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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 and following the Asian financial 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 to, during and following that crisis. An adaptation 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, while there is no clear evidence of undervaluation as of 2004, China's real effective exchange rate was on the low side in the lead-up to and during the crisis, due in part to an extraordinary rate of accumulation of foreign reserves and an associated trade surplus following the integration of its hitherto multiple exchange rates in 1994. If, instead, China had run a more typical trade deficit, say amounting to 10 per cent of export revenue or 1.5 per cent of GDP, it is estimated that China's real effective exchange rate would have been higher by about a tenth prior to the crisis.

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 financial crisis.[1] Yet the peg may have been associated with substantial undervaluation of the RMB prior to and during the crisis, substantial revaluations against Asian competitors notwithstanding.[2] Although the suitability of the *de facto* peg was widely questioned, leading to the modest relaxation of 2005,[3] the associated fluctuations in

[1] See, for example, Dornbusch (1999), Chen (1999) and Ni (1999). Prior to 2000, when the RMB might have depreciated under a more flexible regime, 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. Yet, after 2001, there was a clamour in the US Congress for flexibility upward (as reflected in speeches by Bunning R-KY; Green R-Wis and Senator Schumer D-NY). See also Frankel (2004).

[2] For evidence on real exchange rates during the crisis, see Fernald and Babson (2000), Tyers and Yang (2000) and Yang and Tyers (2001).

[3] For criticism of the peg, see Zhang and Shen (2000) and Yang and Tyers (2001). Even the IMF advocated a move toward greater flexibility, as suggested in the Australian Financial Review (AFR), 27 June 2000. Comments by the governor of the People's Bank of China (PBC), Dai Xianglong, suggested as early as 2000 that a more flexible policy was under consideration (AFR, 20 July 2000). On 21 July 2005 the People's Bank of China, with the authorisation of the State Council, announced the change of regime. Henceforth, the RMB would follow a "managed float" based on a basket of currencies the content of which, and the associated weights, have not been revealed.

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.

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. Ma (2000) 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 of the wholesale prices of China's 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 2004 and then use 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 key 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 also ask how it might have differed under alternative macroeconomic policies.

Our results suggest the Chinese real exchange rate was depreciating after 1990 with a reversal of this trend following the integration of its exchange rates in 1994. In spite of the subsequent real appreciation, however, the model gives evidence of undervaluation in this period, and through the remainder of the decade, due primarily to

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

an extraordinary accumulation of official foreign reserves.[5] This meant that China's exports may have been "artificially" competitive relative to those of its Asian neighbours in the lead-up to, and following, the 1997 Asian financial crisis. As imports were permitted to expand after 2000, however, the continuation of the extraordinary reserve accumulation merely sterilised expanded private capital inflows. The results therefore offer no clear case for undervaluation in the latter part of the period.[6]

We canvass alternative explations for the extraordinary accumulation of reserves, including the view that it is motivated by mercantilism (Dooley et al., 2004) and that it is due to a "savings glut" relative to investment opportunities (Chinn and Ito, 2005), but conclude that the primary influence is perceived financial immaturity, motivating the retention of capital controls and stable nominal parity against the US$.[7] In this macroeconomic environment, the stability of the domestic price level depends on the corresponding stability of the real exchange rate. Since the financial crisis, at least, reserve accumulation has retained this stability while allowing substantial foreign direct investment.

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 private inflows on the capital account. Other things equal, the larger these are relative to the rate at which foreign reserves are accumulated, the larger will be the equilibrium real effective exchange rate. We address this by considering a range of possible trade balance settings. 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

[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.
[6] This is in accord with recent work by Cheung et al. (2006), amongst others.
[7] China's capital controls are trending toward greater openness, as indicated by Xiao and Kimball (2006).

equilibrium real effective exchange rates are derived and compared with those observed. Section 7 offers conclusions.

2. The Model

The economy is modelled as 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:

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

where the αs are (exogenous) share parameters and $\rho > -1$. When maximised subject to the budget constraint, $p^D D + p^M M = GNP$, the first order conditions yield:

(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 $\sigma = 1/(1+\rho) > 0$. Changes in consumption tastes through time may have led to alterations in α_D and α_X in a manner that is exogenous to the determination of relative prices. This is allowed for by setting:

(3) $$\alpha = \left(\frac{\alpha_M}{\alpha_D}\right)^{\Omega} = e^{\left(a_0 + a_1 t + a_2 t^2\right)}.$$

In proportional change form, then, (2) reduces to:

(4) $$\hat{M} - \hat{D} = \sigma\left(\hat{p}^D - \hat{p}^M\right) + \hat{\alpha},$$

where, from (3), $\hat{\alpha} = a_1 + 2a_2 t$.

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

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

where the βs are (exogenous) share parameters and $\delta < -1$. The optimising behaviour of firms serves to maximise nominal $GDP = p^D D + p^X X$, subject to this constraint. Again, the first order conditions yield:

$$(6) \qquad \frac{X}{D} = \left(\frac{\beta_D}{\beta_X}\right)^{\Omega} \left(\frac{p^X}{p^D}\right)^{\Omega}$$

where the elasticity of transformation is $\Omega = -1/(1+\delta) > 0$. Before constructing the proportional change form, consideration must be given to the effects of China's considerable economic expansion between 1987 and 2004 on this supply relationship. The growth can be thought of as shifting the entire production possibility frontier outward. An unbiased shift would simply expand Q and have no effect on relative prices. There has, however, been a recorded rise in X/D, suggesting a bias in the underlying factor accumulation and technical change patterns that favours exportables.[8] This suggests that there may have been changes to β_D and β_X that are exogenous to the determination of relative prices. We allow for a non-linear effect of factor accumulation and technical change by setting:

$$(7) \qquad \beta = \left(\frac{\beta_D}{\beta_X}\right)^{\Omega} = e^{\left(b_0 + b_1 t + b_2 t^2\right)} \quad .$$

In proportional change form, then, (6) reduces to:

$$(8) \qquad \hat{X} - \hat{D} = \Omega\left(\hat{p}^X - \hat{p}^D\right) + \hat{\beta} \quad ,$$

where, from (7), $\hat{\beta} = b_1 + 2b_2 t$.

