# China's Economic Growth and its Real Exchange Rate*

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## Abstract

Pressure from abroad to revalue China's currency appears to associate its rapid economic growth with the likelihood of a real appreciation. In a world of open economies and differentiated traded goods, however, development-related productivity and endowment growth shocks tend to cause real *depreciations*, the principal exception being the Balassa case where non-traded service sectors are large and productivity growth is considerably faster in traded sectors. Yet China is special amongst developing countries because its labour force is likely to decline in future and this will cause upward pressure on its real exchange rate. This paper quantifies the links between growth shocks and the Chinese real exchange rate using a dynamic model of the global economy with open capital accounts and full demographic underpinnings to labour supply. The results suggest that, in the short run, the dominant force is financial capital inflows, which are appreciating. In the long run demographic forces prove to be weak relative to skill transformation and services sector productivity. These are both comparatively powerful and depreciating. While financial capital inflows driven by expected appreciation may be self-fulfilling in the short run, these results suggest that the fundamental forces are more likely to favour a trend toward real depreciation.


## 1 Introduction

The underlying trend of China's real exchange rate is of critical importance to Chinese macroeconomic policy and to the global capital market. A recent influx of financial capital, combined with international political pressure to revalue the *Renminbi* (RMB), implies an expected appreciation.[1] If it is also expected that the Peoples Bank of China will give future priority to domestic price stability, anticipation of an underlying real appreciation is implied.

Yet real growth is associated with technical advances and factor accumulation, both of which reduce costs relative to those in less rapidly expanding trading partners. Growth shocks might therefore be expected to depreciate the real exchange rate. Indeed, real depreciations must occur in countries subjected to growth shocks when all goods are tradeable and equally substitutable. The story is more complex, however, when tradability varies across a country's goods and services and technical change is slower in the non-traded sectors. Then, growth has a Balassa (1964) dimension whereby it is imagined that comparatively low wages and per capita incomes in developing economies are due to their comparatively low factor productivity in tradable goods sectors.[2] Productivity contrasts are seen in this context as less great in non-traded service sectors, particularly for services that are labour intensive in both developing and industrialised economies. As growth ensues and productivity converges on industrial economy

[1] The surge in private inflows is noted by Prasad and Wei (2005). The claim that the RMB is mercantilistically undervalued occurs frequently in the scholarly literature, as in Dooley et al. (2004) and Eizenman and Lee (2006), and in more partisan political fora, as in of Bernanke (2006).
[2] See Balassa (1964) and, more peripherally, Samuelson (1964).

levels, real wages are driven up more quickly than labour productivity in non-tradable services. While the prices of tradable goods are constrained by imports, those of non-traded services rise, placing upward pressure on the real exchange rate.

Yet overall GDP growth stems not only from tradeable productivity improvements. For one thing, in many expanding developing countries productivity has been found to grow quickly in non-traded services.[3] More importantly, however, there are numerous changes in factor endowments due to demographic change, the skilling of the labour force, changes in saving rates and financial reforms that lead to declining investment premia and expanded financial capital inflows. Population growth and skill-upgrading expand endowments of labour and human capital, while changes in saving rates and interest premia alter the rate of growth of the physical capital endowment. Other things equal, factor endowment growth relative to trading partners reduces the home real exchange rate. The net effect therefore depends on the pattern of endowment changes and the sectoral distributions of productivity growth and tradability. In China's case, however, demographic change would appear to be of particular importance. Unusually for a country of its level of development, fertility is low and declining and population and labour force growth are slowing, with the likelihood that they will begin to decline within the next decade.[4] Other things equal, this should foster growth in real wages and therefore tend to appreciate the real exchange rate.

This paper explores these interactions for the case of China in a dynamic numerical model of the global economy that embodies full demographic behaviour. To identify conditions under which the Chinese real exchange rate will appreciate, changes to population policy, skill-upgrading rates, saving rates, financial reform and factor productivity growth are introduced, the latter differentially across the food, industrial and services sectors. While the modelling confirms the Balassa conjecture that productivity growth in the tradeable sectors alone leads to real appreciation, the majority of the growth-related shocks considered place downward pressure on the real exchange rate. Demographic change proves not to be a major determinant. In the short run increased net capital account inflows, as might be induced by financial reform, prove dominant and are appreciating while, in the long run skill-upgrading and services productivity are both dominant and depreciating. A predisposition toward real depreciation is suggested in the long run. The section to follow briefly reviews the recent debate about the RMB, the patterns of real exchange rate change in East Asian economies and the evidence on Chinese productivity growth. Section 3 then describes the global model used and Section 4 discusses the adopted

[3] See Miyajima (2005).
[4] See Golley and Tyers (2006).

baseline simulation to 2030. Section 5 then describes the use of the model to construct time paths of elasticities of China's real exchange rate to alternative growth shocks. Section 6 then concludes.

## 2 The RMB Debate and the Evidence on Productivity

While the People's Bank of China has long been committed to maintaining a stable nominal exchange rate, there is increasing pressure for the Chinese authorities to allow the currency to float more freely.[5] Many analysts believe that this will necessarily lead to a further appreciation of the RMB (as it has done, albeit slowly, since the relaxation of the *de facto* US dollar peg in July 2005). Yet it is not guaranteed that the only way the RMB can go is up. While the majority of recent scholarly research finds undervaluation[6], a number of studies do not.[7] Prasad et al. (2005) point to the potential for depreciation following the gradual liberalisation of the capital account, which could lead to net outflows as domestic investors seek to diversify their portfolios.[8] Moreover, there is already substantial evidence of (informal) private outflows from China (Prasad and Wei, 2005), which would be expected to expand if legalised, placing further downward pressure on the exchange rate. In addition, the recent surge in speculative inflows in anticipation of appreciation is likely to be temporary and could easily be reversed.[9] In essence, if and when the People's Bank of China (PBC) introduces a yet more flexible exchange rate regime, it seems possible that anything could happen. One thing is clear, however: with a freely floating exchange rate, the PBC is likely to follow the practice of central banks abroad and focus on the control of inflation. This means that the forces underlying real exchange rate dynamics will also determine the path of the nominal exchange rate.

In a world of open economies and differentiated tradable goods, productivity and factor endowment growth shocks tend to cause real depreciations. The key issues, then, are the scale and sectoral distribution of productivity shocks, tradability and the direction of endowment shocks. With regard to the latter, demographic change would appear to be important for China.

[5] See Lardy (2006), Prasad et al. (2005), Prasad and Rajan (2006) and Bernanke (2006).
[6] See Frankel (2004), who finds that the RMB was undervalued by 36% in 2000, Goldstein (2004), who claim it was undervalued by 15-30% in 2004 and Coudert and Couharde (2005), who find the undervaluation to be larger.
[7] See Dunaway and Li (2005) for a survey, including one that finds overvaluation (Wang, 2004, 2005). Tyers et al. (2007) use a structural model to find evidence of undervaluation in the mid to late 1990s but offer no clear finding for 2004.
[8] Whether this happens or not depends on whether the PBC's current policy of soaking up domestic saving by issuing its own bonds, and then purchasing foreign bonds on behalf of its citizenry, offers a national portfolio with more or less foreign assets than would emerge in the absence of interventionist central banking and with an open capital account. This is noted by Prasad et al. (2005) and it is a weakness in the partisan case made by Bernanke (2006).
[9] According to Fan (2006), speculative inflows were as high as USD 105 billion in 2004. See also Prasad and Wei (2005).

Cai and Wang (2005) claim that about one-quarter of per capita GDP growth between 1980 and 2003 can be attributed to the "demographic dividend", associated with the high proportion of the population in the working-age range during this period.[10] This has played a critical role in keeping wages – and hence the real exchange rate – low, thereby enabling the rapid expansion of labour-intensive manufacturing exports. However, Cai and Wang predict that this dividend will be exhausted in China by the year 2015, after which the aged dependency ratio will rise steadily, reaching 40 per cent by 2030.[11] The upward pressure that this will exert on real wages and, therefore, the real exchange rate makes China a unique case among developing countries.

While there is considerable debate over the precise figures, there is little doubt that total factor productivity (TFP) growth has made a positive contribution to China's overall economic growth during the reform period. Chow and Lin (2002) analyse aggregate economic growth during the period 1978 to 1998 using standard Cobb-Douglas growth accounting, showing that economy-wide TFP grew at 2.6% and accounted for 29% of GDP growth during this period. Wang and Yao (2003) incorporate human capital accumulation into their growth accounting (arguing that failing to do so places an upward bias on TFP estimates), but still find that TFP contributed 25.4% to China's real GDP growth rate during the period 1978-1999.[12] If it is assumed that these studies imply economy-wide productivity improvements China's TFP record could be said to have contributed to its low real exchange rate.

