GTAP-Based Comparative Static Macroeconomics: An Application to China's Policy Options*

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May 2000

Working Papers in Economics and Econometrics No. 384
Australian National University

ISBN: 86831384X

This paper was presented at the Third Annual Conference on Global Economic Analysis, Monash University, Melbourne, 27-30 June 2000. It extends China Economy Program Working Paper No. CEP2000-1, Asia-Pacific School of Economics and Management, Australian National University, by consolidating the analysis through the use of a single global macro model. Thanks are due to George Fane, Meng Xin, Max Corden, Warwick McKibbin, Xiaolu Wang, Xinpeng Xu, E.C. Hwa, Ben Smith, Graeme Wells, Kevin Hanslow and Kar-yiu Wong for useful discussions and comments.

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Abstract

Although the "country runs" of the Asian crisis stopped at the Chinese border, their effects nonetheless included a realignment of real exchange rates and a rise in the risk premium demanded of investments in China. Effective analysis of these shocks, and the Chinese policy response, requires a full macroeconomic model with multiple product and factor markets. This paper introduces a multi-region, multi-commodity comparative static macroeconomic model that has its genesis in GTAP. By quantifying changes in the macroeconomic fundamentals, the results lend useful insights into China's post-crisis macroeconomic policy dilemma.

1. Introduction

The crisis of 1997 led to "country runs" and very substantial nominal depreciations elsewhere in Asia yet the government of China held fast to its nominal US dollar parity. Its comparatively large official foreign reserves, its history of capital controls and its protected banking system made China less vulnerable than some of its neighbours. Nonetheless, the crisis appears to have combined with simultaneous domestic reforms and changes in macroeconomic policy to retard overall economic growth and increase unemployment.[1] The extent of this growth slowdown and the associated unemployment were the subject of an earlier paper (Yang and Tyers 2000). Here we extend that analysis by integrating the macro and micro components into a single global macro model for comparative static analysis.

The use of multi-product global general equilibrium is important in the assessment of crisis-type shocks because it enables us to capture transmission through both bilateral trade and capital flows. Moreover, it offers a clearer picture of the distributional effects of such shocks than do comparatively aggregated macro models.[2] We therefore begin with the modified version of the GTAP global model used in our earlier treatment of the crisis and its effects.[3] To this general equilibrium base we first add an LM relationship to characterise money markets in all regions. The consumption-saving choice is represented by a reduced form consumption equation, direct tax is introduced to complement the indirect taxes already represented and government spending is made exogenous to facilitate fiscal policy

[1] See Meng (1999), Wu (1999).
[2] Several earlier quantitative examinations of the crisis (Adams 1998, Noland et al. 1998 and Yang and Tyers 1999) have used comparative static, general equilibrium analysis but the models did not represent the effects on both real and nominal variables.
[3] See Tyers and Yang (2000) and Yang and Tyers (1999, 2000).

experiments. Both private and government savings (or dissavings) are pooled globally and allocated across regions as investment on the assumption that capital is interregionally mobile at a common global rate of return adjusted for exogenous regional risk premia. Nominal exchange rates are defined and these may be set as fixed or flexible. Thus equipped, we reexamine the crisis period with a view to highlighting the effects of China's monetary, fiscal and labour market policy in its wake. We first assess the so-called "soft budget" policy. Then we analyse the effects of the 1999 nominal wage rises. And, finally, we examine the potentially expansionary effects of devaluation.

In Section 2 a brief review of the crisis and the associated events in China is offered. The integrated global model is then described in Section 3. The construction of the crisis and policy shocks is described in Section 4 along with the simulation results. Section 5 concludes.

2. Events in the crisis countries and China:

For the most affected Asian economies, and particularly Korea, Southeast Asia and Japan, the primary real shocks were of two types. First, as savings fled domestic investment declined. Second, nominal exchange rate adjustments precipitated a financial collapse and a surge in insolvency rates, causing a further short run decline in domestic production in the affected economies. In China, a history of capital controls and a protected banking system militated against a further "country run" and fixed nominal parity with the US dollar was retained throughout. This did not mean that China escaped the impact of the crisis, however. There were two key effects. First, nominal parity with an appreciating US dollar in a period of low global inflation caused real appreciations against almost all of China's trading partners, as indicated in Figure 1. Second, capital controls notwithstanding, outflows on the capital account accelerated markedly in 1997 and 1998. Indeed, there was a US$60 billion reversal in net private flows, offset only partially by a US$30 billion slowdown in the accumulation of official foreign reserves.[4] This substantial increase in net outflows appears to have been stimulated by a crisis-linked rise in the premium demanded on returns earned by investments in China[5] and fuelled by a rise in the domestic rate of private saving. This rise in saving stemmed not only from increased real interest rates in the lead-up to the crisis period

[4] For a discussion of calculations on which the capital account changes are based, see Yang and Tyers (2000).
[5] Fernald and Babson (1999) estimate that this premium rose by about 250 basis points between 1996 and 1998.

but also domestic economic reforms that increased private responsibility for health, education and retirement expenses.[6]

China's retention of fixed US dollar parity tended to constrain monetary policy, forcing a progressive tightening. Its "soft budget" policy, which had been maintained since the mid-1990s and yielded a fiscal deficit of 1.1 per cent of GDP in 1998, was too insubstantial to offset the contractionary effects of both increased private saving and tight monetary policy. Aggregate demand slowed and the domestic price level fell. According to official statistics, growth in the CPI, which had exceeded 24 per cent in 1994, has since declined each year, reaching –0.8 per cent in 1998. Officially estimated GDP growth slowed as a consequence, from the 10 per cent achieved in the mid-1990s to 7.8 per cent in 1998. Official estimates of the 1998 price level and GDP are widely believed to err on the high side, however. Unofficial estimates of GDP growth range as low as just under five per cent.[7]

This slowdown could be explained either by slower productivity growth or by nominal wage rigidity in the face of the demand contraction and hence a rise in unemployment. In spite of the contractionary monetary policy, total investment as a share of GDP rose slightly and productive capacity continued to be transferred from the state sector to the presumably more productive private sector, all of which suggests the slowdown was not the result of slower productivity growth. Wage rigidities are not unexpected in China's regulated labour market, however. Evidence reviewed in Yang and Tyers (2000) suggests that the deflation in 1998 was indeed associated with a spurt in real wage levels. On balance, we conclude that there was a slowdown in output growth associated with a rise in unemployment. Strangely, given this, in an apparent attempt to expand private consumption the nominal wages of government workers were raised in 1999 by between 20 and 30 per cent. At the same time, the minimum wage paid to workers in the private sector was raised 30 per cent.