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, broadly defined to include changes in official foreign reserves. 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

[8] Of course, this may also suggest that the official statistics undervalue the non-traded components of GDP. Our analysis assumes the official statistics are accurate. This is also assumed by Whalley and Xin (2006), who conclude that there is an extremely large gulf between labour productivity in the export-oriented industries that are the destinations for China's considerable FDI compared with others. This view receives

account, CA, must be zero. The net (private and official) inflows on the capital account are:

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

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:

(10) $$CA = p^X X - p^M M + N$$

where N is net factor income from abroad. If foreign labour income is ignored, this is approximately $N = r^* K_{CW} - rK_F = r^*\left(K_{CW} - K_F\right) - \pi K_F$, 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, K_F is the total holding of Chinese assets by foreigners and π is the premium on the rate of return on investments in China. Since $KA + CA = 0$, we use (9) and (10) to define the trade balance ratio, λ, as

(11) $$\lambda = \frac{p^M M}{p^X X} = 1 + \frac{N + S_{NF}}{p^X X} - \frac{\Delta R}{p^X X} \quad .$$

The parameter λ is used 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.[9] The parameter λ might therefore be thought of as approximately one plus net income and 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. It is, however, inversely proportional to ΔR. Equation (11) is then readily converted to proportional change form as[10]:

(12) $$\hat{p}^M + \hat{M} = \hat{p}^X + \hat{X} + \hat{\lambda} \quad .$$

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further support from Rodrik (2006), who notes the high quality of China's exports, compared with the exports of other developing countries of similar income per capita.

[9] We are aware that China has had capital controls in place throughout the period of interest here, thus imposing policy constraints on S_{NF}. These did not prevent substantial private capital account flows, however, and a considerable redirection of these outside China during the Asian financial crisis, as indicated by Tyers and Yang (2000).

[10] 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 (10) 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.

We then have three simple equations in proportional changes, (4), (8) and (12). By subtracting (8) from (4) and then (12) 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:

$$(13) \qquad \hat{p}^D = \left(\frac{\Omega\, \hat{p}^X + \sigma\, \hat{p}^M}{\Omega + \sigma} \right) + \left(\frac{\hat{p}^X - \hat{p}^M}{\Omega + \sigma} \right) + \left(\frac{\hat{\lambda}}{\Omega + \sigma} \right) + \left(\frac{\hat{\beta} - \hat{\alpha}}{\Omega + \sigma} \right),$$

where, from (3) and (7), $\hat{\alpha} = a_1 + 2a_2 t$ and $\hat{\beta} = b_1 + 2b_2 t$. The beauty of this expression is that it allows the endogenous change in the domestic price level to be decomposed into four components, the first being due to a change in foreign prices, the second to a change in the terms of trade, the third to a change in net inflows on the capital account and the final one to changes in consumption tastes on the one hand and factor supply and technology bias on the other. 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, and changes in official foreign reserves in particular, directly to the real exchange rate.

We define the nominal exchange rate, E, according to modern convention, as the number of units of foreign exchange that 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:

$$(14) \qquad e_i^R = E_i \frac{P^Y\left(p^D, p^X\right)}{P_i^Y}.$$

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

$$(15) \qquad e^R = \sum_i \left[\left(\frac{p_i^X X_i + p_i^M M_i}{\sum_i p_i^X X_i + \sum_i p_i^M M_i} \right) E_i \frac{P^Y\left(p^D, p^X\right)}{P_i^Y} \right]$$

Where p_i^X and p_i^M are bilateral trading prices while p^X and p^D are indices over all the focus country's exports and non-traded goods, respectively.[11]

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 (11). The price of the domestic non-traded good, p^D, then depends positively on λ via equation (12) and finally, the real effective exchange rate depends positively on p^D via equation (14). The equilibrium real exchange 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 the Chinese authorities do not supply these, 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[12] it is the best available option if equilibrium 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_t^X, $t \in (0,T)$, which is a weighted average of commodity prices, p_{jt}^X, across traded commodities, j for each year, t. If the base year, from which the weights are derived, is $t=0$, we seek:

[11] 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.

[12] 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) $$p_t^X = \frac{\sum_i p_{it}^X X_0^i}{\sum_i p_{i0}^X X_0^i} .$$

This is the same as:

(17) $$p_t^X = \sum_i \left[p_{it}^X \left(\frac{X_0^i}{\sum_i p_{i0}^X X_0^i} \right) \right] ,$$

where the weight is given in the interior parentheses. Since trade data offers only values, V_t^i, and volumes, X_t^i, equation (16) becomes:

(18) $$p_t^X = \sum_i \left[\frac{V_t^i}{X_t^i} \left(\frac{X_0^i}{\sum_i V_0^i} \right) \right] .$$

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 2004. 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. 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:

$$p^D = \frac{P^Y - S_X p^X}{1 - S_X} \quad , \tag{19}$$

where S_X is the export share of GDP.

The time path of the US$/Yuan exchange rate is plotted in Figure 1 and the corresponding domestic currency prices of exports, p^X, and imports, p^M, and the non-traded good, p^D, are plotted in Figure 2. These prices are listed, along with our constructed index for the domestic price of home goods in China, p^D, in Table 1.[13]

4. Estimating the Parameters:

Estimates are required of the elasticity of transformation in supply, Ω, the elasticity of substitution in demand, σ, and the structural parameters representing shifts in consumer tastes on the demand side and factor endowments and technology on the supply side. For the short adjustment intervals of interest here, Devarajan et al. (1998) suggest that the transformation elasticity is less than unity for most developing countries and 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 detailed econometric studies at the sectoral level (Devarajan et al. 1993). In the absence of an appropriate database for such elasticities we estimate each directly from time series.

From (2) and (3), we have that

$$\ln \frac{M}{D} = \ln \alpha + \sigma \ \ln \frac{p^D}{p^M} \quad . \tag{20}$$

To determine the appropriate treatment of the first term on the right hand side, the logs of M/D and p^D/p^M are first tested for stationarity. The hypothesis that there is a unit root is accepted for M/D and rejected for p^D/p^M. The two series are therefore not cointegrated

[13] We thank Gonca Okur for supplying an alternative set of export and import price index estimates, constructed by the Development Data Group at the World Bank, for the latter part of the period covered. While not identical with our series, these differed only slightly and so we have persisted with our own.

and the first term on the right hands side of (20) is considered to carry the non-linear time trend indicated in (3).[14] Indeed, it is found to fit best when this trend has an autoregressive component, possibly reflecting lags in adjustment to relative price changes.[15] Regression (ordinary least squares) on annual data over the period 1987 to 2004 yields:

$$\ln\frac{M_t}{D_t} = -1.173 + 0.00269\,t^2 + 0.456\,\ln\frac{M_{t-1}}{D_{t-1}} + 0.141\,\ln\frac{p_t^D}{p_t^M}$$

(-2.04) (2.10) (1.78) (0.223)

Adjusted R^2=0.94, F=83.1, SSE=0.195.

The numbers in parenthesis are t-statistics. The substitution relationship is not strong after de-trending, which is not surprising since it represents only short run (one year) responses to relative price changes. The elasticity of substitution is nonetheless of the correct sign and of credible magnitude given the work of Devarajan et al. (1998).