Yet the Balassa story depends on sectoral contrasts in productivity performance and, in particular, on productivity growth in relatively non-tradable services. If the non-traded sector is large enough and its productivity growth lags sufficiently behind that of traded sectors then wages rise with tradable productivity, pushing up relative service prices and thereby placing upward pressure on the real exchange rate. The empirical evidence from searches for dominant Balassa effects in rapidly growing developing countries is mixed, however. Choudhri and Khan (2004) find evidence for it from a small sample of developing countries that does not include Mainland China, Taiwan or Hong Kong. Miyajima (2005) focuses on growth spurts and finds contradictory evidence, stemming in part from high rates of services productivity growth in some countries during periods of comparatively rapid expansion.

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[10] See Bloom and Williamson (1998) for a generic discussion of the demographic dividend in developing countries.

[11] Tyers and Golley (2006) confirm this, finding that the non-working aged dependency ratio could rise to 43 per cent.

[12] See also Wang and Fan (2000), who estimate China's average annual TFP growth to be 1.46% between 1979 and 1999; Wang and Yao (2003) find that the rate was 2.32% between 1978 and 1998; Young (2003), using new human capital data and drawing on official and unofficial data to find TFP growth of 1.4% between 1978 and 1998; Islam et al. (2005) place average TFP at 2.26% between 1978 and 2002; and Guo and Jia (2005), who use frontier analysis to estimate China's TFP, derive a relatively low annual rate at 0.891%.

Indeed, the East Asian evidence associating real appreciations with growth surges is certainly mixed. Figure 1 plots bilateral real exchange rates against the US for Mainland China and some of its neighbours since 1980. There is no clear pattern.[13] This could suggest that the Balassa effect is offset by the scale of across-the-board productivity gains or, consistent with the story offered by Aizenman and Lee (2006), by mercantilistic sapping of domestic aggregate demand through the soaking up of home savings and the "hoarding" of foreign reserves. Applied to mainland China, however, the latter argument could founder on the effectiveness of capital controls in preventing foreign holdings by private firms and households. To explore the productivity issue further, we turn to the China-focussed literature. This is mainly in Chinese and it is dominated by the work of Lu Feng at the China Center for Economic Research, Peking University.[14]

In his most comprehensive study, Lu (2006a) estimates labour productivity in China's manufacturing and service sectors between 1978 and 2004. He describes the evolution of China's manufacturing labour productivity after 1978 as a two-stage process: during the first stage (1978-1990) it was only 1.9% per year, compared with a per capita GDP growth rate of 7.5%; while during the second stage (1991-2004) it increased dramatically, averaging 13.1%, significantly higher than the official per capita GDP growth rate of 8.2%. Labour productivity in the service sector averaged 4.3% per year over the entire period. He divides manufacturing labour productivity by service labour productivity to get yearly estimates of relative tradable to non-tradable labour productivity. Assuming a value of 100 in 1978, this reveals that relative productivity dropped to 84 in 1990 but rose rapidly thereafter, reaching 276 in 2004. He then calculates manufacturing/services relative labour productivity in the US and 13 OECD economies over the same period, and uses these to construct *comparative* labour productivity indices for China in terms of the US and the OECD. Both indices show the same trend, dropping between 1978 and 1991 and increasing strongly between 1994 and 2004.

Lu asserts that this pattern is demonstrative of the RMB's early overvaluation and subsequent undervaluation. In particular, he takes the view that the rapid growth of Chinese manufacturing productivity since 1994 (relative to Chinese services and also to US and OECD manufacturing productivity) suggests a trend of real exchange rate appreciation in this period. The fact that this pattern is not borne out in the Chinese real exchange rate series of Figure 1 suggests that the tendency for relative productivity to cause real appreciation has been more than

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[13] Korea is a possible exception if the period is divided into episodes. Prior to the Asian financial crisis it was appreciating, losing ground during the crisis and commencing an appreciating trend again thereafter.
[14] See Lu (2006a, 2006b, 2007) and Lu and Han (2006).

offset by the corresponding tendencies for across-the-board productivity growth, relative factor accumulation and Aizenman-Lee reserve hoarding to cause real depreciation.

Assumptions about factor productivity in the traded and service sectors are clearly critical determinants of real exchange rate changes. Yet there are numerous measurement difficulties, including the undercounting of industrial employment in China due to the influx of unregistered rural workers to urban areas, the lack of clear volume measures for services and of quality or composition adjustments to estimates of the capital stock.[15] To clarify our own perspective, we chose to re-examine the data for China since 1986.

**A reassessment of recent productivity growth in China**

We estimate simple Solow residuals for the economy as a whole and for three sectors: "Food", "Industry" and "Services".[16] Assuming Hicks neutral technological progress and constant returns Cobb-Douglas technology, the annual Solow residual takes the form:

(1) $$\frac{\Delta A}{A}=\frac{\Delta Y}{Y}-\alpha\frac{\Delta K}{K}-\left(1-\alpha\right)\frac{\Delta L}{L},$$

where $Y$ is output, $K$ is physical capital and $L$ is labour, at all skill levels. $\alpha$ is the elasticity of output to the capital stock and the capital share of value added. We apply this relationship to annual data from 1985 to 2005 for the economy as a whole and for the three sectors.[17] From the *China Statistical Abstract* (2006), we obtain constant price indices on for "primary industry", "secondary industry", "tertiary industry" and construction. These broad sectors are not precise fits to the sectors we define, however, so we construct deflators from constant and current price industry output indices. We then use these to restructure the price and output quantity statistics by sector. This gives us output series in constant 2000 prices for "food", "industry" and "services".[18] The implied rates of annual sectoral and GDP price inflation are illustrated in Figure 2 and the corresponding price indices are shown in Figure 3. For the period as a whole relative service price inflation is somewhat obscured by rises in primary product prices. For the

[15] While quality adjusted volume measures are available for most primary products and manufactures there is generally no comparable quality-adjusted measure of services volume and hence no accurate index of service prices. The same point can be made about the capital stock – in most countries it is increasingly computation-intensive, yet the price of computation services has declined relative to those of other capital goods. Standard estimates of capital stocks tend therefore to be underestimates.
[16] The "Food" sector is defined as Primary Industry plus Food processing, "Industry" as Secondary Industry minus Construction and Food processing, while "Services" as Tertiary Industry plus Construction.
[17] Output data are from the *China Statistical Year Book* (2005), *China Industrial Economic Statistical Year Book* (every year after 1985) and *China Statistical Abstract* (2006). Employment data are from *China Statistical Year Book* (2005), *China Industrial Economic Statistical Year Book* (every year after 1985) and *China Labor Statistical Year Book* (every year after 1985). China's capital stock, at 2000 prices, is from Holtz (2006).
[18] The availability of constant and current price statistics notwithstanding, for reasons indicated previously, we are not sanguine about the accuracy of the resulting price series, and particularly that for services.

relatively stable fixed exchange rate period beyond 1995 the pattern is clearer, however. In that period service prices have clearly inflated relative to those of traded merchandise.

A particular difficulty in the case of China concerns statistics on labour use. According to Cai and Wang (2006), China's officially published urban employment data may be underestimated due to the omission of workers present in urban areas "unofficially", without urban registration. They estimate the unrecorded "residual" in urban employment data at 11.3 per cent between 1991 and 1995, 23.8% in 1996-2000 and 38.4% in 2001-2004. We therefore enlarge employment in industry and services from 1991 to 2005 based on the proportions estimated by Cai and Wang.

In order to estimate the Solow residual separately for each of the three sectors, the capital stock must be split between them. To do this we assume rates of return on physical capital do not differ greatly between sectors and hence that the sectoral distribution of physical capital use is the same as that of expenditure on capital. For the latter, we use the sectoral splits of "operating surplus" in China's input-output tables for 1992, 1995, 1997, 2000, and 2002.[19] Finally, we need estimates for the capital share of value added, $\alpha$ . Again, we use the input-output tables. Ignoring "net taxes on production" and "total depreciation of fixed assets", we take total value added as the sum of "operating surplus" and "compensation of labour". The capital share is then the share of operating surplus in this total.[20]

The average annual changes in the Solow residuals for each sector are given in Table 1. These show strong productivity performance by the Chinese economy since the mid-1980s, with a slowdown in the 1998-2001 period associated with the Asian financial crisis and the post-millennium stock market corrections.[21] Consistent with the analysis of Lu (2006a), productivity growth appears to have been strongest in the industrial sector. The averages disguise higher recent productivity growth in the food sector however, as rural to urban migration accelerates.[22]

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[19] Operating surplus is $r_i K_i$ where $r_i$ is the return rate to capital in sector $i$ and aggregate compensation to capital is $\overline{r}\overline{K} = \sum r_i K_i$ , where $\overline{r}$ and $\overline{K}$ are the aggregate capital return rate and the physical capital stock. We assume that $\overline{r} = r_i$ for all $i$, making it possible add the operating surpluses and allocate them sectorally ('food' needs to be split between the value-added shares of Food Processing and Food Manufacturing). Then, for each of the three sectors, the share of capital stock is given by: $r_i K_i \big/ \sum r_i K_i$ .

[20] Our estimates of $\alpha$ are smallest for the "food" sector and largest for the "industry" sector. There is an important trend, however, for industry to become less capital intensive and both "food" and "services" to become more capital intensive. In 2005, the shares are food: 14%, industry: 40%, services 32%.

