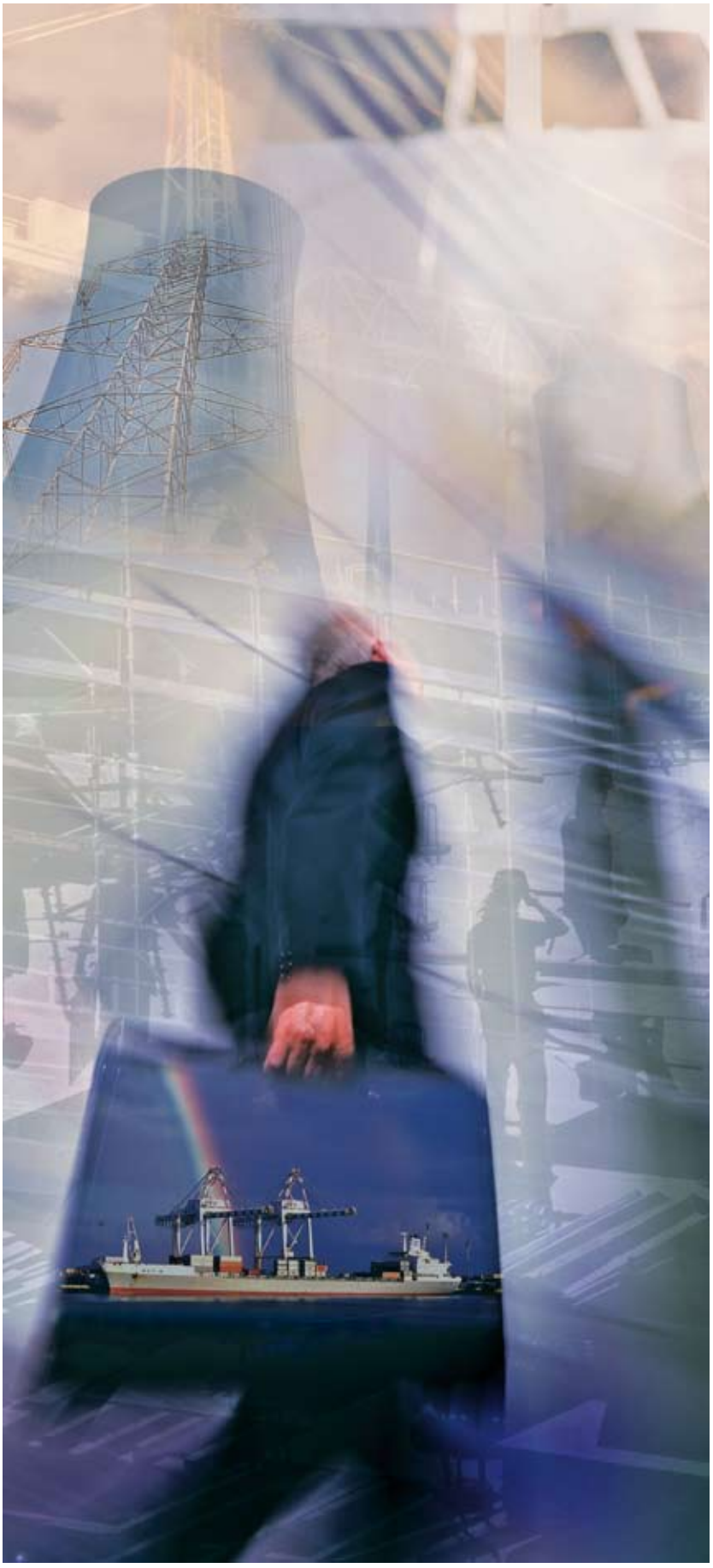

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The Economic Society of Australia warmly welcomes you to the Gold Coast, Queensland, Australia for the 37th Australian Conference of Economists.

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Education Reforms in China: The Implications of Rapid Skill Accumulation

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Abstract

The proportion of skilled labour relative to the population in China is only a fraction of that of the developed countries despite the rapid expansion of skilled workers in recent years. This paper considers the economy wide implications of policy changes to accelerate the supply of skilled labour in China through education and labour market reforms. The analysis uses a dynamic, multi-sector general equilibrium model with endogenous human capital accumulation. We find that the growth in the supply of skilled labour has a large effect on capital accumulation and wages as well as generating increasing skill premiums in the short term. The economy experiences strong growth in the outputs and exports of the more skill intensive sectors such as durables and traded services.

Keywords: Human Capital, Economic Growth, Education, China, Computable General Equilibrium Models

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*Corresponding author: Jessica Xu, School of Economics, UNSW, Sydney 2052. Email: jessicax@student.unsw.edu.au. This paper is based on part of an ongoing PhD thesis, thus the results are preliminary.

1. Introduction

In the "Tenth Five-Year Plan", covering the period 2001 to 2005, the Chinese government set a target of 16 million students to be enrolled in tertiary institutions. In 2004, that goal was surpassed with 18.9[1] million students. Yet despite these large and rapidly growing enrolments, the proportion of skilled labour in China, workers with higher education degrees, is low by the standard of the developed economies. The acceleration in student enrolments in recent years has not yet had a large impact on the stock of skilled workers. Consequently, China is undergoing a rapid transition in terms of the skill composition of its labour force.

The growth of skilled labour in China reflects several different circumstances. First, the legacy of the Cultural Revolution meant that by 1990 the proportion of skilled labour in China was well below other countries with similar income levels. Much of the increase in student numbers is due to the removal of barriers to tertiary education. The resulting flow of graduates will continue to raise the human capital stock in China for some decades.

A second factor has been the reforms in the education sector with the establishment of private "minban" institutions and introduction of tuition fees. The expansion of student enrolments has been encouraged by modest increase in government expenditure to public education. However, the increase in enrolments has been mostly financed by private spending, made possible by the removal of state monopolies.

Finally, but perhaps most importantly, has been the reforms in the labour market which have led to a significant increase in the returns to education. As documented by Heckman and Li (2001), wage fixing and labour market regulations suppressed the private returns to education. Notwithstanding the labour market reforms, there is considerable evidence that private returns constitute only a fraction of the marginal product of skilled labour and hence will increase further and create incentives for demand of higher education.

The aim of this paper is to explore the implications of these policy measures and to examine the inevitable rise in the skill composition of China's labour force. To do this, a multi-sector, multi-region dynamic computable general equilibrium (CGE) model of China and East Asia is used. In particular, the model emphasises the links between factor accumulation, international trade flows and wage inequality.

We find the growth in the supply of skilled labour will significantly improve the welfare of the economy, rising both the real GDP and consumption substantially. Wage inequality between skilled and unskilled workers initially widens, generating a short term increase in inequality but this disappears in the long term. Accompanying the expansion of human capital stock is a large increase in the accumulation of physical capital. The economy experiences strong growth in the outputs and exports of skill intensive sectors of durables and traded services.

[1] This number includes students from regular higher education institutions, adult higher education institutions and private institutions.

This paper is organised as follows. Section 2 presents a brief literature review on human capital. Section 3 provides an overview of China's higher education situation and reforms to expand its enrolments in higher education level. Section 4 describes the structure and the data calibration for the CGE model. Section 5 discusses the policy simulations and results. Section 6 concludes.

