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Strategic issues and quantitative assessments

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Peter Drysdale and Ligang Song

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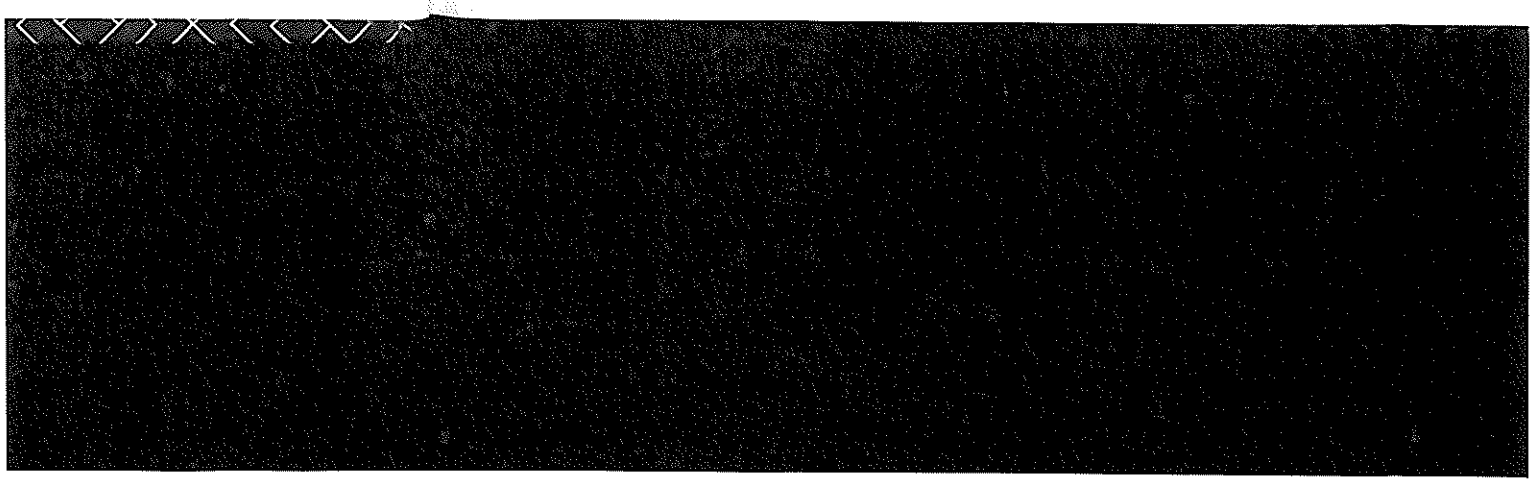

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12 Rapid economic growth in China

Implications for the world economy[1]

Warwick J. McKibbin and Yiping Huang

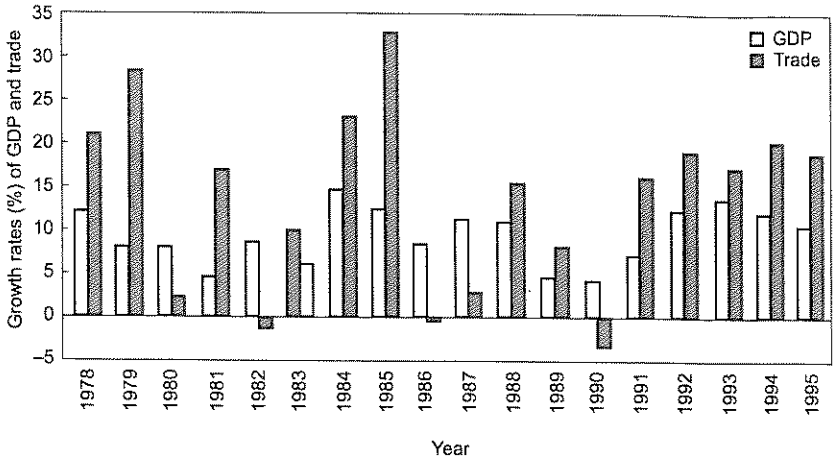
INTRODUCTION

Economic reforms starting from 1979 have brought significant changes to the Chinese economy. The growth rate of real gross domestic product (GDP) averaged 9.1 per cent per annum between 1978 and 1995 (Figure 12.1). While the official statistics, such as those published by the World Bank (1995), still suggest a very low per capita income in the early 1990s in China ($510 in 1994), they are widely regarded as substantially underestimated (Summers and Heston 1991, Garnaut and Ma 1993 and Ren 1995). Garnaut and associates, based on careful comparison of consumption patterns of food and other commodities in China and the other East Asian economies, suggest that the income level in China was underestimated by a factor of three in the year 1990, which implies a GNP per capita of about $1,000 in 1990 and $1,500 in 1994 (Garnaut and Ma 1993; Garnaut, Ma and Huang 1995).[2] This estimate of income level is consistent with the findings of most other studies (Perkins 1992, Lardy 1994 and Ren 1995) and places China at the lower end of the range of the middle-income economies.

One important characteristic of the growing Chinese economy is its increasing outward orientation. Chinese foreign trade grew at an annual rate of 13 per cent in the period 1978–95. The share of merchandise exports in total GDP (appropriately measured) rose from about 3 per cent in 1978 to nearly 7 per cent in 1995. China's share of world merchandise exports increased from less than 1 per cent to 2.5 per cent over the same period. The rapid export growth has, in turn, been led by the dramatic expansion of labour-intensive manufactured exports. The share of labour-intensive manufactured goods in total exports rose from around 30 per cent in 1978 to 56 per cent in 1995.

In the early 1990s, China became the largest recipient country of foreign direct investment (FDI) among the developing economies and the second in the world only after the United States. In the mid-1990s, China also became the largest investor in the rest of the world among the developing countries.

Figure 12.1 Growth rate of GDP and trade in China, 1978–95 (per cent)



Source: Plotted using growth rate figures of GDP and trade from the Statistical Yearbook of China 1997.

