China's Equilibrium Real Exchange Rate: A Counterfactual Analysis*

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Abstract

China's maintenance of a *de facto* peg against the US dollar during the Asian crisis caused a realignment of exchange rates in the Asian region. This paper explores the "equilibrium" level of China's real effective rate in the lead-up and during that crisis. A derivative of the Devarajan-Lewis-Robinson three-good general equilibrium model is employed to estimate time paths of the equilibrium real effective exchange rate under a variety of assumptions about the balance of trade. Key requirements of the model are indices of import and export prices in time series. Since these are unavailable from secondary sources they are here constructed from trade data. The results suggest that China's real effective exchange rate was on the low side in the four years prior to the crisis, due in part to an extraordinary rate of accumulation of foreign reserves. If, instead, no more than 10 per cent of annual export revenue had been set aside as reserves in this period, it is estimated that China's real effective exchange rate would have been higher by between five and 12 per cent.

1. Introduction

The Chinese government's *de facto* peg to the appreciating dollar in the latter half of the 1990s is said to have stabilised financial flows in the region during the Asian crisis.[1] Yet the peg did lead to substantial nominal and real appreciations against most of China's Asian export competitors.[2] Although the suitability of the *de facto* peg is increasingly being questioned,[3] the associated fluctuations in China's real effective exchange rate highlight the need to identify an "equilibrium" real effective rate and a mix of macroeconomic policies that might bring it about.

[1] See, for example, Dornbusch (1999), Chen (1999) and Ni (1999). One substantial proponent of the dollar peg was the US government, which feared that a devaluation of the RMB would worsen the bilateral trade imbalance with China and raise protectionist pressures in the build-up to the 2000 election. Insiders suggest that one reward for the maintenance of the peg was US agreement on China's accession to the WTO.

[2] For evidence on real exchange rates during the crisis, see Fernald and Babson (2000) and Tyers and Yang (2000).

[3] For recent criticism of the peg, see Zhang and Shen 2000 and Yang and Tyers 2000. Even the IMF has begun to advocate a move toward greater flexibility, as suggested in the Australian Financial Review (AFR), 27 June 2000. And the People's Bank of China (PBC) has responded, in that recent comments by its Governor, Dai Xianglong, confirm that the suggestion of a more flexible policy is 'worth studying' and under consideration (AFR, 20 July 2000).

Earlier papers to address the Chinese real exchange rate include that by Chou and Shih (1998). They investigate movements of the purchasing power parity (PPP) exchange rate, concluding that the *RMB* was overvalued through the 1980s and undervalued in the early 1990s. From a comparison of official exchange rates with an estimated shadow price of foreign exchange, however, they conclude that official rates overvalued the *RMB* throughout the 1980s and early 1990s. Ma (2000) takes a third approach. He constructs a time series for the real exchange rate by deflating changes in the nominal rate. This is then regressed against government expenditure, domestic bank loans, the terms of trade, net exports and the domestic interest rate premium and the fitted values extracted as the "equilibrium" real exchange rate. By this means he finds that the RMB was overvalued after 1995. Finally, Hussain and Radelet (2000) use an index based on the ratio the wholesale prices of Chinas trading partners with China's consumer price index. They find that China experienced a trend real appreciation after 1990, one that accelerated through the Asian crisis.

In this paper, rather than comparing prices across countries directly, we focus on their relative changes through time. Our criterion for "equilibrium" is not the coincidence of the law of one price but instead a "sustainable" range of net inflows on the capital account, defined broadly to include changes in official foreign reserves. We estimate China's real effective exchange rate from recorded data for the period 1987 through 1998 and then use a a simple general equilibrium model to conduct counterfactual experiments. The model is a derivative of that used previously by Devarajan, Lewis and Robinson.[4] It includes only three goods and therefore requires only two behavioural parameters: an elasticity of substitution in consumption and an elasticity of transformation in production. With it, we can not only address the trend of China's real exchange rate but ask how it might have differed under alternative macroeconomic policies. Our results suggest the Chinese real exchange rate was fairly flat after 1990, appreciating only from 1995. Indeed, we assert that it was undervalued after the unification of China's exchange rate in 1994 and through the lead-up period to

[4] See Devarajan et al. (1990, 1993) and Devarajan (1999).

the Asian crisis, due at least in part to an extraordinary rate of accumulation of foreign reserves in this period.[5]

Two important difficulties arise in the application of the model, however. First, the key to the equilibrium level of the real effective exchange rate is a judgement about the "sustainability" of the associated net inflow on the capital account. The larger this is, the larger will be the equilibrium real effective exchange rate. We address this by considering a range of possible net inflows, as proportions of export earnings. Second, the model requires price indices for imports and exports. These are not available from Chinese statistics and so we estimate them from international trade data.

The section to follow reviews the Devarajan-Lewis-Robinson model and our approach to its use. Section 3 then describes the construction of the price indices required while Section 4 derives estimates of the key elasticities in the model. In Section 5 the sustainability of capital account flows is discussed and, in Section 6, a range of equilibrium real effective exchange rates are derived and compared with those observed. Section 7 offers conclusions.

2. The Model

Our economy is small and open and its output includes two imperfectly transformable varieties, one of which, *X*, is exported and the other, *D*, is consumed domestically. From the viewpoint of consumers, *D* is an imperfect substitute for imports, *M*. Devarajan et al. (1990) call this characterisation of a single economy with two activities (*D* and *X*) and three commodities (*D*, *X* and *M*) the 1-2-3 model. In it the representative household has constant elasticity of substitution (*CES)* utility:

$$U = \left(\alpha_D D^{-\rho} + \alpha_M M^{-\rho}\right)^{-\frac{1}{\rho}} \tag{1}$$

where the αs are (constant) share parameters and $\rho > -1$. When maximised subject to $p_D D + p_M M = Y$, the first order conditions yield:

[5] China's premier Zhu Rongji defended the massive reserve accumulation in early 1997 as helping "to keep Hong Kong stable" (Wei and Zeckhauser 1998). Since we find that this accumulation of reserves suppressed China's real effective exchange rate in the lead-up to the financial crisis, however, the question arises as to whether this action might have had a destabilising effect on the other exporters in the region.

