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Article

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Global Business & Finance Review (GBFR)

Provided in Cooperation with:

People & Global Business Association (P&GBA), Seoul

Suggested Citation: Chan, Man-Ching (2015) : Real exchange rate anomalies in China: Sterilization by the people and trade liberalization, Global Business & Finance Review (GBFR), ISSN 2384-1648, People & Global Business Association (P&GBA), Seoul, Vol. 20, Iss. 2, pp. 67-81, <https://doi.org/10.17549/gbfr.2015.20.2.67>

This Version is available at:

<https://hdl.handle.net/10419/224335>

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Real Exchange Rate Anomalies in China: Sterilization by the People and Trade Liberalization

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ABSTRACT

When a fixed exchange rate country is faced with a sudden increase in foreign exchange inflows, its economy would normally experience higher inflation and real exchange rate appreciation. Between 1998 and 2006, however, China underwent a period of surging influx of foreign exchange and accumulation of vast reserves with little inflation or changes in the real exchange rate. Instead of sterilization by the central bank, this paper argues that the small change was largely due to “sterilization by the people”—the public voluntarily increased their holdings of monetary balances because of a rise in income or change in preferences—hence alleviating the inflationary pressure on the economy. In addition, the easing of import restrictions also helped offset some of the extra foreign exchange coming into China. An open economy model that highlights the role of the monetary approach is used to demonstrate how increased money demand and trade liberalization can mitigate the impact of the inflows on the domestic price level and the real exchange rate.

Keywords: Real exchange rate; Monetary approach; Foreign exchange inflows; Trade liberalization; China

1. Introduction

When a country is faced with a sudden increase in foreign exchange inflows, we should expect natural forces to be at work to propel the economy to its new equilibrium regardless of the exchange rate system in place. In the case of a fixed exchange rate, the adjustments normally entail rising domestic prices and real exchange rate appreciation (Calvo, Leiderman & Reinhart, 1993; Edwards, 2000). In some circumstances, however, other economic forces accompany the economic adjustments, and one cannot truly explain what is going on in such

countries using a standard theoretical framework without taking these other forces into account.

One prominent example is China during its fixed exchange rate period between 1998 and 2006. The country received huge inflows of foreign exchange during the period amid rapid economic growth and liberalization, which led to an enormous accumulation of international reserves and expansion in monetary base. Instead of observing a surge in inflation, however, consumer prices increased by less than one percent a year on average. The real exchange rate even depreciated moderately over the 2002-2006 period as the hike in world price level outpaced the rise in domestic prices. Is the Chinese experience an anomaly, or can additional forces be at work in the economy that help reconcile the differences?

One may argue that the policy actions taken by the

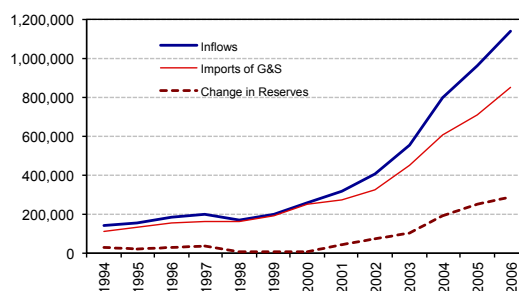
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People’s Bank of China (PBC) helped absorb the excess liquidity in the economy and prevent the inflationary pressure from building up. Yet despite the efforts by the PBC to sterilize the inflows by selling government securities and raising the required reserve ratio, broad money expanded at an average annual rate of almost 16 percent over the 1998-2006 period, while domestic inflation rate amounted to only 0.7 percent a year on the average over the same period. It appeared that the sterilization operations engaged by the central bank alone could not explain the lack of domestic price adjustment or real exchange rate appreciation over the period.

By examining the macroeconomic adjustments that took place in China over the period, clearly while the natural forces were at work to bring about the change in relative price that was necessary to eliminate any disequilibrium in the economy, the Chinese people were also sterilizing the inflows by increasing their demand for monetary balances. Such phenomenon has been dubbed “sterilization by the people” as it achieves similar effects as sterilization by the central bank. The Chinese public absorbed what might otherwise be excess liquidity by increasing its willingness to hold extra cash balances. Without such a force working in conjunction with the surge in inflows, the country would have experienced a huge increase in the domestic price level given the rapid growth in its reserves and broad money. In addition, trade liberalization, which includes the easing of import restrictions, also helped offset some of the extra foreign exchange entering China (Chan, in press).

A simple small open economy model is presented in this paper to demonstrate the fundamental adjustment mechanism of an economy that experiences an influx of foreign exchange while operating under a fixed exchange rate system. The money demand equation in the model includes a parameter that represents the public’s money holding preference. A rise in its value captures the increased willingness of the economic agents to hold larger monetary balances, the phenomenon observed in the case of sterilization by the people. Also incorporated is a per unit tax on imports which can be treated as a measurement of the extent of import restrictions.

The rest of the paper is organized as follows. The process of real exchange rate adjustments in china over the 1998-06 period is discussion in Section II. Section III presents the static and dynamic versions of the model. Section IV summarizes the study and concludes.



Sources: International Financial Statistics, 2015; author’s calculation.

Figure 1. China’s foreign exchange inflows, imports of goods and services, and changes in international reserves (in millions of USD).

II. Sterilization by the People and Trade Liberalization in China

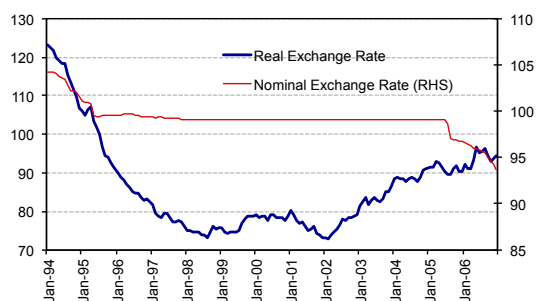
China experienced an enormous influx of foreign exchange without undergoing significant appreciation in their real exchange rate over its fixed exchange rate period, particularly between 1998 and 2006. As shown in Figure 1, the total inflows of foreign exchange in the country increased sixfold from USD 170 billion in 1998 to over USD 1 trillion in 2006. On the one hand, the surge in inflows reflected the liberalization of the country’s current account around the time of its accession to the World Trade Organization in 2001 as exports in goods and services grew at an impressive rate of 20 percent a year on average. On the other hand, a steady increase in portfolio investment was observed as China loosened its capital account restrictions beginning in 2002 by allowing greater access to its stock and bond markets by foreign investors (Prasad, Rumbaugh & Wang, 2005).