From China's perspective, then, the key macroeconomic shocks in the crisis period were (1) the real appreciation relative to competing exporters, (2) the rise in the interest premium on investments in China, and (3) the rise in private saving in the home economy. The associated policy shocks were (1) the adoption of a fixed nominal parity with the US dollar, (2) the fiscal expansion, and (3) the 1999 rise in nominal wages. The crisis shocks are

[6] For discussion of the reasons for China's savings increase, see Yang and Tyers (2000).

examined in some detail in our earlier analysis (Yang and Tyers 2000). Our emphasis here is on the policy shocks. To examine these we turn to our global model.

3. A Global Comparative Static Macro Model

We focus on a short run in which the stock of physical capital is fixed and sectorally immobile. Investment makes demands on capital goods sectors but at this length of run it does not raise the productive capital stock. Also at this length of run, nominal wages are sticky downward in some regions (China, Europe, Canada and Australasia) but flexible elsewhere. Savings are mobile abroad and investment is allocated between countries to equate its expected rate of return net of exogenous risk premia. In the spirit of comparative statics, although price levels do change in response to shocks, no continuous inflation is represented and so there is no distinction between the real and nominal interest rates.

The real part of the model is based on our modified version of GTAP.[8] As a starting point, it offers the following useful generalisations: (1) a capital goods sector in each region to service investment, (2) explicit savings in each region, combined with open regional capital accounts that permit savings in one region to finance investment in others, (3) multiple trading regions, goods and primary factors, (4) product differentiation by country of origin, (5) empirically based differences in tastes and technology across regions, (6) non-homothetic preferences, and (7) explicit transportation costs and indirect taxes on trade, production and consumption.

In the original model, each regional household receives all income from primary factors and indirect taxes on trade, production and consumption. Its expenditure is then a Cobb-Douglas composite of private consumption, savings and "government expenditure". Private consumption is then a CDE composite of goods and services while government expenditure is a corresponding CES composite.[9] All individual goods and services are CES blends of home products and imports. In turn, imports are a CES blend of the products of all regions the composition of which depends on regional trading prices. Savings are pooled globally and investment is then allocated between regions from the global pool according to

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[7] See the discussion by Fernald and Babson (1999), p 6, and that by Wu (1999).
[8] For a detailed description of the standard version of this model, see Hertel (1997). Our modifications to the structure of the model are principally changes to the factor demand structure (Yang and Tyers 2000) and the sector specificity of capital in all regions.
[9] CDE is "constant difference in elasticities". It offers non-homotheticity of consumption demand. See Huff et al. (1997).

rules that accommodate a range of assumptions about international capital mobility. Within regions, investment places demands on the domestic capital goods sector which is also a CES composite of home produced goods, services and imports in the manner of government spending. The differentiation of home products from imports essential to this structure facilitates the departures from the law of one price that tend to occur even in tradeable goods sectors in the short and medium run.[10]

Simplifying only slightly, the accounting relationships for each home produced (superscript *H*) commodity or service, *i*, in each region satisfy

$$Y_i = C_i^H + I_i^H + G_i^H + X \qquad (1)$$

where Y_i is domestic output net of intermediate demand. Since consumption, investment and government spending generate demands for imports, *M*, we can also write

$$M_i = C_i^M + I_i^M + G_i^M \qquad (2)$$

Adding imports in this form to the right hand site of the first accounting relationship and using the result in a home price weighted sum across goods and services yields the central accounting identity.

$$Y = C + I + G + X - M \qquad (3)$$

3.1 Direct taxes and government spending

Our first modification to the model is to make the government financially independent by incorporating direct taxes explicitly and allowing for the exogeneity of government spending. Regional households then receive only regional factor income, Y_F, and from this they pay direct tax at a constant marginal rate, τ. The disposable income that remains is then divided between private consumption and private saving so that the regional household's disposal identity is

$$Y_F(1-\tau) = C + S_P \qquad (4)$$

[10] The early literature on real exchange rate changes tended to focus on associated relative price changes where tradeable goods prices retained parity with international trading prices. More recently it has become certain that short run departures from the law of one price occur across all tradeable goods sectors. See Engel (1999).

Government saving, or the government surplus, is then

$$S_G = T_I + \tau Y_F - G \qquad (5)$$

where T_I is the revenue from indirect taxes on trade, production and consumption. Each region then contributes its total saving, $S_T=S_P+S_G$, to the global pool from which investment is derived. For an individual region, relations (4) and (5) still imply that GDP is

$$Y = Y_F + T_I = C + S_T + G \qquad (6)$$

and this, with (3), implies the balance of payments identity which sets the current account surplus equal to the capital account deficit:[11]

$$X - M = S_P + S_G - I \qquad (7)$$

Of course, the model's accounting relations, summarised by (1) and (2), and the household and government budget constraints (4) and (5) make it unnecessary to include the balance of payments identity, (7), in the model explicitly.