2. Literature Review

The research of Becker (1964) reveals that human capital was vital in lifting worker productivity. Schultz (1961) finds that in both developing and developed countries, a better educated workforce increased agricultural productivity. As a consequence, there was growing perception that investing in education and increasing the supply of skilled labour was fundamental to the productivity of countries. It was not until the 1990s that human capital was formally and fully incorporated into the theory of economic growth. Up to that point, the focus was on the direct contribution of educated workers to the productivity of agriculture, manufacturing and services, as workers in those sectors.

An extensive literature exists on the contribution of human capital to economic growth (Barro, 1991; Sala-i-Martin, 1997; Mankiw et al., 1992; Krueger and Lindahl, 2001). Barro (1991), Sala-i-Martin (1997) and Benhabib and Spiegel (1994) show a positive correlation between schooling and the growth rate of per capita GDP across countries. Bils and Klenow (2000) use a model with finite-lived individuals in which human capital can grow with rising educational attainment to quantify the strength of the impact of schooling on growth. While more reserved in their attribution of a casual relationship from education to economic, they also report a modest effect of schooling on economic growth over the period 1960 to 1990.

However, the contribution of human capital on the growth experience of developing countries has produced diverse results. The countries in the former Soviet Union, for example, have among the highest levels of schooling in the world but their economic growth has stagnated for decades (Pritchett, 2001). In contrast, investment in education was a major contributor of economic growth for the East Asian economies of Hong Kong, Singapore, Taiwan and South Korea during their development process (Mankiw et al., 1992; Krueger and Lindahl, 2001).

A possible explanation for the variations observed between the developing countries is the role of quality and quantity of education. Recent work indicates that the effectiveness of investment in human capital on economic development depends on the quality and length of education. Hanushek and Kimko (2000) in a cross-country econometric study find that the quality of schooling, as measured by scientific and mathematic test scores have a large and strong positive influence on the economic growth rates. Barro and Sala- i-Martin (1999) carry out an empirical analysis of cross country differences in growth. The results show that there was a substantial effect of schooling on growth and the proportion of population with secondary and higher education is most significantly correlated with growth. A similar view has been expressed in WEIP (2002) which note that secondary and tertiary education is critical for economic growth to translate into

steady growth. Fogel (2006) states that the labour productivity of a worker with college education is 3.1 times more productive than that of a worker with primary education while a worker with secondary education is 1.8 times more productive.

Economies that can offer employment to skilled workers[2], that is where demand for skilled labour is increasing will benefit from higher investment in human capital. For countries that have sluggish demand for educated labour, investment in education can fail. Furthermore, countries with dynamic and diverse production structures will have less difficulty in absorbing skilled workers. While East Asian economies have been successful in utilising their higher education graduates, other countries that have enlarged their tertiary education system such as Jordan, Philippines and Egypt have proved to be less successful.

In China, there is ample evidence to suggest that education, specifically higher education, has been a force in its economic development. Fleisher and Chen (1997) determine the total factor productivity (TFP) across 25 provinces during 1978 to 1993 and find that TFP are positively and significantly related to the share of higher educated workers in the population. The relationship is robust to the level and first difference specifications of the time series regression.

Demurger (2001) uses a panel of 24 provinces over the period 1984 to 1998 to show a positive and robust relationship between the proportion of population with a secondary or tertiary education and per capita growth. Chen and Feng (2000) estimate a cross sectional growth equation for 29 provinces in China covering the period 1981 to 1989. They report that the university enrolment rate has a statistically significant and substantial impact on provincial economic growth rates. Fogel (2006) expect that lifting the tertiary enrolment ratio to 50 percent in the next 20 years would add 6.7 percent to the overall growth rate in China.

While not directly estimating the effect of education, Wang and Yao (2003) use growth accounting methods to introduce education into the aggregate production function for China. Wang and Yao (2003) conclude that investment in human capital contributes to around 11 percent to overall per capita economic growth between 1978 and 1999[3]. In the growth accounting context, education is treated as a factor of production than as contributing to TFP (Krueger and Lindahl, 2001).

There have been very limited CGE models that analyse the economy wide implications of the accumulation of human capital for China, with Peng (2005) being an exception. Peng (2005) employ a modified version of PRCGE[4], an applied general equilibrium model of China to examine the macroeconomic impact of augmentation of human capital for a given ageing population profile. In the study, human capital is defined as the average

[2] The positive effects of investment on human capital are conditional on the assumption that employment in productive sectors can be gained for students after the completion of their education.
[3] Their estimates are robust to alternative assumptions on physical capital depreciation rates and factor shares.
[4] See Zheng and Fan (1999) for details of the original PRCGEM.

years of schooling of the population aged between 15 and 64. Peng (2005) evaluates the effects of the growth of human capital stock by means of increased public expenditure on education. The simulations indicate that rising education spending to increase the human capital formation in China raises both the total output and per capita real income dramatically.

3. Overview of Higher Education in China

China's higher education system is governed and regulated by the Ministry of Education (MoE), which is a central government agency under the control of the State Council. The Ministry is responsible for setting specific educational policies and regulations, planning national educational development, coordinating the numerous government agencies pertaining to education and guiding the systematic reform of education. Although policies related to higher education institutions are mostly stipulated by MoE, the State Council and the local governments are also involved in the governing and administering of tertiary education.

There are two types of higher education institutions in China, regular public institutions and other institutions. The regular institutions of higher education are educational establishments that enrol graduates straight from senior secondary schools and offer higher education training and programs. In 2004, there were 1731 regular institutions of higher education. The other institutions include both adult public higher education institutions and private institutions. The institutions of higher education for adults refer to the establishments that usually enrol students who are in the labour force and provide higher education courses in several forms whether full time, part time or distance learning (Zhang, 2006). Students trained in these institutions receive a qualification equivalent to students studying at the regular higher institutions. Privately-run tertiary institutions are a new phenomenon and growing sector, established to support higher education development in China.

There is evidence of under investment in human capital in China, especially in the higher education end (Fleisher and Wang, 2004; Heckman, 2005). Total spending on higher education from both public and private sources has risen in China but the public expenditure as a percentage of GDP remains below many of the other countries. The economic performance of China can be enhanced by the accumulation of its tertiary educated labour force. While skilled workers are highly productive, they do not appear to benefit proportionately from their acquired skills in China (Fleisher and Wang, 2004).

3.1 Enrolments of Students and Skilled Labour

China has the highest number of students enrolled in higher education institutions in the world. Despite the huge enrolment in absolute numbers, once one account for population, China's higher education population is comparatively small relative to its population. Table 1 presents the tertiary gross enrolment rates[5] for several countries in 2004. China

[5] For tertiary education, the gross enrolment rate is defined as the ratio of the total enrolment in higher education to the population aged 18 to 24.

had a tertiary gross enrolment rate of 19.1 percent, which is below the world average of 24.8 percent. The enrolment rate was also considerably lower than most of its Asian neighbours and even lower than that of countries with a lower income per capita[6] such as Jordan (39.3 percent), Egypt (32.6 percent) and Armenia (26.2 percent).

