu)^{-(1-\mu)}$. Same as in section 2, the economy would converge to a balanced growth path along a saddle path. We focus on the decomposition of the consumer's consumption.

$$P_T C_T = P_w V_T + P_d D_T = \frac{\beta}{1-\beta} \hat{P}_N C_N \tag{3.7}$$

$$P_w V_T = \frac{\mu}{1-\mu} P_d D_T \tag{3.8}$$

$$P_N V_N = \frac{\mu}{1-\mu} P_d D_N \tag{3.9}$$

Therefore, the total expenditure satisfies

$$\begin{aligned} E = PC = P_T C_T + \hat{P}_N C_N &= (P_w V_T + P_d D_T) + (P_N V_N + P_d D_N) \\ &= \frac{1}{(1-\mu)} P_d D_T + \frac{1}{(1-\mu)} P_d D_N = \frac{1}{(1-\mu)} P_d D \end{aligned} \tag{3.10}$$

where $D = D_T + D_N$ is the consumer's total consumption of the services from the distribution sector.

3.2 Producers

Now there are three sectors in the economy: a perfect competitive traded goods sector; a nontraded goods sector consists of a continuum of N monopolistic competitive firms; a distribution sector consists of a continuum of A monopolistic competitive firms.

The technologies for the traded and the nontraded goods sectors are the same as in section 2. The technology for the distribution sector is

$$\mathrm{x}(j)+\varphi=\theta_{\mathrm{x}}(\mathrm{t})\mathrm{K}_{\mathrm{x}}^{\alpha}(j)\mathrm{L}_{\mathrm{x}}^{1-\alpha}(j) \tag{3.11}$$

where we assume that $\theta_{\mathrm{x}}(\mathrm{t})=\theta_0 \mathrm{e}^{g_x t}$. Economic growth is usually concentrated in the traded goods sector, so we assume that $g_x = mg_T$, and $0 \le m < 1$. Moreover, we assume that the distribution sector has the same capital intensity as the traded goods sector. The only difference is that, the distribution sector needs a fixed set-up cost, φ. The consumer's demand for the distribution service is

$$D=\left(\int_0^A x(j)^{\varepsilon}\,dj\right)^{\frac{1}{\varepsilon}} \tag{3.12}$$

where $0 \le \varepsilon \le 1$. ε measures the elasticity of substitution of consumer's demand for different varieties of the distribution services. The increase in A reflects the endogenous growth in the productivity.

The specialized producers in the distribution sector have market power, as in section 2, so we have

$$P_x=\frac{1}{\varepsilon}\phi_{\alpha}\frac{W(t)^{1-\alpha}r^{\alpha}}{\theta_x(t)} \tag{3.13}$$

Similarly, $P_x x\left(\frac{1}{\varepsilon}-1\right)=P_x\cdot\varphi$. Therefore, the sales of each distribution firm is a constant. Moreover, we have $P_d D = P_x A x$. Repeating similar steps, we have

$$P_d = A^{1-\frac{1}{\varepsilon}} P_x \tag{3.14}$$

3.3 The Real Exchange Rate and the General Equilibrium

3.3.1 The Real Exchange Rate

First, according to equation (3.4), we have

$$\frac{\dot{P}}{P} = \beta \frac{\dot{P}_T}{P_T} + (1-\beta)\frac{\dot{\hat{P}}_N}{\hat{P}_N}$$
$$= \beta\left[\mu \frac{\dot{P}_w}{P_w} + (1-\mu)\frac{\dot{P}_d}{P_d}\right] + (1-\beta)\left[\mu \frac{\dot{P}_N}{P_N} + (1-\mu)\frac{\dot{P}_d}{P_d}\right]$$
$$= (1-\mu)\frac{\dot{P}_d}{P_d} + (1-\beta)\mu \frac{\dot{P}_N}{P_N} \tag{3.15}$$

where the change in the price index of the nontraded goods is given in section 2. Proposition 2 describes the change in the price index of the distribution services, $\dot{P}_d / P_d$.

