THE AUSTRALIAN NATIONAL UNIVERSITY

WORKING PAPERS IN ECONOMICS AND ECONOMETRICS

China's Economic Growth and its Real Exchange Rate*

Rod Tyers
College of Business and Economics
Australian National University

Jane Golley
College of Business and Economics
Australian National University

Bu Yongxiang **
Peoples Bank of China

Iain Bain
College of Business and Economics
Australian National University

Working Paper No. 476

First draft December 2006
Revised January 2008

Forthcoming in the *China Economic Journal* 1(2), 2008

ISBN: 086831 476 5

Key words:
Exchange rate, economic growth, demographic change, Chinese economy

JEL codes:
C53, C68, E27, F21, F43, F47, J11, O11

Coordinating author:
Professor Rod Tyers
College of Business and Economics
Australian National University
rod.tyers@anu.edu.au

* Funding for the research described in this paper is from Australian Research Council Discovery Grant No. DP0557889 and from National Natural Science Foundation of China Grant No. 70573121. Thanks are due Peter Dixon, Steve Dowrick, Lu Feng, Dominique van der Mensbrugghe and Heather Anderson for useful discussions on the topic of this paper and to participants in seminars at the CCER, Peking University, the International Monetary Fund and the Reserve Bank of Australia.

** Dr. Bu is Deputy Director of the Research Department at the People's Bank of China. The views expressed in this paper stem from research undertaken at the Australian National University and so are those of the authors alone and in no way represent the perspective of the People's Bank of China

China's Economic Growth and its Real Exchange Rate*

Abstract

The shocks that underlie China's comparatively rapid growth include gains in productivity, factor accumulation and policy reforms that increase allocative efficiency. The well-known Balassa-Samuelson hypothesis links productivity growth in tradable industries with real appreciations. Yet it relies heavily on the law of one price applying for tradable goods, against which there is now considerable evidence. In its absence, other growth shocks also affect the real exchange rate by influencing relative supply or demand for home product varieties. This paper investigates the pre-conditions for the Balassa-Samuelson hypothesis to predict a real appreciation in the Chinese case. It then quantifies the links between all 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 financial capital inflows most affect the real exchange rate in the short term, while differential productivity is strong in the medium term. Contrary to expectation, in the long term demographic forces prove to be weak relative to changes in the skill composition of the labour force which enhance services sector performance and depreciate the real exchange rate.

1 Introduction

The trend of China's underlying real exchange rate is of critical importance to Chinese macroeconomic policy and to the global capital market. Numerous studies suggesting nominal undervaluation, combined with international political pressure to revalue the *Renminbi* (RMB), imply that future nominal appreciations are expected.[1] If it is also expected that the Peoples Bank of China will give future priority to domestic price stability, an underlying real appreciation is implied. Yet real growth is associated with technical advances and factor accumulation and, in general, both of these tend to reduce costs relative to those in less rapidly expanding trading partners. The story is more complex when tradability varies across a country's goods and services and technical change is slower in the non-traded sectors. Then comparatively rapid growth has a Balassa (1964) - Samuelson (1964) dimension whereby international trade maintains tradable price parity and faster tradable productivity growth pushes up relative wages, necessitating in turn that non-tradable prices rise and hence the real exchange rate appreciates.[2]

Yet overall GDP growth stems not only from tradable productivity improvements. For one thing, at some stages of development productivity has been found to grow more quickly in

[1] The claim that the RMB is mercantilistically undervalued occurs frequently in the scholarly literature, as in Dooley et al. (2004), Frankel (2004), Tung and Baker (2004), Cline (2005), Coudert and Couharde (2005), Aizenman and Lee (2006) and Lardy (2006), and in more partisan political fora, as in Bernanke (2006) and Callan (2007).
[2] See Balassa (1964) and, more peripherally, Samuelson (1964).

non-traded services.[3] Even where there is clear evidence of relatively rapid tradable productivity growth, other growth shocks affect real exchange rates if there is failure of a key assumption of the Balassa-Samuelson hypothesis (BSH), namely the law of one price for tradable goods. Yet there is now abundant evidence of the failure of this law in other contexts and comparatively serious infrastructural constraints in developing countries suggest "wider borders" there.[4] As soon as this failure is conceded, factor endowment changes and demand switching via the saving rate or trade policy come into play. And China's recent economic history is riddled with rapid changes in its labour force, capital stock, saving rate and trade policy.

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-acquisition rates, saving rates, financial reform and factor productivity growth are introduced, the latter differentially across the agricultural, industrial and services sectors. While the modelling confirms the BSH corollary that productivity growth in the tradable sectors alone leads to real appreciation, many of the growth-related shocks considered are shown to place downward pressure on the real exchange rate in the long run. The section to follow briefly reviews the BSH and the international evidence in support of it. Section 3 then examines the Chinese evidence, presenting a new analysis of sectoral productivity performances in China. Section 4 offers a generalisation of the BSH, leading to Section 5, which describes the more general global model used. Section 6 then describes the use of the model to construct time paths of elasticities of China's real exchange rate to alternative growth shocks. Conclusions are offered in Section 7.

2 The Balassa-Samuelson Hypothesis and its Fragility

If the nominal exchange rate, *E*, is defined as the number of units of foreign exchange obtained for a unit of the domestic currency, then the real exchange rate, e^R, can be defined correspondingly as the rate of exchange between the home product bundle and corresponding bundles produced abroad. It follows that the bilateral real exchange rate for a focus (home) country with foreign trading partner *i* can be approximated as the common currency ratio of the gross domestic product (GDP) prices (deflators) of the two countries, $P^Y\left(p^N, p^T\right)$ and

[3] See Miyajima (2005).
[4] See, for example, Engel (1993), Engel and Rogers (1996) and Bergin et al. (2006).

$P_i^Y\left(p_i^N, p_i^T\right)/E_i$, where p^T and p^N are indices over all the focus country's non-traded and traded goods and services, respectively.[5]

$$(1) \qquad e_i^R = \frac{P^Y\left(p^N, p^T\right)}{P_i^Y\left(p_i^N, p_i^T\right)/E_i} = E_i \frac{P^Y\left(p^N, p^T\right)}{P_i^Y\left(p_i^N, p_i^T\right)}$$

This is the fundamental relationship between the real and nominal exchange rates. Consider the case in which prices at home and abroad are measured relative to a common global numeraire, the share of non-traded products in GDP, θ, is the same at home and abroad, prices are aggregated using a Cobb-Douglas index and the law of one price applies to all traded goods. The latter implies that trade is costless and undistorted, so that $p^T = p_i^T$. Under these conditions, the real exchange rate becomes

$$(2) \qquad e^R = \frac{\left(p^N\right)^\theta \left(p^T\right)^{1-\theta}}{\left(p_i^N\right)^\theta \left(p_i^T\right)^{1-\theta}} = \left(\frac{p^N}{p_i^N}\right)^\theta$$

From this, the key role of non-traded goods prices is clear. When prices are measured in a common currency, or relative to a common international numeraire, it is the ratio of the home and foreign non-traded goods prices that matters in determining the real exchange rate.