The inflows of foreign exchange led to an accelerated accumulation of foreign reserves. In standard theory, this increase in reserves arises as the central bank follows the rules of the fixed exchange rate system and purchases the foreign exchange inflows at the predetermined exchange rate. In the process of absorbing the foreign exchange, the central bank prints new money and injects additional liquidity into the banking system, which leads to an excess supply of real monetary balances over the demand for them. The excess money supply is then expected to be spent partly on nontradables, which bids up the domestic price level, and partly on tradables, which leads to a trade

deficit and a loss of reserves (Dornbusch, 1973; Blejer, 1979; Frenkel & Mussa, 1985; Harberger, 2008). The resulting increase in the relative price of home goods (i.e., a real appreciation of the exchange rate) leads to a further expansion of imports and contraction of exports.

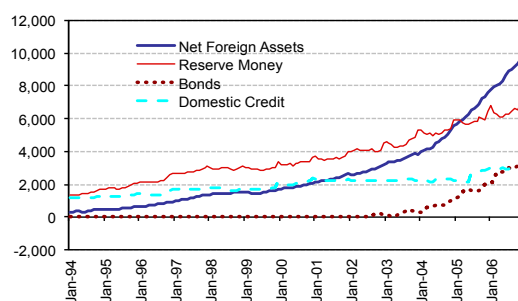
In China's case, total imports rose by more than five times between 1998 and 2006, partly due to the inflows of capital and rapid income growth over the period. The growth in imports, however, was also due to the removal of trade barriers that began in the 1990s (Santos-Paulino, 2002). According to the World Bank's World Development Indicators (2015), the average tariff rate was reduced to 4.3 percent in 2006 from a high level of 32.2 percent in 1992. Also, other non-tariff barriers such as import quotas and licensing requirements were virtually eliminated by 2005. As a result of the trade liberalization, the imports expansion helped slow down the buildup of international reserves and relieve some of the inflationary pressure on the economy. Despite that, China's international reserves continued to climb to reach record levels, while its inflation rate averaged to less than one percent per annum over the 1998-2006 periods. The country even went through a period of real exchange rate depreciation between 2002 and 2006 because the rate of increase in the world price level exceeded that of the domestic price level (Figure 2).

Why did domestic prices not rise more given China's foreign exchange inflows and reserves expansion over the period? A possible explanation is that the central bank might have engaged in sterilization activities—a common practice among developing countries. One such way to sterilize the foreign exchange inflows is through a tightening of domestic credit in the consolidated banking system (Saxena & Wong, 1999). As shown in the central



Sources: International Financial Statistics, 2015; author's calculation.

Figure 2. China's real and nominal exchange rates (1995=100).



Sources: International Financial Statistics, 2015.

Figure 3. China's central bank balance sheet (in billions of RMB).

bank's balance sheet (Figure 3), however, the Chinese authorities had no intention of doing so as it allowed domestic credit to expand steadily, rising from RMB 1.8 trillion in 1998 to RMB 3.1 trillion in 2006. Although the PBC did raise the required reserve ratio from 3 to 6 percent over the 2003-2006 period, they did not utilize reserve requirement as a major policy tool until 2007 (Ma, Yan, and Xi, 2013). To absorb the excess liquidity and control the growth in money supply, the PBC engaged in sterilized intervention beginning in 2002 and intensified its bond sales from RMB 150 billion to almost RMB 3.0 trillion in 2006. Even though additional attempts such as financial market reforms were carried out during this period (Wang, 2010), the growth rate of broad money remained high at 16 percent a year on average over the period.

A plausible explanation for the lack of inflation pressure in the face of high money growth, as proposed by Harberger (2008), is that the Chinese people were at the same time "sterilizing" the inflows by holding much larger monetary balances. As the central bank purchases the foreign exchange inflows under a fixed exchange rate system and injects newly printed money into the economy, domestic prices will go up if households and firms spend the excess liquidity on nontradables. On the other hand, such inflation will not occur if private agents in the economy choose to increase their holdings of monetary balances instead of spending them down. The effect of such actions by the public is similar to the sterilization operations carried out by the central bank as described earlier.

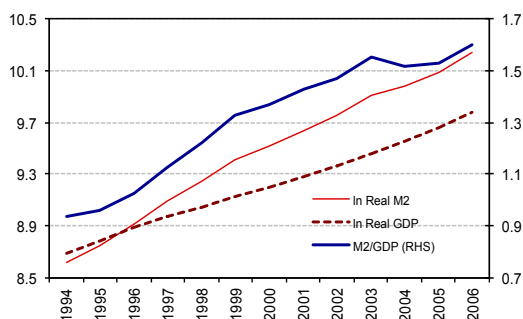
China appeared to have undergone such sterilization by the people over the period as the public increased its willingness to hold greater amount of money balances

amid the inflows of foreign exchange. Several factors are observed to explain the change in their money holding behavior. First of all, as discussed in Makin (2006), the increase in money demand in China is likely a consequence of the surge in real GDP that grew at over 9 percent a year on average. As household income rises, people desire to hold more cash balances for the purchase of goods and services. Secondly, as evidenced by the increase in the M2-to-GDP ratio shown in Figure 4, a change in preference might also be at work as people accumulate larger monetary balances per unit of real GDP. Such a change might be attributable to the high income and expenditure uncertainties, the deterioration of social safety nets, and the lack of well-developed insurance and financial markets in China. As pointed out by Wen (2011), Chinese households face higher income and expenditure risks “such as unexpected spending for housing, education, and health care, or unpredictable expenditures related to accidents, property damages, and volatile fluctuations in consumption goods prices” (p. 28), and such risks in China are estimated to be at least 25 times higher than that in the U.S. For example, studies have shown that China has higher rates of car accidents and work-related injuries (Xing, Liu, Sun & Zhang, 1996; Wang, 2009). Also, due to privatization of the healthcare system, limited availability of medical and unemployment insurance, and reduced compensation for workers provided either through the government or the employers, the Chinese people have to save a larger portion of their income to insure against idiosyncratic risks (Lardy, 2006; Ma & Wang, 2010). As an example, access to medical insurance do not exist in rural area (Wang, Xu & Xu, 2007), and only 39 percent of urban residents are covered by some form of medical insurance

in China (Xu, Wang, Collins & Tang, 2007). In addition, the underdevelopment of the financial markets helps explain the fact that a large share of the precautionary savings is in the form of either cash or bank deposits (Wen, 2009). Finally, the imperfect financial system and the limited access to credit also induce Chinese corporations to save a larger amount of their retained earnings as liquid assets (Jha, Prasad & Terada-Hagiwra, 2009; IMF, 2009). All these factors contribute to the significant shift in China’s money demand over the last decade or so.