Proposition 2. $\frac{\dot{P}_d}{P_d} = \left[\left(1-\frac{1}{\varepsilon}\right)\left(\frac{1}{1-\alpha} - (1-m)\right) + (1-m)\right] g_T$ **. If** $\varepsilon > \alpha$ **, then as long as** $0 \le m < \frac{\varepsilon - \alpha}{1-\alpha}$**, then** $\frac{\dot{P}_d}{P_d} > 0$**, and** $\frac{\dot{P}_T}{P_T} > 0$**.**

Proof. First, using equation (3.14), we have

$$\frac{\dot{P}_d}{P_d} = \left(1 - \frac{1}{\varepsilon}\right)\frac{\dot{A}}{A} + \frac{\dot{P}_x}{P_x} \tag{3.16}$$

Using $g_x = m g_T$, and equation (3.13), we have $\dot{P}_x / P_x$ = (1-m) g_T.

Second, we prove $\frac{\dot{A}}{A} = \left(\frac{1}{1-\alpha} - (1-m)\right) g_T$.

We defined the consumer's expenditure $e = E / e^{g_w t}$. Using equations (16) and (3.10), we have $e = \frac{1}{(1-\mu)} \frac{P_d D}{e^{\left(g_T/_{1-\alpha}\right)t}}$. Using equation (3.14) to eliminate P_d, and using the equilibrium condition $D = X_T = A^{\frac{1}{\varepsilon}} x$, we have $e = \frac{1}{(1-\mu)} \frac{A x P_x}{e^{\left(g_T/_{1-\alpha}\right)t}}$, where e is the effective expenditure and fixed at 1. Therefore, $\frac{\dot{e}}{e} = 0 \Rightarrow \frac{\dot{A}}{A} + \frac{\dot{P}_x}{P_x} - \frac{g_T}{1-\alpha} = 0 \Rightarrow \frac{\dot{A}}{A} = -\frac{\dot{P}_x}{P_x} + \frac{g_T}{1-\alpha}$. We already have $\dot{P}_x / P_x$ = (1-m) g_T.

Therefore, we have $\frac{\dot{A}}{A} = \left(\frac{1}{1-\alpha} - (1-m)\right) g_T$. Plugging it and $\dot{P}_x / P_x = (1\text{-m}) g_T$ into equation (3.16),

we have $\frac{\dot{P}_d}{P_d} = \left[\left(1 - \frac{1}{\varepsilon}\right)\left(\frac{1}{1-\alpha} - (1-m)\right) + (1-m)\right] g_T$. The constant in the square brackets is positive

when $0 \le m < \frac{\varepsilon - \alpha}{1-\alpha}$, therefore, $\dot{P}_d / P_d > 0$. Then using equation (3.5), we have $\frac{\dot{P}_T}{P_T} = (1-\mu)\frac{\dot{P}_d}{P_d}$.

Therefore, as long as $\dot{P}_d / P_d > 0$, we have $\dot{P}_T / P_T > 0$. Q.E.D.

Proposition 2 shows that the expanding varieties (the growth) of the distribution sector actually cause the real exchange rate to appreciate (see equation 3.15). This is consistent with the empirical finding of MacDonald and Rucci (2005). In other words, we need the value of m to approach 0 to generate predictions consistent with MacDonald and Rucci (2005). In contrast, Devereux (1999) needs m to approach 1 to generate $\dot{P}_T / P_T < 0$. Based on Devereux (1999), we further introduce monopolistic competition into the nontraded goods sector. In so doing, we have $\dot{P}_N / P_N < 0$. As long as this effect dominates the effect of the distribution sector in increasing the price index of the traded goods (i.e., the effect of making $\dot{P}_T / P_T > 0$), then the total CPI still decreases. This can explain the East Asian experience (a small open economy experienced both high growth and the real exchange rate depreciation), while remains consistent with the empirical findings of MacDonald and Rucci (2005). Moreover, it is consistent with the common view that the distribution sector behaves like the nontraded goods sector (Burstein et al., 2000; Devereux, 1999). In contrast, MacDonald and Rucci (2005) conclude that their empirical findings contradict with the common view that the distribution sector behaves similarly as the the nontraded goods sector, so they refute the view. However, based on our theory, one need not refute the view to be consistent with empirics. That is, the distribution sector in our model still behaves similarly as the nontraded goods sector.

3.3.2 The General Equilibrium

Similarly, because the labor supply is fixed at L, the labor market clearing condition can pin down the output level of each sector. The labor market clearing condition is

$$L = L_T + NL_N + AL_x$$

where L_T, NL_N and AL_x are the total labor demand of the traded goods sector, the nontraded goods sector and the distribution sector respectively. Therefore, we can prove that, on the balanced growth path, the total employment of the nontraded goods sector and the distribution sector is fixed. Therefore, the output growth of the traded goods sector is still $\frac{\dot{Y}_T}{Y_T} = \frac{1}{1-\alpha} g_T$.