To illustrate the associated dependence on productivity, imagine that labour is the single fixed factor and that the rates of output per worker in the home traded and non-traded sectors are A^T and A^N. In trading partner *i*, the corresponding rates are A_i^T and A_i^N. The relationships between the wage rate and product prices in the traded and non-traded sectors follow from equating the wage in both sectors with the values of the marginal products of labour in each: $W = A^T P^T = A^N P^N, W_i = A_i^T P_i^T = A_i^N P_i^N$, from which it follows that the divergence in wage rates between trading partners depends only on their tradable productivities: $W/W_i = A^T / A_i^T$.
If the non-traded productivity level is the same in all trading partners ($A^N = A_i^N \ \forall i$), we then have that

$$(3) \qquad \frac{P^N}{P_i^N} = \frac{A^T}{A_i^T} = \frac{W}{W_i} \text{ and } e_i^R = \left(\frac{p^N}{p_i^N}\right)^\theta = \left(\frac{A^T}{A_i^T}\right)^\theta = \left(\frac{W}{W_i}\right)^\theta .$$

Under the assumptions of the BSH, then, an economy that is growing faster than its trading partners also has faster tradable productivity growth ($\hat{A}^T > \hat{A}_i^T$),faster wage growth ($\hat{W} > \hat{W}_i$),relative service price inflation ($\hat{p}^N > \hat{p}_i^N$), and an appreciating real exchange rate

[5] Here we imagine that, rather than the continuum of tradability that is observed across goods and services, traded and non-traded goods are separated starkly as *T*, *N*.

($\hat{e}^R > 0$). The hypothesis then implies that, if developing countries are poorer because their tradable labour productivity is lower, then their comparatively rapid growth should be associated with real appreciations against their richer trading partners.

The empirical evidence from searches for dominant BSH effects in rapidly growing developing countries is mixed. Choudhri and Khan (2004), for example, find favourable evidence using a small sample of developing countries that does not include mainland China, Taiwan or Hong Kong. Bergin et al. (2006) find a positive association between price levels and real per capita income that is strong only in large samples of countries. Miyajima (2005) uses a sample of 15 Organisation for Economic Cooperation and Development (OECD) countries between 1970 and 2000 to establish that the hypothesis does not always hold during growth surges, which on numerous occasions were led by productivity growth in non-traded sectors. The East and Southeast Asian evidence since 1980 is also mixed. Only Japan showed a rapid real appreciation following the demise of the Bretton Woods system in 1972 and in association with its correspondingly rapid export-led growth.[6] As Figure 1 shows the same pattern is not observed for Korea, Taiwan or for any of the larger Southeast Asian economies. Thus, in East and Southeast Asia at least, where comparatively high rates of GDP growth riding on manufacturing exports would suggest high tradable productivity growth, the BSH effect appears frequently to be more than offset by other forces.

The China-focussed literature on the BSH is mainly in Chinese and it is dominated by the work of Lu Feng at the China Center for Economic Research, Peking University.[7] 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 (largely non-traded) service sector averaged 4.3% per year over the entire period. He divides manufacturing by service labour productivity to get yearly estimates of Chinese relative tradable to non-tradable labour productivity. Assuming a value of 100 in 1978, this reveals that relative tradable to non-tradable productivity dropped to 84 in 1990 but rose rapidly thereafter, reaching 276 in 2004. He then calculates corresponding ratios for the US and 13 OECD economies over the same period,

[6] Japan is a special case in the East and Southeast Asian experience. It was the first to develop rapidly but its economy, and particularly its services sector, remained far more closed than for its neighbours, and particularly relative to China.
[7] See Lu (2006a, 2006b, 2007) and Lu and Han (2006).

and uses these to construct “relative-relative” labour productivity indices for China in terms of the US and the OECD. The results show the same trend, with China’s relative tradable to non-tradable productivity dropping compared with its trading partners 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 relative manufacturing productivity since 1994 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 appears to confirm that the tendency for relative tradable productivity to cause real appreciation has been more than offset by other forces. Yet productivity measurement is beset by numerous difficulties, including the undercounting of industrial employment in China due to the influx of unregistered rural workers to urban areas, inadequate volume measures for services and the lack of quality or composition adjustments to estimates of the capital stock.[8] To clarify our own perspective, re-examine the data for China since 1986 using a multi-sectoral and multi-factor approach.

3 Sectoral Productivity in China

We estimate simple Solow residuals for the economy as a whole and for three sectors: “Agriculture”, “Industry” and “Services”.[9] Assuming Hicks neutral technological progress and constant returns Cobb-Douglas technology, the annual Solow residual takes the form:

$$\frac{\Delta A}{A} = \frac{\Delta Y}{Y} - \alpha \frac{\Delta K}{K} - (1-\alpha)\frac{\Delta L}{L}, \tag{4}$$

where Y is output, K is physical capital and L is labour (unskilled and skilled). α 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.[10] From the *China Statistical Abstract* (2006), we obtain constant price indices for “primary industry”, “secondary industry”, “tertiary industry” and construction. These broad

[8] 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.

[9] The “Agriculture” 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.

[10] 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).

sectors are not precise fits to the sectors we define 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 "agriculture", "industry" and "services".[11] For the period as a whole relative service price inflation is somewhat obscured by early rises in primary product prices. The implied sectoral price indices are therefore plotted in Figure 2 from 1990 onward. For the relatively stable fixed exchange rate period beyond 1995, service prices 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, the total for which is drawn from the recent work of Holtz (2006), 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.[12] Finally, we need estimates for the capital share of value added, α. 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.[13]

The average annual per cent 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

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[11] 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.

[12] 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 $\bar{r}\bar{K} = \sum r_i K_i$, where $\bar{r}$ and $\bar{K}$ are the aggregate capital return rate and the physical capital stock. We assume that $\bar{r} = r_i$ for all i, making it possible add the operating surpluses and allocate them sectorally ('agriculture' 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: $r_i K_i \big/ \sum r_i K_i$.

[13] Our estimates of α are smallest for the "agriculture" sector and largest for the "industry" sector. There is an important trend, however, for industry to become less capital intensive and both "agriculture" and "services" to become more capital intensive.

the post-millennium stock market corrections.[14] Consistent with the analysis of Lu (2006a), productivity growth appears to have been strongest in the industrial sector and strong relative to the US.[15] The averages disguise higher recent productivity growth in the agriculture sector, however, as rural to urban migration accelerates.[16] Importantly, the growth rate of productivity in services is always slower than in the tradable sectors. Yet, particularly in recent years, the differences are not large. While this offers support to the BSH, the gap has been clearly insufficient to overcome long run depreciating forces that are not accounted for in its assumptions. A generalisation is required.

4 Generalising Balassa-Samuelson

The keys to generalising the BSH lie in its underlying assumptions. We offer a critique of each and then discuss the key implications of the most important failures.

Only tradable productivity grows, and faster in the focus economy

During some periods and in some developing countries, productivity growth has been observed to be higher in the non-tradable sector,[17] leading to $\hat{A}^N > \hat{A}_i^N$ and tending to depreciate the real exchange rate. Modern transport, financial, health and education services offer considerable potential for productivity catch-up. Whatever the relative performance of China's services sector in the past, recent evidence suggests substantial potential for catch-up and accelerated productivity growth in the future (Ma 2006).

The law of one price for tradable goods

Failures of the law of one price have been observed for tradable goods in specific instances.[18] That it fails particularly in the trade between China and the US is clear from the analysis by Amiti and Freund (2007). Goods and services are not homogeneous across countries

[14] The productivity performance in this period appears to have remained strong in the industrial sector while deteriorating in agriculture and services. This may be caused by the financial crisis, its associated economic slow-down and the retreat of unrecorded workers from industry to agriculture and services.
[15] For a summary of corresponding US productivity performance, see Gordon (2006).
[16] The omission of the skill content of the labour force probably contributes to some overestimation of Solow residuals. This tendency is reinforced by changes in the composition of the capital stock that cause its underestimation..
[17] For example, the Cold War infrastructure investments in Korea and Taiwan reduced service costs at early stages in their periods of rapid expansion.
[18] See, for example, Engel (1993), Engel and Rogers (1996), Bergin et al. (2006); Crucini et al. (2005); and Drine and Rault (2005).

but are differentiated at minimum by country of origin.[19] Supply and/or demand side factors that raise the volume of tradable production move the home country down the global demand curves for its product varieties, reducing its supply prices and resulting in deterioration in the terms of trade and a depreciation of its real exchange rate. Factor endowment growth and changes in policy that lead to substitution away from home toward foreign products lower relative home product prices and depreciate real exchange rates.