The increasing outward orientation of the rapidly growing Chinese economy has already had an important impact on the world economy, particularly its neighbouring East Asian economies. The fact that the rate of China's total trade grew by an average of 13 per cent and that in most years of the past one and half decades, China experienced trade deficits suggest that the rest of the world enjoyed a rapidly expanding market for their exports in the course of Chinese economic growth. There has also been a significant relocation of labour-intensive plants to China from Taiwan, Hong Kong and Korea in the past few years which also facilitated structural adjustment in these East Asian economies.

The sustainability of China's rapid growth is a matter of concern for China as well as for the international community. While there are some uncertainties related to the leadership succession, political stability and possibilities of mistaken macroeconomic policy, the general consensus among economists is that China is likely to be able to sustain its current growth momentum for a relatively long period (Lau 1993; Lin, Cai and Li 1994; Huang and Duncan 1995). The sustainability of China's economic growth will have important implications for the rest of the world as well as being dependent on the reactions of the rest of the world toward the emerging Chinese economy. The strategies adopted by the other countries, in turn, are largely determined by their perception of the opportunities and challenges brought to them by the ascendancy of the Chinese economy. China is already an important player in the international economy, yet it is nonetheless still excluded from the World Trade Organisation. Negotiations between China and the member countries of the

GATT/WTO over China's accession have been going on for about ten years and there is still no clear sign of a successful conclusion in the near future.

This raises the importance of a careful assessment of the implications of China's rapid growth for the world economy. There is currently a debate in the literature about whether China will be able to continue its export-led growth. Lau (1993) predicts that the export ratio will fall in the future because the world economy will not be able to adjust to continued rapid increases in Chinese exports and because there will be opportunities to increase the relative importance of internal trade. Lau's view implies a sharp and large break from the past relationship between trade and growth in China in the reform era. Taking into account the under-measurement of GDP discussed above, Garnaut and Huang (1995) argue that the export–GDP ratio in China is still lower than those of the other East Asian economies and lower than that of large countries like the United States. Their assessment is that, within an effective, rule-based international trading system, and continued Chinese trade liberalisation in the framework of the Uruguay Round settlement, China's foreign trade will continue to grow more rapidly than output.[3]

The international community is concerned about a number of issues related to the rapid growth in China, particularly given its size and institutional history. Will China's continued rapid growth take away trade and investment opportunities from the other poor countries at similar levels of development and cause difficulties in structural adjustment for the industrialised economies (Lardy 1994, Garnaut and Huang 1995)? As China's population and income continue to grow, will it lead to a scarcity of agricultural products resulting in a dramatic food shortage for a large part of the world's population (Brown 1995)?

In this study, we will apply the dynamic general equilibrium model called G-CUBED, developed by McKibbin and Wilcoxen, to explore possible future paths of the Chinese economy based on projections of population growth, productivity growth, and energy efficiency improvements in the Chinese economy. This model captures not only the composition of the direct trade impacts of development in the Chinese economy but also the implications of the endogenous financial capital on macroeconomic adjustment in the world economy. The study focuses on the likely changes in the period 1990–2020. It allows an examination of the implications of low and high productivity growth in China for the rest of the world.

This chapter is organised as follows. The next section reviews the existing studies on the economy-wide and sectoral productivity growth of the Chinese economy to give an historical context for the projections we are undertaking. The G-CUBED model is introduced in the following section, focusing on the key features of the model that are important for the results of this chapter. The alternative future scenarios, simulated using

the G-CUBED model, are then presented, followed by the concluding section. The approach taken in this chapter is very much in the spirit of the single economy study by Ho *et al.* (1995), although in this chapter the interdependence of the Chinese economy with the global economy is more of a focus.

We find that alternative growth scenarios have important implications for the world economy. We stress that the results are sensitive to the assumptions of the model we use and to the assumptions of variables that are exogenous to the model. The goal of this chapter is to point to the important insights that a modelling approach to future scenarios for the Chinese economy can provide rather than to provide definitive answers about the shape of China and the world economy in 2020.

PRODUCTIVITY GROWTH IN THE CHINESE ECONOMY

The sources of economic growth

In projecting possible future paths for the Chinese economy, it is important to incorporate growth projections of the global economy. In undertaking these growth projections it is important to have a clearly specified growth accounting framework. We will get to the global assumptions, but before this, it is useful to set out some core assumptions of the approach taken.

At an abstract level there are four sources of growth within an individual economy:

1) increases in the supply of labour, capital and other inputs;
2) increases in the quality of these inputs;
3) improvements in the way inputs are used (technical change); and
4) improvements in the way that inputs are allocated across industries.

For the world economy as a whole, a fifth source of growth is reallocation of inputs among countries. In the following modelling framework each of these sources of growth are explicit, although some of these sources of growth we take to be exogenous and some sources of growth are endogenous in the model.

To understand the way growth accounting is used in this chapter, consider a simple model. Following Bagnoli, McKibbin and Wilcoxen (1996), suppose the production process may be represented by a constant returns to scale function Q which depends on the level of technology, A, and quality-adjusted inputs of capital, labour and materials:

$$Y_t = Q(A_t, F_tK_t, G_tL_t, H_tE_t, I_tM_t) \quad (1)$$

where Y_t is output at time t; K_t, L_t, E_t and M_t are inputs of capital, labour, energy and materials; A_t is a coefficient reflecting the overall level of

productivity; and F_t, G_t, H_t and I_t are coefficients capturing the quality of each input. This expression can be transformed into a relationship between growth rates by differentiating with respect to time and dividing through by Y_t. If firms minimise costs, taking prices as given, it is straightforward to show that the rate of output growth will be given by:

$$y=\left(\frac{1}{Q}\frac{\partial Q}{\partial A}\right)a+S_K(f+k)+S_L(g+l)+S_E(h+e)+S_M(i+m) \qquad (2)$$

where the first term on the right hand side is called the rate of total factor productivity (TFP) growth, and S_K, S_L, S_E and S_M are the shares of capital, labour, energy and materials in total costs.

As an empirical matter, decomposing output growth into its constituent elements is a difficult task. For many industries, measuring the rate of output growth y is fairly straightforward: the quantity produced in one year is compared to the quantity produced the previous year. However, determining the source of the growth requires very careful accounting to measure the quality-adjusted rates of growth of factor inputs. Any errors in measuring inputs will cause the rate of total factor productivity growth to be mis-stated.

