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# RAPID ECONOMIC GROWTH IN CHINA: IMPLICATIONS FOR THE WORLD ECONOMY

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# Rapid Economic Growth in China: Implications for the World Economy

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ABSTRACT

*Rapid growth of the Chinese economy in the past decade and its potential for strong growth into the foreseeable future have caused anxieties in the rest of the world. Some commentators see Chinese growth wholly in terms of competition for trade and investment opportunities with other developing economies and a major cause of structural adjustments in the advanced industrialized economies. In particular there have been warnings of severe consequences for international agricultural markets. In this paper we use a dynamic general equilibrium model called the G-CUBED model (developed by McKibbin and Wilcoxen) to explore possible future paths of the Chinese economy based on projections of population growth, sectoral productivity growth, energy efficiency and technical change in the Chinese economy. This model captures not only the composition of the direct trade impacts of developments in the Chinese economy but also the implications of the endogenous flows of financial capital on macroeconomic adjustment in the world economy. The study focuses on the period from 1990 to 2020. Rather than being a problem for the world economy, we find strong growth in China is beneficial for the world economy directly through raising world incomes.*

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## 1 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 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 (Summer 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 under-estimated 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 forthcoming).[1] This estimate of income level is consistent with 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 merchandised 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 the 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 labor-intensive manufactured exports. The share of labor-intensive manufactured goods in total exports rose from around 30 per cent in 1978 to 56 per cent in 1995.

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

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

The increasing outward-orientation of the rapidly growing Chinese economy has already made an important impact on the world economy, particularly its neighboring East Asian economies. The fact that China experienced an average growth rate of 13 per cent for its total trade, and that in most years of the past one and half decades China had trade deficits, suggests 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 labor-intensive plants to China from Taiwan, Hong Kong and Korea in the past years which also facilitated the 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 trading organization (WTO). The negotiations between China and the member countries of the GATT/WTO over China accession has been going on for about eight years and there is still not yet a clear sign of a successful conclusion of the negotiations in the very near future.

This raises the importance of careful assessments of the implications of China's rapid growth for the world economy. There is currently a debate in the literature about whether or not China would 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 for increasing 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. Garnaut and Huang (1995) argue, taking into account the under measurement of GDP discussed above, that the export/GDP ratio in China is still lower than those of the other East Asian economies and lower than large countries like the United States. Their assessment is that, within an effective, rule-based international trading system, and continued Chinese trade liberalization in the framework of the Uruguay Round settlement, China's foreign trade will continue to grow more rapidly than output.[2]

The international community is concerned about a number of issues related to the rapid growth in China, particularly given its size and institutional history. A number of issues arise for the world economy. 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 industrialized economies (Lardy 1994; Garnaut and Huang 1995)? As China's

[2] Garnaut and Huang (1995) admit that eventually the "Lau factor" will take the edge off the powerful momentum in trade growth.

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. Implications of low and high productivity growth in China for the rest of the world can be examined.

This paper is organized as follows. Section II reviews the existing studies on 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 section III focusing on the key features of the model that are important for the results of this paper. The alternative future scenarios, simulated using the G-CUBED model, are presented in Section IV, which is followed by conclusions in the final section. The approach taken in this paper is very much in the spirit of the single economy study by Ho et. al. (1995); in the current paper, however, 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 paper 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.

## II. Productivity Growth in the Chinese Economy

*a. 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 below. First, however, it is useful to set out some core assumptions of the approach taken in this paper.

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

(1) increases in the supply of labor, 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 modeling 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.

In order to clearly understand the way growth accounting is used in this paper 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, labor and materials:

$$Y_t = Q(A_t\ ,\ F_t\ K_t\ ,\ G_t\ L_t\ ,\ H_t\ E_t\ ,\ I_t\ M_t)$$

where: $Y_t$ is output at time t; $K_t$, $L_{t,}$ $E_t$ and $M_t$ are inputs of capital, labor, energy and materials; $A_t$ is a coefficient reflecting the overall (non-factor specific) level of productivity; and $F_t$, $G_t$,, $H_t$ , and $I_t$ 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 minimize costs taking prices as given, it is straightforward to show that the rate of output growth will be given by:

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

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, labor, energy and materials in total costs.

As an empirical matter, decomposing output growth into its constituent pieces 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 misstated.

Thus, in order to project the world economy over the next few decades we would need underlying projections of each country's labor 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. In practice it is difficult to get measures for each factor and in the results presented below we compress the changes in the quality of inputs into TFP or labor augmenting technical change. 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 section 3 we describe the key features of the G-CUBED model. In the next 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.