Labour arbitrage

In most developing economies, the marginal product of industrial labour exceeds that of rural labour due to the more rapid accumulation of industrial capital. There is, therefore, a Harris-Todaro gulf between wages in the expanding and contracting sectors. Yet the key Balassa-Samuelson assumption is that the same wage is paid in the traded and non-traded sectors, principally the manufacturing and the services sectors. This assumption could fail if labour mobility between the rural and industrial sectors is inferior to that between the rural and service sectors (particularly construction). Were this the case, industrial productivity growth would drive up the industrial wage but the services wage need not rise to the same extent and this would moderate relative service price increases and hence real appreciations. Evidence for this difference in mobility is offered by Chang and Tyers (2003).

Closed capital account

The assumption that the real exchange rate depends only on interactions among countries associated with trade in merchandise is clearly violated in many of today's developing countries, and particularly in China. Its violation, in concert with failures of the law of one price for traded goods, means that any influx of payments (in the form of a foreign direct investment or portfolio capital flow) raises aggregate demand. Since traded goods are supplied more elastically via imports than are non-traded goods—which depend on home resources—such an influx must raise relative non-traded prices and therefore appreciate the real exchange rate. Conversely, effluxes cause real depreciations.

Key implications of failures

With failure of the law of one price for tradable goods, numerous growth shocks, other than productivity increases, become important determinants of the real exchange rate.

[19] This is a standard assumption in the most widely used numerical models of open economies and global trade. See, for example, Dixon et al. (1982); McKibbin and Sachs (1991); Hertel (1997); and Dixon and Rimmer (2002).

Labour endowment changes:

Shocks to the labour force, the supply of skilled workers and to the capital stock are considered here. These act by altering domestic factor costs and hence producer prices. Consider first changes in China's labour force. During the past two decades it has enjoyed a 'demographic dividend', stemming from the high proportion of working-aged people in the total population (Bloom and Williamson 1998). This, according to Cai and Wang (2005), accounted for about one-quarter of per capita GDP growth between 1980 and 2003. It is seen as having been important in keeping wages low, thereby enabling the rapid expansion of labour-intensive manufactured exports. In future the ageing of the population and the consequent decline in the labour supply will have the opposite effect, boosting both wages and the overall dependency ratio and placing upward pressure on China's unit costs and its real exchange rate. Tyers and Golley (2008b) project China's labour force to begin declining in about a decade, as illustrated in Figure 3. They also show that the dependency ratio, which is now still declining as youth dependency falls with China's birth rate, will commence rising at about the same time.[20] Alternative population policies, such as the relaxation of the One Child Policy, clearly stand to affect economic growth via the labour supply, and therefore to impact on the real exchange rate as well.

Because largely non-traded services are comparatively skill-intensive, the endowment of skilled labour is also a key determinant. The third row of Table 2 makes it clear that for China, as for most other economies, a change in the skilled wage has by far the largest effect on the services sector. Fogel (2006) predicts that investment in human capital has the potential to serve as China's key engine of economic growth for the next two decades, a point that is well recognised by China's leaders (as emphasised in the eleventh Five-Year Plan). He qualifies the impact of enhancing the quality of labour through education on the growth rate of per capita income and shows that increasing secondary and tertiary enrolment ratios have a sizeable impact on the growth of labour productivity and per capita GDP growth.[21] This foreshadows a potentially large effect of accelerated education and training on China's real exchange rate.

Capital endowment shocks and financial flows:

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[20] See Tyers and Golley, *op cit*: Figure 6.

[21] For example, he calculates that if the tertiary enrolment ratio rose from six to 25 in the next 20 years (putting China where the Western European nations were in 1980), the growth rate of labour productivity would rise by 4.4 per cent between 2000 and 2020, and that this would account for more than 60 per cent of the per capita GDP growth target set in 2002. With the tertiary ratio increasing from 12.5 per cent to 19 per cent between 2000 and 2004, if anything, his estimates could be too conservative.

Shocks to the capital stock tend to be associated with changes in net financial flows on the balance of payments. These stem from the gap between saving and investment and, as Figure 4 shows, this gap favours saving and has been enlarging since the financial crisis years of the late 1990s. Indeed, while China's investment is, by international standards, large in relation to its GDP, its gross saving rate of over 50 per cent is truly extraordinary. There are two separate underlying causes of this. The first is that China's investment interest premium, which measures the gap between the average interest rate at which investment is financed in China and the corresponding average rate abroad (say in the US), has been declining with continuing financial reform. It remains high by developed country standards because a substantial proportion of China's private investment is still financed through the informal sector at very high rates (Tyers and Golley 2008b). Yet its decline expands China's share of global funds for investment and thus the ratio of China's investment to its GDP.

The second is that China's private saving rate has been growing. Private households save about a third of their disposable income (Azziz and Cui 2007). This is high by international standards but not extraordinary for Asia. It stems from intertemporal choices by private households that are driven by changes in the provision of health, education and retirement benefits as more of the population works in China's expanding private sector. The key to the very high proportion of GDP that is saved is an extraordinary level of corporate saving. This derives in part from enormous profits made by some monopoly state owned enterprises (Lu et al. 2007) and hence the infancy of China's competition policy. Even though these firms pay dividends to minority private share-holders, there is no return to the government as majority owner, causing too-heavy taxation of private households. Moreover, in recent years at least, these firms have appeared to dispose of these savings in ways that do not create new investment, at least not immediately. The high saving rate is therefore structural and, as financial reforms continue and competition and tax policies are implemented more effectively it can be expected to decline. In the meantime it has the consequence of creating a substantial and controversial current account surplus. This net financial outflow reduces home aggregate demand and hence depreciates the real exchange rate.[22]

Demand switching trade liberalisation:

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

[22] See Tyers and Golley (2008a) for a decomposition of the change in China's real exchange rate in the decade 1997-2006, which shows the high saving rate to be the largest single contributor to the real depreciating trend.

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 toward foreign varieties, then, is to reduce the relative prices of home varieties and hence to depreciate the real exchange rate.

The roles of monetary policy and the nominal exchange rate regime:

While it is beyond the scope of this paper to address associated monetary policy issues, it is commonly argued that the failure of China's real exchange rate to appreciate significantly has been due to a pegged or bounded nominal exchange rate, secured by an extraordinary rate of accumulation of official foreign reserves. We do not take this view. China's current account surplus stems from its high saving rate. The associated net financial outflows take the form of reserve accumulation because capital controls are maintained, with the objective of avoiding a future financial crisis while China's domestic financial sector remains immature, and most private households are therefore not permitted to hold foreign assets (Ma and McCauley 2007). The reserves are, in effect, foreign assets held by China's central bank on behalf of its private households, who would otherwise acquire the assets themselves.[23] In what follows we focus on the microeconomic determinants of the underlying real exchange rate. Once changes in it are thus determined, from Equation (1) it is clear that monetary and exchange rate policy represent the central bank's choice between accommodating price level or nominal exchange rate changes.