[21] The productivity performance in this period appears to have remained strong in the industrial sector while deteriorating in food and services. This may be a statistical aberration caused by the overall economic slow-down in this period and the retreat of unrecorded workers from industry to agriculture and services.

[22] The omission of the skill content of the labour force probably contributes to what appear to be rates that are on the high side. Aside from the cautionary notes already mentioned, changes in the composition of the capital stock inevitably lead to the underestimation of its real value and hence to overestimation of Solow residuals.

Importantly, the growth rate of productivity in services is always slower than in the tradeable sectors. Yet, particularly in recent years, the differences are not large. While this offers the standard Balassa explanation for the relative inflation in the services sector that is indicated in Figure 3, the gap has been clearly insufficient to overcome long run depreciating forces. To further explore the relative strengths of the many forces on the real exchange rate we resort to the use of a numerical model.

## 3 The Model

The approach adopted follows Tyers and Shi (2007a, b), in that it encompasses both demographic and economic change. Our initial emphasis on the demography stems first from our expectation that China's eventual labour force slow-down would place upward pressure on real wages and, therefore, on the real exchange rate. Second, since China's service sector is relatively intensive in skilled labour, the real exchange rate is also likely to be sensitive to the rate at which production worker families acquire skill. A complete demographic sub-model is therefore integrated within a dynamic numerical model of the global economy in which regional households are disaggregated by age group, gender and skill level.[23]

**Demography:**

The demographic sub-model tracks populations in four age groups, two genders and two skill categories: a total of 16 population groups in each of the 14 regions listed in Table 2.[24] The four age groups are the dependent young, adults of fertile and working age, older working adults and the mostly-retired over 60s. The skill subdivision is between households that provide production labour (unskilled) and those that provide professional labour (skilled).[25] Each age-gender-skill group is a homogeneous sub-population with a group-specific birth and death rate and rates of both immigration and emigration.[26] The final age group (60+) has duration equal to measured life expectancy at 60, which varies across genders and regions. The key demographic parameters, then, are birth rates, sex ratios at birth, age-gender specific death, immigration and emigration rates and life expectancies at 60. The birth rates, life expectancies at 60 and the age

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[23] The model has its origins in *GTAP-Dynamic*, the standard version of which is a derivative of its comparative static progenitor, *GTAP* (Hertel, 1997). Its dynamics is described by Ianchovichina and McDougall (2000).
[24] The demographic sub-model has been used in stand alone mode for the analysis of trends in dependency ratios. For more complete documentation, see Chan and Tyers (2007).
[25] The subdivision between production and professional labour accords with the ILO's occupation-based classification and is consistent with the labour division adopted in the GTAP Database. See Liu et al. (1998).
[26] Mothers in families providing skilled labour are assumed to produce children who will grow up to be skilled workers. The children of mothers in production worker families are correspondingly assumed to become production workers, except that a fixed proportion of them are transformed into skilled workers each year.

specific mortality rates all trend through time asymptotically, converging on exogenous target levels. In particular, the declining trend in Chinese fertility extends the fall during the decade prior to the base year (1997) in an asymptotic approach toward, but not reaching, the birth rate observed in Japan in that year.[27]

A further key parameter is the rate at which each region's education and social development institutions transform production worker families into professional worker families. Each year a particular proportion of the population in each production worker age-gender group is transferred to professional (skilled) status. These proportions depend on the regions' levels of development, the associated capacities of their education systems and the relative sizes of their production and professional labour forces. The resulting rates of transformation are based on changes during the decade prior to the base year, 1997, in the composition of aggregate regional labour forces as between production and professional workers. They are constant within each region and through time and have the consequences for changes in skill endowments through time indicated in Table 3.[28] The share of China's labour force that is skilled (professional) is projected to rise through time while that in North America remains static. The contrast is due to North America's higher initial skill share, its high rate of unskilled immigration and its higher fertility rate.

*Labour Force*

To evaluate the number of "full-time equivalent" workers we first construct labour force participation rates, by gender and age group for each region from ILO statistics on the "economically active population". We then investigate the proportion of workers that are part-time and the hours they work relative to each regional standard for full time work. The result is the number of full-time equivalents per worker.[29] For each age-gender group and region, a target country is identified whose participation rate is approached asymptotically. China's aged labour force participation is projected to rise slightly to allow for the expected shortfall in pension income as more retirees leave private sector employment. This, combined with the effects of ageing, raises the trend of the labour force above that of the population, as indicated in Figure 4. Most striking in this figure, though, is the projected reversal of the trend in China's labour supply.

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[27] Since 1997 the Japanese fertility rate has fallen from 1.4 to 1.25. These projections are slightly lower than those by the Development Research Centre of the State Council of China (2000) and Sharping (2003), yet the latter two make no attempt to allow Chinese fertility to follow the declining trends observed in neighbouring countries.

[28] Note that, as regions become more advanced and populations in the production worker families become comparatively small, the skill transformation rate has a diminishing effect on the professional population. These transformation rates are held constant in this analysis but are made endogenous to real per capita incomes and to the skilled wage premium in Tyers, Bain and Vedi (2006).

[29] See Tyers et al. (2005: Tables 11 and 12) for further details.

**The Global Economic Model**

We adopt a multi-region, multi-product dynamic simulation model of the world economy. Money is not included and the prices of goods and assets are set relative to a global numeraire. In the version used, the world is subdivided, consistent with the demographic sub-model, into the 14 regions indicated in Table 2. Industries are aggregated into the three sectors investigated in the previous section: food (including processed foods), industry (mining and manufacturing) and services. To reflect composition differences between regions, these products are differentiated by region of origin, meaning that the "food" produced in one region is not the same as that produced in others. Consumers substitute imperfectly between foods from different regions.

As in other dynamic models of the global economy, the endogenous component of simulated economic growth is physical capital accumulation. Technical change is introduced in the form of exogenous productivity growth that is sector and factor specific. Skill (or human capital) acquisition is driven by constant transformation rates of production into skilled worker households. A consequence of its capital accumulation dynamics and its incorporation of diminishing returns to all factor use is the Solow-Swan property that an increase in the growth rate of the population raises the growth rate of real GDP but reduces the level of real per capita income.[30] What distinguishes the model from Solow-Swan is the endogeneity of saving rates and its multi-product and multi-regional structure.

All regional capital accounts are open and investors have adaptive expectations about real regional net rates of return on installed capital. In each region the level of investment is determined by a comparison of expected net rates of return on domestic installed capital with borrowing rates yielded by a global trust, to which each region's saving contributes, adjusted by calibrated region-specific interest premia. Lagged adjustment processes ensure, however, that financial capital is not fully mobile internationally in the short run but that the paths of domestic and global interest rates become parallel, separated only by exogenous premia, in the long run. In representing China, however, one caveat is that no explicit control is imposed on the outflow of private financial capital. General financial reform is represented by a diminution of the interest premium and this causes an unambiguous influx of financial capital to China. In reality, these reforms have tended to be associated with relaxation of controls so that, even though reserve accumulation may slow, private outflows could increase rendering the net effect of financial reforms on capital account flows more obscure than the model represents.

[30] See Pitchford (1974).

To capture the full effects of demographic change, including those of ageing, the model incorporates multiple age, gender and skill groups compatible with its demography. These 16 groups differ in their shares of regional disposable incomes, consumption preferences, saving rates and their labour supply behaviour. While the consumption-savings choice differs for each age-gender group, it is dependent for all on group-specific real per capita disposable income and the real lending rate. Governments balance their budgets while private groups save or borrow.[31]

*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. Since our modelling is in real terms it is then natural to define the real exchange rate, $e^R$, correspondingly, as the number of baskets of foreign produced goods and services for which a corresponding basket of domestically produced goods and services could be traded. It follows that the bilateral real exchange rate for a focus country (China) with trading partner $i$ depends on the ratio of the GDP prices (deflators) of the two countries, $P^Y(p^S, p^T)$ and $P_i^Y$:

$$(2) \qquad e_i^R = E_i \frac{P^Y\left(p^S, p^T\right)}{P_i^Y} \ .$$

Here $p^T$ and $p^S$ are indices over all the focus country's traded and non-traded goods and services, respectively.[32] The corresponding real effective exchange rate is then a trade weighted average of these bilateral real exchange rates. In our analysis, however, we focus on the bilateral real exchange rate against the region "North America", since this best parallels China's nominal exchange rate policy and the RMB valuation debate.

## 4 Constructing a Baseline

The baseline scenario is a "business as usual" projection of the global economy through 2030. Although policy analysis can be sensitive to the content of this scenario, our focus is the extent of departures associated with shocks to the various determinants of China's real exchange rate. Nonetheless, it is instructive to describe the baseline primarily because all scenarios have a

[31] Unlike the standard *GTAP* models, in which regional incomes are split between private consumption, government consumption and total saving via an upper level Cobb-Douglas utility function that implies fixed regional saving rates, this adaptation first divides regional incomes between government consumption and total private disposable income and then allows endogeneity of group saving rates depending on real disposable income levels and real interest rates.