(2) $$\frac{M}{D} = \left(\frac{\alpha_M}{\alpha_D}\right)^{\sigma}\left(\frac{p_D}{p_M}\right)^{\sigma}$$

where the elasticity of substitution is $\sigma = 1/(1+\rho) > 0$. In proportional change form this equation becomes:

(3) $$\hat{M} - \hat{D} = \sigma\left(\hat{p}_D - \hat{p}_M\right).$$

The production side is summarised by a constant elasticity of transformation (CET) surface:

(4) $$Q = \left(\beta_D D^{-\delta} + \beta_X X^{-\delta}\right)^{-\frac{1}{\delta}}$$

where the βs are (constant) share parameters and $\delta < -1$. The profit maximisation behaviour of firms serves to maximise nominal GDP, $Y = p_D D + p_X X$, subject to this constraint. Again, the first order conditions yield:

(5) $$\frac{X}{D} = \left(\frac{\beta_D}{\beta_X}\right)^{\Omega}\left(\frac{p_X}{p_D}\right)^{\Omega}$$

where the elasticity of transformation is $\Omega = -1/(1+\delta) > 0$. In proportional change form this is:

(6) $$\hat{X} - \hat{D} = \Omega\left(\hat{p}_x - \hat{p}_D\right).$$

It remains to specify the balance of payments. Here we abstract from tariff and non-tariff barriers affecting trade and emphasise the role of the capital account. The exogenous border prices, p_x and p_M, are measured in US dollars and then converted to domestic currency. No distortions are considered, aside from those embodied in this currency conversion. For balance, the sum of net inflows on the capital account, *KA*, and net inflows on the current account, *CA*, must be zero. The net (private and official) inflows on the capital account are:

(7) $$KA = S_{NF} - \Delta R$$

where S_{NF} is the net inflow of private foreign savings to finance investment and ΔR is the annual increment to official foreign reserves. Those on the current account are:

(8) $$CA = p_X X - p_M M + r^* K_{CW} - rK_F$$

where r^* and r are the foreign and domestic rates of return, K_{CW} is the total holding of assets abroad by Chinese households and public and private institutions and K_F is the total

holding of Chinese assets by foreigners. Since *KA + CA = 0*, we have from (7) and (8) that:

$$(9) \qquad \frac{p_M M}{p_X X} = 1 + \frac{[r^*(K_{CW} - K_F) - \pi K_F] + [S_{NF} - \Delta R]}{p_X X} = \lambda$$

where π is the premium on the rate of return on investments in China ($r = r^* + \pi$), the first term in square parentheses is the net income component of the current account and the second, which has most often dwarfed the first in magnitude, is the net inflow on the capital account.

The parameter λ is defined here for consistency with the approach of Devarajan, Lewis and Robinson. We spell it out in this way to make clear its dependence on net inflows on the capital account and the extent to which private net inflows, S_{NF}, might be offset by the accumulation of foreign reserves, ΔR.[6] The parameter λ might therefore be thought of as approximately one plus net capital account inflow as a proportion of export earnings. When this inflow rises relative to export earnings imports also rise relative to export earnings and so λ rises. Equation (9) is then readily converted to proportional change form as[7]:

$$(10) \qquad \hat{p}_M + \hat{M} = \hat{p}_X + \hat{X} + \hat{\lambda}$$

We then have three simple equations in proportional changes, (3), (6) and (10). By subtracting (6) from (3) and then (10) from the result we have the following expression for the proportional change in the price of domestic goods in terms of the corresponding proportional changes the border prices and in λ:

$$(11) \qquad \hat{p}_D = \left(\frac{\Omega\,\hat{p}_X + \sigma\,\hat{p}_M}{\Omega + \sigma}\right) + \left(\frac{\hat{p}_X - \hat{p}_M}{\Omega + \sigma}\right) + \left(\frac{\hat{\lambda}}{\Omega + \sigma}\right)$$

The beauty of this expression is that it allows the endogenous change in the domestic price level to be decomposed into three components, the first being due to a change in

[6] We are aware that China had capital controls in place throughout the period of interest here. These did not prevent substantial private capital account flows, however, and a considerable enlargement of these flows during the subsequent crisis, as indicated by Tyers and Yang (2000).

[7] This form is slightly awkward since λ comprises both components we expect to make exogenous, in particular S_{NF} and ΔR, and the value of exports, which is endogenous. We will treat it as an exogenous variable, however, choosing its value in relation to export earnings. Alternative proportional change reductions of equation (9) are no more attractive in the case of China because the sign of the trade balance (and the capital account balance) changes during the period of interest.

foreign prices, the second to a change in the terms of trade and the third to a change in net inflows on the capital account. Given that the border prices are observable and exogenous to the small open economy and that changes in the domestic price level are the keys to real exchange rates, this expression allows us to relate capital account flows directly to the real exchange rate.

We define the nominal exchange rate, *E*, according to modern convention, as the number of units of foreign exchangethat might be obtained in return for a unit of the domestic currency. It is then natural to define the real exchange rate, e^R, correspondingly, as the number of baskets of foreign produced goods and services obtained were a corresponding basket of domestically produced goods and services to be likewise relinquished. It follows that the bilateral real exchange rate with trading partner *i* depends on the ratio of the GDP deflators of the two countries, $P^Y(p_D, p_X)$ and P_i^Y:

$$e_i^R = E_i \frac{P^Y(p_D, p_X)}{P_i^Y}. \tag{12}$$

The real effective exchange rate is then a trade weighted average of these bilateral real exchange rates:

$$e^R = \sum_i \left[\left(\frac{p_X^i X_i + p_M^i M_i}{\sum_i p_X^i X_i + \sum_i p_M^i M_i} \right) E_i \frac{P^Y(p_D, p_X)}{P_i^Y} \right] \tag{13}$$

Where p_X^i and p_M^i are bilateral trading prices while p_X and p_M are indices over all the focus country's exports and imports, respectively.[8]

The link between the real effective exchange rate and flows on the capital account is now clear. It begins with the parameter λ, which depends positively on net inflows on the capital account (S_{NF} - ΔR) via equation (9). The price of the domestic non-traded good, p_D, then depends positively on λ via equation (11) and finally, the real effective exchange rate depends positively on p_D via equation (13). The equilibrium real exchange

[8] A commonly used alternative measure (Hussain and Radelet, 2000) is the trade-weighted average of the ratio of the local consumer price to the wholesale price of each trading partner. This measure retains prices of non-traded services in the numerator but not in the denominator. For "small" open economies, this measure and the ratio of GDP deflators used in this paper follow very similar paths through time.

rate can then be calculated from these equations based on either a recorded series for the trade balance parameter, λ, or a counterfactual one.

3. Construction of the Price Indices:

As is clear from the previous section, the model depends critically on the availability of import and export price indices. Since these are not supplied by the Chinese authorities, it has been necessary for us to construct them from UN Commodity Trade Statistics by averaging unit values across traded commodities. While this approach shares a number of deficiencies with all index construction[9] it is the best available option if equilbrium real exchange rates are to be analysed at the suggested level of aggregation. A deficiency of particular importance is that the trade data are available only on an annual basis. This constrains the quality of our subsequent estimates of the elasticities of substitution and transformation.

To make clear our method, consider the case of the export price index, p_{Xt}, $t \in (0,T)$, which is a weighted average of commodity prices, p_{Xt}^{j}, across traded commodities, j for each year, t. If the base year, from which the weights are derived, is $t=0$, we seek:

$$p_{Xt} = \frac{\sum_i p_{Xt}^i X_0^i}{\sum_i p_{X0}^i X_0^i}. \tag{14}$$

This is the same as:

$$p_{Xt} = \sum_i \left[p_{Xt}^i \left(\frac{X_0^i}{\sum_i p_{X0}^i X_0^i} \right) \right], \tag{15}$$

where the weight is given in the interior parentheses. Since trade data offers only values, V_t^i,and volumes, X_t^i, equation (15) becomes:

[9] The same deficiencies are common amongst averages of prices across disparate commodities in time series. First, there is the problem of emerging and expiring goods. Then, the composition within categories of goods changes through time. Even if it did not, the quality of goods changes through time. Finally, trade unit values need not reflect product prices at the margin.

$$(16) \qquad p_{Xt} = \sum_i \left[\frac{V_t^i}{X_t^i} \left(\frac{X_0^i}{\sum_i V_0^i} \right) \right].$$

This is our operative relationship for the export price index and the approach taken to the import price index is the same.