III. The Model

The main objective of this section is to lay out a simple model that captures the fundamental adjustment mechanism of an economy such as China—a country that experiences an influx of foreign exchange and other economic forces while operating under a fixed exchange rate. Derived from the work of Harberger (1986), the basic model with nontradable goods is extended to allow for both exportables and importables. To simplify the model, it is assumed that the economy consumes none of the exportables it produces and imports all of its demand for importables. A more extensive model could include a demand equation for exportables and a supply equation for importables, such that total exports are derived from an excess supply of exportables, and total imports are from an excess demand for importables. However, the addition will only complicate the model without providing additional qualitative insights in our analysis. The small open economy studied here therefore has three sectors: exports, imports, and nontradables.



Sources: International Financial Statistics, 2015; author’s calculation.

Figure 4. China’s real broad money, real GDP, and the broad money to GDP ratio.

A. The Comparative Static Model

The model in a comparative static form is first presented. The supply of exportables, which is equal to total exports, is given by

$$EX = a_0 + a_1(P^X - w), \tag{1}$$

where EX is the exports of goods and non-financial services, P^X is the price of exports, and w denotes the nominal wage or the level of factor costs. The supply of nontradables, in a similar fashion, can be written as

$$H^s = b_0 + b_1(P^H - w), \quad (2)$$

where H^s and P^H represent the supply and prices of nontradable goods respectively. Correspondingly, the real output is given by

$$y = EX + H^s. \quad (3)$$

Assuming there is no change in the productivities of the export and nontradable sectors or in the amount of available resources, the full employment condition implies that

$$y = H^s + EX = \bar{y} \text{ or } dH^s = -dEX.$$

(The equilibrium nominal wage or factor costs can be derived from the full-employment condition. More specifically, if the economy employs all available resources, we have

$$dy = a_1(dP^X - dw) + b_1(dP^H - dw) = 0,$$

which can be re-written as

$$dw = \frac{a_1}{a_1 + b_1} dP^X + \frac{b_1}{a_1 + b_1} dP^H.$$

On the demand side, the demand for importables is expressed as

$$IM = c_0 - c_1(P^M + T^M - P^H) + c_2y + c_3B, \quad (4)$$

where IM is the imports of goods and non-financial services, P^M is the cif price of imports, T^M represents a per unit tax on imports which can be treated as a measurement of the extent of trade restrictions, y is the

level of real output, and B denotes net capital inflows which is exogenously determined. Similarly, the demand for home goods is given by

$$H^d = c_0' + c_1'(P^M + T^M - P^H) + c_2'y + c_3'B, \quad (5)$$

where H^d is the demand for nontradables. A higher T^M implies a higher trade barrier or tighter restriction on imports of goods and non-financial services. The imposition of import restrictions such as tariffs, import quotas, and import licenses would raise import prices. In contrary, a lower T^M is associated with trade liberalization and a lowering of import prices.

It is assumed that $c_2 + c_2' = 1$, which means that people spend all of their income on either imported goods or home goods. This spending, of course, includes demand for investment goods as well as for consumption. Similarly, c_3 and c_3' should add up to unity as the entire amount of capital inflows is assumed to be spent on either imports or nontradables. Lastly, c_1 should equal c_1' due to the symmetry property of the substitution effects.

The prices of tradable goods are given by

$$P^X = E \cdot P^{X*} \quad (6)$$

and

$$P^M = E \cdot P^{M*}. \quad (7)$$

Table 1. An Increase in Net Capital Inflows

Variable	Initial Value	Final Value	Absolute Change	Percentage Change
P^H	1.00	1.11	0.11	10.62
w	1.00	1.08	0.08	8.37
$H^d = H^s$	65.00	67.93	2.93	4.51
EX	35.00	32.07	-2.93	-8.37
IM	35.00	42.07	7.07	20.20
y	100.00	100.00	0.00	0.00
M^d	40.00	43.35	0.00	0.00
M^s	40.00	43.35	0.00	0.00
B	0.00	10.00	10.00	-

The world prices of exports P^{X*} and imports P^{M*} are determined exogenously as the country is assumed to be too small relative to the rest of the world to affect the world price level. The nominal exchange rate, which can influence the domestic price level of imports, is held fixed in our model.

The demand for money balances is given by

$$M^d = kyw \quad (8)$$

and the balance of payments is expressed as

$$0 = EX - IM + B. \quad (9)$$

As the country is assumed to pursue a fixed exchange rate policy, any net inflow of foreign exchange, given by $EX - IM + B$, that the central bank purchases will be added to the international reserves. However, as a new equilibrium is reached, the change in reserves will be zero.

Finally, the money market clears when

$$M^s = M^d,$$

and the equilibrium condition for the market of nontradables is given by

$$H^s = H^d.$$

B. The Comparative Static Analysis

A comparative static analysis is carried out in this section with the aim to demonstrate how the real exchange rate will react when an economy is faced with an influx of foreign exchange. First is a look at a basic case where the economy experiences a surge in net capital inflows and a subsequent appreciation in its real exchange rate, and then study how policy actions or additional disturbances can offset the impact of the inflows on the real exchange rate. More specifically, the scenarios under analysis are 1) an increase in capital inflows and 2) increased capital inflows along with trade liberalization. The assumptions that are used for the parameters and initial equilibrium values of the model can be found in the Appendix.

1. The basic scenario: An increase in net capital inflows

The first exercise is to study the simple case of a sudden increase in net capital inflows equivalent to 10 percent of output. The results which are reported in Table 1 show that the surge in capital inflows is followed by a real exchange rate appreciation of around 10.6 percent, a rise in nontradable and imports consumption of 4.5 percent and 20.2 percent respectively, a fall in total exports by roughly 8.4 percent, and a rise in wage rate by the same percentage. The share of nontradables production in total output increases from 65 percent to almost 68 percent whereas that of exports declines from 35 to 32 percent. On the monetary side, both the demand for and supply of money increase by 8.4 percent, reflecting a higher level of domestic prices.