[32] 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.

common a set of assumptions about future trends in key exogenous variables and because some exposition of the baseline makes the construction of departures from it clearer. We begin by discussing the various exogenous components of the projection and then offer a brief description.

*Shifts in consumption-saving preferences*

Consumption-saving preferences are represented by age-gender specific consumption equations that relate real per capita consumption to real per capita income and the real lending rate in each region. There is no endogeneity of saving rates to longevity even though death rates decline through time and 60+ life expectancy increases in all regions. Consumption-saving preferences are shifted through time, however, in the few regions where changes are expected to stem from developments not represented in the model. In particular, aged saving rates in East Asia are projected to decline. Unlike the aged dissaving of Europe and North America, the aged of Asia are positive savers, due to high aged labour force participation rates and the mixing of incomes in extended families. In China, the 60+ age group currently has low labour force participation but high state-financed retirement incomes. Because the proportion of the aged retiring on relatively generous state pensions is declining, China's 60+ groups are assumed to have underlying saving rates that fall through time.

*Exogenous factor productivity growth*

The model simulates growth due to the accumulation of labour, skill and physical capital. Other sources of growth, including all that passes for "technical change", are introduced via exogenous productivity growth shocks. These are applied separately for each of the model's five factors of production (land, physical capital, natural resources, production labour and professional labour) and in each of the three sectors. The overall rate of economic growth proves to be quite sensitive to these exogenous shocks since the larger these are for a particular region the larger is that region's marginal product of capital. The region therefore enjoys higher levels of investment and hence a double boost to its growth rate. Baseline productivity in the "food" sector is assumed to grow more rapidly than that in the other sectors in China. This allows continued shedding of labour to those sectors.[33] In general, baseline productivity growth rates in services are assumed to be slower than in the tradable goods sectors in all regions. The baseline values of each productivity growth rate for China and North America are given in Table 4.

[33] Wang and Ding (2006) have recently estimated that there are 40 million surplus workers in China's agricultural sector. While underemployment is not explicit in our model, the assumption of high labour productivity growth in agriculture implies that agriculture is capable of shedding labour more quickly than in other sectors. This essentially mimics the surplus labour problem, which is thereby accounted for implicitly.

*Interest premia*

The model takes no explicit account of financial market maturity or investment risk and so tends to allocate investment to regions that have growing marginal products of physical capital. These tend to be labour-abundant developing countries with still rapidly expanding labour forces. Although these regions are attractive prospects for this reason, we know that considerations of financial market depth, segmentation and systemic risk limit the flow of foreign investment at present and that these are likely to remain important in the future. To account for this we have constructed a "pre-base" simulation in which we set the relative growth rates of investment across regions as exogenous. This allows us to capture the implied investment premium changes between the base year, 1997, and 2005, for which we have data on actual investment patterns. Thereafter, of course, while the pre-base path of investment in each region remains exogenous, values are judgemental. Simulated global investment rises and falls depending on the level of global savings, but its allocation between regions is thus controlled. To do this an interest premium variable is included in the model and made endogenous in this pre-baseline simulation. This creates wedges between international and regional borrowing rates. The results show high interest premia for the populous developing regions of Indonesia, India, South America and Sub-Saharan Africa. In regions where labour forces are falling or growing more slowly premia tend to be smaller or to fall through time.

In the case of China, investment is financed at an initial rate substantially above the Chinese government's long term bond rate (the trend of which has exceeded the corresponding US rate by 40 per cent). The pre-base path of China's domestic interest rate declines initially, wiping out most of the initial Chinese premium as shown in Figure 5.[34] This has the important consequence that the rental price of physical capital in China declines in the early years of the pre-base simulation. Relatively competitive capital costs are therefore factors tending to force a depreciating trend in China's pre-base real exchange rate. The baseline simulation is then a repeat of the pre-base in which the trajectories of regional interest premia are set as exogenous and regional investment levels are made endogenous. This simulation then forms the basis for comparison with others in which real exchange rate determinants are altered.

[34] See Tyers and Golley (2006) for further details.

*The baseline projection*

Overall baseline economic performance is suggested by Table 5, which details the average GDP and real per capita income growth performance of each region from 1997 to 2030. In part because of its comparatively young population and hence its continuing rapid labour force growth, India attracts substantial new investment and is projected to take over from China as the world's most rapidly expanding region. Comparatively rapid population growth detracts from India's long term real per capita income performance, however. By this criterion, China is the strongest performing region through the three decades.

## 5 Determinants of the Future Course of China's Real Exchange Rate

Our focus is on shocks that enhance the rate of GDP growth. These include productivity *increases*, factor endowment *increases*, skill transformation rate *increases*, birth rate *increases*, interest premium *decreases*, tariff *decreases* (increases in openness) and, less certainly as to direction, average saving rate *increases*. Productivity growth is considered at the outset, followed by parameters primarily affecting endowment levels: the skill acquisition rate, the birth rate and the interest premium. Finally, parameters that primarily affect aggregate demand and the balance of payments are considered. These are the average saving rate and the level of openness on the current account as it is determined by trade policy. In each case we make a new simulation in which the determinant in question is shocked once-and-for-all, as of 2005. An elasticity of the real exchange rate to that determinant is then constructed, the value of which is tracked through time to 2030.

**Productivity growth**

To match our empirical analysis of sectoral productivity in China, we shock total factor productivity separately in each sector.[35] The resulting elasticities are indicated in Figure 6. Productivity growth in both tradables sectors yields real appreciations but "industry" is by far the most open and therefore the most significant for the real exchange rate. The appreciating effects of tradable productivity increases are sustained, due to wage growth and Balassa service price inflation. They are bolstered in the short run by increased investment and hence greater net inflows on the capital account. In the long run, however, the enlargement of the capital stock reduces costs and hence offsets the real exchange rate gains. Faster service productivity growth,

[35] Labour productivity was also shocked but the results added little additional insight. This is because the model has labour, skill and physical capital equally substitutable in every region. Capital-skill complementarity would make labour productivity shocks more contrasting. See Tyers and Yang (2000).

on the other hand, depreciates the real exchange rate, modestly in the early years but to a dominant extent in the long run when it is reinforced by associated capital accumulation.

If productivity is boosted equi-proportionally in all sectors, the net effect is a small real appreciation in the short run and a substantial real depreciation in the long run. There is no Balassa effect and hence no relative service price inflation. Instead, the short run net appreciation stems from an associated rise in capital returns and hence from the attraction of increased investment from abroad. Beyond a decade, as costs are reduced by the across-the-board rise in productivity, combined with the associated capital expansion, the elasticity turns negative and very quickly expands in that direction. The particular strength of changes in service productivity is notable, suggesting that the forecasting of real exchange rates depends importantly on this difficult-to-measure behaviour. Indeed, if our productivity estimates in Table 1 are correct, the difference between China's productivity performance in tradables and services is not large. This suggests that the net long run impact of productivity changes on China's real exchange rate is substantially in the direction of a real depreciation.[36]

**Endowment parameters**

Economic growth also results from shocks to endowments of labour, skill and physical capital. Such shocks depend on demographic change, the rate at which skill is acquired and the effects of financial reforms in reducing the premia that segment capital markets between regions.

*The skill acquisition rate*

The model splits whole populations between production worker (unskilled) family members and professional worker (skilled) family members. A fixed proportion of each region's production worker family members are transformed in to professional family members in each age-gender group in each year. When this rate is increased in developing regions like China, where the production worker population is larger than its professional counterpart, the proportional boost to the skill supply is larger than the proportional loss of production workers. The result is greater output and, other things equal, a real depreciation. This tendency is exacerbated, however, by the fact that the services sector is comparatively intensive in skill, so that the shock causes a comparatively large boost to service output and hence a comparatively large fall in the service price. The result is, then, a relatively large real depreciation. The elasticity shown in Figure 7 is constructed by raising the transformation rate once and for all by a

[36] Whatever the relative performance of China's services sector in the past, recent evidence suggests very substantial potential for catch-up and accelerated productivity growth in the future. See Ma (2006).

small proportion, from 2005 onward. It is the per cent departure of the real exchange rate for each per cent of the population in production worker families that is transformed each year.[37] As the figure shows, defined this way, skill transformation places downward pressure on the real exchange rate of magnitude similar to total factor productivity in services, at least in the long run.

*Birth rate*

The birth rate affects the real exchange rate by raising the population (initially) and the labour force (subsequently). The initial effect is to raise aggregate demand but not to contribute to supply since income is redistributed to the non-saving and non-working young. Net inflows on the capital account rise and the real exchange rate appreciates. In the long run, when the increased birth rate yields a larger workforce, the supply effects predominate. Wage costs are lower and the real exchange rate declines. Surprisingly, however, the elasticity to the birth rate, also shown in Figure 7, is comparatively small in magnitude. Once again, it is calculated by imposing a once-and-for-all shock to the birth rate and dividing the per cent change in the real exchange rate by the percentage point increase in the birth rate. The results suggest, somewhat surprisingly given the labour supply pattern of Figure 4, that China's birth rate is only a modest contributor to the future of its real exchange rate.