Given the disastrously low enrolments prevailing in the 1970s and 1980s, it is not surprising that even now China has a below average enrolment ratio. Even in the early 1990s, tertiary education enrolment ratios in China were about the same as those in the very low income countries of Cameroon and Pakistan, all of which had about 3 percent tertiary enrolment ratio. The low higher education activity of China in the 1970s and 1980s reflects the low income in the country at that time and the legacy of the Cultural Revolution. The revolution targeted intellectuals and had a devastating effect on higher education. The heads of universities and those in educational management were eliminated from their positions. During the Cultural Revolution, from 1966 to 1976, higher education in China was essentially stopped (Chow, 2002). Regular enrolments in tertiary institutions with the re-introduction of the national university entrance examination did not resume until 1978 (Zhang, 2006).

The enrolment data in tertiary education[7] are shown in table 2. The students in higher education institutions rose from 2.3 million in 1978 to 3.7 million in 1990 and to 5.5 million in 1995 and then to 17.5 million in 2004. The extraordinary increase in enrolments since the early 1990s constitutes not only a great leap in numbers but also in relation to China's population. The tertiary gross enrolment ratio in China was merely 1 percent in 1985 but it increased to 3 percent in 1991 and further soared to 19 percent in 2004. Although China still has a lower tertiary education enrolment ratio in comparison to other countries, China has been making remarkable progress in catching up.

Wang and Yao (2003) and Islam et al. (2004) construct the annual distribution data of educational attainment by levels of schooling in the total population for China following the perpetual inventory method introduced by Barro and Lee (2000). The perpetual inventory method uses the enrolment rates to derive the number of people belonging to the different educational attainment categories. Both studies take India's education attainment distribution in 1960 from Barro and Lee (1997, 2000) for the initial human capital stock for China in 1951. However, Wang and Yao (2003) differ from Islam et al. (2004) by classifying people with incomplete primary education together with people with no schooling and assume that specialised secondary require two years to complete instead of three years. Islam et al. (2004) find that the number of people whose highest educational attainment is tertiary education increased fivefold between 1978 and 2002.

Figure 1 shows the ratio of students enrolled in higher education to the labour force and the ratio of workers with higher education qualification to the labour force. The ratio of

[6] Measured in terms of GNI per capita, purchasing power parity from the World Development Indicators Database.

[7] The enrolments refer to students in regular higher education institutions and adult higher education institutions.

students in higher education to the labour force rose from 0.6 percent in 1990 to 2.3 percent in 2004 while the ratio for skilled labour to the labour force rose from 0.9 percent in 1990 to 1.5 percent in 2004. However, by the standards of the developed countries, the percentage of college educated workers in China remains low given that the percentage of college educated workers in numerous industrial economies is in excess of 30 percent (Heckman, 2005).

3.2 Expenditures on Education

In 2004, the total spending on education in China was over RMB724 billion, which represents an increase of about 10 times of that in 1991. The spending on education as a percentage of GDP and public spending on education as a percentage of GDP are shown in figure 2. China's aggregate education expenditure as a percentage of GDP grew from 3.4 percent in 1991 to 5.3 percent in 2004. The government's expenditure on education has increased steadily, at annual rates that have progressively risen over time. In the past few years, government spending increased at a rate that either exceeds or is similar to that of GDP. As a percentage of GDP, the government expenditure on education rose slightly from 2.9 percent in 1991 to 3.3 percent in 2004. Due to the historical under investment of education by the government in China, the share of government expenditure to GDP is below that of many countries (Heckman, 2005; Zhang, 2006).

In the higher education sector, spending has risen significantly with substantial funding being provided to the sector since the early 1990s. China's overall spending on tertiary education was 0.5 percent of GDP in 1990. An OECD study[8] (2002) state that the expenditure on higher education in 1999 for China was 0.8 percent of GDP; this is lower than the average for the sample of developing countries in the study of 1.2 percent and the OECD countries of 1.3 percent. The additional resources devoted to higher education have lead to spending on tertiary education to rise to 1.6 percent of GDP in 2004. However, the public expenditure on tertiary education as a percentage of GDP was only 0.7 percent in 2004, which is lower than the selected sample of developing countries of 0.9 percent, and the OECD average of 1.0 percent in the OECD study (2002) for 1999.

3.3 Reforms in the Higher Education

There have been a series of reforms in the higher education system that has accompanied China's economic transition and the opening up of the economy to the outside. In particular, reforms in the higher education sector have been accelerated since the mid 1990s, to boost the number of students enrolled in higher education. The government have expanded the enrolment of students in tertiary institutions to provide greater access to higher education, where traditionally the opportunity for higher education was restricted to a tiny minority of elite students. The shift from elite to mass education is a reflection of the government's desire to ensure that there is sufficient level of skilled labour to maintain its strong economic growth and to transform China to an innovation oriented economy.

[8] Detailed comparative education expenditure data on numerous countries was compiled by OECD for the year 1999 (OECD, 2002).

According to MoE, the average number of students in regular institutions of higher education jumped from 2074 in 1992 to 7704 in 2004. To supplement the expansion in public higher education, the government has permitted social organisations and private citizens to operate and finance private higher education institutions, known as "minban" institutions. These private institutions of higher education were made possible and legally established by a succession of legislations in the 1990s. A new law adopted in 2002 gave private institutions the same legal status as public institutions and guarantees their autonomy. In 2004, private institutions numbered 226 and enrolled 1.4 million students (Zhang, 2006). The private institutions are expected to account for a larger share of higher education enrolments in the near future and play an increasingly important part in China's higher education (Min, 2005).

The tertiary education expenditures in China have risen strongly due to increases in both public and private sources of funding. The higher education institutions have benefited from rising public sector support with the increase in appropriation to education at all levels of the government. The sustained income growth in China has stimulated demand for higher education and has allowed for the increased non-governmental expenditures with tuition fees becoming a critical source of funding. The growth in tuition fees have contributed to the growth of private sector funding of higher education.

Until 1990, universities did not charge students tuition (Zhang, 2006). After 1990, reforms in the financing of higher education were implemented and universities were able to charge tuition and fees and these have gradually increased such that currently all students must pay tuition and fees. Student loan and scholarship programs were launched by the government at the same time to support students from low income families (Zhang, 2006). The tuition and fees are a way to raise resources for tertiary education without imposing additional fiscal pressure on the government. At present, more than one fifth of the operational budgets of the higher education institutions are covered by tuition and fees (Min, 2005).

The growing reliance on tuition and fees for financing on the part of higher education institutions means that the responsibility for obtaining a higher education degree is being transferred from the government to the students and their parents. The amount of tuition fees that a regular higher education institution can charge is proposed by the institution but ultimately determined by the MoE after taking various factors into consideration. The tuition and fees poses a heavy financial burden for many households wanting to send their children to higher education. The gap of ability to pay among different income groups is becoming larger and larger with the increase in tuitions (Min, 2001).

The reforms in the labour market have complemented the liberalisation policy in higher education to lift the enrolments of students in tertiary education. Historically, the wage policy in China forced a low rate of return to skilled labour and there are still distortions on the wage setting in the labour markets (Heckman, 2005). From the initiation of economic reform in 1978 to the early 1990s, wages differences by level of schooling were very narrow. Fleisher and Wang (2004) analyse the productivity of education in the workforce in producing the output based on a panel survey of 200 large rural enterprises.