*b. 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 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 percent per year and after the reforms around 1979 GDP growth average around 8 percent per year depending on the period of the study. The contribution of capital to both pre-reform and post reform periods appears to be large. The contribution of labor, both in terms of labor force growth and improvements in labor 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 2. The results in Table 2 show that the experience at the sectoral level in China is very different to the average overall productivity experience. This stylization 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 as well. 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.

## III. 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 endogenizes 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 3. Each region is further decomposed into a household sector, a government sector, a financial sector, the twelve industries shown in Table 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 have not subscripted variables by country except where needed for clarity. The complete model, however, consists of eight of these submodels linked by international trade and asset flows.

**Producer Behavior**

Each producing sector is represented by a single firm which chooses it inputs and its level of investment in order to maximize 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), labor (L), energy (E) and materials (M). Omitting industry and country subscripts the production has the following form:

$$Q = A_O \left( \sum_{j=K,L,E,M} \delta_j^{1/\sigma_O} X_j^{(\sigma_O - 1)/\sigma_O} \right)^{\frac{\sigma_O}{(\sigma_O - 1)}}$$

where Q is the industry's output, $X_j$ is the quantity of input j, and $A_O$, $\delta_j$ and $\sigma_O$ are estimated parameters which vary across industries. In addition, the $A_O$ and $\delta$ parameters vary across countries. Without loss of generality we constrain the $\delta$'s to sum to one. We introduce technical change by specifying that $X_L$ , the effective input of labor in each industry, is equal to hours of work multiplied by a country- and industry-specific labor quality adjustment factor. This specification has the effect of making stationary the ratio of prices to wages per effective labor 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:

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

where $X_E$ is the industry's input of energy, $X_j$ is the quantity of input j, and $A_E$, $\delta_j$ and $\sigma_E$ are estimated parameters which vary across industries. As before, $A_E$ and the $\delta$ 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 data set 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 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 data set constructed by Dale Jorgenson and his colleagues to decompose the value added rows of the tables, and a data set produced by the Office of Employment Projections at the Bureau of Labor Statistics to provide product prices. We use this data to estimate the elasticities of substitution in production at different levels of the nest.

To parameterize 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 U.S. counterparts. The share parameters for the remaining regions, which are aggregates of individual countries, are calculated by adjusting U.S. 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 data set contains few observations. The problem is severe outside OECD countries.

Maximizing 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 parameterize 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 output, 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 maximize 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 formalize 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 behavior 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 labor and capital services as well as intermediate inputs. We represent its behavior 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 labor and capital services. Household capital services consist of the service flows of consumer durables plus residential housing. Households receive income by providing labor 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 behavior can be modeled 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 maximizes 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 labor 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-optimizing consumers and that the remainder is determined by after-tax current income. This can be interpreted as liquidity-constrained behavior or as permanent income behavior when household expectations are backward-looking. Either way we assume that total consumption is a weighted average of the forward looking consumption and backward-looking consumption.

Within each period the household allocates expenditure among goods and services in order to maximize 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 labor 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 a lot; 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 paper (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 summarized 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 equalized 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 direct foreign 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 modeling financial markets in the developing regions of the model. Finally, we assume that OPEC chooses its foreign lending in order to maintain a desired ratio of income to wealth subject to a fixed exchange rate with the U.S. dollar.

**Labor Markets**

We assume that labor is perfectly mobile among sectors within each region but is 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 labor demand relative to labor supply. In the long run labor 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 labor. For a given nominal wage, the demand for labor 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 financial markets in China we treat the financial prices as shadow prices that are used in making economic decisions.

## IV 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 labor augmenting technical change of 1% per year for 5 years beginning in 1990. We examine the impacts of this higher growth rate for China and the world economy.

***a. 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 summarize of key aspects of the procedure. The model used in the current paper differs from that earlier paper primarily because the data for China has 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 summarized in Table 5.

We also need to make assumptions about productivity growth and technical change. In this paper we assume that all technical change and productivity growth is labor augmenting technical change (i.e. 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 of this section all references to productivity growth and technical change are in terms of labor augmenting technical change (LATC). The assumptions about LATC are also given in Table 5. In this paper we assume each sector in each economy experiences the same rate of labor augmenting technical change (Harrod neutral) . This is likely to be an unsatisfactory representation of reality but is taken as a benchmark. In future papers 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 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 exactly replicate 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 on the marginal effects of a change in the assumptions about Chinese productivity growth to see how 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 2.This figures 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% from 1991 to 1999, 5.2% from 2000 to 2009 and 4.3% from 2010 to 2019.

***b. 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 percent 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 3 through 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 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 to 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 4 where we present the deviation from baseline of the Chinese trade and current account balances as a percent 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 the 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 5 show the impact on GDP in the rest of the world. The United States and LDCs 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 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 that 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 in China 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 reallocated from 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 5 years yet the adjustment is still under way by 2020.