As indicated earlier, we use annual data from 1986 through 1998. We go down to four digits of the Standard International Trade Classification, which yields about 400 types of goods. The emerging and expiring goods problem, combined with the loss of those categories that specify the value of trade but no volume, reduces the coverage of the index to about half the total value of imports and exports. The resulting price indices are converted to domestic currency at the prevailing nominal exchange rate for each year. In years where China maintained two segmented foreign exchange markets (the internal settlement and the swap markets) an exchange market value-weighted average of the two rates is used.

The problem of emerging and expiring goods is quite significant in the results. The proportion of product categories that are present throughout the interval covers between a quarter and a half of the total value of exports and imports. The precise proportions for each year are listed in Table 1. These relatively low proportions notwithstanding, we have chosen to include only those product categories that have content throughout the series since allowing the content of the index to vary would exacerbate errors due to aggregation bias and product quality escalation.

Data for China's annual nominal exchange rates and the GDP deflators of its main trading partners are from the IMF's *International Financial Statistics.* Current value and real GDP are drawn from China's *Statistical Yearbook.* The volume, D, and price, p_D, of domestic non-traded goods are derived from the Chinese national accounts via the GDP identity $p^Y Y = p_D D + p_X X$ and:

$$(17) \qquad p_D = \frac{P^Y - S_X p_X}{1 - S_X},$$

where S_X is the export share of GDP.

The resulting series for the US$ prices of China's exports and imports are plotted in Figure 1. The time path of the US$/Yuan exchange rate is plotted in Figure 2 and the

corresponding domestic currency prices of exports, p_X, and imports, p_M, are plotted in Figure 3. These prices are listed, along with the our constructed index for the domestic price of home goods in China, p_D, in Table 2.

4. Estimating the Elasticities:

Estimates are required of the two essential parameters, the elasticity of transformation in supply, Ω, and the elasticity of substitution in demand, σ. For the short adjustment intervals of interest here, Devarajan et al. (1998) suggest that these aggregate elasticities are less than unity for most developing countries and that they are smallest for low-income primary-exporting economies. One approach to estimating them is to use values that represent the weighted averages of sector-specific elasticities, which might stem from comparatively accurate econometrics (Devarajan et al. 1993). Here we rely on simple time series econometrics to estimate them.

From equation (2), we have that

$$\ln\frac{M}{D} = \sigma \ln\frac{\alpha_M}{\alpha_D} + \sigma \ln\frac{P^d}{P^m} \quad . \tag{18}$$

Regression on our annual data over the period 1987 to 1998 yields:

$$\ln\frac{M}{D} = -1.68 + 0.30 \ln\frac{P^d}{P^m} + 0.34 dm1 \tag{19}$$

(-28.09) (0.67) (3.54)

Adjusted R^2=0.49, F=6.31, SSE=0.14

The numbers in parenthesis are t-statistics and *dm1* is a dummy variable that is unity in the years 1994, 1995 and zero otherwise. The dummy variables allow for variation in the constant term in the years most affected by China's foreign exchange reforms. The result is not strong but the estimate that follows from it, an elasticity of substitution $\sigma = 0.3$, is in the anticipated range following Devarajan et al.

Turning to the elasticity of transformation, from equation (5), we have that:

$$\ln\frac{X}{D} = \Omega \ln\frac{\beta_D}{\beta_X} + \Omega \ln\frac{P_X}{P_D} \tag{20}$$

Regression on the same period as above yields

$$\ln\frac{X}{D} = -1.53 + 0.66\ln\frac{P_X}{P_D} - 0.41\,dm2 \qquad (21)$$

(-14.09) (0.58) (-2.33)

Adjusted $R^2 = 0.71$, F=9.90, SSE=0.15

The numbers in parenthesis are t-statistics. This sime the dummy variable is included to allow adjustment in the constant term during the domestic instability just prior to the end of the decade. From this we adopt a measure of the elasticitiy of transformation of Ω*=0.66*. Once again, the result is not a strong one, though it also accords with estimates for other developing countries by Devarajan et al.

5. Current Account Sustainability

China's current account switched from deficit to surplus by the end of the 1980s and it was only once again in deficit, in 1993, the magnitude of the surplus rising steadily thereafter. Prior to 1993 deficits and surpluses never exceeded two per cent of China's GDP. Yet the surpluses rose to five per cent by the late 90s. The corresponding values of λ, the ratio of import cost to export revenue, are given in Table 3 along with values for other East Asian countries. The dramatic decline in λ during the mid-1990s is unique to China, though Singapore does exhibit a much more gradual decline. Surprisingly, though their economies are developing and comparatively capital-scarce, for most of the 1990s "greater China" (including Taiwan and Hong Kong) and Singapore maintain trade surpluses and capital account deficits. This pattern fairly common in Asia though it is uncommon amongst other developing countries. Indeed, the Asian surpluses notwithstanding, for developing countries as a group there is a substantial current account deficit.[10]

The reason for China's surplus is a trend toward net outflows on the capital account driven, after 1993, by a rapid expansion in China's official foreign reserves.[11] Indeed, more than three per cent of China's GDP was salted away each year into official foreign assets between 1994 and 1997. The association between λ and this pattern of changes in foreign reserves is clear from Figure 4. Only in 1998 does there appear to be

[10] See IMF, *World Economic Outlook*, October 2000, Table 30.

a significant departure. In that year, although the accumulation of reserves almost stopped, there were significant private outflows. These stemmed, first, from a rise in domestic savings due to domestic reforms and second, to a risk premium increase associated with the Asian financial crisis (Fernald and Babson 2000, Tyers and Yang 2000).

The patterns of changes in both λ and the rate of reserve accumulation followed corresponding changes in export revenue, particularly after 1993. To see this we fitted an exponential time trend to China's exports and plotted the residuals along with the change in reserves as proportions of export earnings, as shown in Figure 5.[12] Except for the years 1989 through 1991, the correspondence is very close. Clearly, at least after the exchange rate was unified, better than trend export earnings were retained in part as foreign reserves. As the figure shows, however, in the years 1994 through 1997 the share of export earnings salted away was larger than the over-trend proportion. By the time of the Asian crisis China's official foreign reserves amounted to 15 per cent of GDP, an extraordinary proportion for developing and developed countries alike.[13] Holding back this proportion of export earnings surely kept China's real exchange rate lower (and hence more competitive for exporters) than it would otherwise have been. This, along with insurance against then unforeseen events like the eventual Asian financial crisis, surely motivated the choice to do so.