5 Modelling Real Exchange Rate Dynamics

Here we examine quantitatively the relationship between shocks associated with China's economic growth and its real exchange rate. For this purpose a numerical model is required that is global in scope and that incorporates the generalisations of the BSH assumptions discussed above. Recall that these included productivity growth in non-tradable as well as tradable sectors, departures from the law of one price for tradable goods, a more sophisticated representation of the labour market and an open capital account. With these generalisations, almost all shocks to the economy have implications for the real exchange rate.

We use a model that offers these generalisations. Adapted from Tyers and Shi (2007a, 2007b), it is a multi-region, multi-product dynamic simulation model of the world economy.[24] In the version used, the world is subdivided into 14 regions (Table 3). Industries are aggregated into three sectors: agriculture (including processed foods), industry (mining and manufacturing) and

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[23] For an in-depth discussion of the debate over China's monetary policy and exchange rate regime, see Tyers and Bain (2007), Xiao (2006) and Woo and Xiao (2007).

[24] 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 are described in Ianchovichina and McDougall (2000).

services (including construction)—the latter being little traded in comparison with the other two. Failures of the law of one price are represented by product differentiation, so that consumers substitute imperfectly between products from different regions. As in other dynamic models of the global economy, the principal endogenous source 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, allowing the analysis of productivity performance that differs between tradable and non-tradable sectors. Consistent with the results indicated in Table 1 for China, baseline productivity in the agriculture sectors of most regions grows more rapidly than that in services. This allows continued shedding of labour by agriculture as part of the development process.[25]

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 premiums. Lagged adjustment processes ensure that financial capital is not fully mobile internationally in the short term, but that the paths of domestic and global interest rates become parallel, separated only by exogenous premiums in the long term. General financial reform is represented by a diminution of the interest premium and this tends to raise China's share of global funds for investment through time.[26] The saving rate is high initially, so the baseline simulation maintains a diminishing current account surplus.

To characterise changes in labour supply and quality, it encompasses both demographic and economic behaviour. It tracks populations in four age groups, two genders and two skill categories: a total of 16 population groups in each of the 14 regions. The skill subdivision is between production labour (unskilled) and professional labour (skilled).[27] Each age–gender–skill group is represented as a homogeneous sub-population with a group-specific birth and death rate, labour force participation rate and rates of immigration and emigration. Because the non-traded sector is relatively intensive in skill, trends in skill composition prove to be particularly important. These depend on the rate at which each region's education and social development

[25] In the case of China, Wang and Ding (2006) recently estimated that there were 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 without consequence for its output as workers are drawn away by urban capital accumulation.

[26] For further details on the implementation and calibration of the investment interest premium, see Tyers and Golley (2008b).

[27] The subdivision between production workers and professionals and para-professionals accords with the International Labour Organisation's occupation-based classification and is consistent with the labour division adopted in the GTAP Database. See Liu et al. (1998).

institutions transform unskilled (production-worker) families into skilled (professional-worker) families. Each year a particular proportion of the population in each production-worker age–gender group is transferred to professional status. The initial values of 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. Rates of transformation change through time in response to corresponding changes in real per capita income and the skilled wage premium.[28] This skill accumulation process offers the second of the two endogenous sources of growth in all regional economies.

These demographic details help to generalise the model's characterisation of labour supply and quality in each region. A related BSH generalisation that could prove important is the difference in labour mobility between the rural and industrial sectors on the one hand and the rural and service sectors on the other. In the absence of reliable estimates of the relevant elasticities of labour substitution, however, this behaviour is omitted from the model. While skill compositions of labour demand differ between sectors according to empirical evidence, unskilled labour is assumed to be homogeneous across sectors and its wage to be the same throughout the economy.

The 16 age–gender–skill groups differ in their shares of regional disposable income, consumption preferences, saving rates and labour force participation behaviour. While the consumption–savings choice differs for each group, it is dependent for all on group-specific real per capita disposable income and the regional real lending rate. Governments are assumed to balance their budgets while saving and borrowing are undertaken by the private sector. The baseline scenario is a 'business-as-usual' projection of the global economy to 2030.

6 Growth Shocks and China's Real Exchange Rate

Our focus is on how shocks that enhance the rate of GDP growth impact on the real exchange rate. Given the country aggregation adopted for the model, our interest is in the bilateral rate between China (including Hong Kong and Taiwan) and North America (including Canada and Mexico), since this best parallels China's nominal exchange rate policy and the RMB valuation debate. It is measured as in Equation (1), except that, since we use a real model, the regional GDP prices are expressed relative to a common global numeraire and so no currency conversion is necessary. The determinants of growth performance that are investigated are once-

[28] China's skill share is projected to rise through time while that in its real exchange rate comparator, 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.

and-for-all *increases* in sectoral productivity growth rates, *increases* in China's skill transformation rate, birth rate *increases*, interest premium *decreases* (which raise investment and reduce net financial outflows), average saving rate *increases* (which yield more self-financing of investment and more net financial outflows) and tariff *decreases* (*increases* in openness or in the import penetration ratio). In each case, we run a new simulation in which the determinant in question is shocked once and for all, as of 2005. We then extract the elasticity of China's real exchange rate to each shock, tracking the values through time to 2030.

Productivity growth is considered at the outset, followed by shocks to endowment levels: the skill acquisition rate, the birth rate and the investment interest premium. Finally, demand switching shocks are considered. These are to 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 growth 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.

Faster productivity growth

To match our empirical analysis of sectoral productivity in China, we shock total factor productivity separately in each sector. The overall rate of economic growth proves to be quite sensitive to such productivity 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. In each case the real exchange rate elasticity is measured as the percentage departure of the projected real exchange rate for each percentage per annum increase in total factor productivity. The resulting elasticities are indicated in Figure 5.

First, consider the effects of higher productivity growth in both tradables sectors. This is shown to yield the expected real appreciations but "industry" is by far the most open and therefore the most significant for the real exchange rate.[29] The appreciating effects of tradable productivity increases are consistent with the BSH and the simulation results show that they are, as expected, due to wage growth and relative service price inflation. They are bolstered in the short term by increased investment and hence greater net inflows on the capital account. In the long term the enlargement of China's industrial capital stock reduces its capital costs and hence tends to abate the real appreciating effects. Next, the corresponding shock is applied to the services sector. Also, as expected from the dominance of non-traded sector prices in Equation

[29] The elasticity to agricultural productivity is not shown in the figure because its effects on the real exchange rate are small by comparison with industrial productity.

(2), faster service productivity growth depreciates the real exchange rate, modestly in the early years but to a dominant extent in the long term 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 ***de***preciation in the long run. There is no net BSH 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 a catch-up in China’s services productivity, the potential of which is suggested by Ma (2006), could come to dominate the effects on the real exchange rate, causing a depreciating trend.

Higher skill acquisition rate

As already discussed, one of the endogenous sources of growth in our model is human capital accumulation, or skill acquisition. The proportion of each region’s production worker family members are transformed in to professional family members in each age-gender group in each year is the skill acquisition rate. As modelled, it depends on such things as the regional skilled wage premium. Here the equation determining this rate is shifted so as to raise it for any given skilled wage premium. In developing regions like China, where the production worker population is larger than its professional counterpart, the resulting proportional boost to the skill supply is larger than the proportional loss of production workers. GDP increases and, other things equal, there is a real depreciation. This tendency is exaggerated by the fact that the services sector is comparatively intensive in skill, so that the shock causes a relatively large boost to service output and hence a comparatively large fall in the service price. The elasticity, shown in Figure 5, 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. 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.