In figure 7 we show the changes in current accounts, as a percent 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' capital account by the largest amount when scaled to GDP but not in absolute dollars.

## V. Conclusion

This paper 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. These preliminary results are based on the assumption of uniform productivity growth changes across each sector in the Chinese economy. Yet we know from the results in Bagnoli, McKibbin and Wilcoxen (1996) that differential sectoral productivity growth is very important for the aggregate outcomes. In particular it is likely to change the composition of the trade adjustment although not so much the overall adjustment of trade and current account balances that are driven by aggregate changes in investment and saving decisions.

In future research we will explore further the impact of different sectoral productivity growth rates in China. Nonetheless, the aggregate results in this paper illustrate that the impact of changes in Chinese economic growth impact on the world economy. One effect is through the increase in growth on the demand for foreign goods which leads to changes in trade flows. Another important channel is through the reallocation of financial capital, and ultimately physical capital, in the global economy. This latter effect is shown to be very important and have long term consequences for trends in the world economy. Overall stronger growth in China is likely to raise world incomes although tensions could arise from significant changes in the location of production.

table 1 here

table 2 here

## Table 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

***Table 4: Summary of Main Features of G-CUBED***

- specification of the demand and supply sides of industrial and developing economies;
- integration of real and financial markets of these economies;
- intertemporal accounting of stocks and flows of real resources and financial assets;
- imposition of intertemporal budget constraints so that agents and countries cannot forever borrow or lend without undertaking the required resource transfers necessary to service outstanding liabilities;
- short run behavior is a weighted average of neoclassical optimizing behavior and ad-hoc "liquidity constrained" behavior;
- the real side of the model is disaggregated to allow for production and trade of multiple goods and services within and across economies;
- sector specific dynamics with cost of adjustment in moving physical capital between sectors;
- full short run and long run macroeconomic closure with macro and sectoral dynamics at an annual frequency around a long run Solow/Swan/Ramsey neoclassical growth model.
- the model is solved for a full rational expectations equilibrium at an annual frequency from 1990 to 2100.

Table 5: Baseline Assumptions

| | 1990-99 | 2000-09 | 2010-19 |
|---|---|---|---|
| *Population Growth (% per year)* | | | |
| USA | 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)* | | | |
| USA | 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* | | | |
| USA | 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 |

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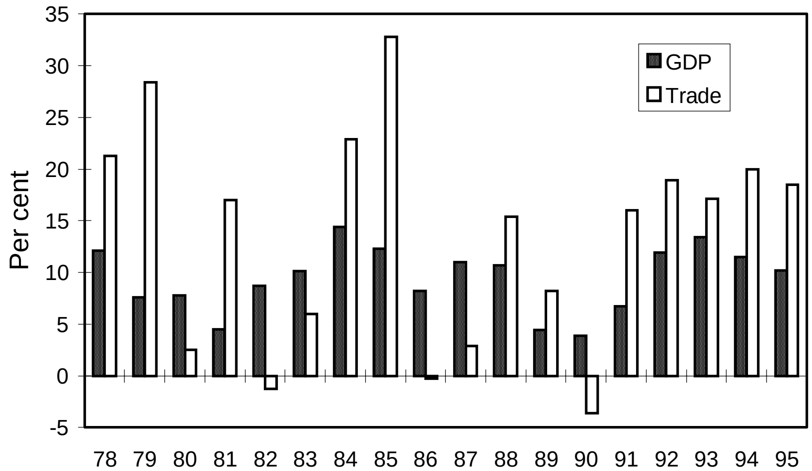
**Figure 1 Growth rate of GDP and trade in China, 1978-95 (per cent)**