Comparing the values of λ across the other countries listed in Table 3, if the years surrounding the Asian crisis are ignored, all countries experienced values in the range 0.9 through 1.1. A sustainable trade account for China must surely exist within this range. As noted earlier, one would expect to see developing countries, which have comparatively low levels of capital per worker and hence must finance a greater proportion of the investment required for growth from abroad, to occur more frequently in the trade deficit category. Indeed, at China's comparatively high rates of economic growth, substantial foreign commitments can be accumulated without any increase in its

[11] This is in spite of unprecedented private inflow during these years in the form of foreign direct investment (Shengman, 1999).
[12] The fitted curve for nominal export earnings is $ln[p_x X] = -322 + 0.164\ t + \varepsilon$, implying an average growth rate of 16 per cent per year.
[13] For comparisons, see IMF: *World Economic Outlook*, October 2000, Table 36.

net foreign debt to GDP ratio. We would therefore expect the sustainable range to have $\lambda>1$. Nonetheless, a conservative range for China's trade balance is surely ($0.9<\lambda<1.1$).

6. The Real Effective Exchange Rate

Before calculating China's real effective exchange rate, it is useful to perform a validation test of the aggregated general equilibrium model. We do this by constructing a simulated series for p_D, using equation (11), from our observed values for p_M, p_X and λ. In Figure 6 this artificial series is displayed and compared with its observed counterpart (which is derived from China's GDP deflator using equation 17). The fit is quite good through 1996 but it fails in the Asian crisis years 1997 and 1998. The model predicts a much lower domestic price level in China than was recorded in those years. In this instance, we are inclined to believe the model rather than the official statistics, which we suspect understated the magnitude of the deflation in that period.[14] Apart from this, the model captures the trends and turning points of p_D well. The amplitude of departures from the trend is slightly larger in the simulated series, possibly suggesting that the elasticities of substitution and transformation (σ and Ω) may be underestimated. Of course, construction from equation (11) is subject to error whenever the annual changes are large[15]

The rising trend in the price of the domestic good in the 1990s arises from substantial increases in 1993, 1994 and 1996. By separating the components of equation (11) we examine the contributions to these rises due to changes in the trade balance, the terms of trade and the level of foreign prices. The results are given in Table 4. The major surge in 1993 is seen to stem primarily from the trade balance. This was a year in which reserves changed little and exports were below trend but in which imports and domestic inflation surged. The following year, however, the exchange rate was unified, export earnings returned to trend and an unprecedented sum was set aside as reserves (Figure 5). The trade balance effect therefore acted to reduce the price of the domestic

[14] A surge in outflows on the capital account, combined with adherance to fixed parity with an appreciating US$ had to depress the home price level significantly. In a different analysis, Tyers and Yang (2000) also find evidence that the deflation was understated by the official statistics.

[15] An alternative hypothesis is that the smaller amplitude of the "actual" series is due to its mode of measurement, which is subject to the many errors discussed in estimating the trade prices in Section 3.

good. This effect was, however, more than offset by a rise in export prices - an improvement in China's terms of trade (Figures 1 and 3). In 1996, the trade balance effect was small but, again, the dominant force pressing upward the price of the domestic good was the marked improvement in the terms of trade indicated in Figures 1 and 3. Although it has not always been the dominant force the trade balance effect corresponds closely with the simulated price changes of the domestic good. This is shown in Figure 7, which compares the annual proportional changes in p_D with those in λ. Given the close correspondence between the trade balance and the accumulation of official foreign reserves indicated in Figure 4, the management of the latter clearly had an important influence over the home price level.

The next step is to calculate the real effective exchange rate from equation (13). We do this first from the raw data, including an estimate of the Chinese GDP deflator derived from nominal and real GDP estimates.[16] We then use the model to derive the artificial series for p_D in Figure 6 and, from it, construct a correspondingly artificial series for the GDP deflator, p^Y. This, in turn, is used in equation (13) to derive a simulated real effective exchange rate based on observed trade balance statistics. The two series are compared in Figure 8 and listed in Table 5. Once again, the tracking is fair prior to the Asian crisis years but the simulation projects lower than the recorded values thereafter.

The final step is to use the model to simulate the real effective exchange rate at the bounds of the "sustainable" trade balance range. To do this we set an artificial path for λ by beginning with the observed value for 1987 and stepping in five per cent increments to one of the target values: $\lambda=(0.9, 1.0, 1.1)$. Equation (11) is then used to calculate an artificial series for p_D. Time-varying but exogenous export shares of GDP are then used to construct a corresponding series for the GDP deflator, p^Y. This is used in equation (13) to prepare our simulated series for the real effective exchange rate. The resulting series are set out in Table 5 and illustrated in Figure 9.

[16] For the effective rate, the weighted average is here taken over the bilateral trade values and price indices of mainland China's six largest trading partners: Japan, the US, Korea, Hong Kong, Taiwan and Germany. Trade with these economies amounted to 68% of mainland China's total trade during the period 1987 through 1998. Sources are the IMF's *International Financial Statistics* and, for Taiwan, the *Monthly Price Bulleting of Gaohsiong*.

The path of China's real effective exchange rate skirts the upper bound of the range briefly in the early 1990s. After 1993, however, it adheres to the lower bound (λ=0.9). In the four years leading up to the Asian crisis there is a tendency for the real exchange rate to be undervalued. As shown in Figure 6, during these years a combination of balance of payments and terms of trade shocks saw China's p_D rise quite rapidly. Yet prices abroad were rising at least as quickly in Chinese currency terms (the nominal exchange rate with the US dollar was very stable after 1994, as indicated in Figure 2), so the real exchange rate did not rise until 1996. Even then, the results in Table 5 indicate that balanced trade in that year would have delivered a real effective exchange rate five per cent higher than observed. Had a modest trade deficit of 10 per cent of exports (roughly 1.5 per cent of GDP) been maintained, the real exchange rate would have been higher by 13 per cent.

This undervaluation is due in part to the extraordinary rate at which official foreign reserves were accumulated in 1994 through 1997. An approximation to the magnitude of its contribution can be gleaned from the following rearrangement of equation (9).

$$\frac{p_M M}{p_X X} = \lambda = \left[1 + \frac{r^*\left(K_{CW} - K_F\right) - \pi K_F + S_{NF}}{p_X X}\right] - \frac{\Delta R}{p_X X} \tag{21}$$

Imagine that the annual increment to official foreign reserves is constrained not to exceed 10 per cent of export revenue. At the same time, imagine that there are no associated changes in the risk premium on investments in China, π, and the magnitude of private flows on the capital account, S_{NF}. Then the term in square parentheses would have remained constant and the changes in λ due to the different series for ΔR would be readily calculated. This calculation is undertaken in Table 6 and the results are displayed in Figure 9. The effect is to raise China's real effective exchange rate in the lead-up to the Asian crisis by between 12 per cent (in 1994) and five per cent (in 1997).