Thus, in order to project the world economy over the next few decades, we would need underlying projections of each country's labour force, capital stock, materials inputs, energy inputs, changes in factor quality and changes in product demand patterns. Many of these will lead to changes in relative prices and thus change the structure of each region's economy. Moreover, the evolution of each country's capital stock will be an endogenous result of domestic and foreign investment decisions. In order to combine all of these projections, capture the effects of relative price changes, and project the future path of the capital stock, we will use a disaggregated intertemporal general equilibrium model called G-CUBED. In the next section we describe the key features of the G-CUBED model. In the subsequent section we survey empirical estimates of Chinese productivity growth rates and discuss the estimates used in G-CUBED to generate projections of the world economy over the next few decades.

Historical evidence on productivity growth in the Chinese economy

In Bagnoli, McKibbin and Wilcoxen (1996) a number of studies of economy-wide and sectoral productivity growth for a range of countries are surveyed. We draw on that earlier survey as well as a number of other studies to produce a table of historical estimates of the source of growth in China. These are presented in Table 12.1. Several points can be made from these results for aggregate growth of the Chinese economy. Prior to the economic reforms, GDP growth averaged under 6 per cent per year and after the reforms around 1979, GDP growth averaged around 8 per

Table 12.1 Economy-wide growth in China: selected studies

Period	*GDP growth*	*Contribution of capital*	*Contribution of labour*	*TFP growth*
Maddison (1989)				
1950–73	5.84	2.74	2.61	0.49
1973–84	6.85	2.35	2.40	2.10
Li/Jorgenson/Zheng/Kuroda (1993)				
1953–78	5.92	5.51	1.21	-0.80
1979–90	8.35	4.25	1.57	2.53
Bosworth/Collins/Chen (1995)				
1960–70	3.60	0.00	1.49	0.97
1970–80	4.91	1.90	-0.93	2.91
1980–86	8.49	2.50	1.84	3.32
1986–92	7.69	3.10	0.35	4.05
Huang/Duncan (1995)				
1952–78	6.00	4.60	1.50	-0.10
1978–92	8.80	6.50	1.00	1.30

Sources: Drawn from studies of Maddison (1989), Li *et al.* (1993), Bosworth, Collins and Chen (1995), Huang and Duncan (1995) and Bagnoli, McKibbin and Wilcoxen (1996).

cent per year depending on the period under study. The contribution of capital to both pre-reform and post-reform periods appears to be large. The contribution of labour, both in terms of labour force growth and improvements in labour quality were less important in both pre- and post-reform periods. The role of total factor productivity (TFP), the residual in our above accounting framework, is more important in the post-reform period than the pre-reform period.

As well as the economy-wide studies, we also present some evidence from sectoral studies of growth in China in Table 12.2. The results in Table 12.2 show that the experience at the sectoral level in China is very different to the average overall productivity experience. This stylisation of sectoral productivity growth is not unique to China but, as surveyed by Bagnoli, McKibbin and Wilcoxen (1996), this result is found for most other countries. Productivity growth varies a great deal across sectors within a country as well as across countries in different time periods. This feature of productivity growth experience makes the forward projection of total factor productivity changes fraught with problems. It also suggests that aggregate projections of productivity may be problematic given the differential experience at the sectoral level. Bagnoli, McKibbin and Wilcoxen (1996) demonstrate that different assumptions of productivity growth at the sectoral level can lead to significant structural differences between any two economies with the same aggregate GDP growth experience.

Table 12.2 China's total factor productivity for G-cubed sectors: selected studies

G-cubed sectors	*Chen* et al. *(1988) 1961–85*	*McGuckin* et al. *(1992) 1980–85*	*Li* et al. *(1993) 1981–87*
Electric utilities	–	-3.64	-4.64
Gas utilities	–	–	–
Petroleum refining	–	0.38	2.28
Coal mining	–	0.25	0.54
Crude oil & gas extraction	–	-1.36	-5.06
Mining	–	-1.35	0.29
Agriculture	–	–	1.18
Forestry & wood products	–	-1.95	0.05
Durable manufacturing	7.00	–	–
Non-durable manufacturing	7.00	–	–
Transportation	–	–	-1.20
Services	–	–	2.18

Sources: Drawn from studies of Chen *et al.* (1988), McGuckin *et al.* (1992) and Li *et al.* (1993).

THE G-CUBED MULTI-COUNTRY MODEL

We now present a brief overview of the features of the G-CUBED model that are important for this study. A more complete description is contained in McKibbin and Wilcoxen (1995) with a range of applications of this model in McKibbin and Wilcoxen (1996).

G-CUBED has several features which together distinguish it from other models in the literature. It uses econometric estimates of parameters describing preferences and production technology; it integrates macroeconomic adjustment with the sectoral adjustment to changes in exogenous variables; it captures the link between flows of goods and flows of assets between economies; and it endogenously determines financial prices such as interest rates and exchange rates, which play a crucial role in the adjustment of the global economy to alternative projections and policies. It also endogenises the investment decision which is determined by expected real and financial rates of return subject to adjustment costs in relocating physical investment once in place.

G-CUBED disaggregates the world economy into the eight economic regions listed in Table 12.3. Each region is further decomposed into a household sector, a government sector, a financial sector, the twelve industries shown in Table 12.3, and a capital goods producing sector. This disaggregation enables us to capture regional and sectoral differences in the impact of alternative economic policies.

In the remainder of this section we present an overview of the theoretical structure of the model. To keep notation as simple as possible we

Table 12.3 Overview of the G-CUBED model

Regions
United States
Japan
Australia
Other OECD
China
LDCs
Oil-exporting developing countries
Eastern Europe and the former Soviet Union
Sectors
Energy:
Electric utilities
Gas utilities
Petroleum refining
Coal mining
Crude oil and gas extraction
Non-Energy:
Mining
Agriculture, fishing and hunting
Forestry/wood products
Durable manufacturing
Non-durable manufacturing
Transportation
Services

Source: From the G-CUBED model developed by McKibbin and Wilcoxen (1995).

have not subscripted variables by country except where needed for clarity. The complete model, however, consists of eight of these sub-models linked by international trade and asset flows.