*Interest premium decline*

As represented in the model, in the short run, the decline in China's interest premium raises investment and therefore increases aggregate demand and the real exchange rate. A positive demand-driven effect is therefore expected in the first instance.[38] In the long run, however, when the effect of the investment on the capital stock is realised, the supply side dominates. More abundant and hence cheaper capital reduces production costs, yielding a real depreciation. Shown in Figure 8, the elasticity to premium *decline* is large and positive in the short run with the lag to the switch in sign at least 15 years. It is calculated by imposing a once-and-for-all shock to the premium and dividing the per cent change in the real exchange rate by the resulting percentage point increase in the home interest rate.

[37] The elasticity would be much smaller were it to be defined based on the per cent change in the transformation rate itself.

[38] The model does not represent China's restrictions on private financial outflow and the associated "bottling up" of domestic saving. Even though the PBC has held massive foreign reserves on behalf of the Chinese private sector, if further financial reforms include the relaxation of these restrictions it is not clear whether the net short run effect will be financial influx or efflux.

**Demand parameters**

Other shocks influencing growth act primarily through changes in demand. Those we consider here are a rise in the average saving rate and a reduction in trade distortions.

*Saving rate*

Here, although saving by each age-gender-skill group is endogenous, we shift the underlying curves to achieve a small, once and for all increment to the average saving rate. With the open capital account assumed in our modelling, this switches demand from consumption to financial capital, causing some leakage abroad. It therefore reduces aggregate demand and hence the real exchange rate. Because financial capital is not perfectly mobile internationally in the short run (though the model has it mobile in the long run), the additional home saving supply does reduce the home interest rate relative to the global one, and so it raises investment, offsetting somewhat the tendency for an initial real depreciation. As time passes, the additional investment and its contribution to the capital stock further erodes the real depreciation. In part because there are offsetting changes in flows on the capital account, the magnitude of the savings effect is small, as is also shown in Figure 8.

*Current account openness*

Trade liberalisation switches demand away from home-produced goods and services toward imported varieties. For a single region, the supply of goods and services from the much larger foreign market is more elastic than that of home varieties, constrained as they are by local factor supplies and technology. The effect of the demand switch, then, is to reduce the relative prices of the home varieties and hence to depreciate the real exchange rate. The elasticity of openness is constructed by dividing the per cent change in the real exchange rate by the percentage point change in the overall import penetration ratio (the ratio of the value of imports to the total value of domestic consumption). The shock on which it is based is a phased removal of all China's merchandise trade barriers over five years.[39] The elasticity proves to be quite large, with the expected negative sign, and it grows in magnitude through time. The latter decline occurs because of the concentration of China's merchandise protection in capital intensive industries. Lower home product prices in these industries reduce average home capital returns and hence reduce investment and capital growth, enlarging the negative elasticity through time.

[39] The elasticity is insensitive to the scale of the liberalisation though not to the composition of China's protection. For the levels of protection embodied in the database for 1997 see Dimaranan and McDougall (2002).

*The principal determinants of the real exchange rate in the short and long run*

The elasticities of the strongest determinants of the Chinese real exchange rate are collected together in Figure 9. The general pattern is that growth shocks tend to cause real appreciations in the short run, due primarily to the aggregate demand boost associated with financial capital influx, and real depreciations in the long run, the scale of which depends critically on the performance of the services sector. Balassa forces are possible contributors in the medium term but the figure shows that they can readily be swamped by financial capital influx in the short run and by a combination of increased openness, human capital growth and services productivity in the long run.

## 6 Conclusion

The magnitudes of the various links between the shocks that are instrumental in China's growth performance and its real exchange rate are quantified. Because of the key role of technical change, China's productivity performance since the 1980s is first reviewed and then analysed numerically. The results confirm very strong productivity growth, concentrated throughout the period in industrial sectors, with some acceleration late in the period in agricultural productivity, driven mainly by rural to urban migration. Significantly, productivity in the largely non-traded service sector is measured as having been slower than in the tradeable sectors. While the measured difference in productivity growth rates is not large it does leave scope for Balassa real appreciation effects and the associated relative inflation of service prices is observed since the mid 1990s.

To examine the effects of the full variety of growth-related shocks on the real exchange rate, we turn to a dynamic model of the global economy with open capital accounts and labour supply behaviour fully underpinned by demographics. A baseline "business as usual" simulation is constructed to 2030, wherein China's growth rate slows considerably due to ageing and slower labour force growth. Comparator simulations are then made for cases in which sectoral factor productivity is higher, the transition of production to professional worker families is faster, financial reform reduces China's interest premium, trade reforms continue to open the economy and the average saving rate rises. The effects of changes in fertility policy are also examined, along with demand shifting changes in saving rates and trade policy. China's real exchange rate realignments are examined in each case.

The results suggest that, while population policy affects the real exchange rate in the directions expected, demographic change is not a strong determinant of the real exchange rate, at least within the three decades examined. In the short run the key determinant is net financial capital influx associated with the effects of financial reform on the interest premium. This emerges as a strong appreciating force, though care is required in its interpretation since the model does not represent China's restrictions on private financial outflow and the associated "bottling up" of domestic saving. Even though the PBC has held massive foreign reserves on behalf of the Chinese private sector, if further financial reforms continue to relax these restrictions it is not clear whether the net effect will be financial influx or efflux.

In the medium term, scope does emerge for Balassa real appreciation, if services productivity lags sufficiently. In the long run, however, measured services sector lags are not sufficient to prevent real depreciation associated with improved services performance. Because services are skill-intensive on average, their performance is bolstered by both productivity improvements and human capital growth. And the sensitivity of the real exchange rate to these effects is so large as to make them dominant. Since Chinese productivity growth has been higher than that of its trading partners for more than a decade, and considerable scope remains for productivity catch-up in services, these long run forces might be expected to bear down on the real exchange rate soon.

The future path of China's real exchange rate depends on the relative magnitudes of the effects considered here. The opening of the Chinese economy since 2000 has integrated its financial and product markets with those abroad to an increasing extent. Foreign investment has boomed and its temporary appreciating effect, combined with Balassa service productivity lags, may have outweighed the long run tendency of across-the-board productivity growth to cause real depreciation. If service sector productivity growth continues to be comparatively weak and financial reform continues to reduce the interest premium, then real appreciations could also continue, at least temporarily. It is difficult to ignore the fact, however, that the majority of the growth-related shocks examined, including overall (and particularly services) productivity growth, professional training and further trade reform, all cause the real exchange rate to depreciate in the long run.