**Sources**: China State Statistical Bureau (1995, 1996).

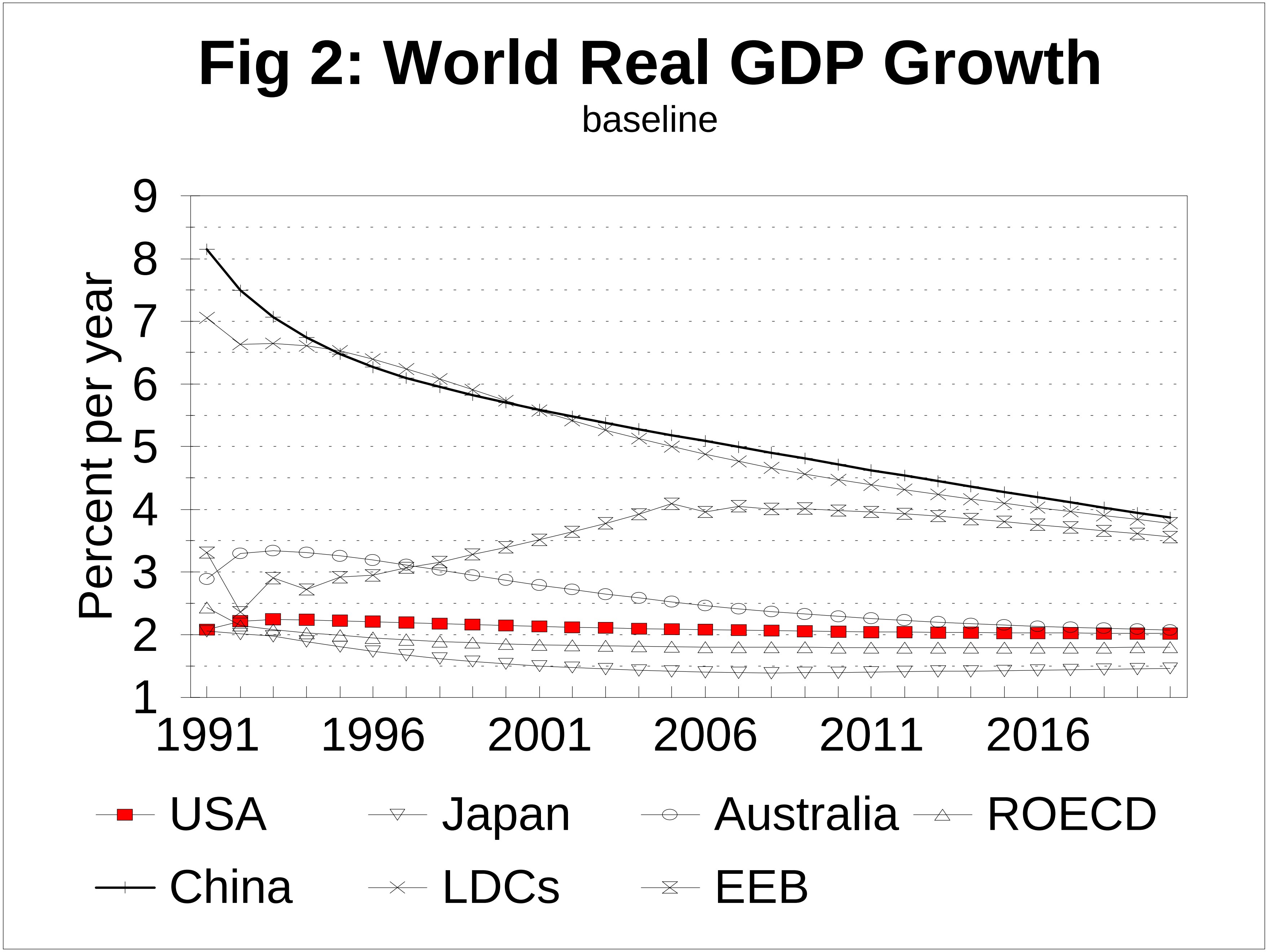


Fig 2: World Real GDP Growth
baseline
Percent per year
9
8
7
6
5
4
3
2
1
1991
1996
2001
2006
2011
2016
USA
Japan
Australia
ROECD
China
LDCs
EEB