The story behind the adjustment process in response to a sudden inflow of capital is as follows. As the country receives a sudden inflow of capital, part of it will be spent on imports and the rest on nontradable goods. The extra demand for nontradables that is not immediately met by an increased supply for it will lead to a rise in the relative price of nontradables. This rise, which represents a real exchange rate appreciation, induces resources to be transferred from the exporting sector to the nontradable sector and therefore increasing the supply of nontradables and reducing the country's total exports. On the other hand, imports will also increase as part of the excess money supply is spent on imported goods. A secondary effect on consumption also takes place as the real exchange rate appreciates. The rising relative price of nontradables to imports increases people's incentives to substitute away from nontradables and toward imported goods. While 70 percent of the increase in imports is a direct result of the change in net inflows, 30 percent of it is induced by a change in relative price.

Under the assumptions of this scenario, the full amount of the capital inflows that enters the economy is drawn down through a decrease in exports and an increase in imports until the balance of payments is once again in equilibrium (with $\Delta R = 0$). The real exchange rate appreciation plays an important role in the adjustment process as it induces imports to go up and offset some of the foreign exchange that comes into the economy.

2. A reduction in import restrictions

In this section, it is assumed that as the country experiences an increase in inflows, it also liberalizes its trade account at the same time. The reduction in import restrictions is represented by a negative change in T^M . Two values for the import restriction term are chosen ($dT^M = -0.1$ and $dT^M = -0.26$) to illustrate the effects of different degrees of trade liberalization on the real exchange rate and the other macroeconomic variables of the economy. Table 2 reports the results for the two cases.

In the first case, an equal amount of net capital inflows (10 percent of output) results in a real exchange rate appreciation of 6.5 percent, 4.1 percentage points lower than that in the basic scenario. Although the economy still experiences a rise in nontradable consumption, a fall in exports, and an increase in wage level as part of the capital inflow is translated into excess demand for nontradables, the magnitude of the changes is smaller than in the previous scenario. Import demand, which increases by 23.5 percent compared to the 20.2 percent in scenario one, is the only variable that exhibits a larger response to the inflows of capital. The reason is that imports in this scenario play a bigger role in offsetting the extra foreign exchange that comes into the economy in the beginning of the period. In addition to the direct spending of net capital inflow and the real exchange rate appreciation that are at work, the lowering of import prices induced by the reduction in import restrictions also helps increase spending on total imports. As a result, a smaller response

in the real exchange rate is needed to generate an equal amount of outflows in foreign exchange.

The assumption of $dT^M = -0.26$ in the second case leads to an extreme outcome—the increase in imports induced by the spending out of B plus the higher degree of trade liberalization is enough to offset all the extra inflows of foreign exchange. Therefore, no real exchange rate appreciation is necessary in this case, and the shares of nontradables and exports in total output remain the same.

C. The Dynamic Model

We now turn to the dynamic version of the model by introducing money into it. In particular, the role of the *monetary approach to the balance of payment* is highlighted as a key mechanism in the adjustment process of the economy. The approach emphasizes the idea that a temporary disequilibrium between the current money supply and the long-run demand for money will give rise to changes in international reserves. More specifically, when the money supply exceeds the amount that the public is willing to hold, economic agents will start to get rid of the excess by spending part of it on tradable goods and part on nontradables. While the increased demand for nontradables will lead to a rise in domestic prices, the expenditures on tradables will lead to a loss in international reserves if the country is pursuing a fixed exchange rate policy (Polak, 2001).

Table 2. An Increase in Net Capital Inflows and Reduction in Import Restrictions

	Case 1 ($\Delta B = 10, \Delta T^M = -0.10$)				Case 2 ($\Delta B = 10, \Delta T^M = -0.26$)				
	Initial Value	Final Value	Absolute Change	Percentage Change	Initial Value	Final Value	Absolute Change	Percentage Change	
P^H	1.000	1.065	0.065	6.48	P^H	1.000	1.000	0.000	0.00
w	1.000	1.051	0.051	5.10	w	1.000	1.000	0.000	0.00
$H^d = H^s$	65.000	66.790	1.790	2.75	$H^d = H^s$	65.000	65.000	0.000	0.00
EX	35.000	33.210	-1.790	-5.10	EX	35.000	35.000	0.000	0.00
IM	35.000	43.210	8.210	23.47	IM	35.000	45.000	10.000	28.58
y	100.000	100.000	0.000	0.00	y	100.000	100.000	0.000	0.00
M^d	40.000	42.040	0.000	0.00	M^d	40.000	40.000	0.000	0.00
M^s	40.000	42.040	0.000	0.00	M^s	40.000	40.000	0.000	0.00
T^M	0.000	-0.100	-0.100	-	T^M	0.000	-0.260	0.000	-

The model is characterized by the following equations:

Supply

$$EX_t = a_0 + a_1 \sum_{i=0}^3 0.25 (P_{t-i}^X - w_{t-i}) \quad (10)$$

$$H_t^s = b_0 + b_1 \sum_{i=0}^3 0.25 (P_{t-i}^H - w_{t-i}) \quad (11)$$

The equations are different from the static version as the supply of exports and nontradables is allowed to respond to a price shock over four periods. The rationale behind the modification is that short-run adjustment in the supply of exports and nontradables usually takes time as resources are moved from one sector to the other.

Demand

$$\begin{aligned} IM_t = & c_0 - c_1 (P_t^M + T_t^M - P_t^H) \\ & + c_2 y_{t-1} + 0.5 \cdot c_3 (B_t - \Delta M_t^d) \\ & + 0.3 \cdot c_3 (B_{t-1} - \Delta M_{t-1}^d) \\ & + 0.2 \cdot c_3 (B_{t-2} - \Delta M_{t-2}^d) \\ & + c_4 (M_{t-1}^s - M_{t-1}^d) \end{aligned} \quad (12)$$

$$\begin{aligned} H_t^d = & c_0' - c_1 (P_t^M + T_t^M - P_t^H) \\ & + (1 - c_2) y_{t-1} + 0.5 \cdot c_3' (B_t - \Delta M_t^d) \\ & + 0.3 \cdot c_3' (B_{t-1} - \Delta M_{t-1}^d) \\ & + 0.2 \cdot c_3' (B_{t-2} - \Delta M_{t-2}^d) \\ & + c_4' (M_{t-1}^s - M_{t-1}^d) \end{aligned} \quad (13)$$

Here it is assumed that consumers spend last period's income and excess money balances in the current period while the spending of the net capital inflows less the change in real money demand (ΔM^d) is spread over three periods. One can motivate the variable $(B_t - \Delta M_t^d)$ by assuming that the increase in real money holdings is directly satisfied by the inflows of capital. It is more intuitive, however, to assume that the inflows are directly spent on tradables or nontradables, but that the increment of demand for real cash balances is accomplished by people not spending that amount. Thus these sources would lead to a net increment to spending in any period that would be linked to $(B_t - \Delta M_t^d)$. Again, all income and net capital inflows (less the increase in money demand) are

spent on either imports or nontradable goods. However, the excess money supply can be spent either entirely in the current period or partially in the current and subsequent periods. Consequently, the only restriction on the money coefficients is $0 < c_4 + c_4' \leq 1$.