PRODUCER BEHAVIOUR

Each producing sector is represented by a single firm which chooses its inputs and its level of investment in order to maximise its stock market value subject to a multiple-input production function and a vector of prices it takes to be exogenous. We assume that output can be represented by a constant elasticity of substitution (CES) function of inputs of capital (K), labour (L), energy (E) and materials (M). Omitting industry and country subscripts the production has the following form:

$$Q = Ao\left(\sum_{j=K,L,E,M} \delta_j^{1/\sigma o}\, X_j^{(\sigma o-1)/\sigma o}\right)^{\frac{\sigma o}{(\sigma o-1)}} \qquad (3)$$

where Q is the industry's output, X_j is the quantity of input j, and A_Q, δ_j and σ_Q are estimated parameters which vary across industries. In addition, the A_Q and δ parameters vary across countries. Without loss of generality we constrain the δs to sum to one. We introduce technical change by specifying that X_L, the effective input of labour in each industry, is equal to hours of work multiplied by a country- and industry-specific labour quality adjustment factor. This specification has the effect of making stationary the ratio of prices to wages per effective labour unit (Harrod neutrality), which is convenient when solving the model.

Energy and materials, in turn, are CES aggregates of inputs of intermediate goods. The form of the function is the same as for the output tier but the inputs and estimated parameters are different. For energy:

$$X_E = A_E \left(\sum_{j=1}^{5} \delta_j^{1/\sigma_E} X_j^{(\sigma_E - 1)/\sigma_E} \right)^{\frac{\sigma_E}{(\sigma_E - 1)}} \tag{4}$$

where X_E is the industry's input of energy, X_j is the quantity of input j, and A_E, δ_j and σ_E are estimated parameters which vary across industries. As before, A_E and the δ parameters also vary across countries. The materials aggregation is defined in a similar manner.

In order to estimate the parameters in these equations we constructed a time-series dataset on prices, industry outputs, value-added and commodity inputs to industries for the United States. The following is a sketch of the approach we followed; complete details are contained in McKibbin and Wilcoxen (1995).

We began with the benchmark input–output transactions tables produced by the Bureau of Economic Analysis (BEA) for the years 1958, 1963, 1967, 1972, 1977 and 1982. The conventions used by the BEA have changed over time, so the raw tables are not completely comparable. We transformed the tables to make them consistent and aggregated them to twelve sectors. We then shifted consumer durables out of final consumption and into fixed investment. We also increased the capital services element of final consumption to account for imputed service flows from durables and owner-occupied housing. Finally, we used a dataset constructed by Dale Jorgenson and his colleagues to decompose the value added rows of the tables, and a dataset produced by the Office of Employment Projections at the Bureau of Labour Statistics to provide product prices. We use these data to estimate the elasticities of substitution in production at different levels of the nest.

To parameterise the other regions we impose the restriction that substitution elasticities are equal throughout the world. In other words, we assume that each industry has the same energy, materials and *KLEM*

substitution elasticities no matter where it is located. This is consistent with the econometric evidence of Kim and Lau in a number of papers (see, for example, Kim and Lau 1994). However, the share parameters for other regions corresponding to individual countries (Japan, Australia, China and approximately the Eastern Europe and Former Soviet Union region) are derived from input–output data for those regions and are not set equal to their US counterparts. The share parameters for the remaining regions, which are aggregates of individual countries, are calculated by adjusting US share parameters to account for actual final demand components from the aggregate national accounts data for each of the regions. In effect, we are assuming that all regions share production methods that differ in first-order properties but have identical second-order characteristics. This is intermediate between the extremes of assuming that the regions share common technologies and of allowing the technologies to differ across regions in arbitrary ways. Finally, the regions also differ in their endowments of primary factors and patterns of final demands. The main limitation of this approach is that there are very few benchmark input–output tables so our dataset contains few observations. The problem is severe outside OECD countries.

Maximising the firm's short-run profit subject to its capital stock and the production functions above gives the firm's factor demand equations. At this point we add two further levels of detail: we assume that domestic and imported inputs of a given commodity are imperfect substitutes, and that imported products from different countries are imperfect substitutes for each other. Thus, the final decision the firm must make is the fraction of each of its inputs to buy from each region in the model (including the firm's home country). We represent this decision using a two-tier CES function, although in this version of the model data limitations have forced us to impose unitary substitution elasticities. We assume that all agents in the economy have identical preferences over foreign and domestic varieties of each particular commodity. We parameterise this decision using trade shares based on aggregations of the 4-digit level of the United Nations SITC data for 1987. The result is a system of demand equations for domestic output and imports from each other region.

In addition to buying inputs and producing outputs, each sector must also choose its level of investment. We assume that capital is specific to each sector, that investment is subject to adjustment costs, and that firms choose their investment paths in order to maximise their market value. The capital stock changes by the amount of gross investment less depreciation of existing capital.

Following the cost of adjustment models of Lucas (1967), Treadway (1969) and Uzawa (1969), we assume that the investment process is subject to rising marginal costs of installation. To formalise this we adopt Uzawa's approach by assuming that in order to install j units of capital, the firm must buy a larger quantity that is quadratic in the rate of investment.

Setting up and solving the firm's investment problem yields an equation for investment that depends on taxes, the size of the existing capital stock and marginal q (the ratio of the marginal value of a unit of capital to its purchase price).

Following Hayashi (1979), the investment function is modified to improve its empirical properties by writing investment as a linear function of optimal investment and current capital income. This improves the empirical behaviour of the specification and is consistent with the existence of firms that are unable to borrow and therefore invest purely out of retained earnings.

In addition to the twelve industries discussed above, the model also includes a special sector that produces capital goods. This sector supplies the new investment goods demanded by other industries. Like other industries, the investment sector demands labour and capital services as well as intermediate inputs. We represent its behaviour using a nested CES production function with the same structure as that used for the other sectors. However, we estimate the parameters of this function from price and quantity data for the final demand column for investment.

Households

Households consume goods and services in every period and also demand labour and capital services. Household capital services consist of the service flows of consumer durables plus residential housing. Households receive income by providing labour services to firms and the government, and from holding financial assets. In addition, they also may receive transfers from their region's government.