They measured the production based return to education rather than the compensation based measure that is widely employed. The econometric results of Fleisher and Wang (2004) suggest that the true return to education was as high as 30 percent or 40 percent in the 1988. The wages paid to skilled workers[9] were just a bit over 10 percent of their marginal product. Unskilled workers' wages are much closer to their marginal productivity. The labour market in China did not pay wages that reflect the true contribution of the educated workers. The private rate of return to education in the early 1990s was 4 percent, far below the true rate of return (Chow, 2002).

Similar to Fleisher and Wang (2004), Fleisher et al. (2006) examine the role of education on worker productivity in China using firm level panel data between 1998 and 2000. They estimate the marginal product for highly educated and less educated workers and find that marginal products are much higher than wages, and the gap is larger for highly educated workers. Highly educated workers are defined as those employees who typically have a bachelor degree or above. Also, Fleisher et al. (2006) find that an additional year of schooling raises marginal product by between 18.3 percent and 24.5 percent.

China's low rate of return for skilled workers has adversely affected individual's incentive to invest in education and thus reduced individuals demand for higher education. Since skilled workers do not directly capture all the gains produced from their education, the motivation for unskilled workers to acquire further education was weak. Prior to the mid 1990s, university graduates were assigned jobs upon graduation by the government, who determine the nature of the work and wages to be paid (Min, 2005). With the gradual transition of China from a centrally planned to a market economy, the occupational prospects and the wage structure of the graduates and skilled workers are increasingly shaped by the labour market.

The average return to education in China has increased markedly since the early 1990s and skilled workers are now being reward more adequately than they have been in the past. Chen et al. (2004) estimate that the return to tertiary education had reached 8.23 percent in 1996. The higher return to tertiary education was supported by Heckman and Li (2004). Heckman and Li (2004) use Chinese micro data to identify the return to college education and find that the rate of return[10] has risen to 11 percent in 2000. However, the rise in returns to schooling in both studies demonstrate and support the notion that the labour markets are freeing up and paying wages that are commensurate with the skills involved, which will encourage more people to enrol in higher education and become skilled.

[9] Fleisher and Wang (2004) use two classes of workers: production workers and technical, administrative and staff (TAS) workers in the context of a production function to estimate the marginal product of these two types of workers. TAS workers have been more years of schooling and are considered to be skilled labour.

[10] Heckman and Li (2004) allows for heterogeneity of students.

4. The Model

4.1 Structure of the Model

The CGE model used in this paper is a multi-sector, multi-region dynamic model developed by Harris and Robertson (2007), and adapted to incorporate features of the Chinese economy. The model focuses on the real side of the economy with substantial details on sectoral output, trade flows and factor accumulation; in particular the model contains endogenous human capital accumulation. It can be regarded as a Walrasian CGE in a dynamic open economy in which interactions among agents are governed by movement in prices.

The world economy comprises of three regions: East Asia, which contains Japan and the four Asian Newly Industrialised Economies (NIEs) of Hong Kong, Singapore, South Korea and Taiwan, China and the Rest of the World (ROW). The East Asian economies and China are modelled as small open economies facing exogenous world prices with six traded and five non-traded commodities and industries. It is customary to make the small country assumption in general equilibrium studies. Even when studying the United States, the largest economy in the world, de Melo and Tarr (1992) have made the small country assumption for most sectors. The ROW supplies and purchases the traded commodities. Within each region, commodities are homogenous in use irrespective of their origins but on the production side the commodities are distinguished by market destination. The model resembles the traditional Heckscher-Ohlin model with homogenous goods as opposed to the common Armington assumption of differentiated good by import source.

The economic agents operating in each region are the firms, the households and the government. The demand for the commodities comprises of both intermediate and final demand. The final demand specifies the demand for goods and services by different final expenditure components i.e. household consumption, investment in physical capital, government purchases and spending by households on education. The commodities are produced by competitive firms using intermediate inputs and seven factors of production. The education sector is an exception which demands but do not supply any intermediate services.

Households maximise utility subject to the budget constraint and expectations. They are assumed to have long run target values of consumption and net foreign assets. The optimal consumption path follows the households minimising a loss function of deviation of consumption and net foreign assets from these targeted values. Government spending follows a simple policy rule that set the total spending as a ratio of GDP. The sources of government revenue are the consumption taxes, the tariffs and export taxes imposed on the traded commodities and the factor taxes. The government achieves a balanced budget at each point in time by redistributing any surplus back to the households in the form of a lump sum transfer.

The gross outputs of the firms are classified into eleven traded and non-traded goods. The five non-traded goods are produced for the domestic market only. For the six traded

goods, the output is the aggregation of the three destination specific goods, one for the home market and the other two for the foreign markets. Firms maximise revenue by producing the optimal mix of destination specific goods. The revenue functions are assumed to be constant elasticity of transformation (CET) functions of the prices in each market.

The seven factors of production are the three reproducible physical capital goods of machinery and equipment, structures, and residential housing, skilled labour, unskilled labour, land and natural resources. The firms' value added technologies are specified as nested constant elasticity of substitution (CES) unit cost functions allowing for capital-skill complementarity. Physical capital and labour are mobile across sectors but immobile across regions. Labour is distinguished between skilled and unskilled labour depending on the educational level of the workers. A skilled worker possesses a tertiary degree or comparable post-secondary qualification. To account for the differences in labour productivity between the East Asian economies and China, labour is measured in terms of efficiency units.

The education sector transforms unskilled workers into skilled workers. The relative supply of skilled and unskilled labour is endogenous to the model and is based on households' decision to invest in education with respect to the cost of the education and the forward looking view on the return to becoming skilled. There are costs involved in making the skilled labour useful once available; these costs can be viewed as job matching and on-the-job training costs. Households choose the optimal current and planned future level of schooling subject to the labour learning and training costs, the retirement rate of the working population and the price of education, to maximise the present values of their total labour income. Therefore, the costs of acquiring skilled labour include foregone unskilled labour and costs of purchasing education services.

Households own the physical capital and derive the demand for investment on these assets to maximise the present value of the capital rental steams. The accumulation pattern of physical capital is influenced by the endogenously determined prices of capital, the depreciation rate and the capital adjustment costs. The adjustment costs are the units of capital used in the installation and utilisation of the capital. The two remaining factors, land and natural resources are solved exogenously.

The structure of the model is summarised in table 3. The equilibrium in the model is a sequence of static competitive equilibria which satisfy perfect foresight. The dynamic path of the economy is a time path of asset prices consistent with the first order conditions for the households' investment decisions and in the limit reaches the steady state solution.

4.2 Data and Calibration

In assembling the benchmark data, the main data source is the GTAP database version 5 which contains 57 sectors, 78 regions and 5 factors. A considerable amount of additional data was supplemented from other sources. The GTAP data set was re-aggregated in such

a way to be consistent with the regional and sectoral classifications used in this study. The model was calibrated to the year 1995 as the benchmark and the initial steady state condition.