Tradable Prices

$$P_t^X = E_t \cdot P_t^{X*}$$

$$P_t^M = E_t \cdot P_t^{M*}$$

Same as before, the domestic prices of exports and imports are determined exogenously at the world level given that the nominal exchange rate is held constant. The world prices of tradables are also assumed to be constant over time.

Balance of Trade and Balance of Payments

The balance of trade is defined as

$$TB_t = EX_t - IM_t \quad (14)$$

while the balance of payments is given by

$$\Delta R_t = TB_t + B_t \quad (15)$$

where ΔR_t is the change in international reserves. Note that in the dynamic version of the model, the trade deficit does not have to be entirely financed by the net inflows of capital as the country is allowed to draw down its international reserves during transitional periods. Rearranging the terms above provides the following identity:

$$F_t \equiv EX_t + B_t = IM_t + \Delta R_t \quad (16)$$

where F_t is the total inflows of foreign exchange. What the equation says is that, if a country experiences a surge in inflows of foreign exchange, it will be reflected in either an increase in imports or a rise in the level of international reserves.

Money Market

The demand for money balances is given by

$$M_t^d = ky_t w_t$$

while the supply of money, M_t^s , is written as

$$M_t^s = M_{t-1}^s + \Delta R_t + \Delta D_t \quad (17)$$

The change in net domestic credit, ΔD_t , is exogenously controlled by the central bank and can act as a policy instrument to influence the level of money supply in the economy. A money multiplier of one is implicitly assumed in the above money supply equation. This money supply equation can be expanded to incorporate a value of money multiply other than one. For example, a money multiplier of 4 can be generated as follows:

$$M_t^s = 1.75R_t + 1.25R_{t-1} + R_{t-3}$$

However, this change leads to no modification of the main conclusions.

Equilibrium Condition

$$H_t^s = H_t^d$$

Finally, the home goods market is cleared when the supply of nontradables is equal to the demand for it.

D. Simulations

A series of simulations are carried out in this section and the results are reported in Figures 5 to 7. By simulating the model economy, we can examine the time paths, magnitudes, and speed of adjustments of our main variables under different scenarios.

Similar to the comparative static analysis discussed in the previous section, the same disturbance is introduced into the model—a surge in capital inflows—to examine how policy actions and other changes in the economy may affect the adjustment process. In addition to a

permanent increase in foreign exchange inflows, the model also aids at looking at the different responses that a temporary change may generate. Furthermore, a case where the increase in inflows is accompanied by a rising demand for monetary balances will also be examined.

Assumptions on the parameter and initial values that were made in the comparative static version of the model are carried over to this model. In addition, it is assumed that 20 percent of the excess money supply from the previous period is spent on imports in the current period, and another 20 percent goes to nontradables ($c_4 = c_4' = 0.2$). Note that there is no good reason why all undesired balances should be spent in the first period. The initial level of international reserves is assumed to be 20. Lastly, the money market is in equilibrium and trade is balanced in the beginning of the period.

1. The basic scenario: A permanent increase in capital inflows

Similar to the comparative static model, we first study the basic scenario of a permanent increase in capital inflows equivalent to 10 percent of output ($B_t = 0.1y_t$ for $t = 1, 2, 3, \dots$). As shown in Figure 5, the new equilibrium is reached in roughly eight periods after the disturbance takes place. The final equilibrium values of most of the key economic variables in the dynamic case, as expected a priori, are the same as in the comparative static version. More specifically, a real exchange rate appreciation, an increase in nominal wage rate, a rise in nontradables and imports consumption, a fall in total exports, and an increase in the supply of and demand for money are observable.

Several economic variables, however, exhibit unique dynamics that cannot be captured in a simple comparative static model. First of all, international reserves increase by 16.7 percent as any net capital inflows in excess of trade deficit in a given period are allowed to be accumulated as foreign reserves. The excess foreign exchange arises in the beginning of the transition periods as economic agents spend only part of the net capital inflows on imports and nontradables in any given periods. The higher final equilibrium level of reserves reflects the increase in money demand stemming from a rise in domestic price level. In this model, there is no desired level of international reserves that the central bank is trying to maintain. The level of foreign reserves is endogenously determined as the central bank simply follows the rules of the fixed