Such a course of action would have raised imports, leading to higher consumption. The higher domestic price level would also have reduced Chinese unemployment and thereby enhanced economic growth in that period. On the other hand, the stock of official foreign reserves at the time of the crisis would have been, on the assumptions made above, only half the 15 per cent of China's GDP held abroad in

1997.[17] This would have rendered China more vulnerable to a "country run" than it was. Yet the crisis had been triggered, at least in part, by declining export competitiveness of the most affected countries, principally Thailand, Korea, Malaysia and Indonesia. Because of its macroeconomic policy, China had gained competitiveness in this period at the expense of these competing exporters. Its share of both Asian and global exports expanded substantially between 1994 and 1997 (Hussain and Radelet, 2000). Had China been less competitive during this period, it is possible that the crisis might have been avoided or it might have taken a different form. Indeed, by overinsuring, China may have helped precipitate the very event it was insuring against.

7. Conclusion:

The trend of China's equilibrium real effective exchange rate in the lead-up to the Asian financial crisis is examined and found to be quite flat until 1996, when it rises significantly for the first time in the 1990s. The Devarajan-Lewis-Robinson three-good general equilibrium model is used to simulate the time path of home prices and the real effective exchange rate from the late 1980s through 1998 under alternative assumptions about the trade balance. To adapt the model, however, accurate series are needed for indices of export and import prices. Since these are not available from Chinese government statistics, estimates are derived from UN commodity trade statistics. When the recorded time path of China's trade balance is used in the simulations the results show a fair fit to the trend of China's implied GDP deflator, except for a more substantial than recorded deflation in 1997 and 1998. We believe it to be quite possible that China's deflation in this period was understated by official statistics.

In part because of an unprecedented rate of accumulation of official foreign reserves, China's trade balance moved well into the surplus range after the unification of its exchange rate in 1994 and through 1997. This caused the domestic price level, and hence the real effective exchange rate, to be lower than it would otherwise have been. Indeed, one would expect a rapidly expanding, capital scarce developing country like China to be able to sustain some degree of trade deficit without any expansion of the net

[17] When the ceiling of 10% of export revenue is imposed after 1987, assuming no change in the volume and price of exports, reserves at the start of 1998 are US$ 78 billion, down from the observed US$ 145 billion.

foreign debt to GDP ratio. Such a strategy, had it been adopted in the 1990s, might have fostered even more economic growth and improvements in living standards than were achieved. We therefore conjecture that China's equilibrium real effective exchange rate was higher than that observed in the lead-up to the crisis. Indeed, a crude estimate based on the addition to official foreign reserves of no more than 10 per cent of export earnings in any year suggests undervaluation by between five and 12 per cent.

China can therefore afford to accumulate reserves more slowly in future and to allow its real exchange rate to appreciate somewhat. This can occur even if it retains its *de facto* peg to the US dollar, since it will have the effect of raising the domestic price level. If monetary policy continues to target the exchange rate, additional increases in the domestic price level can be obtained by further fiscal expansion. While ever monetary policy is thus constrained, such increases in the price level will be self-limiting. In Chinese labour markets, then, the dislocation that is the inevitable consequence of continued domestic economic reform can be more easily managed. The real appreciation that results will see export growth slow and imports rise more quickly, yet the growth of consumption and the size of the overall economy should be accelerated.

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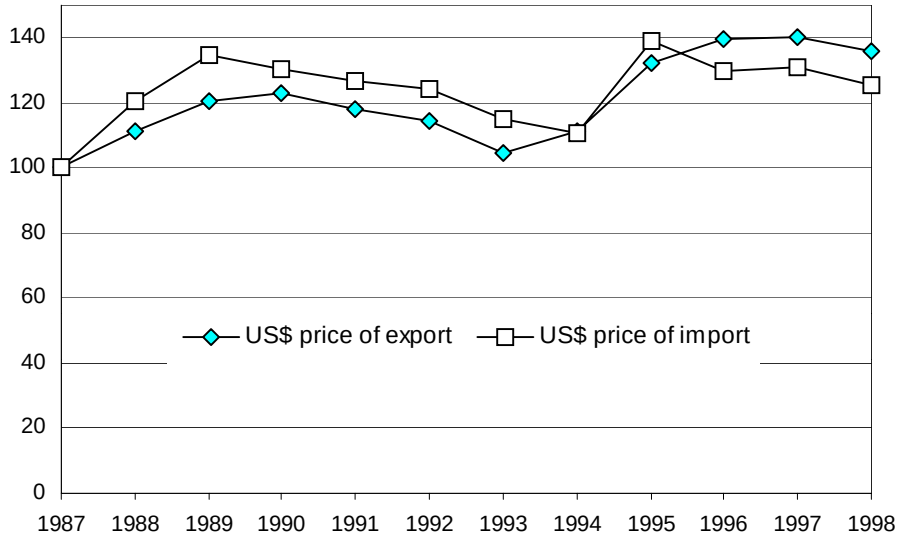
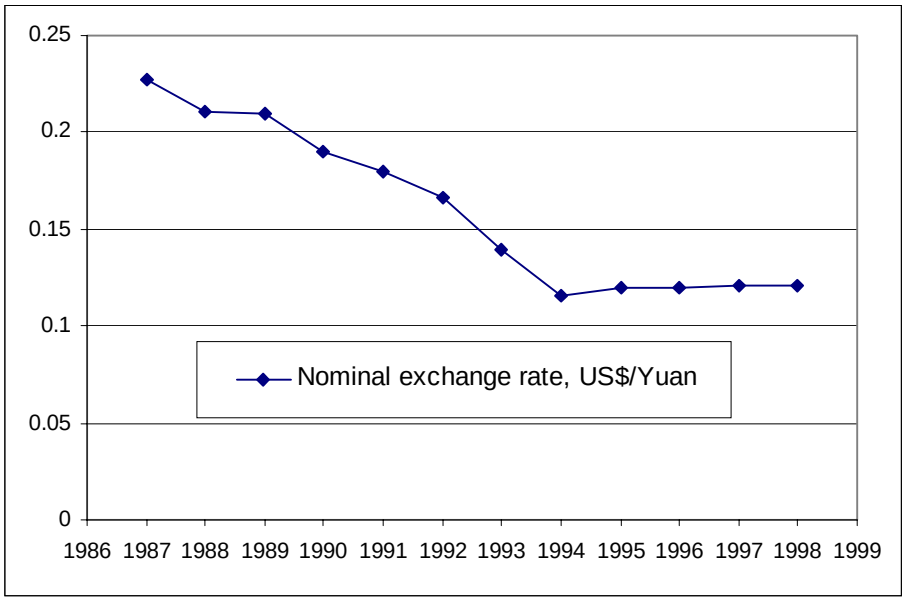
Figure 1: Constructed US$ Prices of Exports and Imports



Source: Constructed from UN Commodity Trade Statistics, as explained in the text.

Figure 2: China's market nominal exchange rate with the US dollar



Source: Prior to 1994 two exchange rates were used (the internal settlement rate and the swap rate). In these years an exchange market value-weighted average of the two rates is used. Data are from the IMF: *International Financial Statistics*.