3.2 Private consumption

The private consumption and saving decision is represented by a reduced form consumption equation with wealth effects included via a sensitivity of consumption and savings to the interest rate. The equation takes the form:

$$C = \gamma r^{\delta} [Y_F (1-\tau)]^{\mu} \qquad (8)$$

where γ is a constant shifter, $\delta < 0$ is the elasticity of private consumption to the regional interest rate and $0 < \mu < 1$ is the elasticity counterpart of the marginal propensity to consume.[12]

3.3 Regional investment demand and risk premia

We have opted to use the most flexible approach to the allocation of investment across regions, implying a high level of global capital mobility.[13] It is allocated across regions so that its proportional change is larger in regions, *j*, with high values of the average

[11] Note that there is no allowance for interregional capital ownership in the starting equilibrium and so there are no factor service flows and the current account is the same as the balance of trade.
[12] In the model, this equation represents consumption and GDP at factor cost in real terms by dividing nominal expenditure on each by a specific price index not shown here.

rate of return on installed capital, r_j^c. In this process, a global "expected return", r^w, is calculated such that $\Sigma_j S_j^T = \Sigma_j I_j (r^w, r_j^c, \pi_j)$, where I_j is real investment in region j and π_j is a region-specific risk premium.[14] The investment demand equation for region j takes the form:

$$\frac{K_j + I_j}{K_j} = \beta \left(\frac{1 + r^w (1 + \pi_j)}{1 + r_j^c} \right)^{-\varepsilon} \qquad (9)$$

where K_j is the (exogenous) installed capital stock, β is a positive constant and ε is a positive elasticity. The numerator on the right hand side is the expected gross return on investment in region j, so that $(1+r_j) = (1+r^w)(1+\pi_j)$ or $r_j \approx r^w + \pi_j$.

Note that our comparative static analysis does not require that the global economy be in a steady state. When shocks are imposed, the counterfactual return on installed capital, r_j^c, need not be the same as the corresponding expected return on investment, r_j. Such shocks, implemented in the current period, change income and savings and, therefore, expected returns in directions that differ from the return on an installed capital that is fixed in quantity and sectoral distribution.

3.4 Money and nominal exchange rates

To include the monetary sector in each region we simply add an *LM* curve. This implies that regionally homogeneous nominal bonds are the only financial assets other than regional money. Even though there is no interregional ownership of installed capital in the initial database these bonds are traded internationally, making it possible for savers in one region to finance investment in another.[15] The yield on the jth region's bonds in the single period represented by the model is the interest rate, r_j, defined above. Cash in advance constraints then cause households to maintain portfolios including both bonds and non-yielding money and the resulting demand for real money balances takes the usual reduced form:

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[13] By which it is meant that households can direct their savings to any region in the world without impediment. Installed capital, however, remains immobile even between sectors.

[14] Before adding to the global pool, savings in each region is deflated using the regional capital goods price index and then converted into US$ at the initial exchange rate. The global investment allocation process then is made in real volume terms.

[15] Since the initial database we use (GTAP Version IV) incorporates no "net income" or factor service component in its current account, our initial equilibria must do likewise. This implies the assumption that, although there are no interregional bond holdings initially, the shocks implemented cause interregional exchanges of bonds and hence a non-zero net income flow in future current accounts not represented.

$$m_D = \alpha Y^{\eta} r^{\phi} \qquad (10)$$

where α is a constant, and η and ϕ are the income and interest elasticities of money demand, respectively. This is equated with the region's real money supply, where purchasing power is measured in terms of its GDP deflator, P^Y.

$$LM \qquad m_S = \frac{M_S}{P^Y} = m_D = \alpha Y^{\eta} r^{\phi} \qquad (11)$$

where M_S is the regional nominal money supply.

Since all domestic transactions are assumed to use the home region's money, international transactions require currency exchange. For this purpose, a single nominal exchange rate, E_j, is defined for each region. A single key region is identified, usually the United States, relative to which these nominal rates are defined. For the United States, then, $E=1$ and E_j is the number of US dollars per unit of region j's currency. In essence, we are adding to the real model one new equation, (11), per region and one new (usually endogenous) variable per region, E_j.[16]

The bilateral rate between region i and region j is then simply the quotient of the two exchange rates with the US, $E_{ij} = E_i/E_j$. Quotients such as this appear in all international transactions. The most straightforward of these in the original model are trade transactions. There the bilateral exchange rate is simply included in all import price equations, along with *cif/fob* margins and trade taxes. In the case of savings and investment, the global pool of savings is accumulated in US dollars. Investment, once allocated to region j, is converted to that region's currency at the rate E_j. The third, and most cryptic, set of international transactions in the original model concerns international transport services. Payments associated with *cif/fob* margins are assumed to be made by the importer in US dollars. The global transport sector then demands inputs from each regional economy and these transactions are converted at the appropriate regional rates.

As an index of competitiveness the real effective exchange rate is also calculated for each region. It is a trade-weighted average of all bilateral real exchange rates in which the price index used is the GDP deflator, P^Y:

[16] More precisely, since for the US $E=1$, we are adding one less (usually endogenous) variable. Where nominal exchange rates are to be endogenous and nominal money supplies exogenous, one additional variable must be made endogenous, such as the nominal money supply in one region. Where nominal exchange rates are fixed

$$e_i^R = \sum_j E_{ij} \left(\frac{P_i^Y}{P_j^Y} \right) \left(\frac{X_{ij} + M_{ij}}{X_i + M_i} \right) \qquad (12)$$

where X_i and M_i are region i's total exports and imports, respectively.

3.6 The labour market:

Without nominal rigidities the model always exhibits money neutrality, both at the regional and global levels. Firms in the model respond to changes in nominal product, input and factor prices but a real producer wage is calculated for both labour and skill as the quotient of the nominal wage and the GDP deflator, so that $w=W/P^Y$. Thus, money shocks always maintain constant w when nominal rigidities are absent. It is in the setting of the nominal wage, W, that we have introduced nominal rigidities to the model. A parameter, $\lambda \in (0,1)$ is inserted, such that

$$\frac{W}{W_0} = \Lambda \left(\frac{P^Y}{P_0^Y} \right)^{\lambda} \qquad (13)$$

where W_0 is the initial value of the nominal wage, Y_0 is the corresponding initial value of the GDP deflator and Λ is a slack constant. While ever Λ is exogenous and set a unity, the nominal wage carries this relationship to the price level and the labour market will not clear except if equation (13) happens to yield a market clearing real wage. A fully flexible labour market is achieved by setting Λ as endogenous and thereby rendering (13) ineffective. At the same time, labour demand is forced to equate with exogenous labour supply to reflect the clearing market.

3.7 Database and parameters:

We use the GTAP Version IV database for 1995 and aggregate to the regions and commodity groups listed in Table 1.