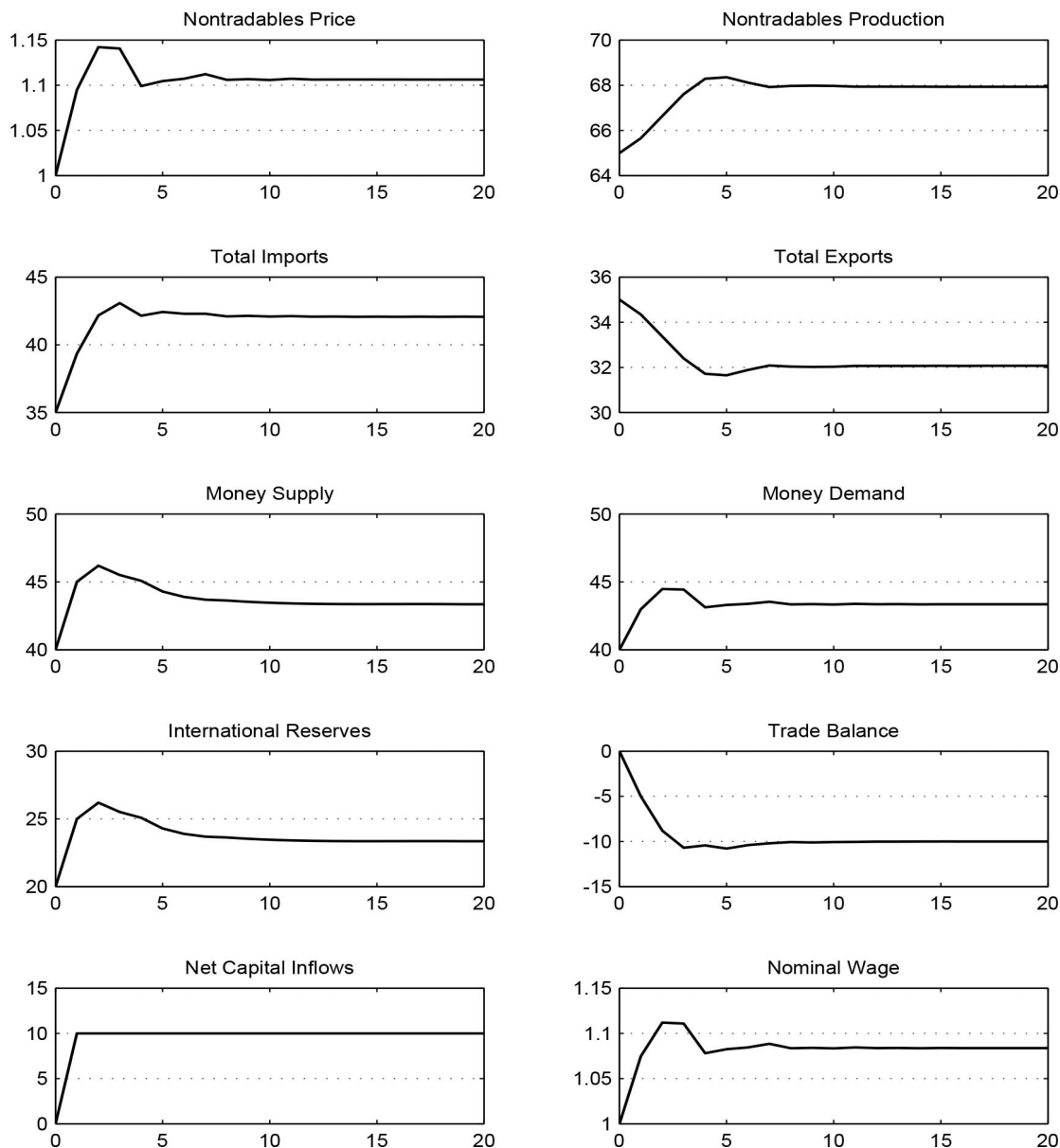


Figure 5. A permanent increase in net capital inflows.

exchange rate system and is obliged to buying any extra foreign exchange coming into the economy. We can easily incorporate a desired level of reserves, R^* , in the model by viewing R^* as a function of GDP. If $R > R^*$, the central bank will contract domestic credit and hence the money supply until $R = R^*$. Similarly, the central bank will expand domestic credit and money supply if $R < R^*$.

This scenario is not explored in this paper as many countries have wide variation in their levels of reserves in reality. There seems to be a region of reserves levels where the country will not run into problems if it stays within it. In other words, there is a level R_L^* , which is the lower bound of reserves below which the central bank will try to regain reserves, and an upper bound R_H^* above which

the central bank will get rid of some of the reserves. However, if $R_L^* < R < R_H^*$, the central bank will simply buy and sell foreign exchange at the predetermined exchange rate in accordance with the rules of the fixed exchange rate regime.

The second departure from the static model is a money market disequilibrium during the transition periods where the money supply is greater than its demand. Since the central bank is committed to buying any extra inflows of foreign exchange under a fixed exchange rate system, it will add to the country's supply of money as it prints and emits new domestic currency in the process. The monetary balances that economic agents hold in excess of what they desire will be partly spent on nontradables and partly on imports until the money market is once again in equilibrium. According to the model, excess money supply jumps to 4 percent of total money balances on impact and is slowly brought down to zero over time.

Lastly, the dynamic model highlights the "overshooting" phenomenon that the real exchange rate is often observed to exhibit. The price of nontradables in the model shoots up by 14 percent before coming down to its final equilibrium level. The underlying explanation for the phenomenon is that although the demand for nontradables goes up immediately following the surge in capital inflows, the adjustments in the supply can only take place gradually over time. Therefore, a sharp appreciation in the real exchange rate is required to equate initially the demand for and supply of nontradable goods. As foreign currency becomes relatively cheaper, resources are gradually driven out of the exporting sector and into nontradables activities. The increased supply of nontradables in response to an expanded demand then helps mitigate the initial jump of the real exchange rate. Nevertheless, the price and production of nontradable goods will permanently remain at higher levels, as the increase in inflows will help finance a higher level of imports and nontradables consumption.

2. Reduction in import restrictions

Next is the case where the country engages in trade liberalization as it experiences a permanent increase in inflows of foreign exchange. In line with the comparative static version, it is assumed that $dT_1^M = -0.1$ and $dT_1^M = 0$ for $t = 2, 3, 4, \dots$. The macroeconomic effects of the reduction in import restrictions are illustrated in Figure 6.

The final equilibrium values obtained in the dynamic model again coincide with those generated from the comparative static one. Imports and exports both exhibit a bigger increase with trade liberalization than without it. The rest of the variables including nontradables output, international reserves, and money supply (and demand) end up smaller with the liberalization than they were in the baseline scenario.

Again, in addition to the direct spending on imports out of foreign borrowings, spending on total imports is further induced by a lower import price brought about by the trade liberalization. As the higher import level helps to speed up the absorption of the extra foreign exchange, the increase in reserves as well as the subsequent expansion in money supply are both less than what are observed in the baseline scenario. All this happens because when inflows jump without a concomitant liberalization, there is a greater excess supply of foreign exchange and hence a greater real exchange rate appreciation than occurs when liberalization is simultaneously at work. As a result, a smaller response in the real exchange rate is needed to generate an equal amount of outflows in foreign exchange.

3. A rise in the demand for real monetary balances

With the incorporation of monetary dynamics in this model, it is now possible to look at a case where the increase in capital inflows is accompanied by a rising demand for monetary balances. The change in money demand is reflected in an increase in k , which represents the increased willingness of the public to hold much larger cash balances than what they would normally hold under the old money demand function. The value of k is chosen in each period such that the change in the unspent portion of the money balances is a reflection of the change in international reserves, i.e. $dM_t^d = dR_t$.