Within each region we assume household behaviour can be modelled by a representative agent with an intertemporal utility function that depends on consumption of private and public goods in each period and a rate of time preference. The household maximises its utility subject to the constraint that the present value of consumption be equal to human wealth plus initial financial assets. Human wealth (H) is the present value of the future stream of after-tax labour income and transfer payments received by households. Financial wealth (F) is the sum of real money balances, real government bonds in the hands of the public (Ricardian neutrality does not hold in this model because some consumers are liquidity-constrained; more on this below), net holdings of claims against foreign residents and the value of capital in each sector. Under this specification, the value of each period's consumption is equal to the product of the time preference rate and household wealth.

Based on the evidence cited by Campbell and Mankiw (1987) and Hayashi (1982), however, we assume that only a portion of consumption is determined by these intertemporally-optimising consumers and that the remainder is determined by after-tax current income. This can be interpreted as liquidity-constrained behaviour or as permanent income

behaviour when household expectations are backward-looking. Either way, we assume that total consumption is a weighted average of forward-looking consumption and backward-looking consumption.

Within each period the household allocates expenditure among goods and services in order to maximise C(s), its intratemporal utility index. In this version of the model we assume that C(s) may be represented by a Cobb–Douglas function of goods and services.

The supply of household capital services is determined by consumers themselves who invest in household capital in order to generate a desired flow of capital services. We assume that capital services are proportional to the household capital stock. As in the industry investment model, we assume that investment in household capital is subject to adjustment costs.

Government

We take each region's real government spending on goods and services to be exogenous and assume that it is allocated among final goods, services and labour in fixed proportions, which we set to 1987 values. Total government spending includes purchases of goods and services plus interest payments on government debt, investment tax credits and transfers to households. Government revenue comes from sales taxes, corporate taxes, personal income taxes, and from issuing government debt. In addition, there can be taxes on externalities such as carbon dioxide emissions.

We assume that agents will not hold government bonds unless they expect the bonds to be serviced, and accordingly impose a transversality condition on the accumulation of public debt that has the effect of causing the stock of debt at each point in time to be equal to the present value of all future budget surpluses from that time forward. This condition alone, however, is insufficient to determine the time path of future surpluses: the government could pay off the debt by briefly raising taxes substantially; it could permanently raise taxes a small amount; or it could use some other policy. We assume that the government levies a lump sum tax equal to the value of interest payments on the outstanding debt. In effect, therefore, any increase in government debt is financed by consols and future taxes are raised enough to accommodate the increased interest costs. Thus, any increase in the debt will be matched by an equal present value increase in future budget surpluses. Other fiscal closure rules are possible, such as always returning to the original ratio of government debt to GDP. These closures have interesting implications but are beyond the scope of this chapter (see Bryant and Long 1994).

International trade and asset flows

The eight regions in the model are linked by flows of goods and assets. Flows of goods are determined by the bilateral import demands described

above. These demands are summarised in a set of bilateral trade matrices which give the flows of each good between exporting and importing countries. There is one 8-by-8 trade matrix for each of the twelve sectors for each country.

Trade imbalances are financed by flows of assets between countries. We assume asset markets are perfectly integrated across the OECD regions. With free mobility of capital, expected returns on loans denominated in the currencies of the various regions must be equalised from period to period according to a set of interest arbitrage relations. In generating the baseline of the model, we allow for risk premia on the assets of alternative currencies, although during simulations we assume these risk premia are constant and unaffected by the shocks under study. For the non-OECD countries we also make the assumption that exchange rates are free to float at an annual frequency. We also assume that capital is freely mobile within the regions and between the regions and the rest of the world. This may seem simplistic since many developing countries have restrictions on short-term flows of financial capital. Many of these countries nonetheless have significant flows of foreign direct investment responding to changes in expected rates of return. In the model, capital flows capture both of these effects because they include foreign direct investment as well as short-term financial capital. Future work will focus more on modelling financial markets in the developing regions of the model. Finally, we assume that OPEC (Organisation of Petroleum Exporting Countries) chooses its foreign lending in order to maintain a desired ratio of income to wealth subject to a fixed exchange rate with the US dollar.

Labour markets

We assume that labour is perfectly mobile among sectors within each region but immobile between regions. Thus, within each region, wages will be equal across sectors. The nominal wage is assumed to adjust slowly according to an overlapping contracts model where nominal wages are set based on current and expected inflation and on labour demand relative to labour supply. In the long run, labour supply is given by the exogenous rate of population growth, but in the short run, the hours worked can fluctuate depending on the demand for labour. For a given nominal wage, the demand for labour will determine short-run unemployment.

Money markets

Finally, we assume that money enters the model via a constraint on transactions. We use a money demand function in which the demand for real money balances is a function of GDP and short-term nominal interest rates. The supply of money is determined by the balance sheet of the central bank and is exogenous. Although there is a lack of explicit finan-

cial markets in China, we treat financial prices as shadow prices that are used in making economic decisions.

FUTURE PROJECTIONS

In this section we first outline our procedure for generating a baseline for the global economy with a particular focus on the Chinese economy. Given this baseline, we then explore the implications of an increase in labour-augmenting technical change of 1 per cent for five years beginning in 1990. We examine the impacts of this higher growth rate for China and the world economy.

The baseline

The procedure for projecting the global economy from 1990 to 2020 is presented in detail in Bagnoli, McKibbin and Wilcoxen (1996). Here we summarise key aspects of the procedure. The model used in this chapter differs from that earlier paper primarily because the data for China have been adjusted to reflect the discussion outlined in the introduction, that Chinese GDP is apparently under estimated in the official statistics. The projections for population growth are based on World Bank projections for each region smoothed on an annual basis. These are summarised in Table 12.3.

We also need to make assumptions about productivity growth and technical change. We assume that all technical change and productivity growth is labour-augmenting technical change (Harrod-neutral technical change). This assumption is required to solve for a unique steady state in the neoclassical framework we are using. In the discussion in this section all references to productivity growth and technical change are in terms of labour-augmenting technical change (LATC). The assumptions about LATC are also given in Table 12.4. We assume each sector in each economy experiences the same rate of labour-augmenting technical change (Harrod neutral). This is likely to be an unsatisfactory representation of reality but is taken as a benchmark. In future studies we expect to modify the sectoral assumptions.