The original commodity sectors in the GTAP database are aggregated into 10 sectors with 6 homogenous traded commodities and 4 homogenous non-traded commodities. The traded service sector is treated differently from the other traded sectors as it consists of both domestically supplied and imported business and recreation services and the proportion of the public, trade, transport and utility services which is tradeable. For the education sector, the data on the intermediate input purchase and the value added shares for the sector was obtained separately from the Japanese and Chinese Input-Output (I-O) tables. The data on education for Japan is used to represent the values for the East Asian region.

The GTAP data was scaled using the Penn World Tables (PWT) version 6.2 such that the income in each region is expressed in terms of purchasing power parity. The national aggregate expenditure shares are derived from PWT augmented with each country's respective statistical yearbook for China and Japan but for the rest of the East Asian economies, the data was gathered from the Asian Development Bank Key Indicators. The data on capital from GTAP is disaggregated into 3 capital stocks of machinery and equipment, structures and residential housing. The value added flows for the sectors are reconciled with the investment spending for the physical capital[11]. The trade flows data was adjusted to ensure a hypothetical equilibrium steady state with balanced trade.

The private and public expenditure data on higher education were used to infer the aggregate education expenditure. Total spending on higher education is 1.4 percent of GDP for East Asia and 0.6 percent of GDP for China in 1995. The bulk of the spending in the education sector for the East Asian economies is on the wage incomes of skilled and unskilled labour while in China it is spent mostly on intermediate commodities.

To determine the gross output of the education sector, the steady state ratios of students to working population and students to skilled labour are needed. Given that the concept of skilled labour is a worker with a university or comparable post-secondary education, the ratio of students to working population is taken to be 5 percent for East Asia; this is based on the data for Japan in 1995 and 1.0 percent for China, which is the average for the period 1994 to 2002.

The ratio for students to skilled labour is around 20 percent for Japan in the mid 1990s, which was taken as the ratio for East Asia. A stylised fact regarding China's stock of university and college graduates is that it is not on a steady state. The stock of skilled labour is growing with more younger aged workers having higher education degrees than their older counterparts. With retirements of older workers, China could reach a steady

[11] The factor income shares are rescaled to ensure that the relationship between factor incomes and investment spending for the capital holds. This means that the total value added by each sector is proportional to total investment spending. In practice, this only required a small adjustment to the value added shares.

state similar to that of East Asian economies in the long run. This means that the current ratio of students to skilled labour in China should fall as the stock of skilled labour is accumulated. Thus, in the benchmark the steady state ratio of students to skilled labour for China is calibrated to that of the East Asian region.

The factor income taxes for labour in East Asia are derived from the calculations of Carey and Rabesona (2002). The tax rate for unskilled labour is the effective labour tax rate in Carey and Rabesona (2002) while the tax rate for skilled labour was scaled to account for the differences in the wages observed between skilled and unskilled labour[12]. Data on the effective tax rates for factors in China are scarce. For unskilled labour, the tax rate is computed by the percentage of the personal income taxes collected by the government from the total wages earned by workers in 1995. The effective tax rate for skilled labour is more difficult to estimate given the distortions in the labour market. Skilled workers are not paid wages that closely approximate their contribution to the economy. The social rate of return to education in China is taken to be 30 percent and the private return for skilled labour is 8.23 percent in the mid 1990s (Fleisher and Wang, 2004; Fleisher et al., 2006; Chen et al., 2004). The effective skilled labour tax rate is determined such that the true rate of return on education equals the private rate of return on education plus the labour tax rate. Table 4 summarises the parameters for the education sector and the effective tax rates for labour in the model.

5. Policy Simulations

5.1 Simulation Designs

To raise the skilled workers in China, the government could implement policy measures to foster human capital. One way to encourage higher education would be to increase the government expenditure on education, China's public expenditure on higher education lags behind other countries. Scenario one involves an increase in the government spending on higher education in the form of an education subsidy, the size of the subsidy is chosen to increase higher education expenditure as a percentage of GDP to 1.4 percent, which is the value for the East Asian economies. Another way to promote human capital accumulation is to free up the labour market for skilled workers. Ensuring that skilled workers receive wages that is closer to their contribution to the economy would motivate individuals to acquire tertiary education without imposing additional costs on the government. Scenario two entails a 32 percent reduction in the effective tax rate for skilled labour so that the private rate of return is around 15 percent which is the rate for numerous countries (Heckman, 2005). The focus is on the impacts of these policy simulations on China itself. The changes are introduced as an unanticipated effect which is fully realised in year 1.

[12] The difference between the wages for unskilled and skilled labour is base on average production wages (APW) data from OECD. The unskilled labour is assumed to be earning 100 percent of APW while skilled labour is assumed to be earning 167 percent of APW.

5.2 Simulation Results

5.2.1 Public Expenditure

Table 5 reports the transitional response of the effects of the increase in public expenditure on higher education for various aggregate economic indicators. There is an immediate decline on real GDP per capita of 0.9 percent but real consumption per capita increase by 2.3 percent. However, the gain in GDP is realised over time with GDP rising by 0.6 percent after 10 years. In the long term, the increase in government expenditure is expected to raise GDP and consumption by 4.1 percent and 2.4 percent, respectively, above their benchmark levels. The impact on GDP mostly reflects the increase in factor endowments.

The higher government expenditure in the form of education subsidy lowers the cost of education for workers, resulting in an expansion in the number of students acquiring tertiary education. The enrolments of students increase by 23.7 percent in the first year and 26.7 percent over 10 years. The supply of skilled labour in the economy rises steadily with the increase in student enrolments. In the long term, the expansion of students leads to a proportionate rise in the supply of skilled labour. Following Krussel et al. (2000) and Harris and Robertson (2007), a relatively high degree of capital-skill complementarity is assumed. The increase in human capital accumulation raises the marginal product of the physical capital. The stock for each type of physical capital remains unchanged initially but in the long term the stock of all three physical capitals increase by more than 3.0 percent.

The real return on machinery and equipment, and structures declines in the short term. The return for these two physical capitals improves in the medium term but then deteriorate slightly. The wages for skilled labour increase by 6.2 percent while the wages for unskilled labour fall by 0.7 percent in year 1. This leads to an increase in the wage inequality between these two groups of workers with skill premium rising by 6.9 percent. However, the increase in the stock of skilled labour erodes and eventually reverses the change in the skill premium. In the steady state, wages for skilled labour fall by 16.3 percent and the wages for unskilled labour rise by 2.9 percent.

The exports of the commodities are reduced initially but recover before year 10. The imports of goods rise by 2.2 percent in the first year but declines in the medium term before rising again. The increase in public spending on higher education generates a modest increase in exports and imports of 2.4 percent and 2.2 percent, respectively, in the long run. Along with the rise in exports and imports, there is a small fall in the terms of trade of 0.4 percent.

At the sectoral level, the steady state results are shown in table 6 and the dynamic results are given in figure 3. The output for each sector converges to a higher level of output over the longer term. In several sectors, the output fall below their benchmark level in the short run. Among them are low tech, intermediate manufacturing and durables. The largest effects on gross output in the steady state are found in the sectors regarded as

more skill intensive such as the public sector with an increase of 6.7 percent followed by traded services and durables, with an increase of 5.5 percent and 4.7 percent, respectively. The expansion of these sectors is not surprising given the increase in the supply of skilled labour in the economy.