Turning to the production side, from equations (6) and (7), we have that:

$$(21)\qquad \ln\frac{X}{D} = \ln\beta + \ln\frac{P^X}{P^D}.$$

As before, to determine the appropriate treatment of the first term on the right hand side, the logs of X/D and p^X/p^D are first tested for stationarity. The hypothesis that there is a unit root is accepted for both series, though exports rise relative to non-traded production while export prices fall relative to non-traded prices. A Johansen test then rejects cointegration.[16] The first term on the right hand side of (20) is therefore considered to carry the non-linear time trend indicated in (7).[17] The regression (ordinary least squares) on annual data over the period 1987 to 2004 yields:

$$\ln\frac{X_t}{D_t} = -2.21 + 0.00626\,t^2 + 0.847\,\ln\frac{p_t^X}{p_t^D}$$

(-28.4) (8.53) (1.56)

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[14] An Augmented Dicky-Fuller test is used, yielding test statistics of *-1.2* for *ln(M/D)* and of *-4.2* for $ln(p_D/p_M)$. The former result strongly supports the existence of a unit root. Although the latter result does not permit rejection of the null hypothesis that there is a unit root at the 1% level, the contrast with *ln(M/D)* is such as to raise doubts. A Johansen test was therefore performed to check for cointegration of these two variables. Cointegration is rejected at the 5% level.

[15] To achieve the best fit we also dropped the linear term in the quantity shifter (3), a_1.

[16] The augmented Dicky-Fuller test yields a test statistic of *–1.51* (significant) for *ln(X/D)* and of *-1.94* for $ln(p_X/p_D)$. Both suggest the presence of unit roots, but, because the trends are in opposing directions, the Johansen test rejectes cointegration.

Adjusted R^2 =0.96, F=190.4, SSE=0.198.

The numbers in parenthesis are t-statistics. The positive factor endowment and technology shifters result from the accelerated expansion in exports relative to non-traded production. Superficially at least, this suggests comparative increases in the capital stock and the skilled labour supply, along with advances in technology in the exportable goods sectors.[18]

Both the elasticity of substitution on the demand side, σ, and the elasticity of transformation on the supply side, Ω, necessarily characterise short run (one year) adjustments, so large values are unexpected. Moreover, the results, $\sigma=0.141$ and $\Omega=0.847$, accord with estimates for other developing countries by Devarajan et al. From (13) it is clear that these, collectively, imply that the elasticity of the home non-traded good price, p^D, to the ratio of import cost to export revenue, λ, is *1.012*. This provides the direct link between other flows on the balance of payments and the real exchange rate.

5. Reserve Accumulation and the Trade Balance

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 about four per cent by the late 90s and did so again after the financial crisis, reaching that benchmark again in 2004. A clearer picture of changes in the balance of payments can be gained if it is expressed in terms of the trade balance:

(22) $$p^X X - p^M M = \Delta R - \left(N + S_{NF}\right) .$$

From this it is clear that the maintenance of a balance of trade requires that net private inflows be precisely offset by reserve accumulation. It is common for capital scarce developing countries to run deficits, financed by inflows of factor income and foreign direct investment.[19] From Figure 3 it is clear that this has not been China's practice since 1994. Indeed, its accumulation of reserves has more than offset net private inflows,

[17] To achieve the best fit we also dropped the linear term in the quantity shifter (7), b_1.
[18] Of course, the growth in *X/D* may also be an indication of the incomplete measurement of non-traded goods and services in GDP.
[19] See IMF, *World Economic Outlook*, April 2005, Table 28.

allowing a substantial trade surplus.[20] This surplus forms an intertemporal lense in the figure which is at its widest in the crisis years of 1997 and 1998. Since then, the growth of both export revenue and private capital inflows has accelerated and, while reserve accumulation has generally kept up, the trade surplus has narrowed.

The corresponding values of the trade balance ratio, λ (the ratio of import cost to export revenue), are shown in Figure 4, along with values for Korea, Malaysia and Thailand, countries that were adversely affected by the Asian financial crisis. It is clear that the decline for China began with exchange integration in 1994 and that the regional neighbours were forced to follow suit from the time of the financial crisis.

The rapid expansion in China's official foreign reserves saw more than three per cent of measured GDP salted away each year into foreign assets between 1994 and 1997 and, as Figure 3 shows, the scale of this accumulation has increased further in recent years with the change in reserves rising from four per cent of GDP in 2001 to more than 12 per cent of GDP in 2004. The association between λ and this pattern of foreign reserve accumulation is is shown in Figure 5. While the correspondence is evident, 1994 and 1998 are outliers, the latter reflecting the virtual cessation of reserve accumulation in during the financial crisis. During 1998 there were significant (mostly illegal) private outflows, rendering reserve accumulation unneccesary. 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). A trend separation appears after 2000. In this period reserves continued to expand but imports did also, suggesting growth in private inflows in the capital account (mainly foreign direct investment) and in the net income component of the current account in the form of interest earnings from China's now vast foreign reserves.

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 have fitted an exponential time trend to China's exports and plotted the residuals along with the change in reserves as proportions of export earnings (Figure 6).[21] Except for the

[20] This is in spite of unprecedented private inflow during these years in the form of foreign direct investment (Shengman, 1999).
[21] The fitted curve for nominal export earnings is $ln[p_X X] = 3.31 + 0.161\, t + \varepsilon$, implying an average growth rate of 16 per cent per year.

years 1991 through 1994, the correspondence is clearly evident. After the exchange rate was unified, a growing proportion of export earnings were retained as foreign reserves. As the figure shows, the share of export earnings salted away was thereafter always larger than the over-trend proportion to an extent that expanded following the financial crisis. By the time of the crisis China's official foreign reserves amounted to an already extraordinary 15 per cent of GDP and by 2004 this proportion had grown to 37 per cent.[22]

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. By itself, this observation tends to support the mercantilist hypothesis for China's reserve policy, though a concern to insure against then unforeseen events like the eventual financial crisis,[23] would also have been a motivating factor. It is interesting, therefore, that reserve accumulation resumed and strengthened after the crisis.[24] The most important reason for the reserve accumulation may therefore be the immaturity of China's financial system and the perceived need to retain capital controls and stable nominal parity against the US$. In this macroeconomic environment, rapidly expanding foreign currency earnings from exports and foreign direct investment would otherwise appreciate the real exchange rate and this would necessitate high domestic inflation.[25]

In the long run, a "sustainable" trade account for China must surely exist within the range ($0.9<\lambda<1.1$). 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 net foreign debt to GDP ratio. We would therefore expect the sustainable range to have $\lambda>1$.