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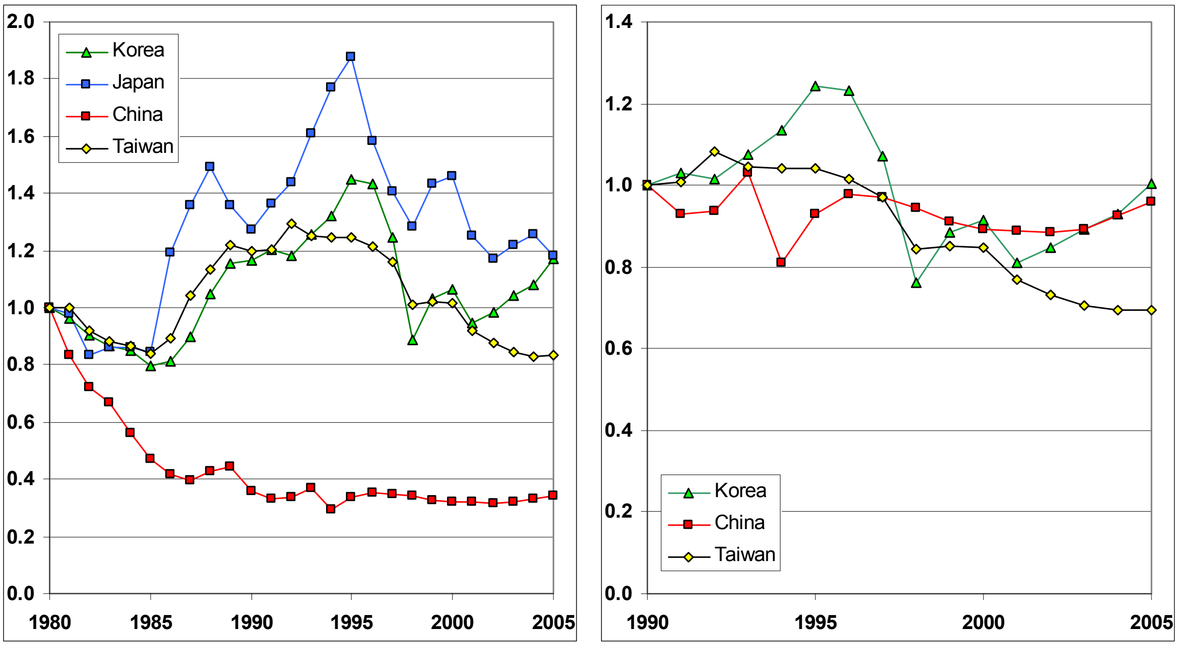
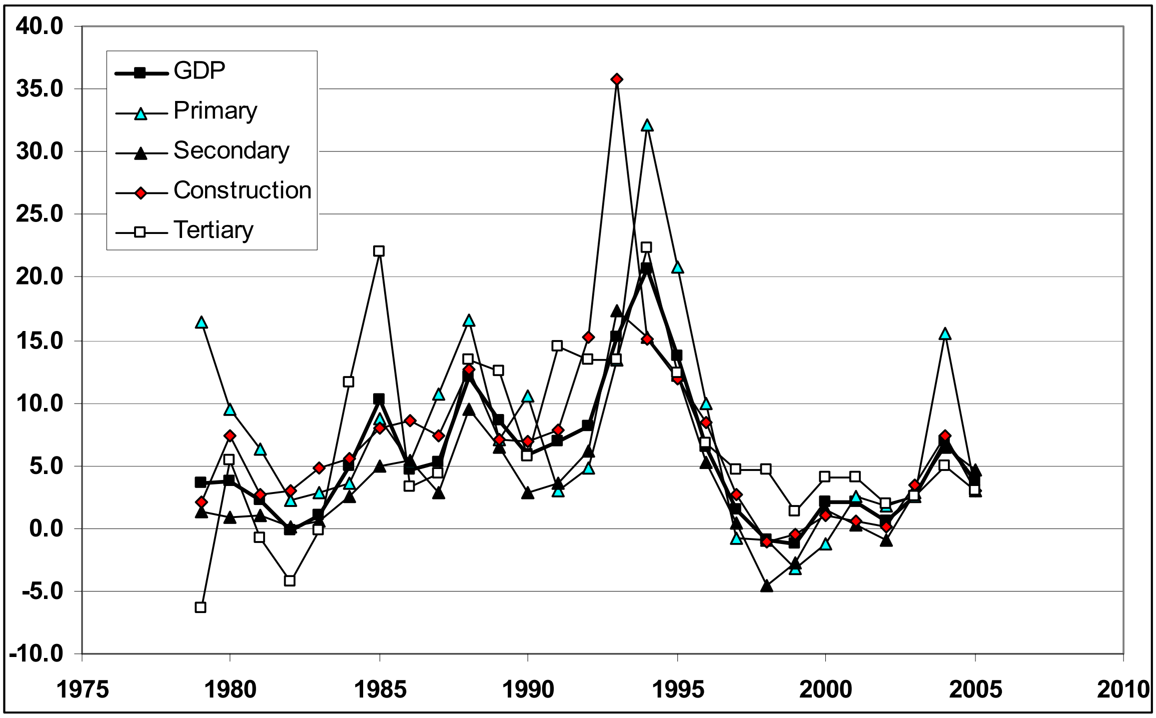
## Figure 1: Asian Real Exchange Rates against the US[a]



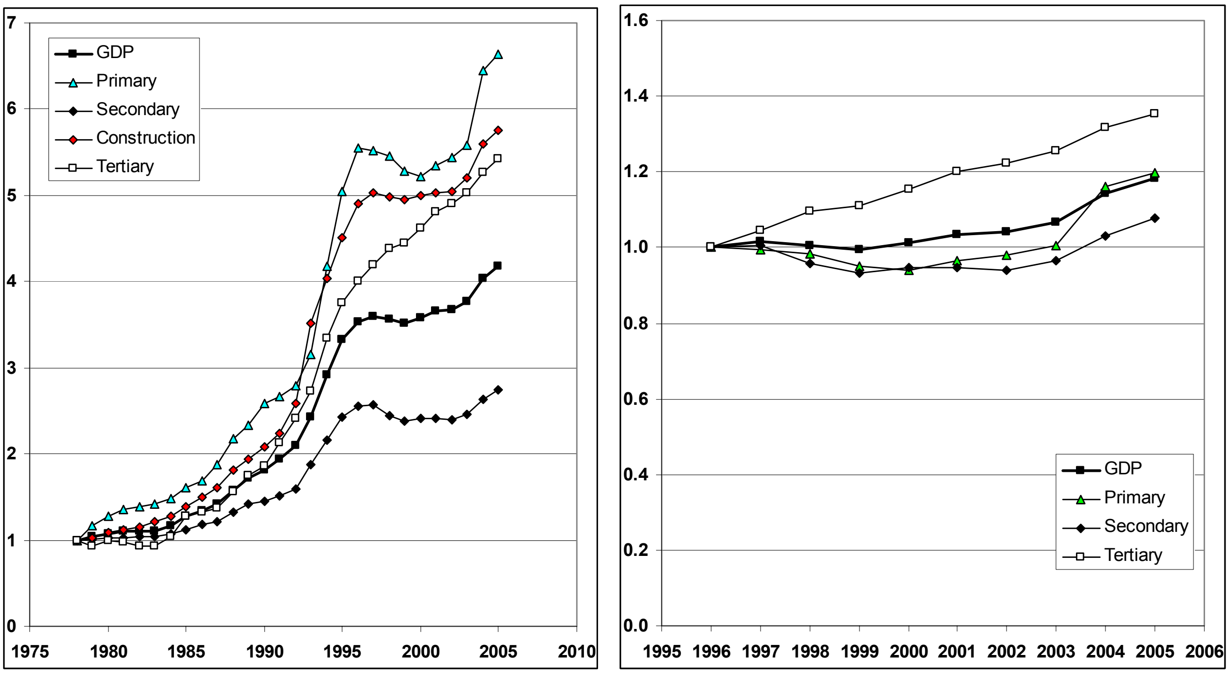

a These are indices of nominal bilateral rates deflated according to $e_R = E \cdot P_Y / P_Y^{US}$, where $E$ is the nominal exchange rate in US$ per unit of local currency, $P_Y$ is the local GDP price and $P_Y^{US}$ is the corresponding US GDP price.

## Figure 2: Chinese Annual Sectoral Price Inflation Rates 1979-2005[a]



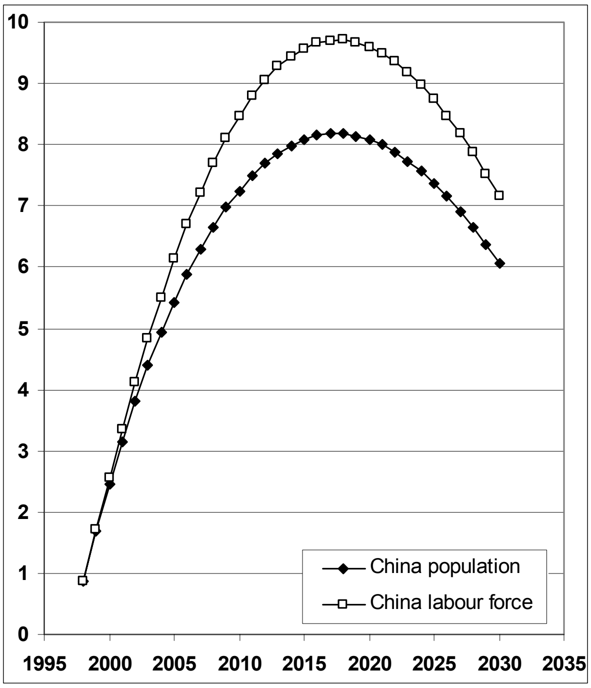

a These are annual rates of change in sectoral price indices implied by data from the *China Statistical Abstract* (2006). "Primary industry" is mainly agriculture, "secondary industry" is primarily manufacturing and construction and "tertiary industry" is other services.

## Figure 3: Chinese Sectoral Price Indices, 1979-2005[a]



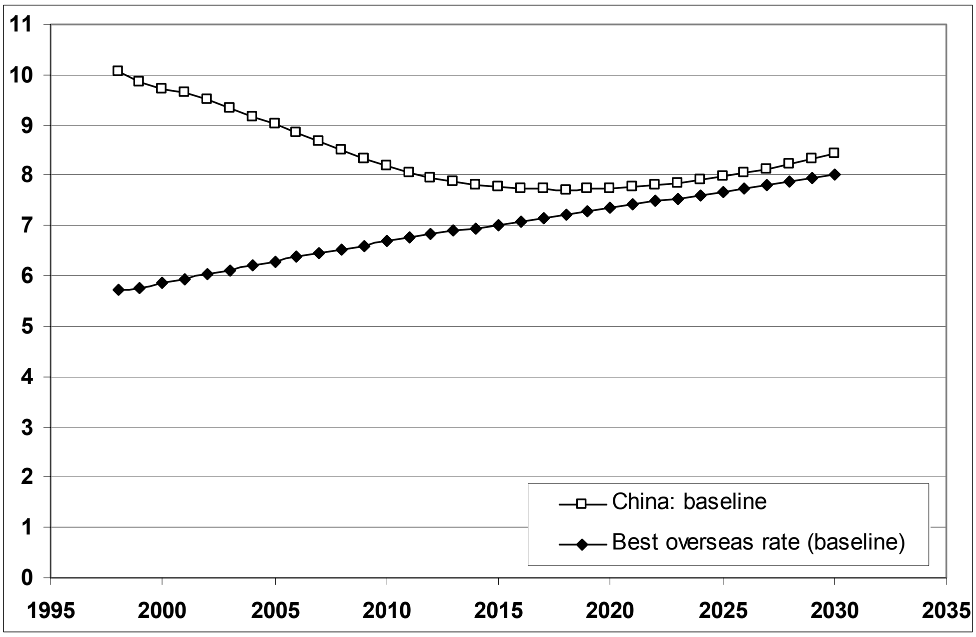

a These are sectoral price indices implied by data from the *China Statistical Abstract* (2006). "Primary industry" is mainly agriculture, "secondary industry" is primarily manufacturing and construction and "tertiary industry" is other services.