All traded sectors register an initial decline in exports but exports improved after year 10 except for the agriculture sector. Similar to gross output, the exports of skill intensive industries record a higher increase. The exports of durables and traded services increase by 3.2 percent and 3.0 percent, respectively, over 20 years. There is an instantaneous increase in the imports for each of the traded sectors. In the long run, the imports of agriculture grew by 8.0 percent while the imports of traded services fall by 0.7 percent.

5.2.2 Skilled Labour Tax

The simulation results on the aggregate variables for the reduction in the effective tax rate for skilled labour are provided in table 7. There is a sharp decline in real GDP of 8.3 percent while real consumption increases by 7.0 percent in the first year. Consumption declines in the medium term reflecting the investment spending on physical and human capital. In the long run, GDP rises by 11.3 percent and consumption rises by 6.8 percent.

The number of students pursuing higher education increase dramatically as the wages received by skilled workers more closely reflects their skills. Student enrolments rise by 59.3 percent in year 1 and further rise by 105.5 percent over 20 years. The proportion of skilled labour in the labour force increase with the increase in students, the ratio of skilled labour to unskilled labour increases by 0.6 percent initially and then by 30.2 percent in year 10. The stocks of machinery and equipment, and structures decline in the first 10 years but rise in the long run by more than 10 percent each.

The cut in the effective tax rate for skilled workers increase the wages for skilled labour by 72.5 percent and decrease the wages for unskilled labour by 3.7 percent in the first year. This represents a 79.2 percent rise in skill premium. The additional supply of skilled labour over time lowers the wage inequality between skilled and unskilled workers. The skill premium reduces by 19.6 percent in year 20. The returns for machinery and equipment, and structures drop by 6.7 percent and 4.5 percent, respectively, in year 1. The decline in the returns for these two physical capitals persists into the long run.

The volume of exports falls by 16.7 percent and the volume of imports increase by 5.9 percent in the first year. Despite the initial decline, exports steadily improve with an increase of 5.8 percent over 20 years and 7.0 percent in the steady state. The rise in imports from the lowering of the skilled labour tax is expected to be maintained in the long term although there is a decrease in the medium term.

The sectoral responses for the skilled labour tax reduction are presented in table 8 and figure 4. As shown, the outputs for the eleven commodity sectors are above their benchmark values in the long term but the path for the sectors is not monotonic. Apart from the increase in the education sector, the outputs of the sectors which are more skill

intensive have a larger increase compare to the other sectors, as was the case for increase in public expenditure on tertiary education. In the first year, durables and public fall by 15.7 percent and 13.4 percent, respectively. However, the outputs for durables increase by 7.0 percent and public by 5.8 percent in the following 19 years.

The exports of agriculture are higher in the short term while the exports for the rest of the traded sectors experience a decline. By year 20, all traded sectors except agriculture have positive increase in exports with the exports of the skill intensive sectors of durables rising by 8.3 percent and traded services rising by 4.6 percent. On the import side, agriculture and minerals increase by 27.7 percent and 17.2 percent, respectively, in the long run while traded services fall by 2.3 percent.

6. Conclusion

This paper analyses the economy wide effects of accelerating the accumulation of the stock of skilled labour in China using a dynamic, multi-sector CGE model. The results from the increase in government expenditure on higher education and the reduction in the effective skilled labour tax rate suggest significant potential economic growth from increase supply of skilled workers. There is also a large gain in consumption in the short and long term.

In both cases, the gross output of skill intensive sectors such as durables and traded services grew more strongly. Similarly, the exports of the more skill intensive sectors increase the most. In the short term, wage inequality between skilled and unskilled workers widens but this is reversed in the long term. Due to the presence of capital-skill complementarity, the increase stock of skilled labour generates substantial accumulation of physical capital.

The results indicate the importance of investing in higher education in China to further develop its economy. A larger and better educated workforce in China will enhance the welfare of its people and ensure that strong growth prospect is sustainable in China. Although China has made great progress in raising the ratio of skilled workers to the labour force, the supply of skilled labour is still short for a modern China. Further measures to promote enrolments in higher education and increase the supply of skilled workers are needed for China to achieve its ambition of becoming an innovation oriented economy.

APPENDIX

Table 1: Gross Enrolment Ratios in Selected Countries/Regions in 2004

	Tertiary Gross Enrolment Rate (%)
China	19.1
India	11.8
Indonesia	16.7
Japan	54.0
South Korea	88.5
Malaysia	32.4
Thailand	41.0
Philippines	28.8
Russia	68.2
Egypt	32.6
Armenia	26.2
Jordan	39.3
Mexico	23.4
Romania	40.2
Australia	72.2
France	56.0
United States	82.4
United Kingdom	60.1
Lower middle income	22.5
World	24.8

Source: World Development Indicators Database

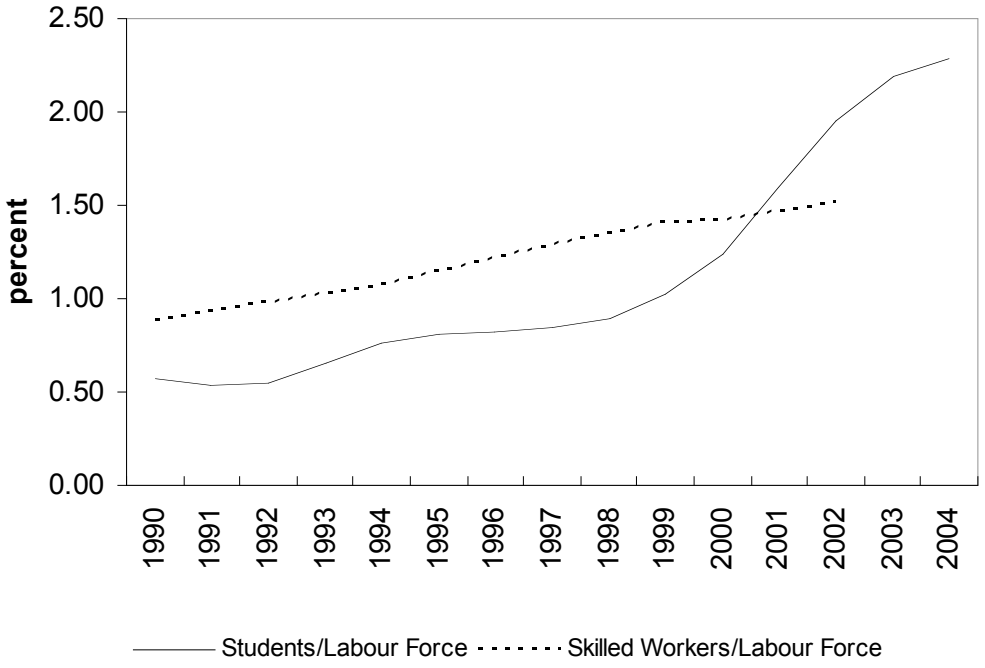
Table 2: Number of Students enrolled in Tertiary Education Institutions (millions)

	Number of Students
1978	2.3
1980	2.7
1985	3.4
1990	3.7
1991	3.5
1992	3.7
1993	4.4
1994	5.2
1995	5.5
1996	5.8
1997	6.0
1998	6.5
1999	7.5
2000	9.2
2001	11.9
2002	14.7
2003	16.7
2004	17.5

Source: Ministry of Education website, author's calculations.