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[22] For comparisons, see IMF: *World Economic Outlook*, October 2000, Table 36.
[23] See Dooley et al. (2004).
[24] Prasad and Wei (2005) do not support the mercantilist hypothesis for this behaviour, though they do not offer a clear alternative, choosing to focus instead on extraordinarily high proportion of FDI in China's foreign investment.
[25] Recall that the real exchange rate is the common currency price of home goods relative to foreign goods. It can be expressed via equation (14) as $e_R=E\,P^Y/P^*$, where E is the nominal rate, P^Y is the home GDP price and P^* is the corresponding foreign price level. Any appreciation of the real exchange rate therefore

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 (13), from our observed values for p_M, p_X , λ and the shifters α and β. In Figure 7 this artificial series is displayed and compared with its observed counterpart (which is derived from China's GDP deflator using equation (19). The simulated version misses a number of turning points, particularly in the three years from 1994. This is because of the effects of the substantial devaluation in 1994 (Figure 1). The annual data we use for China's RMB denominated import and export prices appear, however, to spread the effects of this devaluation over the two years 1994 and 1995 (Figure 2). This inconsistency could be due to differing definitions of the calendar year (values could be chosen as end year values, mid-year values or annual averages, for example) or to invoicing lags. Either way, in the absence of better data, we have retained the anomalies rather than make *ad hoc* adjustments. Of course, construction from equation (13) is subject to error whenever the annual proportional changes are large. These errors and potential errors notwithstanding the model captures the trend of the recorded series of p_D quite well.

The rising trend in the price of the domestic good in the 1990s stems from substantial increases in 1993, 1994 and 1996, prior to the financial crisis. The rising trend is then resumed after 2001. By separating the components of equation (13) we can apportion annual changes amongst the four contributing effects: border price levels, the terms of trade, the trade balance and the quantity shifters reflecting factor accumulation and changes in tastes and technology. The results are given in Table 2. 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 3), yet in that year too the trade balance effect dominates.. In 1995, however, this effect was

requires either a nominal appreciation or a domestic inflation. See Tyers (2001) and Roberts and Tyers (2003).

more than offset by a rise in border prices, due to the apparently lagged effect of the 1994 devaluation (Figures 2 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 8, which compares the annual proportional changes in p^D with those in λ. Given the correspondence between the trade balance and the accumulation of official foreign reserves indicated in Figures 5 and 6, 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 (15). We do this first from the raw data, including an estimate of the Chinese GDP deflator derived from recorded nominal and real GDP levels.[26] We then use the model to derive the artificial series for p^D in Figure 7 and, from it, construct a correspondingly artificial series for the GDP deflator, p^Y. This, in turn, is used in equation (15) to derive a simulated real effective exchange rate based on observed trade balance statistics. The two series are compared in Figure 9 and listed in Table 3. Once again, apart from the turning point errors following the depreciation of 1994, the tracking is fair throughout the period.

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 the target values: $\lambda=(0.9, 1.1)$. Equation (13) 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 (15) to prepare our simulated series for the real effective exchange rate. The resulting series are set out in Table 3 and illustrated in Figure 10.

The path of China's real effective exchange rate skirts the lower bound of the range (λ=0.9) throughout the period. During 1996-2000 the real exchange rate is unambiguously undervalued. As shown in Figure 2, during these years a combination of balance of payments and terms of trade shocks saw China's p^D stabilise. Yet prices

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[26] For the effective rate, the weighted average is here taken over the bilateral trade values and price indices of mainland China's largest trading partners: Japan, the US, Korea, the European Union, Canada, Malaysia, Singapore and Thailand. Sources are the IMF's *International Financial Statistics* and, for Taiwan, the *Monthly Price Bulleting of Gaohsiong*.

abroad were falling in Chinese currency terms (the nominal exchange rate with the US dollar was very stable after 1994, as indicated in Figure 1 and the US$ was appreciating against other currencies). The key reason for the undervaluation in this period was the very substantial contributions made to official foreign reserves in 1994-1997.

The results in Table 3 indicate that the recorded real appreciation between 1995 and 1998 was 22 per cent. Balanced trade in that period would have delivered a real appreciation over 1995 of 43 per cent, 19 percentage points larger than the one actually observed. Had a modest trade deficit of 10 per cent of exports (roughly 1.5 per cent of GDP) been maintained, the real appreciation in this period would have been 54 per cent, larger than that observed by 32 percentage points.

A slower accumulation of official foreign exchange reserves after 1994 would have raised imports, leading to higher consumption. The consequentially higher relative domestic price level might have increased domestic service employment growth but , with the maintenance of fixed nominal parity with the US$, it would have necessitated an inflation. Moreover, in the lead-up to the Asian financial crisis, the stock of official foreign reserves would have been substantially smaller than the 15 per cent of China's GDP held abroad in 1997. 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 the declining export performance of the most affected countries, principally Thailand, Korea, Malaysia and Indonesia. China's share of both Asian and global exports expanded substantially between 1994 and 1997 at the expense of these competing exporters (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 fall prior to 1995, to rise significantly through the crisis period and to remain fairly flat thereafter. To assess whether this path would have differed under alternative macroeconomic policies, 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 2004. 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.

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. The rising trend in the real effective exchange rate in that period notwithstanding, this caused the domestic price level, and hence the real effective rate, to be lower than it would otherwise have been. Indeed, monetary policy concerns aside, a it might have been advantageous for a rapidly-expanding yet capital scarce developing country like China to sustain some degree of trade deficit without any expansion of the net foreign debt to GDP ratio. Were such a strategy to have been feasible it might have fostered even more economic growth and improvements in living standards than were actually 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 simulation with a trade deficit amounting to 10 per cent of export earnings, or 1.5 per cent of a GDP level that was expanding at more than eight per cent per year, suggests undervaluation in 1998 by as much as a fifth.

This undervaluation clearly fostered exports and foreign investment in export industries and the extraordinary rate of reserve accumulation that was its cause helped secure China against a "country run" during the financial crisis. Yet the primary reason for it is unlikely to be either mercantilism or risk-spreading. The reserve accumulation was clearly associated with growth in private saving relative to investment opportunities (the "savings glut" explanation),[27] though its origin is more likely to have been driven by the associated immaturity of China's domestic financial system and the perceived necessity to retain capital controls and roughly fixed nominal parity of the RMB with the US$. With this macroeconomic policy regime, rapidly expanding foreign currently

[27] See Chinn and Ito (2005).

inflows from export earnings and foreign investment in China are highly inflationary without offsetting outflows into foreign reserves. As China's financial sector matures it will accumulate reserves more slowly and allow more exchange rate flexibility. A manageable level of inflation should then assist Chinese labour markets to cope with the continued dislocation that is the inevitable consequence of domestic economic restructuring.