The key parameters in the GTAP-based part of the model are the elasticities of substitution between product groups and between primary factors. Because the length of run is short, we use the smaller-than-standard elasticities of substitution in both demand and supply listed in Table 2. These elasticities emerge from a calibration exercise described in

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and nominal money supplies are endogenous, one additional variable must be made exogenous. This is the case

Yang and Tyers (2000). Preliminary values for the parameters of the consumption and investment demand equations and the money demand equation are then given in Table 3.

4. A Reference Crisis Scenario and Three Experiments:

We begin with a reference scenario that includes all the shocks associated with the crisis as well as the simultaneous changes in China. This scenario was originally constructed for two previous papers (Yang and Tyers 1999, 2000). It was then used for counterfactual analysis. In particular, we estimated the relative contributions of the external shocks on the one hand and the change in Chinese private savings behaviour on the other. Here we use the reference scenario to check that this more complete model generates changes in endogenous variables that tell a feasible and internally consistent story. Then, having further used the model to construct a post crisis database, we experiment with three policy shocks. The first is a fiscal expansion while the second is the nominal wage rise discussed in Section 2. The third is a nominal devaluation of the Renminbi.

4.1 The reference crisis shock:

This shock is of unusual construction in that a number of changes that we would normally think of as exogenous to our comparative static model are unobservable. These include the changes in investment risk premia associated with the crisis and the changes in consumption/savings parameters in China. We therefore render these variables endogenous and introduce shocks to some variables that would normally be endogenous, such as investment levels, trade balances and nominal exchange rates. Thus, the reference simulation serves both to calibrate for some key parameters and to test the behaviour of the model with respect to key variables that remain endogenous. In most regions we set nominal exchange rates as exogenous and impose observed shocks, making nominal money supplies endogenous. Investment and the current account balance are also exogenous, with observed shocks imposed, while (in Asia) the consumption coefficient, γ, is made endogenous.

Importantly, since these reference shocks are restricted to the Asian crisis, they represent an incomplete set for the world as a whole in the period 1997-98.[17] The simulations cannot, therefore, be expected to compare well with observation. The prominence of the

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in the reference crisis shock, introduced later. There we fix a target change in the US CPI, P^C.

crisis in the Asian regions, however, leads us to expect the model should do best in predicting changes in those regions. The specific closure used for the reference simulation is detailed in Table 4.[18]

Apart from the status of the newly added nominal variables, the closures are the same as those used in Yang and Tyers (2000). The regions most directly affected by the crisis are "recessed developing Asia" and Japan. Their treatment is similar to that of the other regions, except that the balance of payments shocks are complemented by exogenous production shocks with endogenous capital utilisation, to reflect the high rate of insolvencies and the sluggish resolution of the associated property rights issues in those regions.[19] In China, the levels of investment and the current account imbalance are also exogenous and shocked as observed in the crisis period. The consumption coefficient, γ, is made endogenous to capture the anticipated change in private savings behaviour (Tyers and Yang 2000, Tyers 2000) and government spending is shocked to account for the fiscal expansion between 1997 and 1998. In China's labour markets, we assume there is downward stickiness of the nominal wage over the length of run considered. Since rigid wages prevail in the state-owned and urban collective sectors and since workers in these two sectors make up about half the total wage bill, we set the nominal wage rigidity parameter of equation (13) at γ=0.5. Also, because both the markets for labour and skill are regulated, we allow their relative wages to vary but impose this rigidity on their average value.

The results for endogenous variables are listed in Table 5. Except to the extent that nominal exchange rates between all regions are forced to change as observed in 1997-98, these results indicate the global effects of the crisis only. Most striking for China is the larger deflation predicted by the model when compared with the official record. Were there no real shocks imposed, nor any nominal rigidities in the model, the fixed nominal exchange rates would ensure that all regions experience the same price level change (the US CPI target). Because there is upward pressure on nominal wages in the industrial regions that regulate labour markets, the only active nominal rigidity is in the Chinese labour market. It is important for China but it is not significant in other regions. The real shocks, however, and in

[17] Indeed, even the annual increments to capital stocks and productivity associated with normal economic growth are ignored in all regions.
[18] In the subsequent policy simulations, investment risk premia are fixed at post-crisis levels and the components of each region's current account are made endogenous. Investment is then allocated across regions so as to equalise expected rates of return adjusted for the fixed risk premia.
[19] This approach and what it implies about the behaviour of firms is detailed in Yang and Tyers (1999).

particular those to investment and the balance of payments, are large for the Asian regions. They cause large changes in real exchange rates and, in turn, require substantial deviations in domestic price levels. Of course, the magnitudes of these real exchange rate changes depend on the set of elasticities used in the model (Table 2) and our short run values for these are not well backed by estimation. Nonetheless, to obtain the official change in China's GDP deflator, we would have needed to use an elasticity set larger in magnitude than that designed for long run applications of the model. We are therefore inclined to suspect that the official statistics understate the fall in China's domestic price level in 1998.

As anticipated, the negative crisis shocks contract China's aggregate demand, the domestic price level falls and nominal wage stickiness ensures that the real wage rises. Employment falls and so output falls, once again by more than the official statistics reveal. Investment in China, which is exogenous in this simulation, falls by very little compared with global investment.[20] The loss of employment, however, substantially reduces the domestic return on installed capital. Other things equal, the latter would discourage investment. For consistency, the model finds that a decrease must have occurred in the investment premium for China. This is in spite of a substantial flight of savings! One difficulty here is that the rise in overall investment in China primarily reflects a boost in state sector investment, including inventory accumulation, the demand for which is not reflected by the model's equation (9). Private investment, which is more likely to behave as simulated, actually declined. In effect, the result indicates that our assumption of international capital mobility is too extreme for China. The very large reversal in private flows on China's capital account notwithstanding, in 1997-98 actual mobility in and out of China fell short of the model's behavioural representation.