Figure 3: Constructed Home Currency Price Indices of Exports, Imports and the Domestic Good

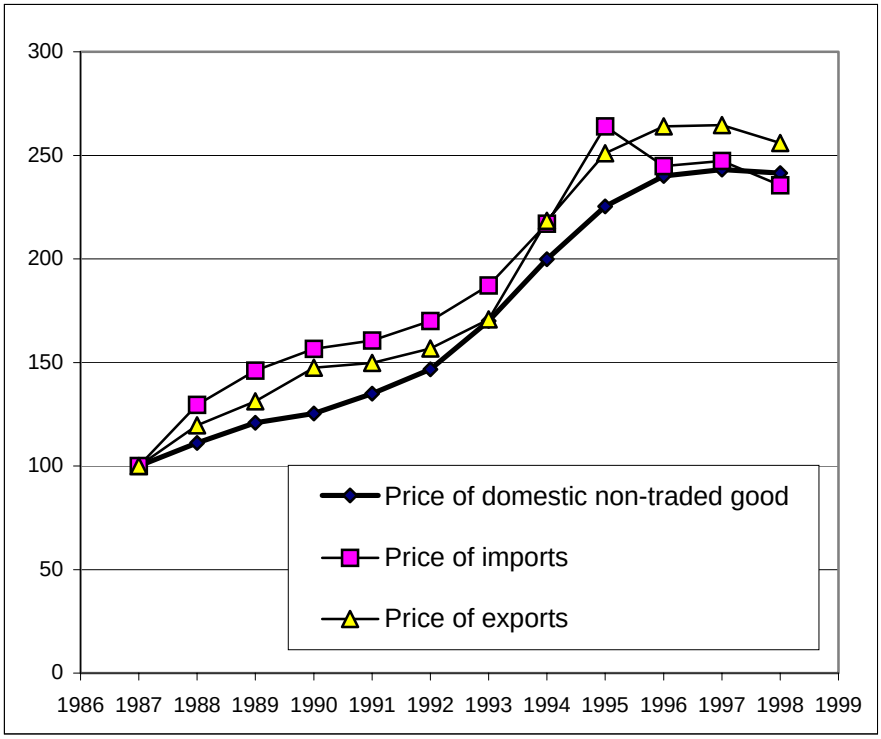


Figure 4: Imports and the annual decline in official foreign reserves as % of export earnings, China

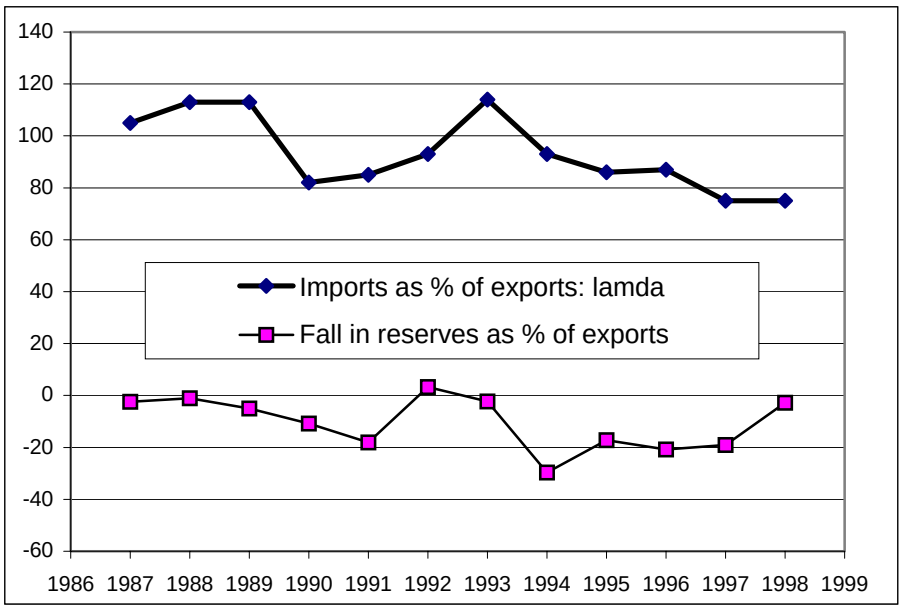


Figure 5: Changes in official foreign reserves and departures from trend export earnings, China

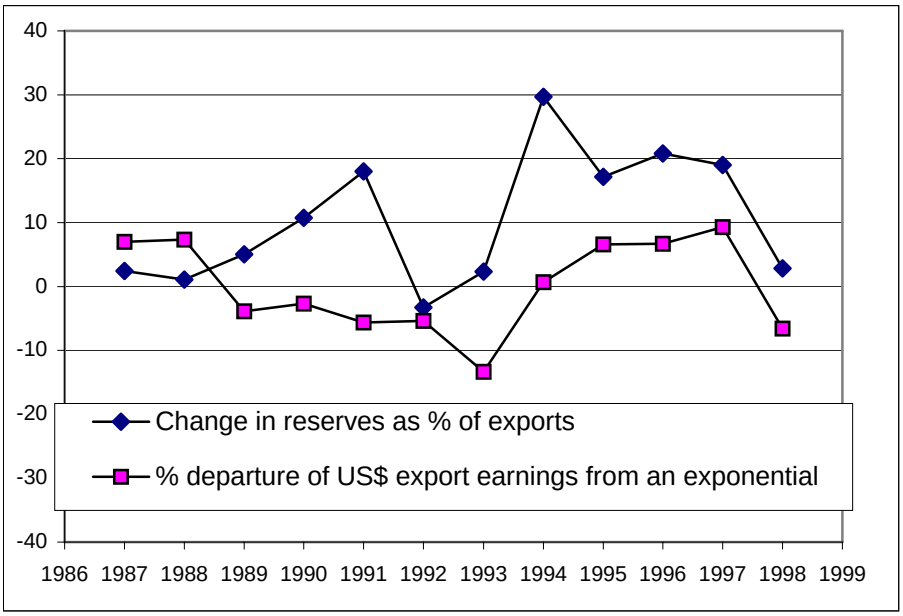
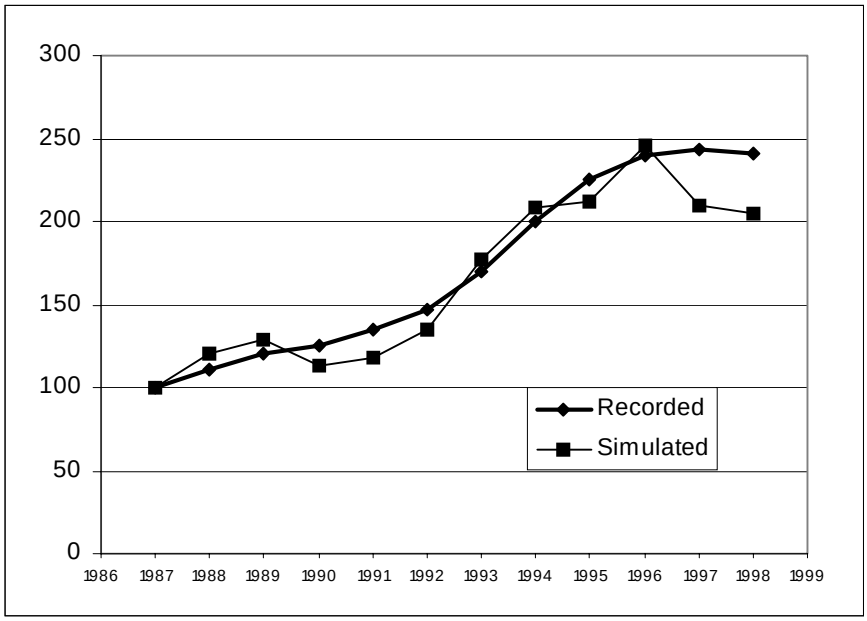
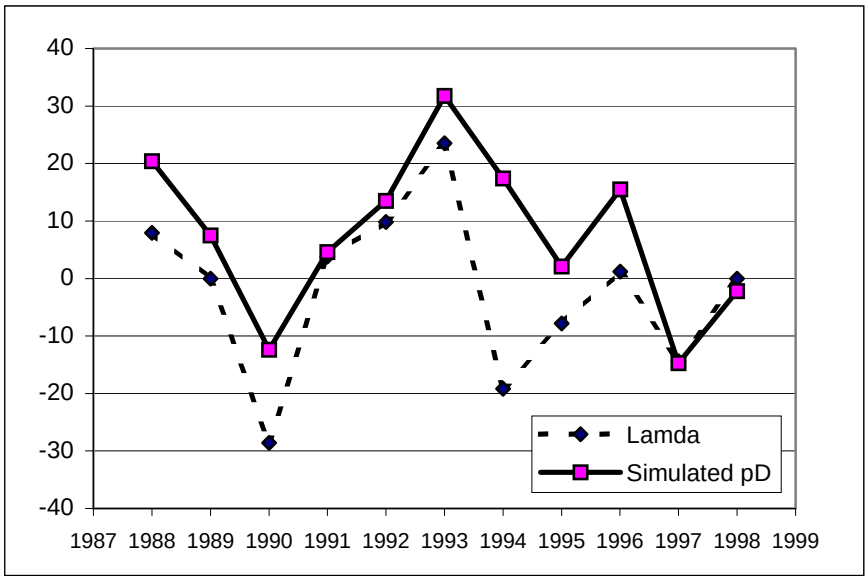