Higher 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 new births necessitate the redistribution of income to the non-saving and non-working young population. 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, the elasticity to the birth rate, shown in Figure 6, is comparatively small in magnitude, at least during the first two decades. Once again, it is calculated by imposing a once-and-for-all shock to the birth rate and dividing the percentage change in the real exchange rate by the percentage point increase in the birth rate.[30]

Investment interest premium decline

Consider first the effects of a decline in China's investment interest premium. In the short term, it raises investment, reducing net financial outflows on the balance of payments. This raises aggregate demand and appreciates the real exchange rate. It is evident in the early years of the path of the elasticity in Figure 5, which is measured as the ratio of the percentage change in the real exchange rate and the resulting percentage point decrease in the home interest rate. We define as *positive* the *decline* in the interest premium (because such declines are associated positively with GDP growth). In the long term, when the effect of investment on the capital stock is realised, the supply side dominates. More abundant and hence cheaper capital reduces production costs. And because both industry services are capital intensive (Table 2), the prices of China's manufactured exports and non-traded services are reduced, unambiguously yielding a real depreciation. The elasticity to the premium decline is large and positive in the short term, with a lag to the switch in sign of about a decade.

Saving rate increase

This is generated in the model by shifting the consumption equations for Chinese age-gender-skill groups so as to simultaneously raise their saving rates.[31] The elasticity of the real

[30] The birth rate is defined on the female population aged 15-29. Were it defined as births over total population a one percentage point shock would have a larger effect and yield a larger elasticity. We use this definition because it is directly proportional to the fertility rate.

[31] In each region the model has 16 age-gender-skill groups each of which has endogenous saving, driven by real disposable income and the real interest rate. Each group consumption equation has a region-wide shifter that can be modified to accord with observed total savings changes or shocked by a small proportion to derive an elasticity of sensitivity.

exchange rate to the average saving rate is defined as the percentage change in the real exchange rate for each percentage point rise in the proportion of disposable income saved. An *increased* saving rate, other things equal, causes a larger current account surplus, a fall in home consumption and therefore in home aggregate demand, and hence a real *depreciation*. And so, controlling for investment, a negative elasticity is expected. Yet there are two other factors that enter the story. First, and least important, investment is directly affected by the saving rate. As modelled, an empirically based proportion of saving in every region is turned directly to domestic investment without becoming available to the global capital market. A higher saving rate therefore also implies that domestic investment should also rise, albeit by a smaller proportion. This makes the net effect of higher savings on financial outflows smaller and hence it boosts the current account surplus by less, and so it might be expected to yield a smaller negative elasticity.

The second factor is that the current account surplus builds up foreign assets which then pay returns that take the form of inflows on the current account. In the short run this effect is small, but the change in foreign asset stock due to a once and for all increase in saving accumulates through time. Eventually, the flow of returns more than offsets the tendency for increased saving to raise the current account surplus. The path through time of the simulated elasticity is shown in Figure 6. The negative effect of increased saving persists for almost two decades, after which returns from new assets held abroad are sufficient to reverse its sign of the elasticity.

At all lengths of run the saving elasticity has smaller magnitude than that of the interest premium. This is not to imply that the saving rate is a less important determinant of the real exchange rate, however. As Figure 4 shows, China's gross saving rate has risen by 14 percentage points since the late 1990s. The corresponding change in the investment interest premium has been estimated to have been only a fraction of a percentage point.[32] During the last decade, the net effect on China's real exchange rate of changes to the interest premium and the saving rate has therefore been dominated by changes to the saving rate, as shown by Tyers and Golley (2008a).

Trade liberalisation

Trade liberalisation increases a region's openness, as measured by the import penetration ratio. The elasticity of China's real exchange rate to its openness to trade is constructed by dividing the percentage change in the real exchange rate by the percentage point change in the

[32] See Tyers and Golley (2008b).

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.[33] The elasticity, shown in Figure 5, proves to be quite large, with the expected negative sign, and it grows in magnitude through time.

The rise in the elasticity's (negative) magnitude through time occurs because, even though the industries most affected by trade liberalisation are capital intensive (Table 2), the broad group "industry" in the model is benefited overall, raising the return on physical capital and attracting additional investment. This apparent anomaly occurs because the "industry" aggregate produces goods that are differentiated from competing imports with the degree of differentiation limiting the extent of demand switching. At the same time this industry group is a large importer of intermediate inputs that are also industrial products. It turns out that the gains to the sector from cheaper intermediates outweigh the losses from import competition in final demand.[34] The effects on GDP are positive, with the raised investment and capital growth tending to reduce costs further and hence to enlarge the negative elasticity through time.

Sensitivity of real exchange rate elasticities to the size of growth shocks

For most growth shocks the non-linearity of the behaviour embodied in the model is not sufficient to make the elasticities shown in Figures 5 and 6 very sensitive to the scale of the shock. The one important exception is the decline in the investment interest premium. The short run (one year) effects of this shock on the real exchange rate are very sensitive to its size. The long run effects (25 years), on the other hand, are no more sensitive than the other growth determinants. This comparative short run sensitivity is illustrated in Figure 7, which shows that the short run elasticity is very large for a large negative shock to the interest premium, and asymptotically approaches zero the less negative or the more positive is the shock.

This occurs because a large negative shock in China's interest premium causes a flood of investment into China, resulting in a large boost to aggregate demand, rises in Chinese relative to foreign product and service prices and hence a short run real appreciation. Because we define the interest premium *decline* as positive (it has a positive effect on GDP growth), the short run elasticity that emerges is also positive. A rise in the interest premium (a negative shock), on the other hand, stifles investment, contracts aggregate demand and Chinese prices and hence causes a real depreciation. This behaviour still yields a positive elasticity but it is smaller the larger is the

[33] 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).
[34] This effect is discussed in detail in Rees and Tyers (2004).

magnitude of the shock. Its diminution is because annual investment expenditure is bounded from below by zero. The short run elasticity for a positive shock is increasing in the size of the shock because the larger its size the larger is new investment as a proportion of GDP and the larger, then, is the proportional aggregate demand boost and the associated real appreciation.[35]

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

Those growth shocks that have the largest real exchange rate elasticities are collected together in Figure 5. The general pattern in this figure 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. BSH 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.

That said elasticities to growth shocks are not always the best measure of potential impact. Outcomes also depend on the magnitudes of the shocks themselves. It is clear from the discussion of investment interest premium and saving rate shocks that the smaller elasticity to saving rate changes belies their significance for the real exchange rate because those changes have in fact been comparatively large in magnitude. The same is true of the productivity elasticities. Actual shocks to Chinese productivity have, thus far, been largest in the industrial sector. Even though the elasticity of the real exchange rate to industrial productivity is smaller than to service productivity, we do not preclude the possibility that China's productivity growth alone has thus far supplied an appreciating force consistent with the conclusion of Lu (2006b).

7 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

[35] The corresponding long run effect is for the larger rise in the capital stock to reduce capital costs and hence (particularly) service prices. The size of the elasticity diminishes with the scale of the shock in this case because costs, and therefore home prices, are bounded from below by zero.

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 BSH real appreciation effects and the associated relative inflation of service prices is observed since the mid 1990s. A generalisation of the BSH is clearly required since there has been no associated tendency for China's real exchange rate to appreciate.