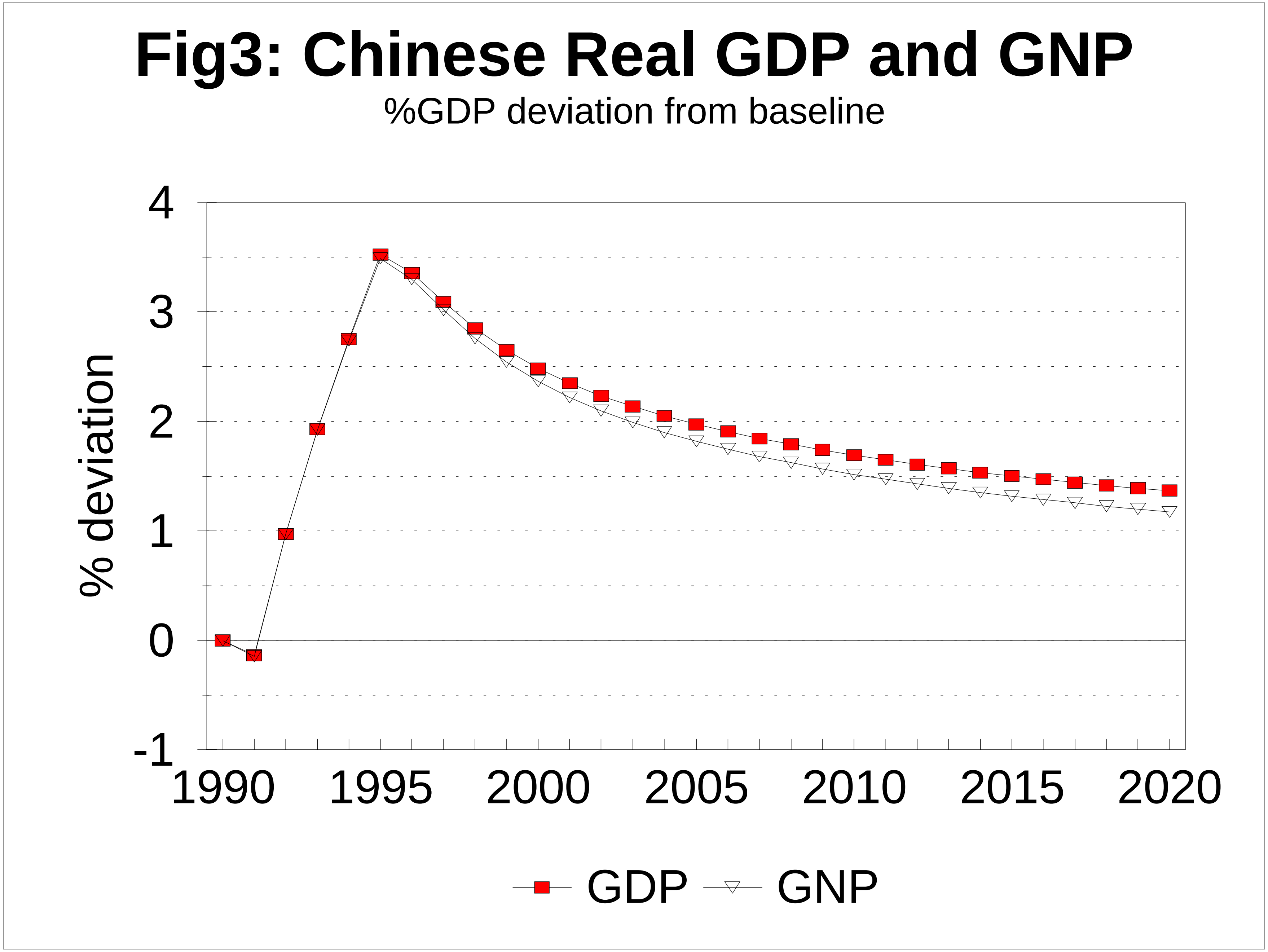


Fig3: Chinese Real GDP and GNP
%GDP deviation from baseline
% deviation
4
3
2
1
0
-1
1990
1995
2000
2005
2010
2015
2020
GDP
GNP