The results, demonstrated in Figure 7, show that real variables such as the real exchange rate, total imports and exports, and nontradables production all remain constant. In contrast, international reserves, money supply, and money demand all go up continuously at steady rates. Specifically, the three monetary variables increase at a constant increment each period, reflecting the full amount of capital inflows coming into the economy.

The overall reduction in extra spending on nontradables

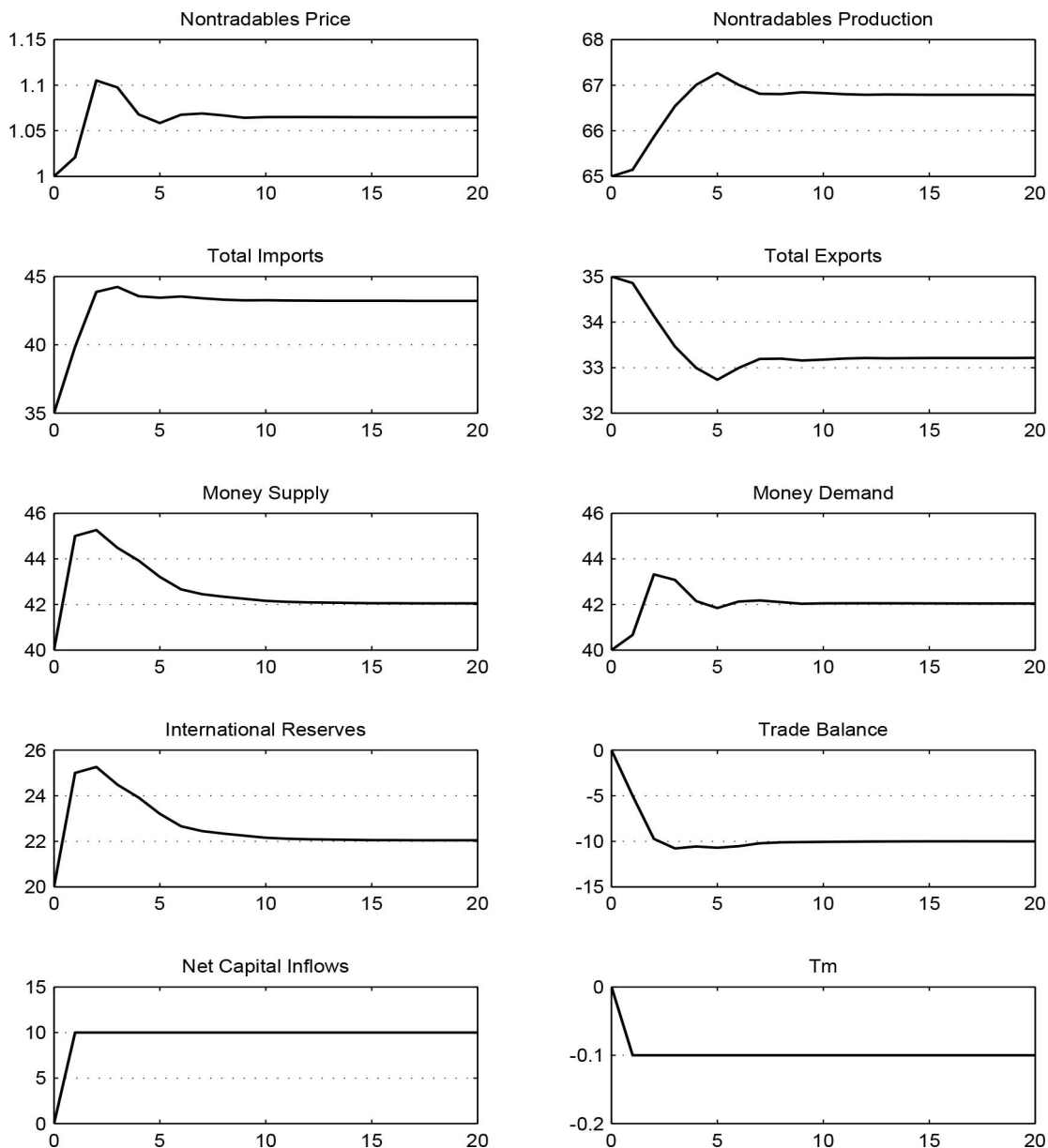


Figure 6. A permanent increase in net capital inflows with trade liberalization.

and imports when compared with the baseline scenario is due to the fact that people are willing to hold all of the excess money as cash balances instead of spending the excess down. As a result, the real exchange rate adjustment required to eliminate the excess money balances in the basic scenario is not necessary in the current case. However, the continuous expansion in foreign reserves and money supply is needed in order to keep up with

the growing monetary balances demanded by the public. If the rising demand for money is not met by a growing supply, the domestic output level will contract, thus creating deflationary pressure on the economy. The results just described capture the notable stability of the domestic price level witnessed in China—the country that underwent a continued expansion in money supply and international reserves without inflation catching up.