Such a generalisation is offered, emphasising widely observed failures of the law of one price. Once these are recognised almost all shocks contributing to China's growth also affect its real exchange rate and many tend to depreciate it, potentially explaining the failure to observe an appreciating trend since the 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 endogenous growth driven by both physical and human capital accumulation, open capital accounts and labour supply behaviour fully underpinned by demographics. A baseline "business as usual" simulation is constructed to 2030 and comparator simulations are then made for cases in which sectoral factor productivity is higher, the skill acquisition rate is faster, financial reform reduces China's interest premium, the average saving rate rises and, trade reforms continue to open the economy. The effects of changes in fertility policy are also examined, along with demand shifting changes in 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 has only a weak influence, at least within the three decades examined. In the short run the key determinant is the change in net financial capital flows associated either with the effects of financial reform on the interest premium or a change in the saving rate. If the premium continues to fall and the currently high saving rate moderates, this will emerge as a strong appreciating force. This would reverse the experience of the past decade, during which China's saving rate has increased, widening its current account surplus and turning this substantial force toward real depreciation.

In the medium term, scope does emerge for BSH real appreciation, if services productivity lags sufficiently behind industrial productivity. In the long run, 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 potentially dominant. Since Chinese industrial productivity growth has been higher than that of its trading partners for more than a decade considerable scope remains for productivity catch-up in services. Indeed, it is possible that services productivity could become the dominant source of future growth in China. This, combined with the massive investments being made by the Chinese government and Chinese families in human capital accumulation foreshadows powerful depreciating forces on the real exchange rate.

Thus, 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 in its tradable goods sectors and its temporary appreciating effect might have been expected to appreciate its real exchange rate. Yet a high and, at least over the decade 1997-2006, rising saving rate, combined with trade policy reforms, appears to have more than offset these appreciating forces. In the coming decades the saving rate is likely to fall and there are few further trade policy reforms to implement. The future direction of China's real exchange rate will then depend on the interplay all the forces discussed here and there is certainly no guarantee that those tending to appreciate the real exchange rate will dominate.

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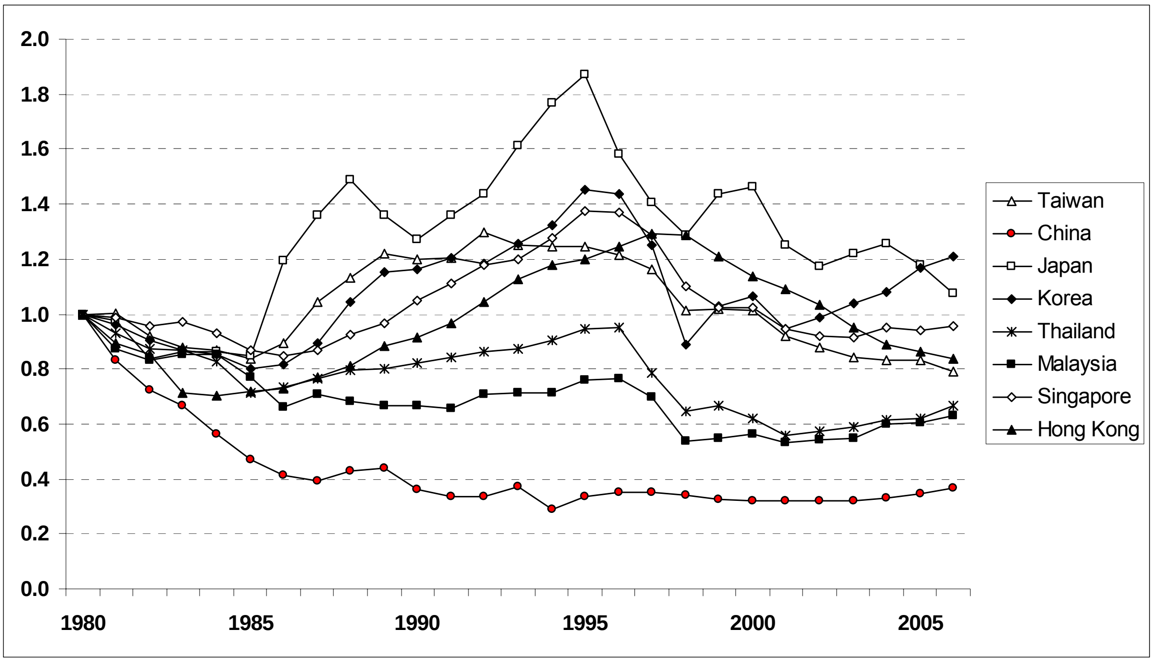
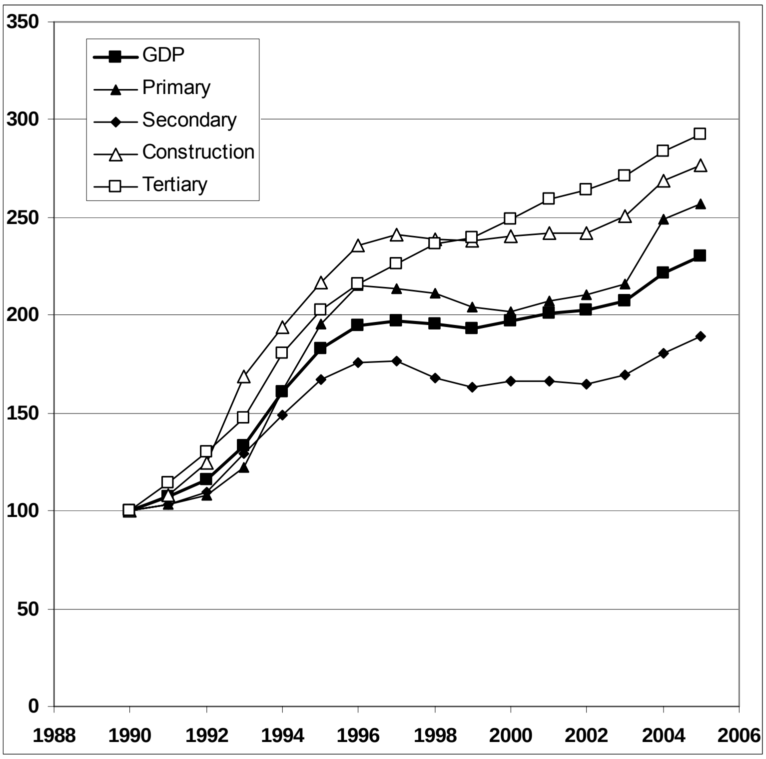
Figure 1: East and Southeast Asian Real Exchange Rates against the US[a]