## Figure 4: China's Projected Population and Labour Force[a]



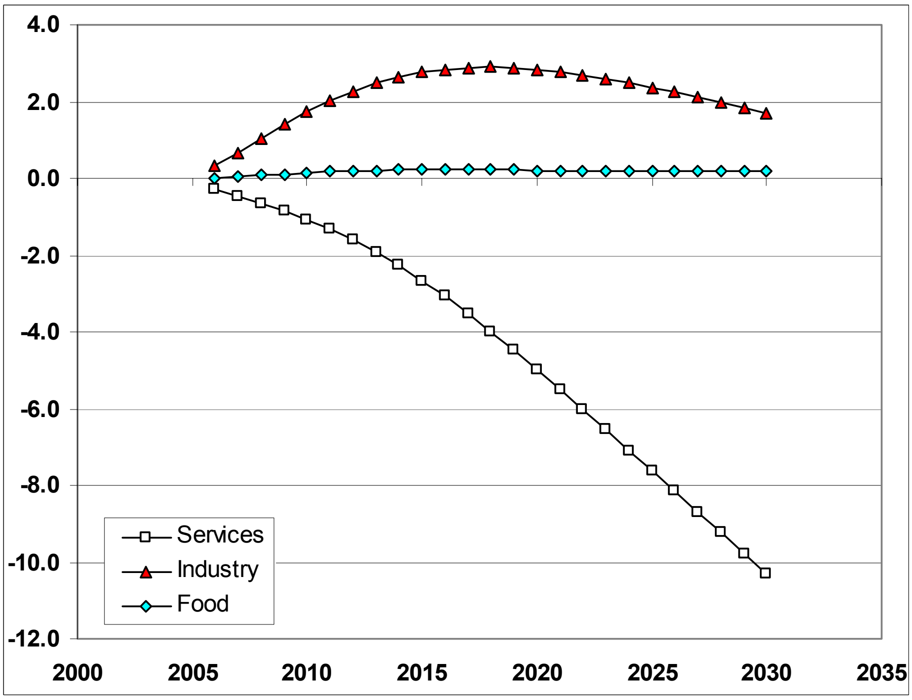

a These are cumulative % departures from the base year 1997, drawn from the *baseline* simulation in which China's fertility is projected to decline from 1.9 to 1.5.

## Figure 5: Baseline Chinese Borrowing Rate and Interest Premium[a], %/year



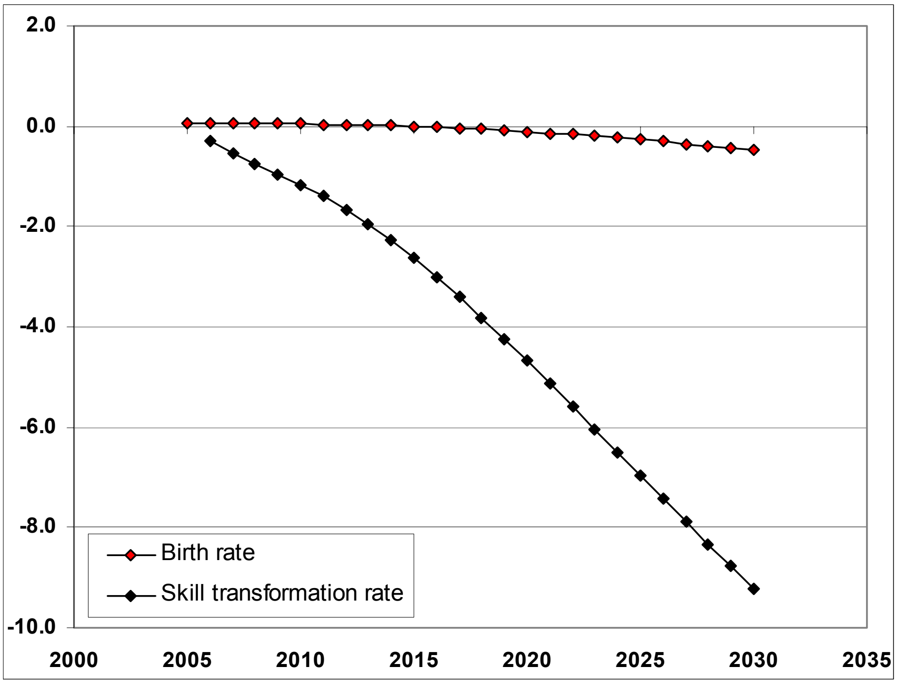

a This compares China's borrowing rate in the baseline simulation with a "best overseas rate" that begins at a level consistent with the base period investment premium and increases through time with the simulated global interest rate. The interest premium is the gap between these rates.

## Figure 6: Elasticity of the Projected Real Exchange Rate to the Rate of Total Factor Productivity Growth in each Sector[a]



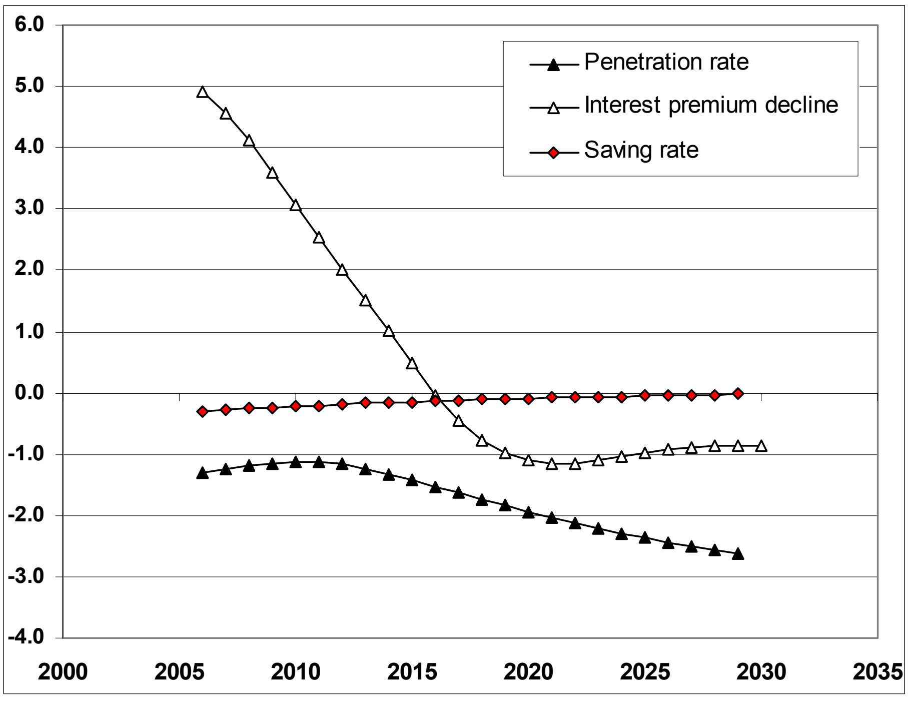

a This is the % departure of the projected real exchange rate for each % per year increase in total factor productivity in each of the three sectors after 2005.