4.2 Post crisis policy simulations

The reference simulation enables us to construct a post-crisis global short run equilibrium. This equilibrium takes the form of a global database upon which we then impose three policy shocks, each independently so as to gauge their separate effects on the post-crisis Chinese economy. Because they are China-specific the effects on other regions are generally small and so, for economy of space, we focus our discussion on the domestic effects. These are summarised in Table 6.

[20] As indicated earlier, the ratio of investment to GDP actually rose slightly, and it does so in this simulation.

(i) Further fiscal expansion, maintaining fixed nominal parity with the US$:

This experiment is to gauge the independent power of fiscal policy to raise output and employment in China. In the standard Mundell-Fleming framework, to which this model should conform, the fixed exchange rate is the target of monetary policy, leaving it unavailable to facilitate expansion following negative shocks. Fiscal policy, however, is not only available but its power to expand the economy is enhanced in the fixed exchange rate environment because the crowding out it causes does not result in a nominal appreciation. The Chinese labour market is characterised by nominal wage stickiness, with the parameter λ in equation (13) set at 0.5, as in the reference simulation.

As expected, the fiscal expansion does raise domestic demand and hence the price level. At the fixed nominal exchange rate this is consistent with a real appreciation relative to the rest of the world. The domestic price rise sees real wages fall and employment and GDP both rise. The increased government dissaving associated with the fiscal expansion raises net inflows on the capital account, however, causing the current account balance to deteriorate, a result that is also consistent with the real appreciation. Increased employment raises the real unit reward of installed capital. At the same time, the increased demands of China on the global saving pool raise the global expected interest rate on investment and therefore the home interest rate. The rise in the return on installed capital dominates, however, and additional real investment is attracted. This deviates from the "crowding out" story that would be present were savings less mobile between regions.

At the industry level, the rise in the real exchange rate reduces export competitiveness but it also reduces the real wage. In the export sector, which is primarily labour intensive manufacturing, the net effect of these two forces is to reduce output. With the cheaper labour, however, the relatively untraded services sector expands. The net result is a real expansion that does not impair future growth, in the sense that investment rises, but wherein the cost is borne by unskilled workers, whose real incomes fall.[21]

[21] Not displayed in Table 6 are the sector specific returns to capital. As expected, these show that manufacturing capital owners are also losers.

(ii) Nominal wage rise, maintaining fixed nominal parity with the US$:

Here we examine the independent effect of the 1999 increase in nominal wages. The Chinese nominal wage is made completely exogenous (λ=1) and raised 5 per cent. Government spending is now fixed as a proportion of GDP. Although intended to raise consumption expenditure, this shock raises the real wage and reduces employment and output. The expected result is a decline in consumption expenditure. And this is borne out, as shown in the second column of Table 6.

The rise in labour costs in all sectors pushes up the domestic price level. This policy would therefore have contributed to arresting China's deflation, suggesting an alternative motivation. With the nominal exchange rate fixed, this raises the real exchange rate, however, and reduces export competitiveness. And because the nominal wage rise also increases the real wage relative to the prices of other inputs and factors of production, employment falls and therefore GDP also falls. The decline in employment causes the marginal product, and therefore the real unit reward, of capital to fall. Thus, even though the associated change in private savings is insufficient to raise the global interest rate significantly, real domestic investment falls in China. By reducing current output and investment, the benefits this policy change would deliver to those workers remaining employed come at the cost of lower overall private consumption and slower future growth.

(iii) Nominal devaluation against the US$:

China's bilateral nominal exchange rate with the US remains fixed (exogenous) in this experiment but its level falls by 10 per cent. This is in keeping with the view that the present state of China's banking sector militates against a move to either a managed or a free float. Government initiated adjustments are feasible, however, in the manner of the 1980s and early 1990s. Government spending is now fixed as a proportion of GDP and the Chinese labour market is once again characterised by nominal wage stickiness, with the parameter λ in equation (13) set at 0.5.

This shock raises the domestic relative price of imports and improves the current account.[22] This change, combined with the required accommodating home monetary expansion, raises the domestic price level and reduces the real wage. Employment and output

[22] No retaliatory devaluations take place in China's export competitors. The effects on output in the other Asian regions are negative and the effect is comparatively strong in recessed developing Asia.

expand. The return on installed capital rises. Again, although private consumption increases, the changes in Chinese saving are not sufficient to alter the global interest rate significantly. Consequently, investment is attracted to China by the higher return on installed capital. All industries benefit from the reduced real wages with the greatest expansion enjoyed by the more export oriented labour-intensive manufacturing. In the end, while output and growth are enhanced, these gains come at the cost of reduced real income in worker households.

It is interesting to compare the final two columns of Table 6. The five per cent nominal wage rise and the 10 per cent devaluation have near opposite effects on all real variables. Although the latter enhances output and growth while the former contracts them, the former rewards skilled and unskilled worker households (at least those remaining employed), an important political constituency.

5. Conclusion:

There is much that can be learned about the effects of investment shocks, like those that were associated with the Asian economic crisis, from appropriately constructed real comparative static analysis. When real flows on the capital account change following such shocks the associated real exchange rate effects are readily modelled in this way and these often tell most of the economic story. Yet an important part of that story is left out. To the extent that nominal rigidities exist at the length of run on which such analyses are focussed, the associated nominal shocks can have substantial real effects. These effects can only be incorporated if the model used has a more complete macroeconomic structure. The extension of a fairly standard global micro model to achieve this has been the objective of this paper.

We have incorporated simple reduced form behavioural relationships from elemental macroeconomics and combined them, thus far, with generic parameter estimates. For our nominal rigidity we have introduced a form of nominal wage stickiness, though the range of labour market behaviours available are very flexible. A key assumption is international capital mobility. In the present version, all private and government savings contribute to a global pool from which real investment is allocated to each region. This allocation process is guided by returns on installed capital and exogenous risk premia for all regions. Our simulation of the effects of the Asian crisis show, among other things, that this assumption is too extreme for our representation of China. A second key assumption, necessitated by our comparative static approach, is that no agents in the model are forward-looking. The

overshooting behaviour that can emerge when expectations are accounted for is not represented. The model therefore offers an advance on comparative static microeconomics but one that is tempered by remaining shortcomings.