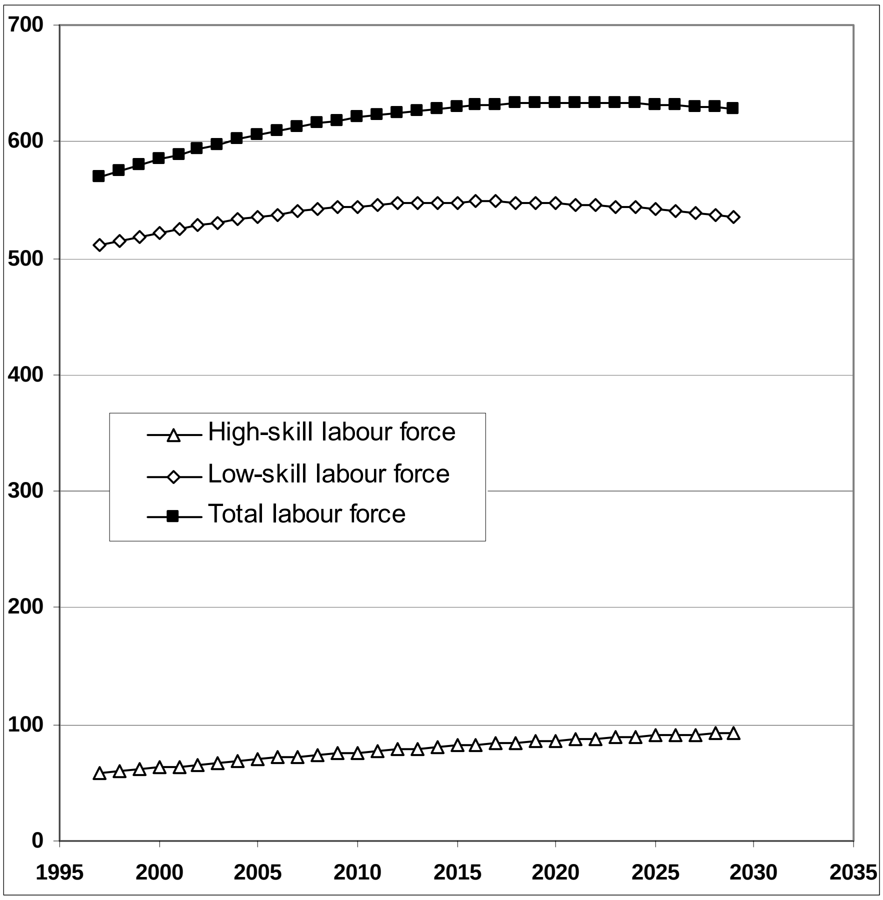
a These are indices of nominal bilateral rates deflated according to $e_R = E \cdot P_Y / P_Y^{US}$, where E is the nominal exchange rate in US$ per unit of local currency, P_Y is the local GDP price and P_Y^{US} is the corresponding US GDP price.
Sources: International Financial Statistics (www.IMF.org) and national statistical authorities.

Figure 2 Chinese sectoral price indices, 1995–2005[a]



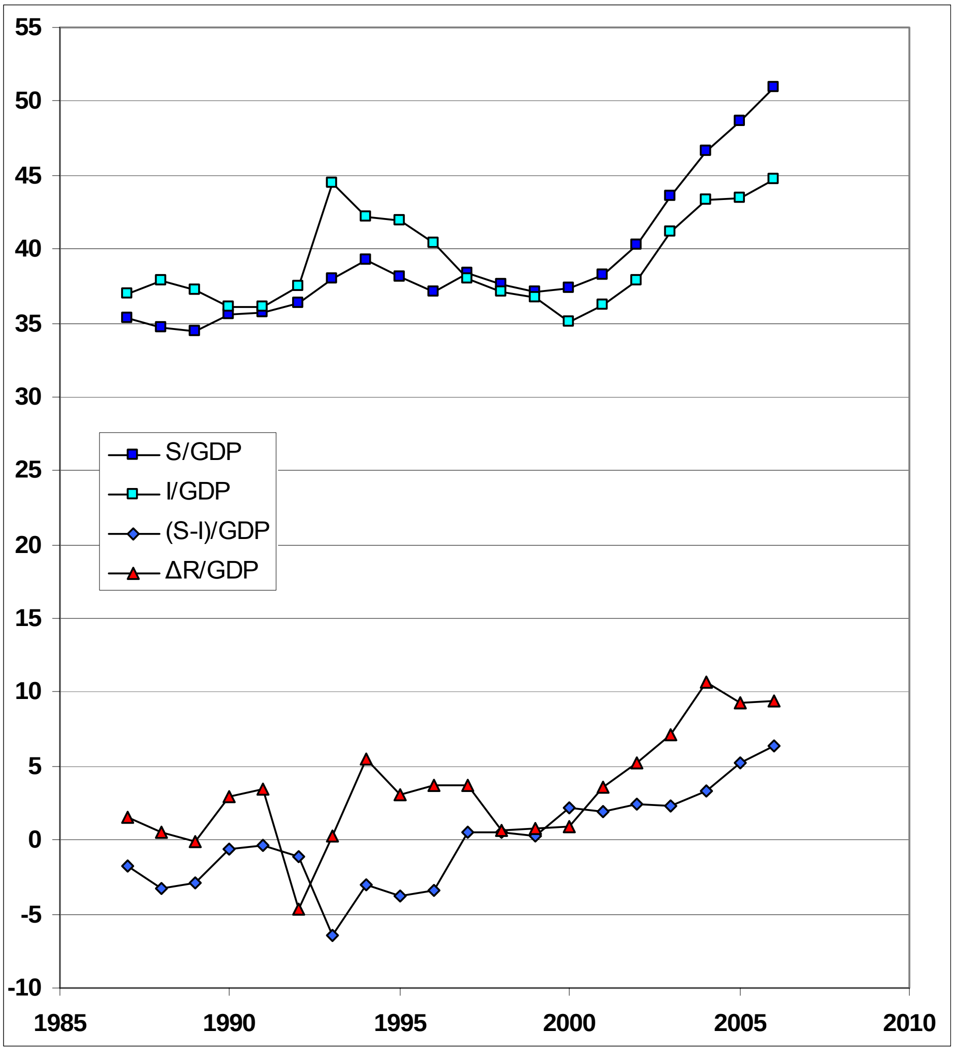
[a] These are sectoral price indices for ‘Primary industry’, which is mainly agriculture; ‘secondary industry’, which is primarily manufacturing and construction; and ‘tertiary industry’, which is other services.
Source: The price indices are implied by volume and value data from the National Bureau of Statistics of China (2007).

Figure 3: China's Projected Baseline Labour Force[a]



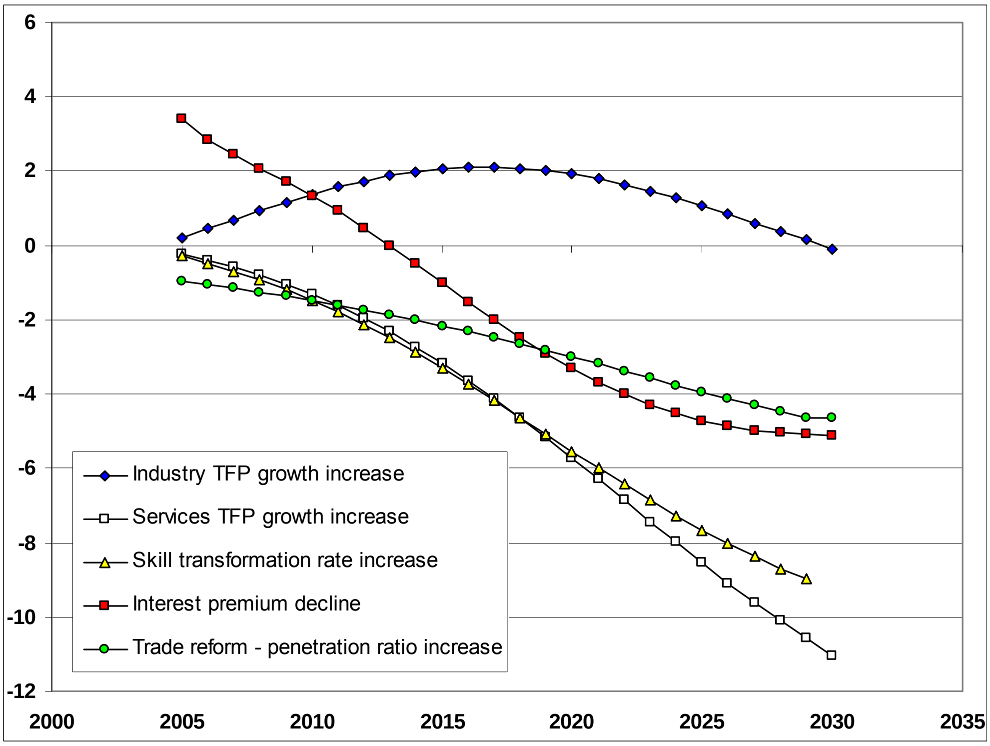
[a] Millions of full time equivalent workers.