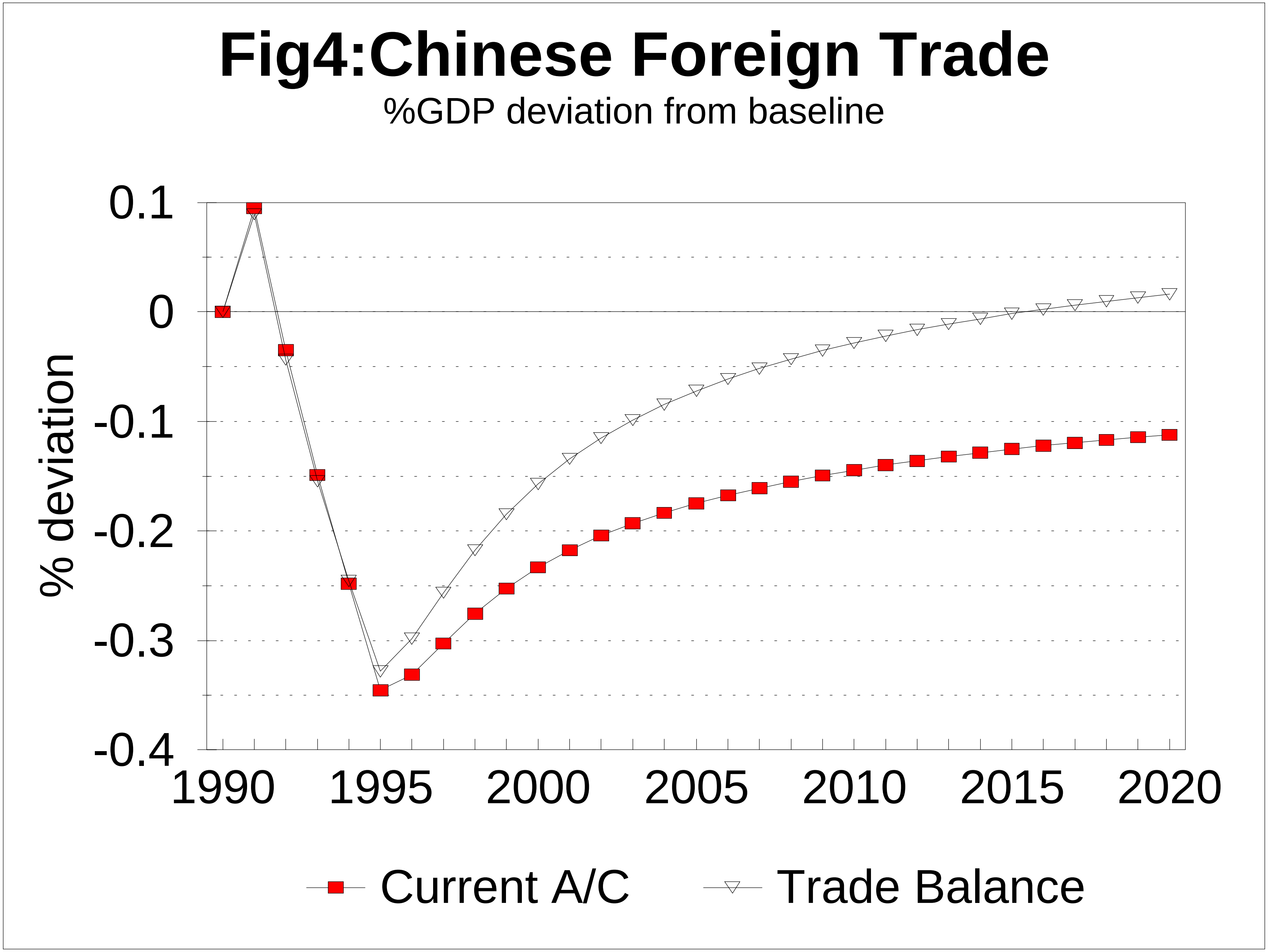


Fig4:Chinese Foreign Trade
%GDP deviation from baseline
% deviation
0.1
0
-0.1
-0.2
-0.3
-0.4
1990
1995
2000
2005
2010
2015
2020
Current A/C
Trade Balance