In addition to the assumptions for technical change and population growth we need to make assumptions about other exogenous variables in the model. Fiscal spending is assumed to be fixed as a share of GDP in each country; monetary policy is assumed to target nominal growth with the target comprising underlying real growth plus the inflation rate observed in 1990; taxes are assumed to be at 1990 levels with a lump sum tax varying over time to satisfy the intertemporal budget constraints of the government; tariff rates are set to 1990 rates; oil prices are partly determined by OPEC supply decisions given a target ratio of income to wealth by the OPEC economies.

Given these assumptions, which should (and will in future research) be subject to sensitivity analysis, we solve the model from 1990 to 2100.

The solution is non-trivial because certain agents in the model have rational expectations. We have developed an algorithm that solves the model for the full rational expectations equilibrium through time such that the model solution for 1990 is equal to the database values for 1990 given the exogenous projections assumed above. Although not described in technical detail here (see McKibbin and Wilcoxen 1995), this algorithm forces the model to replicate exactly the database for 1990 and thus imposes that the year 1990 is on the stable manifold of the model adjusting towards a long-run equilibrium growth path. This is important because it means that, unlike static CGE models, we do not assume that the base year (1990 in this case) is a steady-state equilibrium of the model but that it is on a path (consistent with the rational expectations of agents) that is adjusting towards a long-run stable equilibrium.

We do not focus on the baseline of the model *per se*. Instead, we want to see how, on the marginal effects of a change in assumptions about Chinese productivity growth, these changes impact on China, and through global financial and goods markets, how these changes impact on the rest of the world.

The model projections for aggregate GDP growth in each region are given in Figure 12.2. This figure shows a gradual convergence of growth rates consistent with the convergence of LATC, although convergence is not complete because of different assumptions about population growth in each country during the period. Average GDP growth in China is 6.7 per cent from 1991 to 1999, 5.2 per cent from 2000 to 2009 and 4.3 per cent from 2010 to 2019.

A rise in Chinese productivity growth

To illustrate the adjustment of the global economy to alternative growth scenarios for China, we next simulate a rise in LATC in China. For illustrative purposes we begin the simulation in 1991, assuming that the rate of growth of LATC rises by 1 per cent per year for five years and then returns to the baseline growth rate (although at a higher level) thereafter. This shock is assumed to be anticipated in 1991. Results for this shock are contained in Figures 12.3–12.7.

In China the expectation of stronger future growth leads to a tightening of liquidity as shadow real interest rates rise. This dampens economic activity in 1991 but is more than offset by the rise in investment following the surge in productivity. Real GDP rises strongly (Figure 12.3) until 1996 when the growth in LATC returns to baseline. The overshooting of GDP reflects the investment expenditure which overreacts to the rise in the real return to capital. Part of the extra investment is funded through capital inflows into China. This can be seen by the increasing wedge between GDP (what is produced) and GNP (the income to domestic factors of production). The smaller rise in GNP compared with GDP reflects the increase in servicing costs (or repatriation of dividends) on the foreign

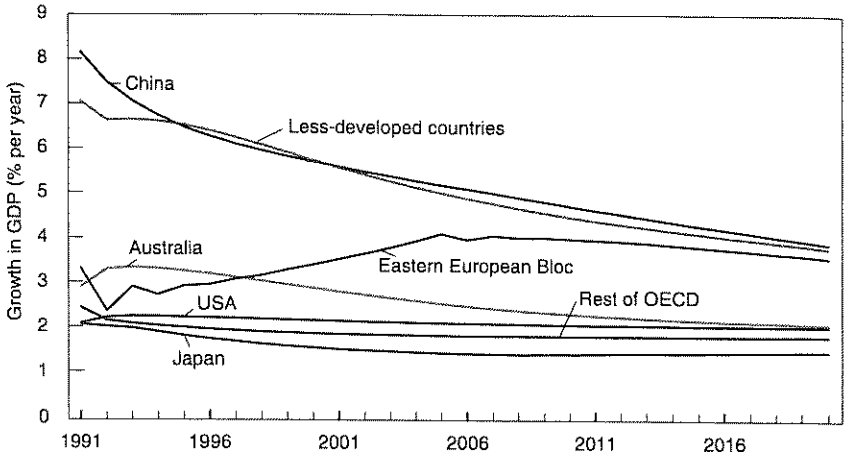
capital that flows into China. It is seen even more clearly in Figure 12.4 where we present the deviation from baseline of the Chinese trade and current account balances as a percentage of baseline GDP. In 1991 there is a capital outflow, but this is quickly reversed between 1992 and 1995 as both the trade and current deficits move towards deficit. This reflects the capital account surplus resulting from foreign capital flowing into the Chinese economy. Part of this adjustment occurs through increased demand for goods in China pulling in imports and part is through a strengthening of the yuan exchange rate. Note that after the shock has passed, the trade balance moves quickly towards surplus reflecting the condition that the build-up of foreign debt and foreign investments in China must be serviced. Ultimately, Chinese exports must rise by more than Chinese imports (at the margin).

In the rest of the world, the rise in Chinese demand for foreign goods, especially capital goods, raises incomes in the regions that produce the goods that China needs. In addition the rise in the return to capital in China yields a higher return to foreign investments in China, which raises incomes of the owners of foreign capital. Figure 12.5 shows the impact on GDP in the rest of the world. The United States and LDCs (less developed countries) gain in terms of GDP. Japan experiences lower GDP as a result of the extra productivity growth in China. This does not imply that Japan is worse off, however. Figure 12.6 shows the income effects of the shock. Capital flows from Japan into the Chinese economy. This financial capital ultimately implies less physical capital put in place in Japan but rather relocated to China (relative to what otherwise would have occurred) and thus production in Japan is less than it otherwise would have been. However, this capital in China earns a higher rate of return than it would have in Japan and therefore GNP (a measure of income to all Japanese factors of production) ultimately rises in Japan.