Figure 6: Recorded and Simulated Values for p_D (1987=100)



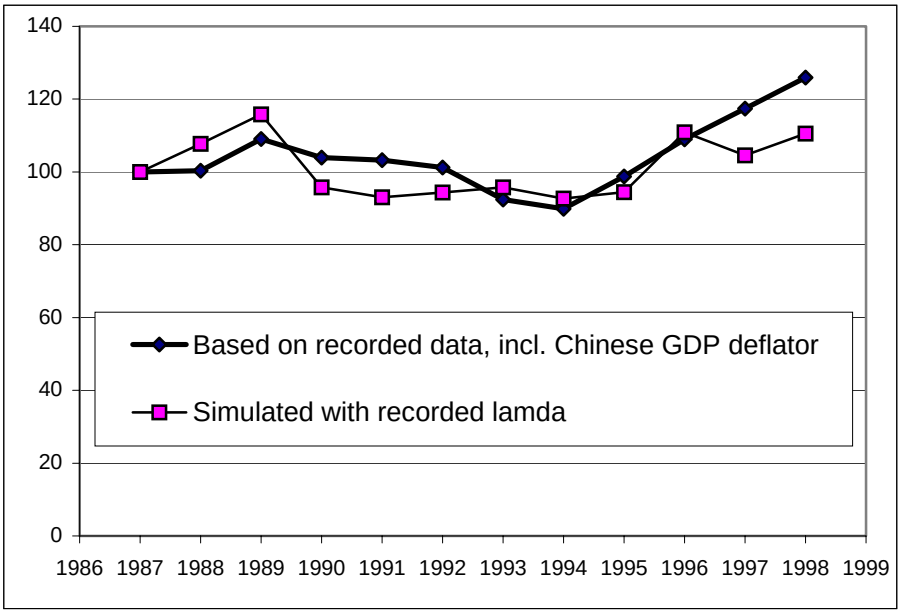
Source: Recorded local currency price of domestic good, estimated from data for real and nominal GDP and the export share of output. Simulations are based on model discussed in the text using the recorded trade balance.

Figure 7: Annual Proportional Changes in λ and simulated p_D, %



Source: Annual % changes in recorded λ from Table 3 and simulated values of p_D.

Figure 8: Comparing Actual and Simulated Real Effective Exchange Rates



Source: Constructed from equation (13) in the text.

Figure 8: Comparing the Actual Real Effective Exchange Rate with Simulated Rates for the Range $\lambda = 0.9 - 1.1$

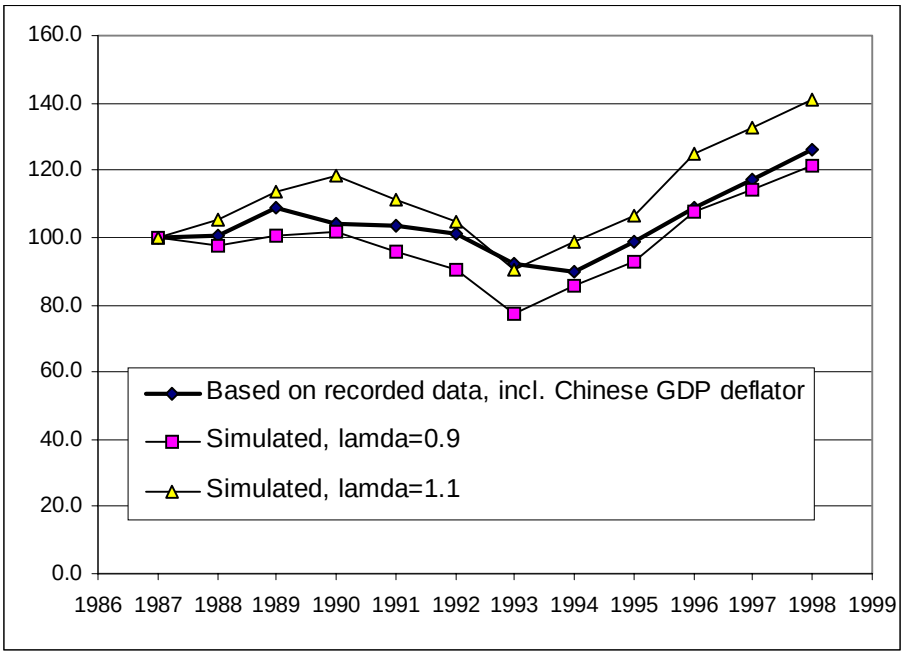


Figure 9: The Effect on China's Real Effective Exchange Rate of a Ceiling on Increments to Reserves of 10% of Exports