Finally, we draw attention to two important caveats associated with these results. First, the simulated counterfactual real exchange rates have a unit elasticity of sensitivity to the sum of the absolute values of our estimates of the elasticities of substitution in demand and transformation in supply. These elasticities are notoriously difficult to estimate accurately. While different estimates of these elasticities would yield differing degrees of undervaluation during the crisis period, we believe the conclusion that undervaluation widened in the crisis period is robust. Second, our model is a comparative static one, subjected to a sequence of annual shocks. It does not endogenise the underlying process of capital accumulation that lies behind China's growth. Rather, shifts in the production possibility frontier come from our econometric analysis and are therefore exogenous and the same for both our base line and counterfactual simulations. Whether China's GDP growth rate would have been higher or lower with more real appreciations and more rapid consumption growth is not a straight-forward question and must be left to more complete models for analysis.

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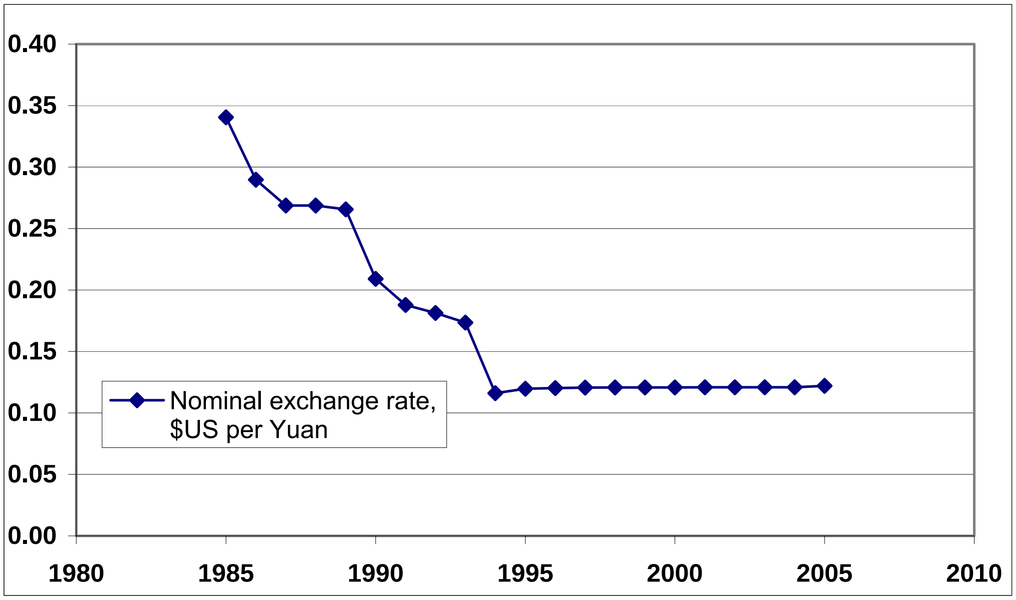
Figure 1: China's Market Nominal Exchange Rate with the US dollar



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 2: Constructed Home Currency Price Indices of Exports, Imports and the Domestic Non-traded Good