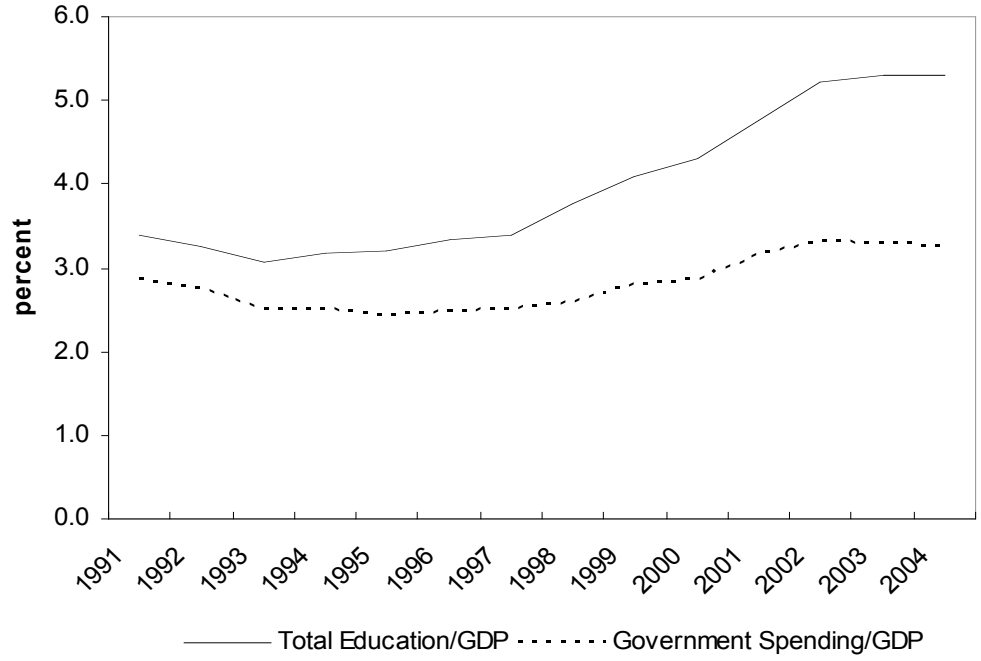
Note: The tertiary education enrolments include only students in regular higher education institutions and adult higher education institutions. The data for 1990 to 2002 are calculated based on the number of students per 100,000 inhabitants.

Figure 1: Ratios of Tertiary Students and Skilled Labour to Labour Force



Source: China Statistical Yearbook 2005, Islam et al. (2004) and Ministry of Education website, author's calculations.

Figure 2: Ratios of Total Expenditure and Public Expenditure on Education to GDP



Source: China Educational Finance Statistical Yearbook 2003, China Statistical Yearbook (various years)

Table 3: Structure of the CGE model

Regions	Commodities	Factors	Aggregate Spending
East Asia	Traded Commodities	Physical Capital	Consumption
China	Agriculture	Machinery and Equipment	Government
Rest of the World	Minerals	Structures	Investment on Machinery
	Low Tech	Residential Housing	Investment on Structures
	Intermediate Manufacturing	Labour	Investment on Res. Housing
	Durables	Skilled Labour	Education
	Traded Services	Unskilled Labour	
	Non-Traded Commodities	Land	
	Construction	Natural Resources	
	Non-traded Services		
	Public		
	Housing		
	Education		

Table 4: Parameters for Human Capital and Effective Labour Tax Rates

	East Asia	China
Higher education spending as a percentage of GDP	1.4	0.6
Ratio of Students to Population	0.05	0.01
Ratio of Students to Skilled Labour	0.2	0.2
Effective unskilled labour tax	0.17	0.02
Effective skilled labour tax	0.23	0.73

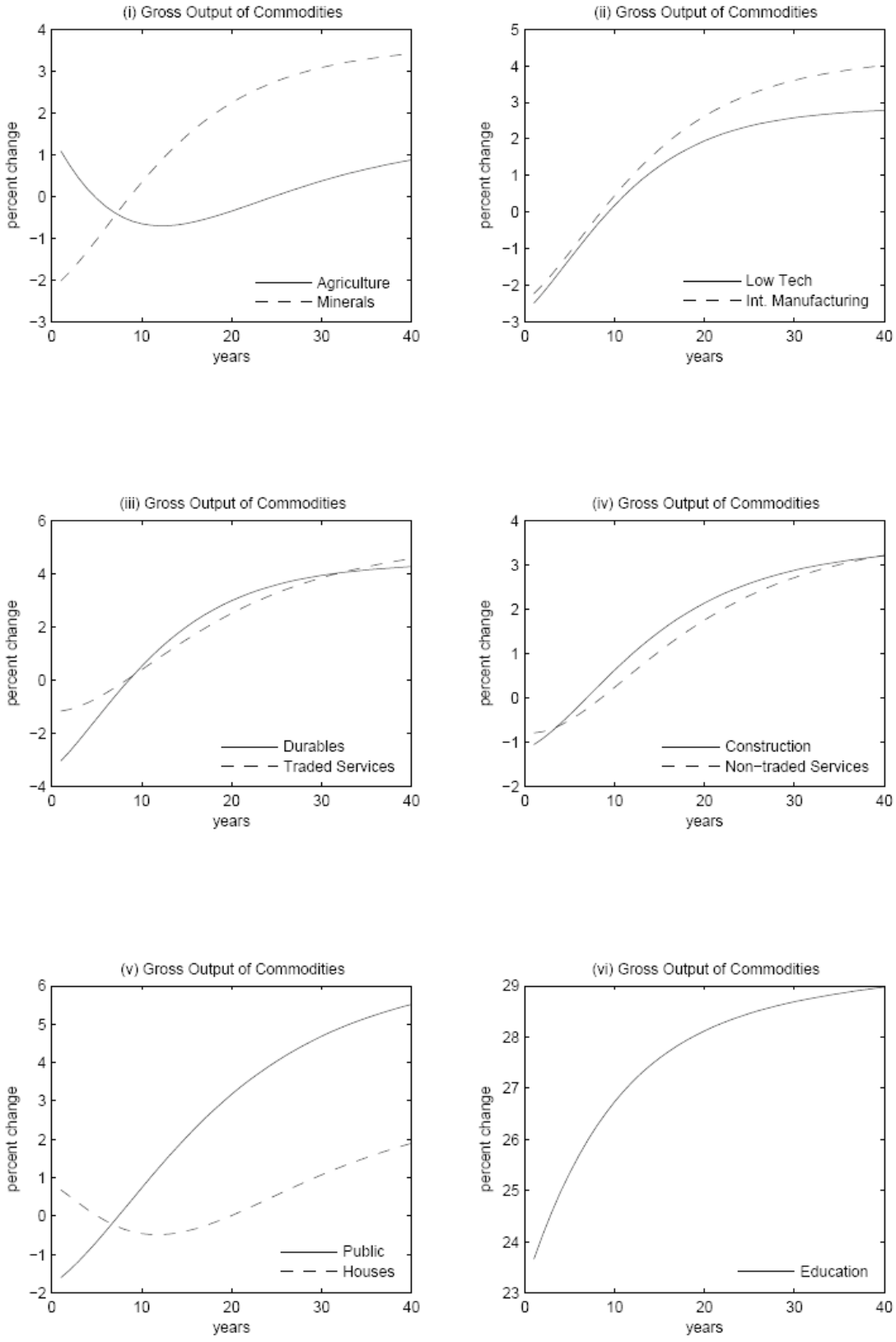
Table 5: Dynamic Simulation Effects on Aggregate Indicators (percent change) from Increase in Public Expenditure on Education