There are thus a number of effects of the stronger productivity growth on the rest of the world. There are demand effects from higher Chinese demand for foreign goods, as well as effects on foreign production as capital is re-allocated to less productive uses outside China into sectors within China with higher rates of return. The adjustment process is quite drawn out since the higher productivity growth lasts five years yet the adjustment is still under way by 2020.

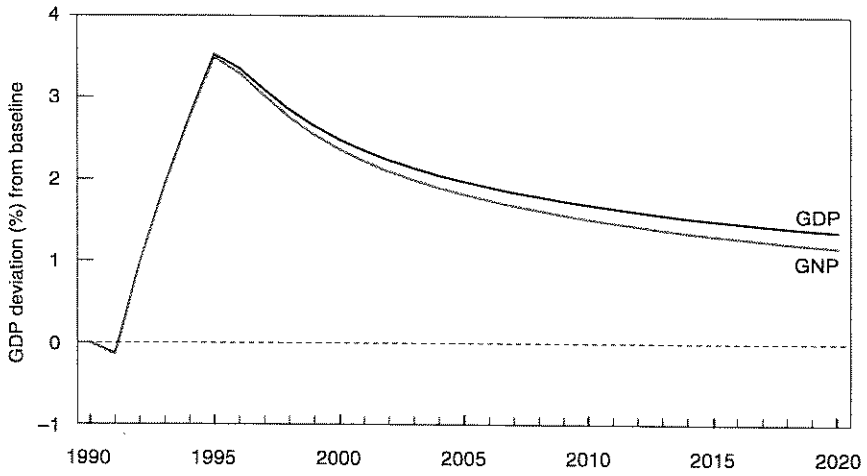
In Figure 12.7 we show the changes in current accounts, as a percentage of baseline GDP in each economy. An improvement in the current account of a country reflects a net capital outflow. This can be seen to occur for each economy except the United States and, of course, China. The US results reflect the strong demand for capital goods from the United States, which more than offsets the capital flow adjustment. The outcome for Australia is quite interesting since there is a redirection of foreign capital away from Australia, which worsens Australia's capital account by the largest amount when scaled to GDP but not in absolute dollars.

Figure 12.2 World real GDP growth, 1991–2016



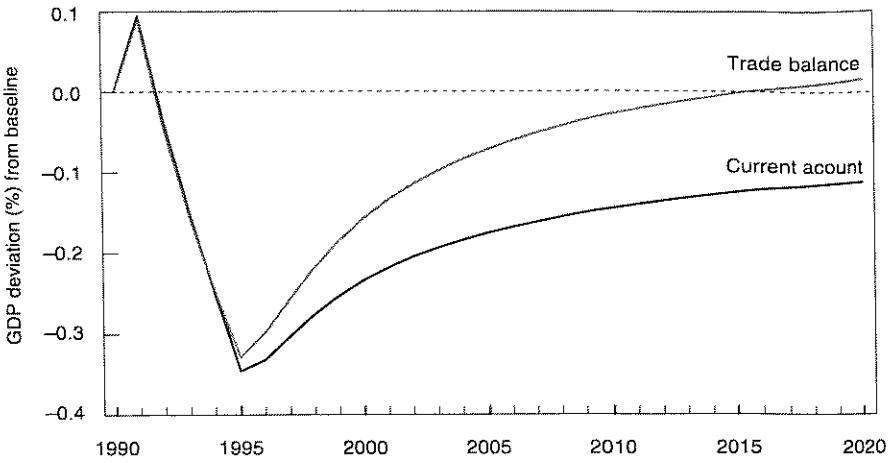
Source: Author's simulations applying the G-CUBED model.

Figure 12.3 Chinese real GDP and GNP, 1990–2020



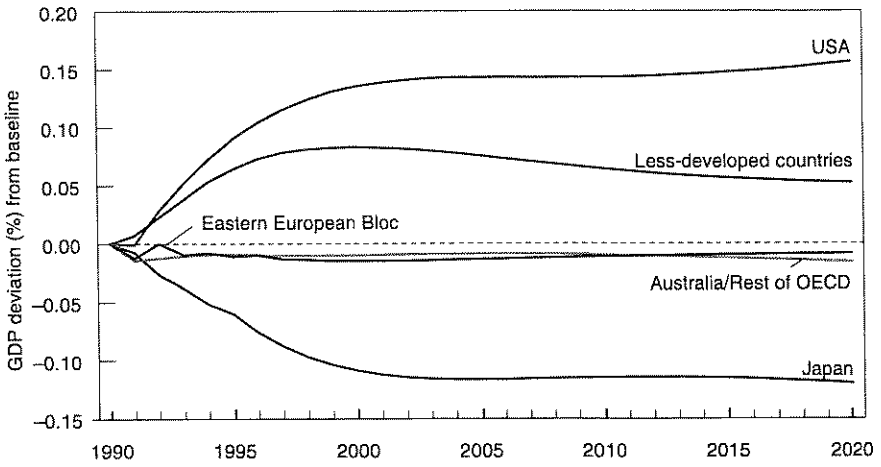
Source: Author's simulations applying the G-CUBED model.

Figure 12.4 Chinese foreign trade, 1990–2020



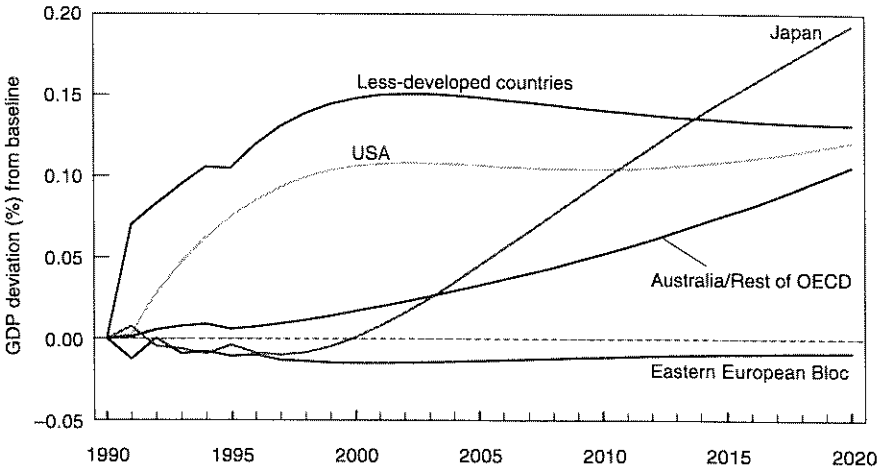
Source: Author's simulations applying the G-CUBED model.