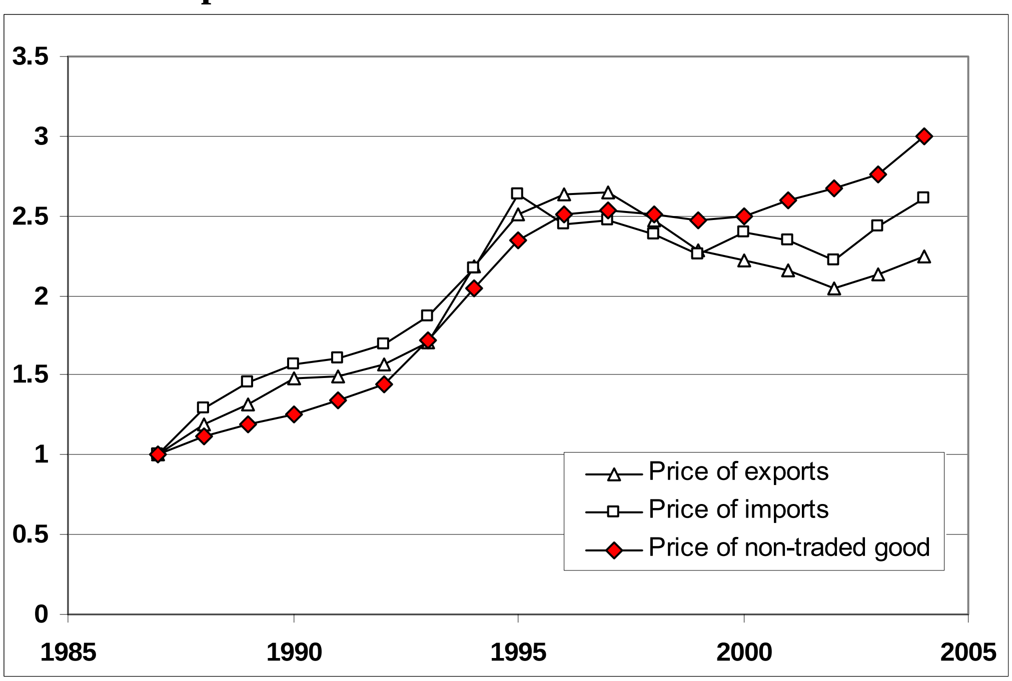


Figure 3: China's Trade and Payments Balances, 1987-2004

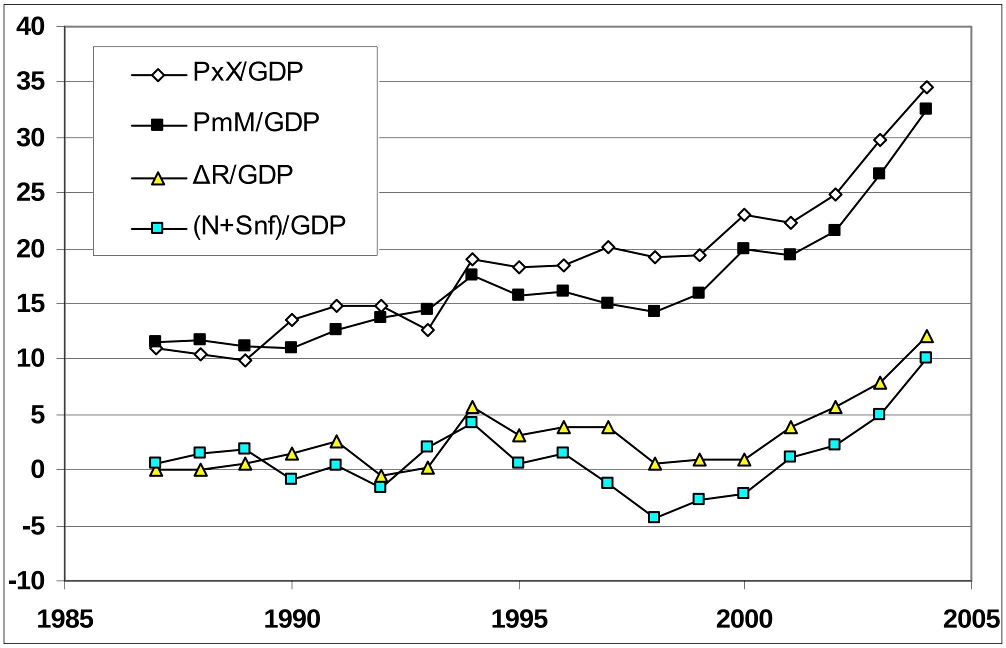
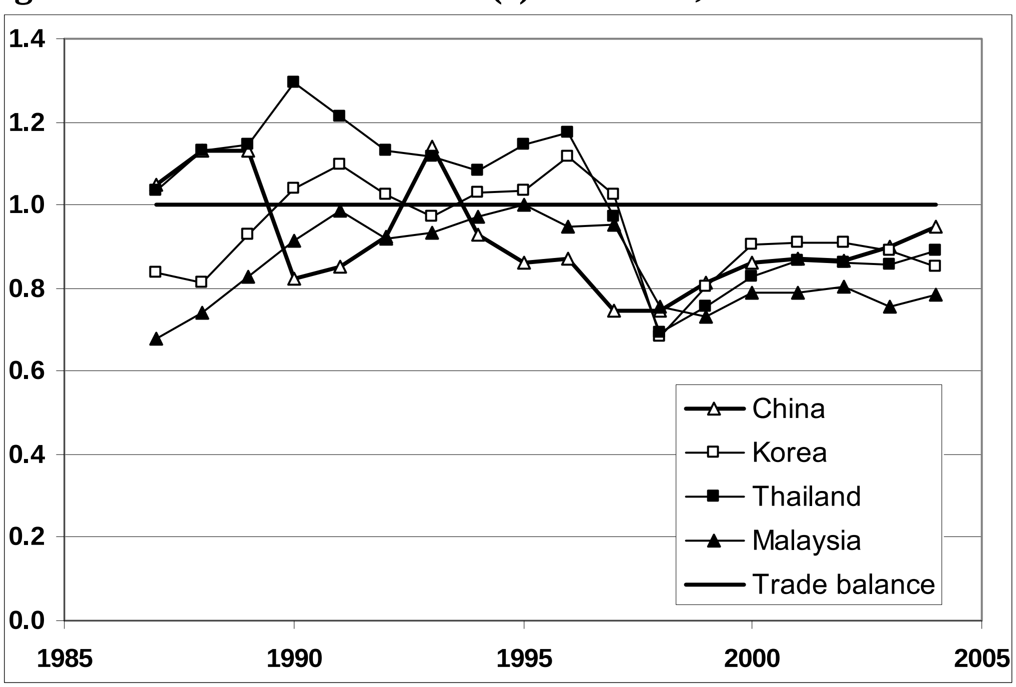


Figure 4: Trade Balance Ratios (λ) for China, Korea and Thailand



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

Figure 5: Imports and the Annual Decline in Official Foreign Reserves

(% of export earnings)

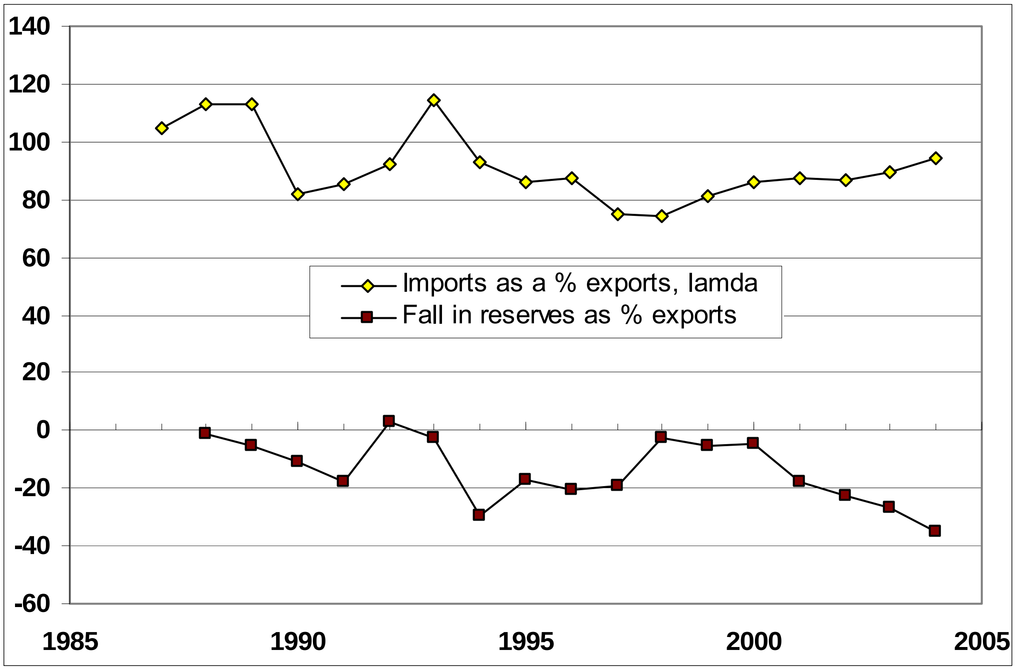


Figure 6: Changes in Official Foreign Reserves and Departures from Trend Export Earnings