Figure 4 China's investment–saving and external balances (percentage of GDP)[a]



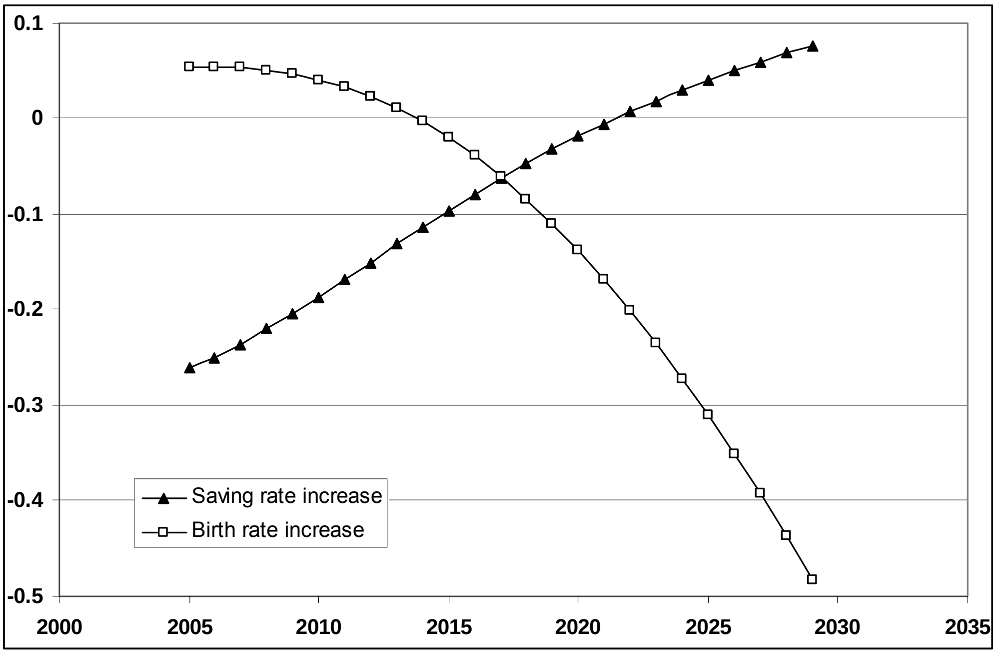
[a] Since errors and omissions are large, we have adjusted the least accurately measured items in each sub-account (usually net factor income and net private flows on the financial account) to ensure balance.
Sources: International Monetary Fund (IMF), 2007a. *International Financial Statistics*, April, International Monetary Fund, Washington, DC. International Monetary Fund (IMF), 2007b. *World Economic Outlook Database*, April, International Monetary Fund, Washington, DC. Some 2006 figures are derived from data from the Chinese National Bureau of Statistics, 2007. Economist Intelligence Unit, Chinese National Bureau of Statistics.

Figure 5: Elasticities of the Projected Real Exchange Rate to the Principal Drivers of China's Economic Growth[a]



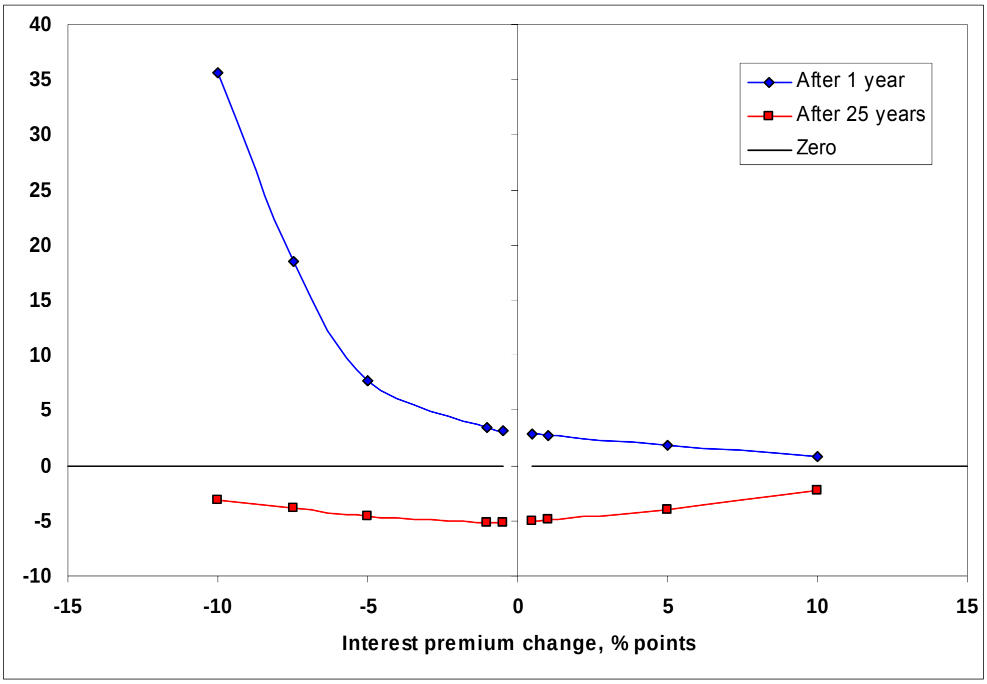
[a] The elasticities of the real exchange rate to each determinant are defined as the % change in the real exchange rate due to the following once and for all changes as of 2005:
Industry and services TFP: % point change in the annual growth rate of total factor productivity,
Skill acquisition rate: % point change in the proportion of the low-skill labour force that is transformed to high skill in each year,
Interest premium decline: % point decline in the home interest rate due to premium decline,
Trade liberalisation: % decline in the import penetration ratio, *M/C*, which changes year to year but which is due to the graduated liberalisation of all trade distortions remaining after WTO accession reforms over 2005-2010.
Source: Simulations using the model described in the text.

Figure 6: Elasticities of the Projected Real Exchange Rate to the Birth and Saving Rates[a]



[a] The elasticities of the real exchange rate to each determinant are defined as the % change in the real exchange rate due to the following once and for all changes as of 2005:
Birth rate: % point change in new births as a share of the fertile population,
Saving rate: % point change in the average (across age-gender-skill groups) proportion of disposable income set aside as saving.
Source: Simulations using the model described in the text.

Figure 7: Sensitivity of the Short and Long Run Elasticity of an Interest Premium Decline to the Size of the Premium Shock[a]



[a] % change in eR for a 1% decrease in the interest premium (elasticity of eR depends on scale of premium shock)

Table 1: Estimated Chinese Total Factor Productivity Growth by Sector

% per year	Whole economy	Agriculture	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: Factor Shares of Chinese Sectoral Value Added

per cent	Agriculture[a]	Industry[b]	Services
Land	24	0	0
Low-skill labour	54	47	34
High-skill labour[c]	**2**	**8**	**22**
Capital	20	45	43
Total	100	100	100

a Agriculture, fisheries and forestry products and processed foods.
b Manufacturing, mining and energy.
c The first three of the ten ISCO occupational categories, comprising mainly professionals and para-professionals.
Source: GTAP 5 Global Database, Dimaranan and McDougall (2002).

Table 3: 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 5 Global Database, Dimaranan and McDougall (2002)..