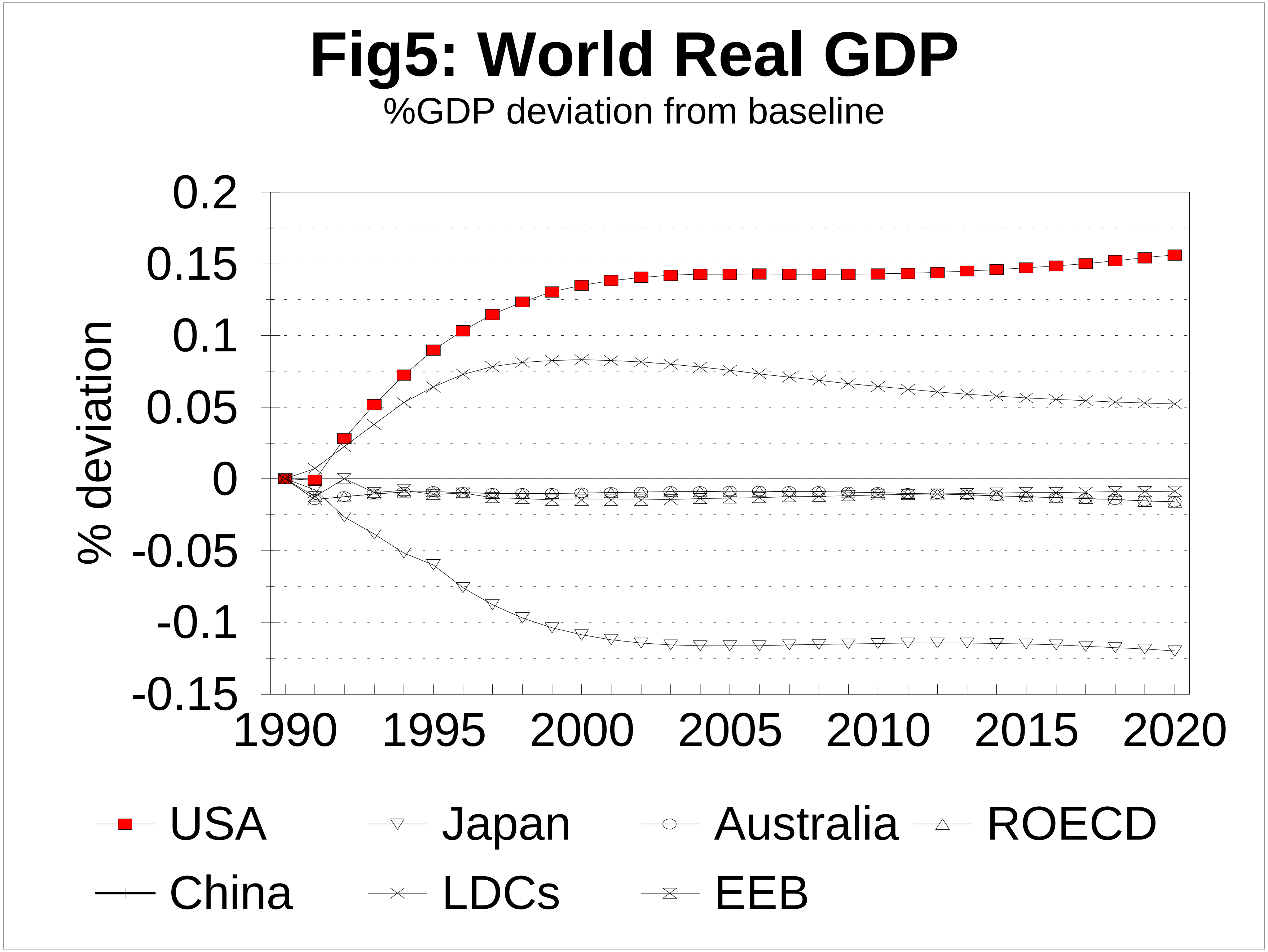


Fig5: World Real GDP
%GDP deviation from baseline
% deviation
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
1990
1995
2000
2005
2010
2015
2020
USA
Japan
Australia
ROECD
China
LDCs
EEB

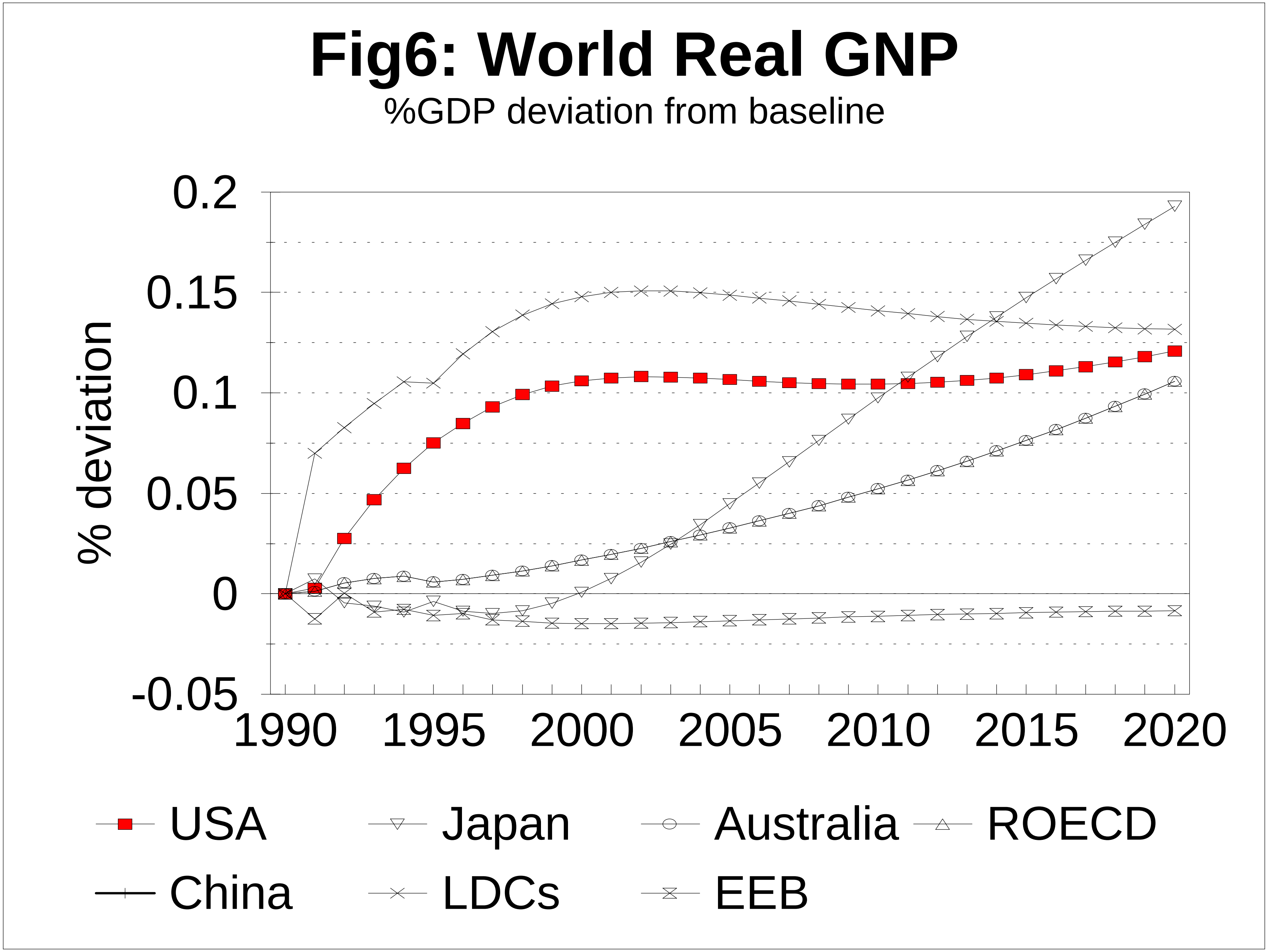


Fig6: World Real GNP
%GDP deviation from baseline
% deviation
0.2
0.15
0.1
0.05
0
-0.05
1990
1995
2000
2005
2010
2015
2020
USA
Japan
Australia
ROECD
China
LDCs
EEB