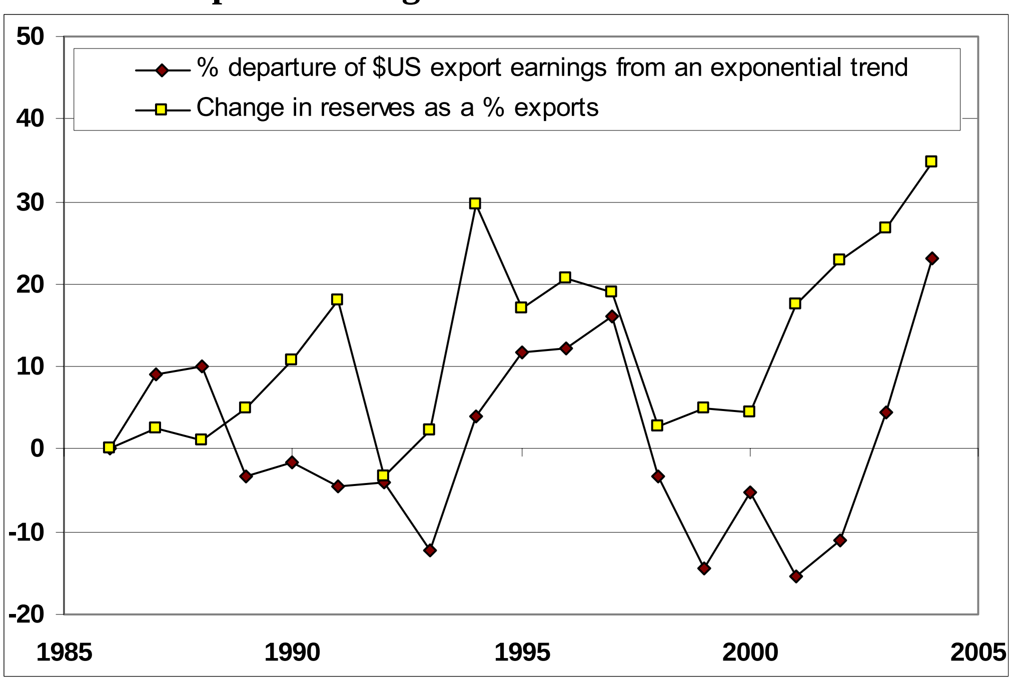
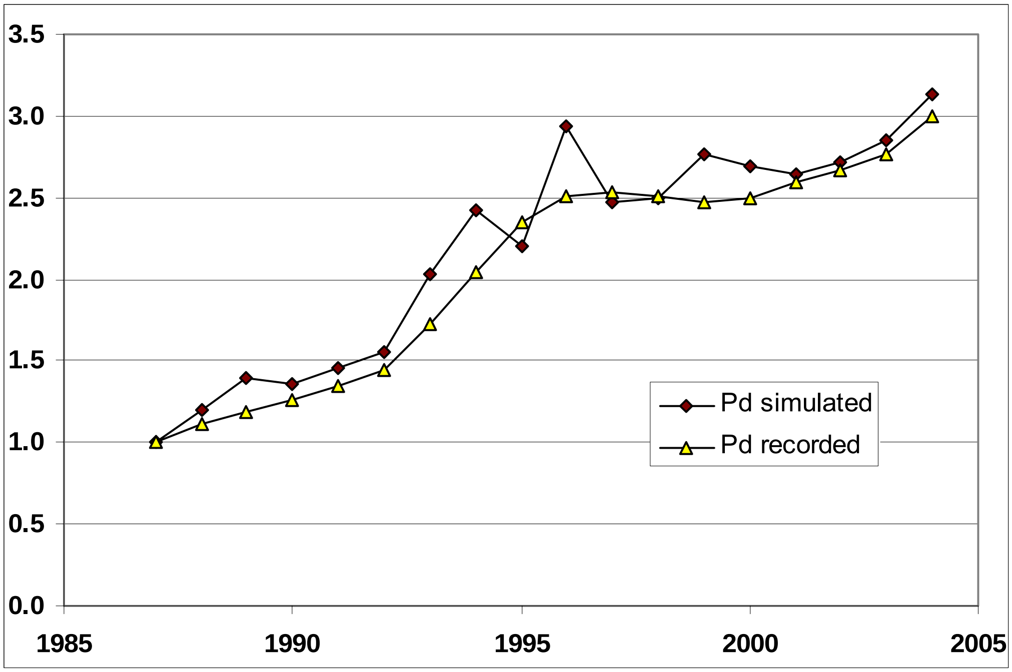
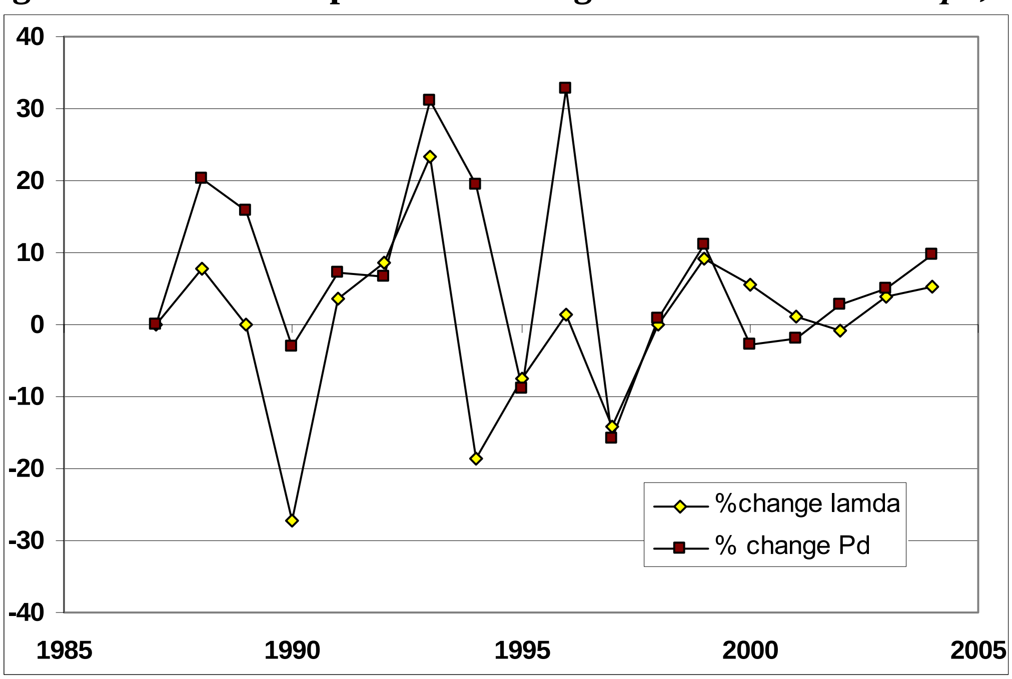


Figure 7: Recorded and Simulated Values for p^D (1987=100)