4. Conclusion and Policy Suggestions

In a small open economy, the faster growth of the relatively more capital-intensive traded goods sector would cause the price of every single nontraded good to increase. This is because the wage rate is equalized across sectors. The faster growth of the traded goods sector causes the faster growth of the wage rate. This in turn causes the unit cost of producers in the nontraded goods sector to increase, which causes their final unit output price to increase.

However, if there is monopolistic competition instead of perfect competition in the nontraded goods sector, even if the total growth rate (including the TFP growth and the increase in the number of varieties) of the nontraded goods sector is lower than that of the traded goods sector, the expanding varieties in the nontraded goods sector tend to decrease the price index of the nontraded goods. This effect would nullify or dominate the effect of the increasing price of the nontraded goods in raising the price index of the nontraded goods. As a result, the price index of the nontraded goods would decrease, which causes the real exchange rate to depreciate. The implication for empirical works is two-fold. On the one hand, a small open economy with a smaller elasticity of substitution of consumer's demand between different types of the nontraded goods, or a larger TFP growth of the nontraded goods is more likely to have lower real exchange appreciation. On the other hand, it is difficult to measure the real exchange rate in the empirical work (see Cheung, Chinn and Fujii, 2007). The theory tells us that, in measuring the price index of the nontraded goods, one needs to measure the number of varieties besides the price of each single nontrade good, with the weight of the number of varieties to be negative.

As far as China is concerned, China's nontraded goods sectors such as transportation, postal service, construction, and health services have experienced fast growth. These sectors are traditional monopolistic sectors. Their fast growth may explain the finding of Cheung, Chinn and Fujii (2007) that the Chinese currency may be undervalued, but it is not statistically significant.

Morevoer, China has adopted the fixed exchange rate regime and achieved fast economic growth and stability. As Cheung, Chinn and Fujii (2007) point out, the sudden change in the exchange rate policy may pose serious challenges for the growth and economic stability of the Chinese economy. However, the major developed countries attribute the global current account imbalance to the undervaluation of the Chinese currency, and exert great pressure on China to appreciate the Renminbi. Although as Cheung, Chinn and Fujii suggested, it needs the suitable policy changes in other developed countries including the U.S. to solve the global current account imbalance, if China wants to maintain the fixed exchange rate regime (the recent empirical work of Aghion et al., 2009 finds that fixed exchange rate regime actually promotes the long-run productivity growth of those countries with a lower level of financial development), it needs to lower the discrepancy between its fixed exchange rate and the market value of its currency. Under current economic situations, in order to ease the appreciation pressure, China can adopt suitable policies, taking count of its current focus on economic structural adjustment. Given the model, the focus of adjustment should be in the nontraded goods sector, some of which are backbone of the Chinese economy. Suggested policies include the allowance of entry into the nontraded goods sectors and the protection of property rights, both of which are good for the innovation via expanding varieties in the nontraded goods sector. These policies can better the market environment, which may spur the monopolistic innovation in those sectors and on the other hand may raise the TFP growth of those sectors.

These would not only slow down the appreciation speed of the Chinese currency so as to maintain the stability of its fixed exchange rate regime, but also streamline the industrial structure and lower its dependence on the fast growth of the export industries (the traded goods sector) and thereby helping to solve the global current account imbalance.

Endnotes

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[1] For example, China's average annual growth of real GDP per worker for the period 1978-2004 is roughly 8%, far exceeding those of leading developed countries.

[2] This is due to free labor mobility across sectors. Resultantly, the wage rates are equalized in the two sectors. The fast growth of the productivity of the tradable goods sector causes the faster growth of the wage rate. In a perfect competitive nontradable goods sector, the price of the nontradable goods is equal to firm's effective unit cost. Since the growth of wage rate far exceeds that of the productivity of the nontradable goods sector, this increases the firm's effective unit cost in the nontradable goods sector, which causes the price increase of the nontradable goods (of course, this has something to do with the fact that the tradable goods sector is more capital-intensive).

[3] It may be possible that growth is inverted-U related to the degree of monopoly as in Aghion et al. (2005).

[4] Otherwise, one would underestimate the effect of the distribution sector in pushing up the CPI and thus the real exchange rate. Nonetheless, the qualitative results are the same if we let the distribution sector only serves the traded goods sector. The calculation would be simpler.

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