Our application to post-crisis macroeconomic policy in China confirms that, while maintaining fixed nominal parity with the US$, continued fiscal expansion will raise the home price level and therefore the real exchange rate, harming exports and export-oriented manufacturing industries. It will, however, reduce the real wage and foster employment growth. With perfect capital mobility, increased government dissaving notwithstanding, this employment growth would drive up the return on installed capital and attract new investment from abroad, thus fostering growth. The nominal wage rise of 1999 (approximated as 5 per cent) will also raise the home price level and the real exchange rate and hence it will also hurt export-oriented manufacturing. Employed workers will gain at the expense of those rendered unemployed and the owners of other factors of production. Reduced employment causes the return on installed capital to fall and so investment falls. Other things equal, this policy change would reduce output, employment and future growth.

Finally, a 10 per cent devaluation is found to have effects that roughly mirror those of the five per cent nominal wage rise. The balance of trade, employment, output and investment are all improved. Yet the analysis ignores the value to China of the maintenance of the exchange rate as the nominal anchor. Moreover, such a devaluation is literally a "beggar thy neighbour" policy and this is clearly shown in the analysis. The good outcome for the economy as a whole (though not for Chinese workers) therefore comes at the risk of retaliatory devaluations amongst China's neighbours and export competitors.

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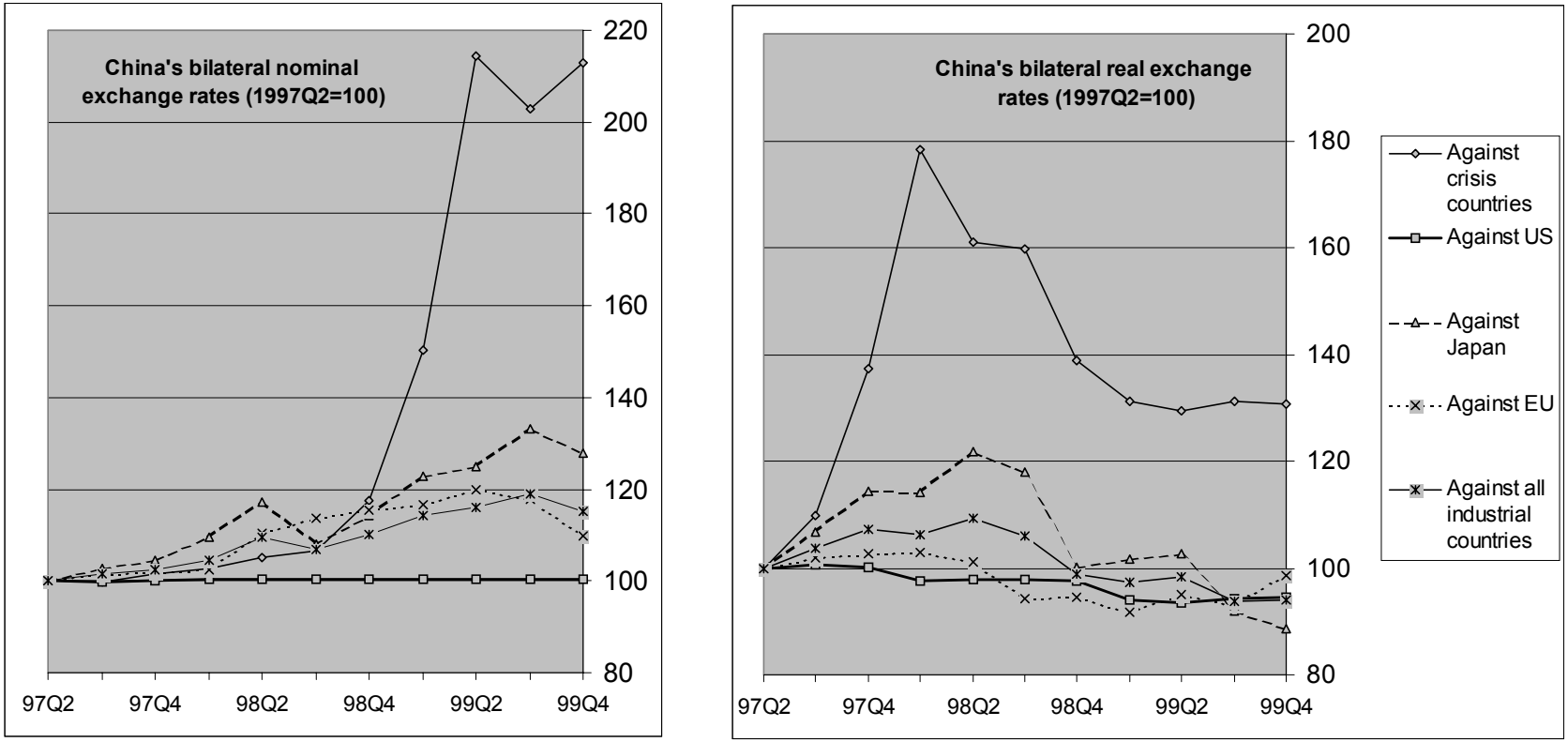
Figure1: China's exchange rates[a]



a The real exchange rate is expressed as $e_{ij}^{R}=E_{ij}.P_i^{Y}/P_j^{Y}$, where E_{ij} is the nominal rate in foreign currency units per unit of home currency, P_i^{Y} is the Chinese price level and P_j^{Y} is the foreign price level. Averaging across countries within the groups shown uses trade weights. Here the "crisis countries" include only Korea, Indonesia, Thailand, the Philippines and Malaysia. Relative to the category "recessed developing Asia" used later in the paper, Hong Kong, Singapore, Taiwan and Vietnam are excluded.
Source: Data are from IMF (2000).