Figure 12.5 World real GDP, 1990–2020



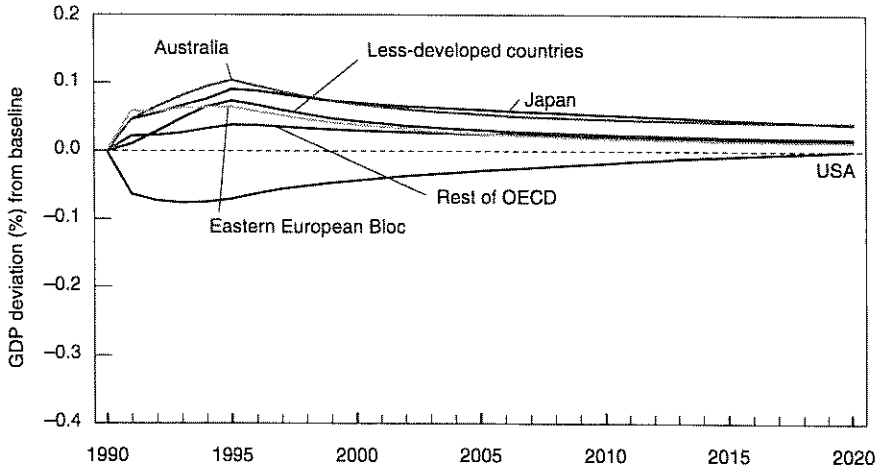
Source: Author's simulations applying the G-CUBED model.

Figure 12.6 World real GNP, 1990–2020



Source: Author's simulations applying the G-CUBED model.

Figure 12.7 World current accounts, 1990–2020



Source: Author's simulations applying the G-CUBED model.

Table 12.4

Population	
US	
Japan	
Australia	
ROECD	
China	
LDCs	
EEB	
Labour-Au	
US	
Japan	
Australia	
ROECD	
China	
LDCs	
EEB	
Autonomo	
US	
Japan	
Australia	
ROECD	
China	
LDCs	
EEB	

Note: ROE
Source: Ba

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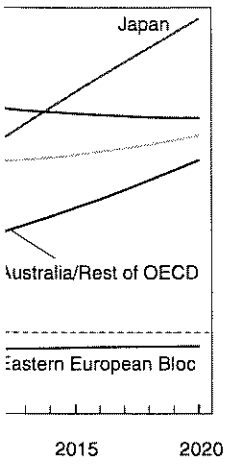
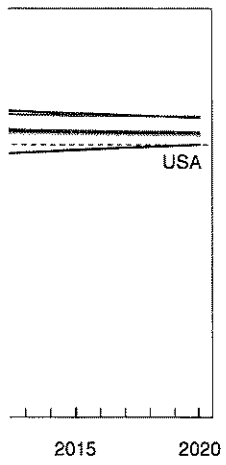


Table 12.4 Baseline assumptions

	1990–99	*2000–09*	*2010–19*
Population Growth (% per year)			
US	0.88	0.65	0.48
Japan	0.12	0.01	0.00
Australia	1.12	0.74	0.49
ROECD	0.19	0.02	0.00
China	1.00	0.77	0.59
LDCs	1.95	1.68	1.44
EEB	0.28	0.26	0.25
Labour-Augmenting Technical Change (% per year)			
US	1.00	1.00	1.00
Japan	1.28	1.05	1.00
Australia	1.82	1.64	1.49
ROECD	1.63	1.47	1.33
China	6.49	5.31	4.34
LDCs	4.57	3.74	3.05
EEB	2.90	4.46	3.89
Autonomous Energy Efficiency Improvements			
US	1	1	1
Japan	1	1	1
Australia	1	1	1
ROECD	1	1	1
China	1	1	1
LDCs	1	1	1
EEB	1	1	1

Note: ROECD is rest of the OECD; LDC is less developed country; EEB is Eastern European Bloc.
Source: Baseline assumptions in applying the G-CUBED model.



CONCLUSION

This chapter has examined the impact of different productivity growth rates in China on the Chinese and the global economy. The results are very preliminary and the actual numbers will undoubtedly change as further research on this project continues in the light of the rich literature on growth potential in particular sectors of the Chinese economy. Perhaps a disappointing aspect of the results is the lack of differential sectoral productivity growth that we have imposed on the model. We know from the results in Bagnoli, McKibbin and Wilcoxen (1996) that differential sectoral productivity growth is very important to aggregate outcomes. In particular, it is likely to change the composition of trade adjustment, although it is not likely to change significantly the overall adjustment of trade and current account balances that are driven by aggregate changes in investment and saving decisions.

NOTES

1 This chapter is based on a paper prepared for the AJRC International Conference on 'China and the WTO: Issues and Impacts on China and the East Asian and Pacific Economies' held in Tokyo, 8–9 May 1996. We thank Justin Yifu Lin and other participants at the conference for comments. The G-CUBED model used in this paper was developed jointly by McKibbin and Peter Wilcoxen of the University of Texas at Austin. The research reported here has benefited from a project on future growth prospects with Wilcoxen and Philip Bagnoli of the Brookings Institution. The development of the G-CUBED model was funded under a cooperative agreement between the Brookings Institution and the US Environmental Protection Agency and from a National Science Foundation grant. This paper also uses data from the International Economic Databank at the Australian National University. The views expressed are those of the authors and should not be interpreted as reflecting the views of the trustees, officers or other staff of the Brookings Institution, Australian National University, Environmental Protection Agency or National Science Foundation.

2 According to Garnaut, Ma and Huang (forthcoming), the underestimation factor has varied since 1990, given the fact that the official income data published by the World Bank have also been adjusted upward gradually.

3 Garnaut and Huang (1995) admit that eventually the 'Lau factor' will take the edge off the powerful momentum in trade growth.

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