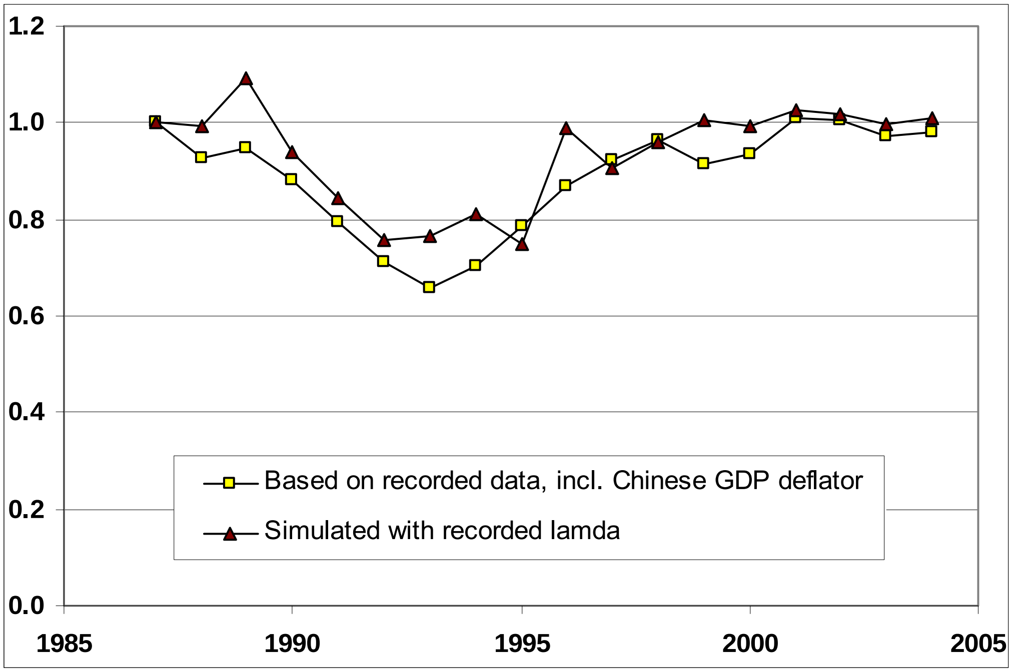
Source: Recorded local currency price of domestic good, estimated from data for real and nominal GDP and the export share of output. Simulations are based on model discussed in the text using the recorded trade balance.

Figure 8: Annual Proportional Changes in λ and Simulated p^D, %



Source: Annual % changes in recorded λ from Figure 4 and simulated values of p^D.

Figure 9: Actual and Simulated Real Effective Exchange Rates



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

Figure 10: The Recorded Real Effective Exchange Rate compared with Simulated Rates for the Range λ = 0.9 – 1.1

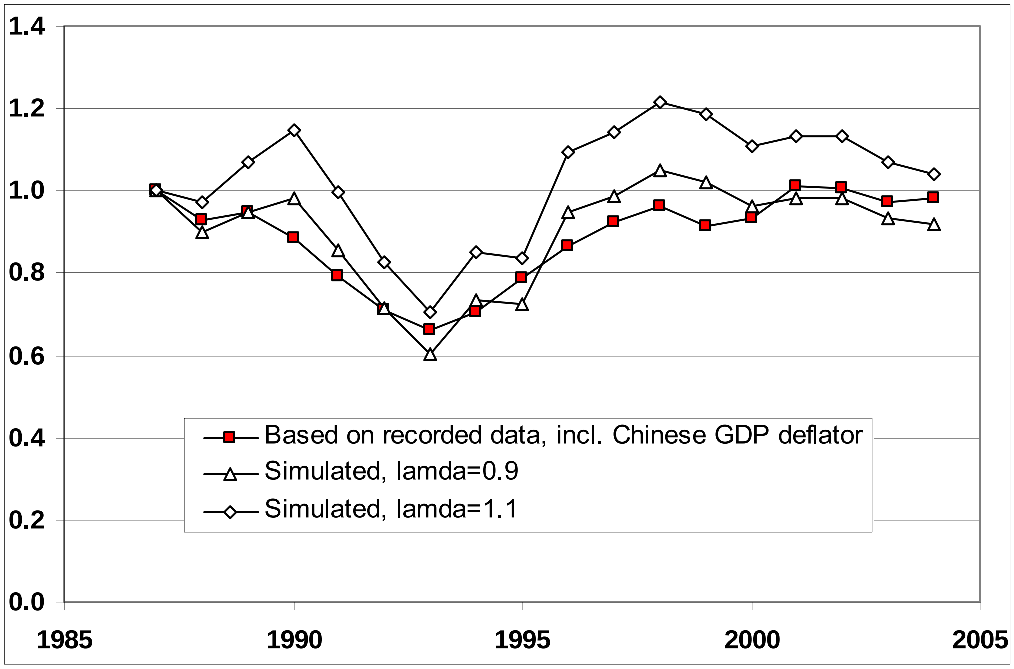


Table 1: Indices for RMB Prices of Exports, Imports and the Domestic Non-Traded Good

	Domestic Currency Prices of		
	domestic good	exports	imports
1987	100.00	100.00	100.00
1988	110.97	119.65	129.51
1989	118.93	131.24	146.00
1990	125.38	147.51	156.56
1991	134.51	149.80	160.61
1992	143.73	156.69	169.94
1993	172.29	170.84	187.18
1994	203.99	218.43	216.94
1995	234.67	250.96	264.04
1996	250.34	264.05	244.86
1997	252.87	264.54	247.23
1998	250.40	247.08	238.57
1999	247.60	228.55	226.41
2000	249.62	221.46	239.54
2001	260.19	216.37	234.03
2002	267.84	204.04	221.86
2003	277.13	213.62	243.38
2004	302.15	224.04	260.52

Source: Calculations described in the text.

Table 2: Contributions to Annual Changes in the Simulated p^D

Year to:	Annual % change in simulated p^D	Contributions (%) due to: Border price levels	Terms of trade	Trade balance, λ	Quantity shifters
1989	20	21	-10	8	1
1990	16	10	-3	0	9
1991	-3	12	5	-28	8
1992	7	2	-1	4	3
1993	7	5	-1	9	-6
1994	31	9	-1	24	-1
1995	19	26	12	-19	0
1996	-9	16	-7	-8	-10
1997	33	3	13	1	15
1998	-16	0	-1	-14	-1
1999	1	-6	-3	0	10
2000	11	-7	-2	9	11
2001	-3	-2	-9	6	2
2002	-2	-2	0	1	-1
2003	3	-6	-1	-1	10
2004	5	5	-5	4	1

Source: Calculations discussed in the text.

Table 3: Real Effective Exchange Rate Indices

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	100	100	100	100
1988	93	99	90	90	97
1989	95	109	95	99	107
1990	88	94	98	106	114
1991	79	85	86	93	100
1992	71	76	71	77	83
1993	66	76	60	65	70
1994	70	81	74	79	85
1995	79	75	73	78	84
1996	87	99	95	102	110
1997	92	91	99	106	114
1998	96	96	105	113	122
1999	92	100	102	110	118
2000	93	99	96	103	111
2001	101	102	98	105	113
2002	101	102	98	106	113
2003	97	100	94	100	107
2004	98	101	92	98	104

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