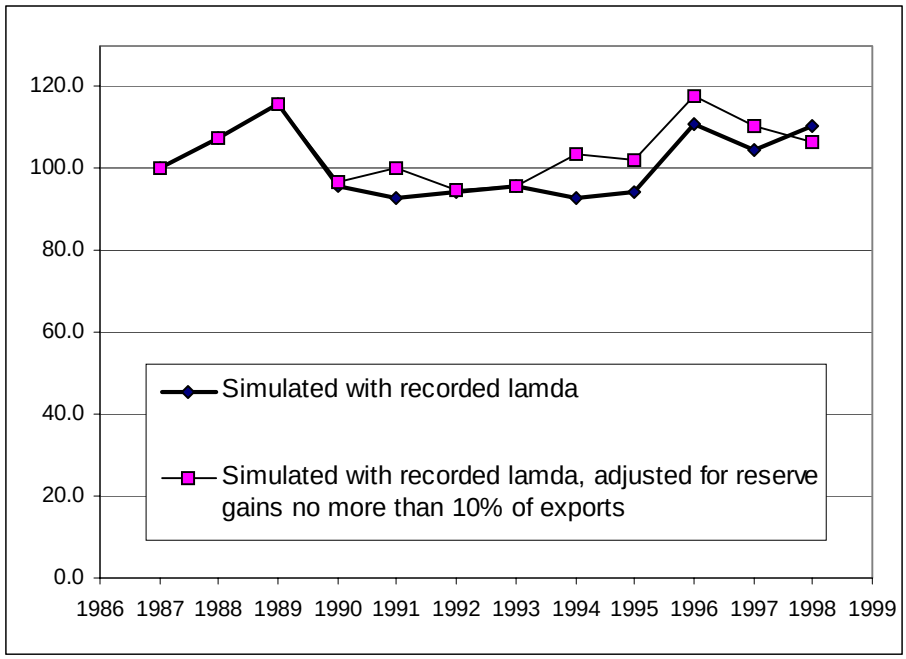


Table 1: Proportion of Total Trade Value Covered by the Export and Import Price Indices

	export	import
1987	0.47	0.42
1988	0.44	0.43
1989	0.41	0.45
1990	0.38	0.39
1991	0.34	0.38
1992	0.30	0.42
1993	0.28	0.41
1994	0.27	0.39
1995	0.27	0.41
1996	0.26	0.40
1997	0.24	0.41
1998	0.22	0.37

Source: Processed from UN Commodity Trade Statistics as explained in the text.

Table 2: Indices for Prices of Exports, Imports and the Domestic Non-Traded Good

	US$ Prices of		Domestic Currency Prices of		
	exports	imports	domestic good	exports	imports
1987	100.00	100.00	100.00	100.00	100.00
1988	111.11	120.26	111.11	119.65	129.51
1989	120.77	134.35	120.79	131.24	146.00
1990	123.05	130.60	125.36	147.51	156.56
1991	118.25	126.79	134.98	149.80	160.61
1992	114.46	124.14	146.72	156.69	169.94
1993	104.80	114.83	169.95	170.84	187.18
1994	111.49	110.72	199.77	218.43	216.94
1995	132.19	139.08	225.35	250.96	264.04
1996	139.70	129.55	240.01	264.05	244.86
1997	140.37	131.19	243.15	264.54	247.23
1998	136.00	125.17	241.49	255.96	235.58

Note:assume price level in 1987=100.

Source: Calculations described in the text.

Table 3: Imports/Exports ratios (λ) for China and other Asian Economies

Year	Korea	Singapore	Thailand	Taiwan	China
1987	0.83	1.09	1.04	0.65	1.05
1988	0.81	1.06	1.13	0.82	1.13
1989	0.93	1.06	1.15	0.79	1.13
1990	1.03	1.10	1.30	0.81	0.82
1991	1.10	1.07	1.21	0.83	0.85
1992	1.02	1.03	1.13	0.88	0.93
1993	0.97	1.03	1.12	0.91	1.14
1994	1.03	0.99	1.08	0.92	0.93
1995	1.04	0.99	1.14	0.93	0.86
1996	1.12	0.98	1.17	0.88	0.87
1997	1.02	0.99	0.97	0.94	0.75
1998	0.68	0.87	0.70	0.95	0.75

Source: The trade data are from the current account of the balance of payments in the IMF: *International Financial Statistics*. Those for Taiwan are from the Ministry of Finance in Taiwan.

Table 4: Contributions to Annual Changes in the Simulated p_D

Year to:	Annual % change in simulated p_D	Contributions (%) due to			
		Border prices	Terms of trade	Trade balance	All effects together
1988	20.4	111	-50	39	100
1989	7.5	143	-43	0	100
1990	-12.4	-87	-43	230	100
1991	4.6	41	-23	83	100
1992	13.5	37	-9	73	100
1993	31.7	30	-4	74	100
1994	17.4	139	72	-110	100
1995	2.1	818	-341	-377	100
1996	15.5	8	84	8	100
1997	-14.8	-3	6	97	100
1998	-2.2	170	-70	0	100

Source: Calculations discussed in the text.

Table 5: Real Effective Exchange Rate Indices, Based on Recorded Data and Simulated

Year	Based on recorded Chinese GDP deflator, P^Y	Simulated based on the following trade balance assumptions:			
		Recorded λ	λ=0.9	λ=1.0	λ=1.1
1987	100.0	100.0	100.0	100.0	100.0
1988	100.4	107.7	97.5	97.5	105.3
1989	109.1	115.8	100.5	104.9	113.3
1990	103.9	95.8	101.4	109.9	118.3
1991	103.2	93.1	95.6	103.4	111.1
1992	101.2	94.4	90.2	97.6	104.9
1993	92.4	95.8	77.5	84.1	90.5
1994	89.8	92.7	85.8	92.4	99.0
1995	98.8	94.4	92.5	99.7	106.7
1996	108.9	110.9	107.6	116.4	125.1
1997	117.4	104.6	114.4	123.6	132.6
1998	125.9	110.6	121.2	131.1	140.9

Source: Calculations based on the analysis described in the text.

Table 6: Counterfactual Real Effective Exchange Rate[a]

Year	$\Delta R/p_X X$		Trade deficit ratio, λ		Simulated real effective exchange rate	
	Recorded	≤ 0.1	Recorded	$\Delta R/p_X X \leq 0.1$	Based on recorded λ	$\Delta R/p_X X \leq 0.1$
1987	2.4	2.4	105	105.0	100.0	100.0
1988	1.1	1.1	113	113.0	107.7	107.7
1989	5.0	5.0	113	113.0	115.8	115.8
1990	10.8	10.0	82	82.8	95.8	96.6
1991	18.0	10.0	85	93.0	93.1	100.2
1992	-3.3	-3.3	93	93.0	94.4	94.6
1993	2.3	2.3	114	114.0	95.8	96.0
1994	29.7	10.0	93	112.7	92.7	103.8
1995	17.2	10.0	86	93.2	94.4	102.0
1996	20.8	10.0	87	97.8	110.9	117.7
1997	19.0	10.0	75	84.0	104.6	110.3
1998	2.8	2.8	75	75.0	110.6	106.3

Source: Calculations based on the analysis described in the text.