## Figure 7: Elasticity of the Projected Real Exchange Rate to the Fertility Rate and the Skill Acquisition Rate[a]



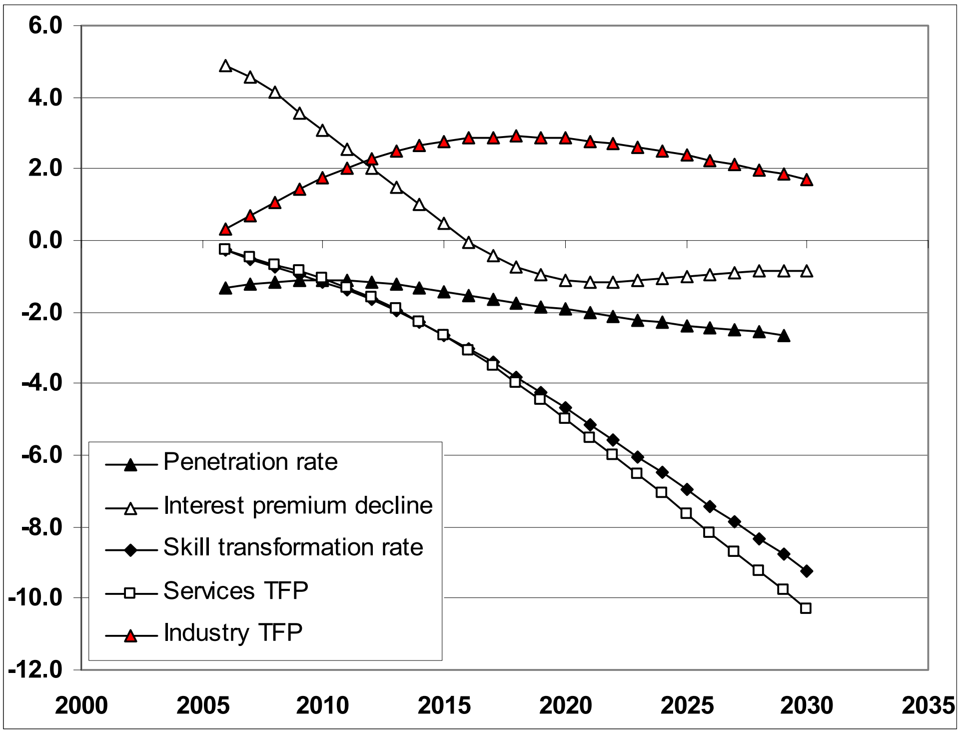

a This is the % departure of the projected real exchange rate for each % point change in the total fertility rate and for each additional % of the population of production worker families that is transformed annually to professional status.

## Figure 8: Elasticity of the Projected Real Exchange Rate to Trade Openness (Market Penetration Rate), the Saving Rate and Interest Premium Decline[a]




a This is the % departure of the projected real exchange rate for each 1) % increase in the overall import penetration ratio, 2) % point increase in the concurrent average saving rate (all group saving rates are shifted by equal proportions), and 3) % point reduction in the domestic interest rate due to a reduced premium, commencing in 2005.

## Figure 9: Elasticity of the Projected Real Exchange Rate to its Key Determinants[a]




a This is the % departure of the projected real exchange rate for each % increase in the overall import penetration ratio, *M/C*, caused by tariff reductions that commence in 2005.

**Table 1: Estimated Chinese Total Factor Productivity Growth by Sector**

| % per year | Whole economy | Food | Industry | Services |
|---|---|---|---|---|
| 1986-1989 | 3.5 | 1.4 | 3.8 | 3.8 |
| 1990-1994 | 5.0 | 1.6 | 7.7 | 2.3 |
| 1995-1997 | 5.7 | 5.5 | 3.7 | 3.2 |
| 1998-2001 | 4.1 | -0.2 | 8.9 | -0.5 |
| 2002-2005 | 6.0 | 5.4 | 6.3 | 4.6 |

Source: Analysis of Chinese statistics described in the text. Original sources are, for output, *China Statistical Year Book* (2005), *China Industrial Economic Statistical Year Book* (every year after 1985) and *China Statistical Abstract* (2006). Employment data are from *China Statistical Year Book* (2005), *China Industrial Economic Statistical Year Book* (every year after 1985) and *China Labor Statistical Year Book* (every year after 1985). China's capital stock, in 2000 prices, is taken from Holtz (2006). Sectoral price indices are from *China Statistical Abstract* (2006). Urban employment is enlarged based on underestimation proportions from Cai and Wang (2006).

**Table 2: Regional Composition in the Global Model**

| **Region** | **Composition of aggregates** |
|---|---|
| Australia | |
| North America | Canada, Mexico, United States |
| Western Europe | European Union, including Switzerland and Scandinavia but excluding the Czech Republic, Hungary and Poland |
| Central Europe and the former Soviet Union | Central Europe includes the Czech Republic, Hungary and Poland |
| Japan | |
| China | Includes Hong Kong and Taiwan |
| Indonesia | |
| Other East Asia | Republic of Korea, Malaysia, the Philippines, Singapore, Thailand and Vietnam |
| India | |
| Other South Asia | Bangladesh, Bhutan, Maldives, Nepal, Pakistan and Sri Lanka |
| South America | Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Peru, Venezuela, Uruguay |
| Middle East and Nth Africa | Includes Morocco through the Islamic Republic of Iran |
| Sub-Saharan Africa | The rest of Africa |
| Rest of World | Includes the rest of Central America, the rest of Indochina, the small Island states of the Pacific, Atlantic and Indian Oceans and the Mediterranean Sea, Myanmar and Mongolia, New Zealand and the former Yugoslavia |

Source: The *GTAP Global Database*, Version 5.

**Table 3: Baseline Transformation (Skill Acquisition) Rates and Labour Force Skilling**

(Per cent of production worker household population transformed to professional each year)

| Region | Rate of transformation of unskilled to skilled households, % per year | Growth in skill supply, 1997-2030, % | Skilled share of labour force 1997, % | Skilled share of labour force 2030, % |
|---|---|---|---|---|
| Australia | 0.12 | 16.3 | 30.6 | 31.2 |
| **North America** | **0.30** | **29.8** | **26.3** | **26.3** |
| Western Europe | 0.13 | -9.4 | 30.7 | 31.2 |
| Central Europe | 0.12 | -11.8 | 24.8 | 25.8 |
| Japan | 0.15 | -7.8 | 31.5 | 32.3 |
| **China** | **0.11** | **18.3** | **12.5** | **14.3** |
| Indonesia | 0.10 | 48.6 | 10.6 | 10.7 |
| Other East Asia | 0.11 | 43.2 | 15.7 | 16.5 |
| India | 0.08 | 78.0 | 10.4 | 11.2 |
| Other South Asia | 0.07 | 104.7 | 10.3 | 10.7 |
| South America | 0.10 | 59.6 | 14.4 | 14.8 |
| Mid East Nth Africa | 0.08 | 74.6 | 5.4 | 5.4 |
| Sub-Saharan Africa | 0.04 | 123.4 | 2.4 | 2.3 |
| Rest of World | 0.10 | 60.8 | 16.3 | 16.0 |

Source: Economy-wide skill subdivisions from the ILO Yearbook, various issues, projections by Goujon and Lutz (2005) and simulations constructed using the model described in the text.

**Table 4: Baseline (Projected) Factor Productivity Growth in China and North America**

| %/yr | Sector | Primary factor | | | | | Regional & sectoral averages |
|---|---|---|---|---|---|---|---|
| | | Land | Production labour | Skilled labour | Capital | Natural resources | |
| **China** | | | | | | | **3.1** |
| | Food | 1.8 | 5.0 | 7.0 | 1.6 | 0.0 | 3.6 |
| | Industrial products | 0.0 | 4.0 | 8.5 | 1.6 | 0.7 | 3.2 |
| | Services | 0.0 | 2.1 | 6.0 | 1.6 | 0.0 | 2.8 |
| **Nth America** | | | | | | | **2.3** |
| | Food | 1.7 | 2.0 | 4.0 | 1.6 | 0.0 | 1.9 |
| | Industrial products | 0.0 | 1.2 | 4.0 | 1.6 | 0.8 | 2.0 |
| | Services | 0.0 | 1.4 | 5.2 | 1.6 | 0.0 | 2.5 |

a Productivity growth is specified by primary factor. For display, sectoral averages are weighted by factor cost shares in each sector and regional averages by sectoral value added shares in each region.
Source: Tyers et al. (2005).

**Table 5: Baseline Real GDP and Real per capita Income Projections to 2030[a]**

| | % change 2030 over 1997 | | Implied *average* annual growth rate, %/yr | |
|---|---|---|---|---|
| | Real GDP | Real per capita income | Real GDP | Real per capita income |
| Australia | 400 | 275 | 5.0 | 4.1 |
| **North America** | **350** | **255** | **4.7** | **3.9** |
| Western Europe | 227 | 276 | 3.7 | 4.1 |
| Central Europe & FSU | 337 | 331 | 4.6 | 4.5 |
| Japan | 214 | 313 | 3.5 | 4.4 |
| **China** | **730** | **563** | **6.6** | **5.9** |
| Indonesia | 253 | 242 | 3.9 | 3.8 |
| Other East Asia | 409 | 467 | 5.1 | 5.4 |
| India | 901 | 407 | 7.2 | 5.0 |
| Other South Asia | 424 | 157 | 5.1 | 2.9 |
| South America | 266 | 205 | 4.0 | 3.4 |
| Mid East & Nth Africa | 319 | 152 | 4.4 | 2.8 |
| Sub-Saharan Africa | 373 | 150 | 4.8 | 2.8 |
| Rest of World | 498 | 277 | 5.6 | 4.1 |

a For China the growth rate of GDP declines through time as it's labour force declines. The average rate over the three decades therefore disguises high growth in the initial years. In some regions, real per capita income grows faster than real GDP. This is either because the population is declining or because there are substantial net factor income flows on the current account.

Source: The baseline projection described in the text.