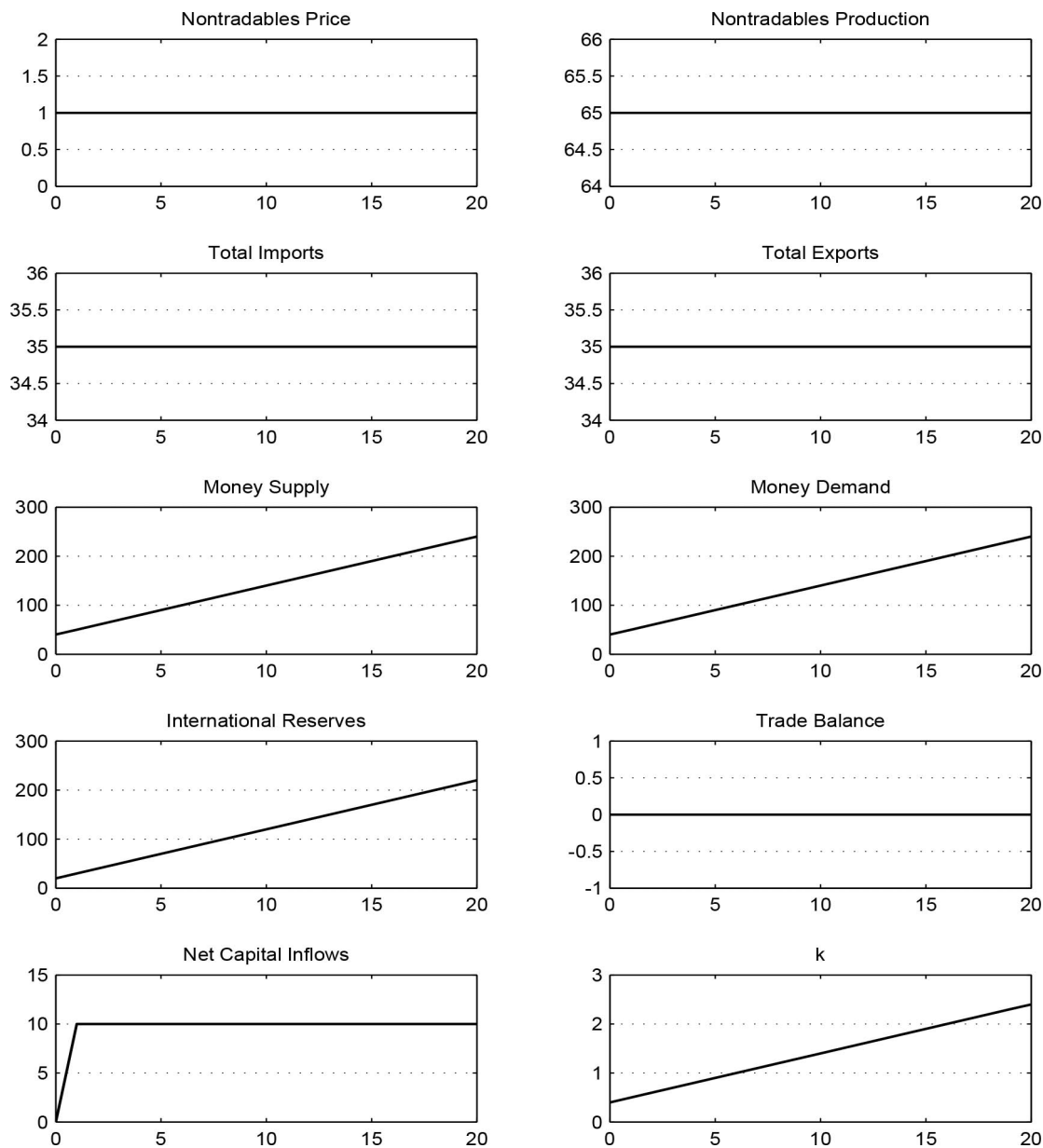


Figure 7. A permanent increase in net capital inflows and a rise in real money demand.

IV. Conclusion

This paper examined the anomalous response of the real exchange rate in China, as it received increasing inflows of foreign exchange while maintaining a fixed exchange rate regime. Contrary to the prediction of a standard theory,

China underwent periods of surging inflows and vast reserves accumulation with little domestic inflation or appreciation in its real exchange rate. Instead of sterilization by the central bank, this has been largely due to sterilization by the people: the public increased their demand for cash balances due to higher income growth and an increase in precautionary savings. Our model demonstrates that

the increased holdings of monetary balances help alleviate some of the inflationary pressure on the economy by absorbing what might otherwise be excess liquidity. In addition, the easing of import restrictions also makes further real exchange rate adjustment less necessary by offsetting some of the extra foreign exchange entering the country.

Many people—economists and politicians among others—have argued that the current account surplus and foreign-reserve buildups in China are due to an undervalued currency, which should lead to a potential disequilibrium in the country's internal macroeconomic environment. This study sheds some light on the controversy by demonstrating why the lack of a real appreciation could well be an equilibrium phenomenon.

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Appendix

The assumptions that are used for the parameters and initial equilibrium values of the static model follow:

- In both scenarios, the economy receives a sudden inflow of capital at the beginning of the period which is equivalent to 10 percent of output ($\Delta B = 0.1y$).
- The initial shares of exports and nontradable supply in total output are 0.35 and 0.65 respectively. Assuming the initial equilibrium value of real output to be 100, the initial supply of exports is 35 and that of nontradables is 65.
- The demand for imports is 35 as it is assumed that trade in goods and non-financial services is balanced initially.
- A value of one is assumed for all prices and wages such that the deviation from its initial value is also the percentage change of the variable. More specifically, P^{X^*} , P^{M^*} , P^H , E and w are all initially equal to one. The initial value of T^M is set to equal to zero so that the domestic price level of imports that the consumers face is one.
- The price elasticities of supply for exports and nontradables are assumed to be 1 and 2 respectively ($\varepsilon_{EX} = 1$, $\varepsilon_H = 2$), and the values imply that $a_1 = 35$ and $b_1 = 130$. The parameter values are obtained from the definition of price elasticity of supply and the initial equilibrium values of the variables:
- $\varepsilon_{EX} = a_1 \cdot \left(\frac{P^{EX}}{EX} \right)$ and $\varepsilon_H = b_1 \cdot \left(\frac{P^H}{H^s} \right)$

where $P^{EX}/EX = 1/35$, and $P^H/H^s = 1/65$.

- On the other hand, the price elasticity of demand for nontradables is assumed to be 0.3 ($\eta_H = 0.3$), which indicates a value of 19.5 for c_1 . The price elasticity of demand for nontradables is defined as positive (see equation 5). Similarly, the parameter value of c_1 is obtained from

$$\eta_H = c_1 \cdot \left(\frac{P^H}{H^d} \right).$$

- The assumed value of the income elasticity of demand for nontradables is 0.7 ($\sigma_H = 0.7$), which implies the marginal propensity to spend on nontradables to be 0.545 ($1 - c_2 = 0.545$). The inferred value of the marginal propensity to spend on imports is then 0.455 ($c_2 = 1 - 0.545$), which indicates the income elasticity of demand for imports to be 1.3 ($\sigma_{IM} = 1.3$). The marginal propensity to spend on nontradables is derived from the following equation:

$$\sigma_H = (1 - c_2) \cdot \left(\frac{y}{H^d} \right)$$

where $y/H^d = 100/65$. The income elasticity of demand for imports can then be calculated as follows:

$$\sigma_{IM} = c_2 \cdot \left(\frac{y}{IM} \right)$$

where $y/IM = 100/35$.

- It is assumed that half of the capital inflows are spent on imports, while the other half go to nontradables ($c_3 = c_3' = 0.5$). Lastly, k is assumed to be 0.4, implying a demand for real monetary balances equal to 40 percent of GDP.