Table 1: Model structure

Regions	Share of world GDP[f]
1. Recessed developing Asia[a]	5.1
2. Japan	18.0
3. China[b]	2.5
4. European Union[c]	29.0
5. United States	25.2
6. Canada and Australasia	3.5
7. Rest of world	16.8
Primary factors	
1. Agricultural land	
2. Natural resources	
3. Skill	
4. Labour	
5. Physical capital	
Sectors[e]	
1. All agriculture	
2. Mining and energy (coal, oil, gas and other minerals)	
3. Skill-intensive manufacturing (petroleum, paper, chemicals, processed minerals, metals, motor vehicles and other transport equipment, electronic equipment and other machinery and equipment)	
4. Labour-intensive manufacturing (textiles, apparel, leather and wood products, metal products, other manufactures)	
5. Skill-intensive services (electricity, gas, water, financial services and public administration)	
6. Labour-intensive services (construction, retail and wholesale trade, dwellings)	

a Korea (Rep.), Indonesia, Philippines, Malaysia, Singapore, Thailand, Vietnam, Hong Kong and Taiwan.

b China excludes Hong Kong and Taiwan.

c The European Union of 15.

d These are aggregates of the 50 sector GTAP Version 4 database. See McDougall et al. (1998).

e Share of 1995 GDP in US$ measured at market prices and exchange rates.

Table 2: Elasticities of substitution in final, intermediate and primary factor demand[a]

Sector	In product demand, between domestic and imported	In import demand, between regions of origin	In factor demand, between primary factor groups[b]
Agriculture	1.8	3.4	0.1
Mining	2.0	4.1	0.1
Manufacturing: labour intensive	2.7	5.8	0.6
skill intensive	1.6	3.3	0.6
Services: labour intensive	0.9	1.9	0.8
skill intensive	1.0	1.9	0.6

a These are group-specific weighted averages across the 50 industries defined in the database. The CDE parameters governing substitution in final demand are discussed in McDougall et al. (1998). Substitution elasticities in intermediate product demand, and between intermediates and primary factors, are set to unity (Cobb-Douglas) in this analysis.

b The complete set of original GTAP factor substitution elasticities are listed in Table 19.2 of McDougall et al. (1998). The elasticity of substitution within the labour group, between skilled and unskilled labour, is set at unity. Households' corresponding elasticity of transformation between skilled and unskilled labour is set to negligibility for this analysis.

Source: GTAP Database Version 4.1. See McDougall et al. (1998).

Table 3: Key Macroeconomic Parameters[a]

Elasticity of	
Real consumption to the interest rate, δ	-0.10
Real consumption to disposable income, μ	0.65–0.80
Investment: $(K+I)/K$ to the gross interest ratio $(1+r)/(1+r^c)$	-10.0
Real money demand to income, η	0.50
Real money demand to the interest rate, ϕ	-0.10

a In this preliminary application, most of these parameter values are common to all regions.

b RDA: 0.7, Japan 0.75, China 0.65, USA, EU, Canada/Australasia 0.8, rest of world 0.75

Sources: Indicative initial estimates only.

Table 4 Reference shocks and closures[a]

Recessed developing Asia and Japan:	
Exogenous:	Regional nominal exchange rate is shocked as observed 1997-98.
	Regional investment is reduced from 1996 to 1998 levels.
	Trade balance, *X*-*M*, changes as observed.
	Sectoral production volumes are shocked as observed.[b]
	(Full) employment – labour and skill are sectorally mobile fully employed.[c]
Endogenous:	Regional nominal money supply.
	Regional risk premium on current investment, π.
	Regional consumption (saving) coefficient, γ.[d]
	Sectoral capital use, so that capital is idled in contracting sectors.[b]
	Nominal and real wages.
China:	
Exogenous:	Regional nominal exchange rate is shocked as observed 1997-98.
	Regional investment as per cent of GDP is raised 3%.
	Trade balance, *X*-*M*, changes as observed.
	Government spending changes as observed.
	Sectoral capital use is fixed.
	Λ in equation (13) with λ=0.5, to reflect sticky nominal wages.
Endogenous:	Regional nominal money supply.
	Regional risk premium on current investment, π.
	Regional consumption (saving) coefficient, γ.[d]
	Sectoral production volumes.
	Employment.
United States:	
Exogenous:	P^C, CPI target of 2% (see footnote 16, Section 3.4).
	Nominal exchange rates as observed.
	Regional current account, *X*-*M*, changes as observed.
	Sectoral capital use.
	(Full) employment.
Endogenous:	Nominal money supply.
	Regional investment.
	Regional risk premium on current investment, π.
	Sectoral production volumes.
	Nominal and real wages.
EU, Australasia & Canada, and the rest of world:	
Exogenous:	Nominal exchange rate changes relative to the US.
	Regional current account, *X*-*M*, changes as observed.
	Sectoral capital use.
	Nominal wage, λ=0 (if *W* would otherwise fall), employment (if *W* would otherwise rise).
Endogenous:	Regional investment.
	Regional risk premium on current investment, π.
	Sectoral production volumes.
	Employment (if *W* would fall), nominal and real wages, or Λ endogenous (otherwise).

a In all scenarios, capital is completely sector specific in all regions, so that the rate of return differs across sectors. Of the large number of variables that are endogenous in this model, this table lists only those endogenous variables that are occasionally made exogenous or that are exogenous in some regions but not in others.

b The approach taken to this, and its numerical consequences, are detailed by Yang and Tyers (1999).

c In recessed developing Asia, the retreat to the rural sector is reflected by a decline in labour productivity in agriculture of 5% and in increase in land productivity of 2%.

d The capital account and current account must be equal in magnitude and opposite in sign, I-S=M-X. For recessed developing Asia, Japan and China, these shocks impose explicit contractions in investment and in imports relative to exports. The volume of saving then follows endogenously, thus determining the coefficient γ in these regions.

Source: IMF (1999a, 1999b, 2000); Statistics from web sites for countries concerned, as summarised in Duncan and Yang (2000). The sources for China are detailed in Yang and Tyers (2000).