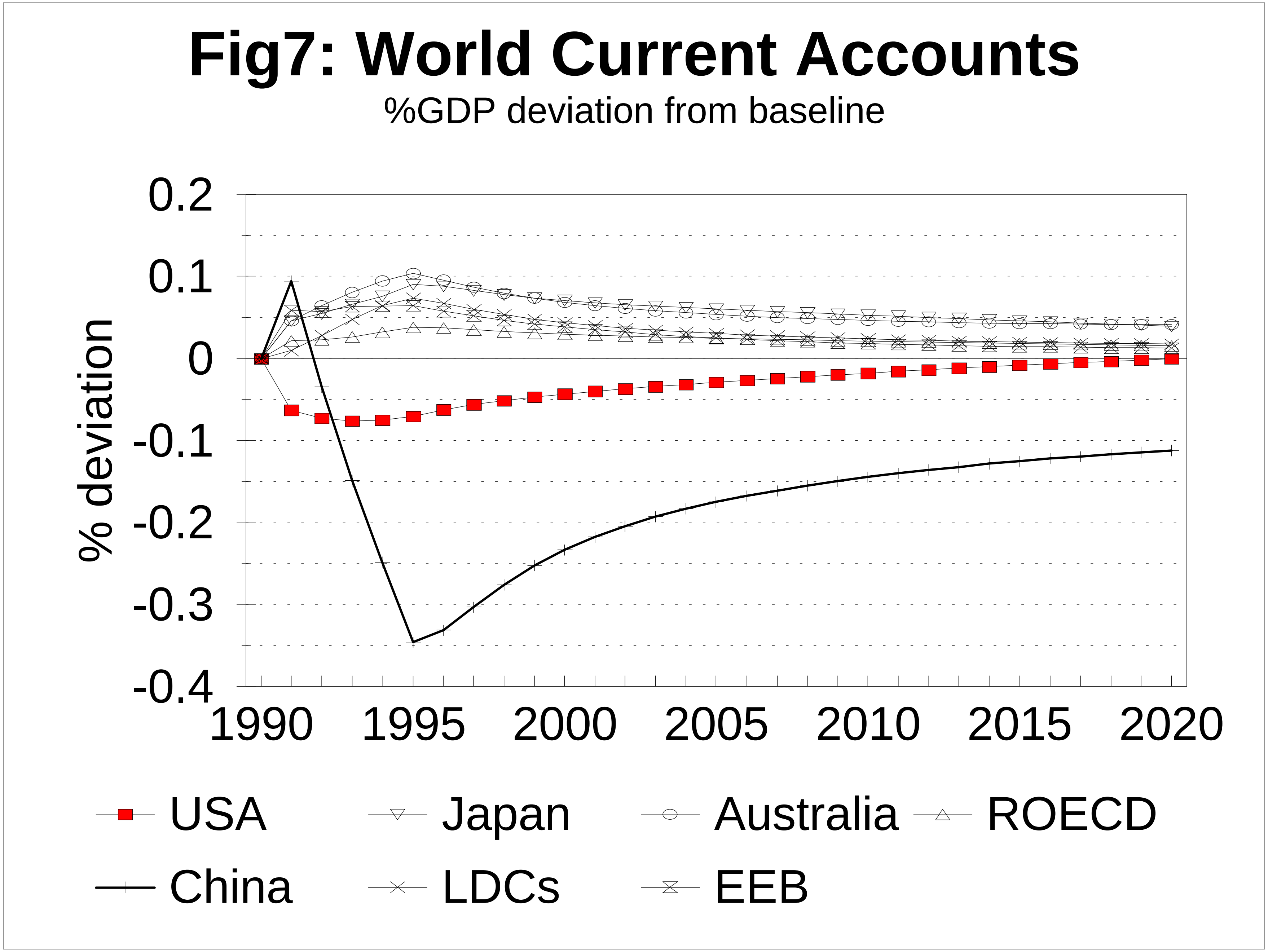


Fig7: World Current Accounts
%GDP deviation from baseline
% deviation
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
1990
1995
2000
2005
2010
2015
2020
USA
Japan
Australia
ROECD
China
LDCs
EEB