Table 5: The simulated global effects of the Asian crisis[a]

Change in	Rec. Dev. Asia	Japan	China	USA	EU	Canada, Aust, NZ
Nominal exchange rate(US$/.), E_i (%)	-38.9*	-18.8*	0.2*	0.0*	-3.4*	-10.8*
Domestic CPI, P^C (%)	44.7	16.1	-9.4	1.9	1.5	11.3
Domestic GDP deflator, P^Y (%)	40.5	15.3	-7.9	2.7	1.7	11.4
Nominal money supply, M_S (%)	24.7	9.4	-8.1	3.3	2.0	11.8
Real effective exchange rate, e_i^R (%)	-11.7	-1.1	-2.0	8.3	2.8	0.9
Real exchange rate against USA, e_{ij}^R (%)	-16.4	-8.8	-10.1	0.0	-4.3	-3.2
Terms of trade[b](%)	-4.4	-2.6	-0.7	6.0	0.8	0.2
Global interest rate, r^w	1.1	1.1	1.1	1.1	1.1	1.1
Investment premium factor, $1+\pi$ (%)	89.9	29.4	-11.5	-6.7	-3.5	-4.0
Home interest rate, r (%)	92.0	30.8	-10.6	-5.7	-2.4	-2.9
Return on installed capital[c], r^c (%)	21.1	20.7	-15.7	1.3	0.5	-0.2
Real domestic investment, I (%)	-37.7*	-10.7*	-0.4*	9.8	4.9	7.8
Real consumption, C (%)	-16.4	-4.0	-22.4	1.3	0.5	0.4
Balance of trade, X-M (US$b)	146*	36*	30*	-137*	-82*	-15*
Real gross sectoral output (%)						
Agriculture	1.2	0.2	-3.4	-0.7	-0.4	-1.0
Mining	-3.9	-2.7	-0.2	-0.2	-0.1	-0.1
Manufacturing: labour-intensive	-11.4	-3.8	-0.5	-1.5	-0.3	-1.1
skill-intensive	-12.1	-3.0	-2.6	-1.3	-0.6	-0.7
Services: labour-intensive	-11.0	-5.4	-3.4	1.0	0.5	0.7
skill-intensive	-10.1	-6.2	-0.4	0.0	0.0	-0.2
Real GDP, Y (%)	-10.2	-5.0	-2.6	0.1	0.1	0.2
Nominal wage, W (%)	18.1	6.5	-4.8	3.0	1.8	11.9
Real wage, $w=W/P^Y$ (%)	-18.4	-8.2	0.0	1.0	0.3	0.6
Employment, L^D (%)	0.0	0.0	-5.0	0.0[d]	0.0[d]	0.0[d]
Unit factor rewards, CPI deflated (%)						
Labour	-18.0	-8.2	4.6	1.1	0.3	0.6
Skill	-19.3	-8.3	7.2	0.8	0.3	0.4
Capital	13.5	10.7	-9.7	0.6	0.3	0.0
Land	-17.3	-5.6	-45.8	-13.4	-4.6	-14.5
Natural resources	-19.9	-8.6	-19.3	-6.8	-3.8	-8.3

a Reference closure and shock details are indicated in Table 5. All variables shown are endogenous, except for the nominal exchange rate and balance of trade for six of the seven regions and the level of real investment in the Asian regions each of which is marked with an asterisk (*).

b Change in the value of exports at endogenous prices, weighted by fixed 1995 (base period) export volumes, divided by the value of imports, weighted by fixed 1995 import volumes.

c Per cent change in payments to capital less the per cent change in the capital goods price index.

d In these cases, real wage rises do not trigger unemployment because the nominal wage is flexible upward.

Source: Model simulations described in the text.

Table 6: Simulated short run effects of policy shocks on the Chinese economy[a]

Change in	10% fiscal expansion, ΔG[b]	5% wage increase, ΔW[c]	10% devaluation, ΔE[d]
Nominal money supply, M_S (%)	1.3	0.1	11.0
Domestic CPI, P^C (%)	0.8	0.5	10.5
Domestic GDP deflator, P^Y (%)	1.1	0.7	10.3
Real effective exchange rate, e_i^R (%)	1.1	0.7	-0.7
Real exchange rate vs USA, e_{ij}^R (%)	1.1	0.7	-0.7
Terms of trade[e] (%)	0.5	0.4	-0.4
Return on installed capital[f], r_c (%)	1.9	-4.2	4.7
Interest rate (expected return), r (%)	0.1	0.0	0.0
Real domestic investment, I (%)	0.1	-0.3	0.3
Real consumption , C (%)	0.6	-0.7	0.8
Balance of trade, X-M (US$b)	-5.7	-2.3	2.5
Real gross sectoral output (%)			
Agriculture	0.1	-1.2	1.2
Mining	0.0	-0.1	0.2
Manufacturing: labour-intensive	-0.4	-1.5	1.7
skill-intensive	-0.2	-1.1	1.3
Services: labour-intensive	0.4	-1.2	1.4
skill-intensive	1.5	-1.4	1.5
Real GDP, Y (%)	0.4	-1.1	1.2
Employment, L^D (%)	0.7	-2.4	2.8
Real wage, $w=W/P^Y$ (%)	-0.4	4.5	-4.8
Unit factor rewards, CPI deflated (%)			
Labour	-0.7	4.6	-5.0
Skill	1.0	3.9	-4.3
Capital	1.4	-2.9	3.2
Land	1.2	-13.7	15.9
Natural resources	0.0	-5.6	6.2

a These shocks are imposed on the post-crisis database, achieved following the changes indicated in Tables 4 and 5. Note that the exchange rate against the US$ is assumed fixed in all three shocks as are all consumption/savings parameters and the investment premia emerging from the reference simulation. All variables displayed are endogenous.

b This is an expansion of government expenditure with revenue from direct and indirect tax endogenous and where the deficit increase is bond financed. As in the reference crisis shock, the labour market is characterised by wage stickiness such that the nominal wage changes by half the CPI (λ=0.5).

c Here the nominal wage completely rigid (λ=1.0) and it is raised for all workers. Government spending is fixed as a proportion of GDP and other conditions are as in a, b above.

d The nominal exchange rate is devalued by 10 per cent once and for all, government spending is fixed as a proportion of GDP and the other conditions are as in a, b above.

e Change in the value of exports at endogenous prices, weighted by fixed 1995 (base period) export volumes, divided by the value of imports, weighted by fixed 1995 import volumes.

f Per cent change in payments to capital less the per cent change in the capital goods price index.

Source: Model simulations described in the text.