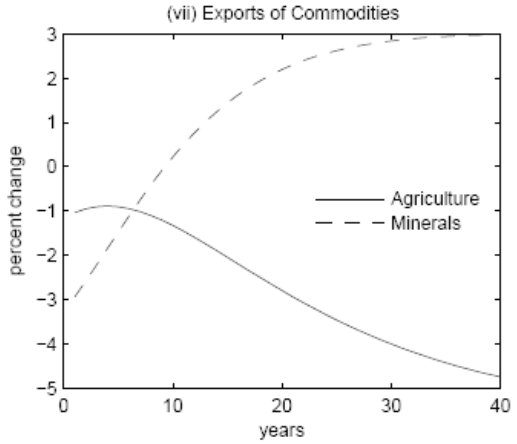
	Year 1	Year 5	Year 10	Year 20	Steady State/Long Run
Indicators					
Real GDP per capita	-0.86	-0.35	0.57	2.18	4.12
Real Consumption per capita	2.31	0.41	-0.75	-0.57	2.42
Exports	-4.15	-2.08	0.12	2.20	2.22
Imports	2.23	1.00	0.14	0.11	1.93
Terms of Trade	-0.82	-0.38	-0.04	0.08	-0.40
Ls/Lu	0.25	5.01	10.16	17.95	31.90
Number of Students	23.66	25.35	26.74	28.12	28.99
Endowments					
Machinery &Equipment	0.00	-0.74	-0.13	1.73	3.36
Structures	0.00	-0.29	0.02	1.30	3.23
Residential Housing	0.00	-0.16	-0.36	0.27	3.66
Skilled Labour	0.00	4.48	9.30	16.56	28.97
Unskilled Labour	-0.25	-0.51	-0.78	-1.18	-1.85
Real Factor Returns					
Machinery & Equipment	-1.43	-0.18	0.21	-0.11	-0.52
Structures	-1.06	-0.36	0.03	-0.09	-0.85
Residential Housing	3.79	0.82	-0.42	-0.43	-0.83
Skilled Labour	6.21	1.12	-3.44	-9.04	-16.27
Unskilled Labour	-0.66	-0.15	0.54	1.59	2.93
Land	0.41	-0.16	-0.26	0.53	2.64
Natural Resources	-1.08	-0.63	0.03	1.14	2.54
Ws/Wu	6.92	1.27	-3.96	-10.47	-18.66

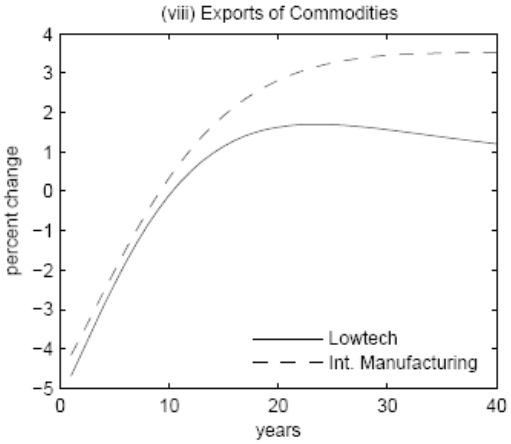
Table 6: Steady State/Long Run Simulation Effects on Sectoral Indicators (percent change) from Increase in Public Expenditure on Education

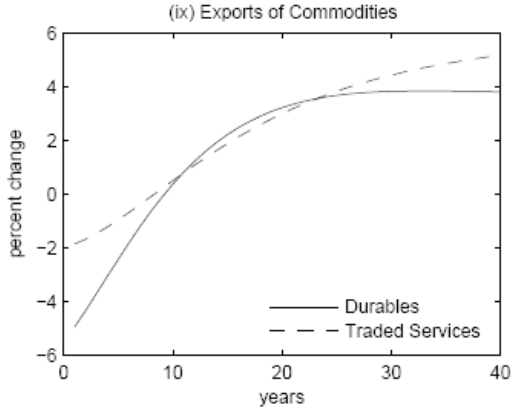
	Gross Output	**Export Volume**	**Import Volume**
Agriculture	1.52	-5.81	8.01
Minerals	3.81	3.07	5.76
Low Tech	2.99	0.60	2.94
Inter. Manufacturing	4.52	3.51	0.88
Durables	4.69	3.69	0.99
Traded Services	5.54	6.19	-0.67
Construction	3.63		
Non-Traded Services	3.89		
Public	6.68		
House	3.07		
Education	28.99		

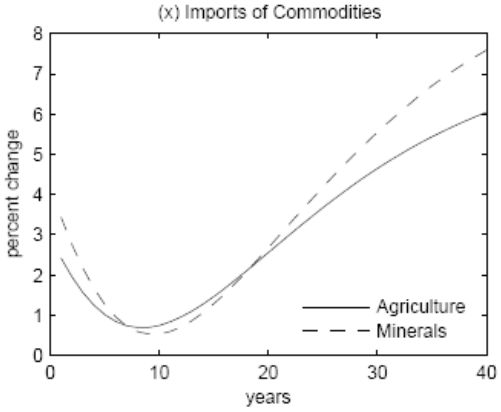
Figure 3: Dynamic Simulations on Sectors from Increase in Public Expenditure on Education

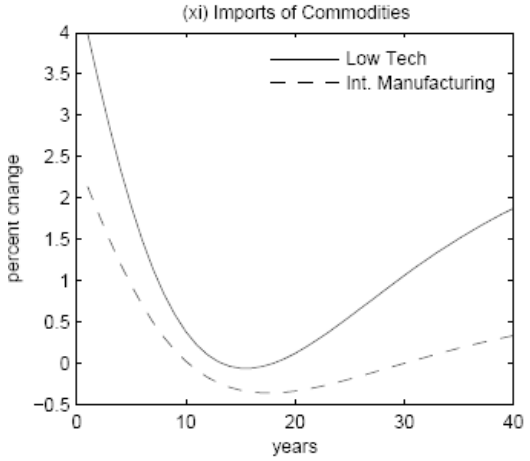



(vii) Exports of Commodities
percent change
years
Agriculture
Minerals


(viii) Exports of Commodities
percent change
years
Lowtech
Int. Manufacturing


(ix) Exports of Commodities
percent change
years
Durables
Traded Services


(x) Imports of Commodities
percent change
years
Agriculture
Minerals


(xi) Imports of Commodities
percent change
years
Low Tech
Int. Manufacturing

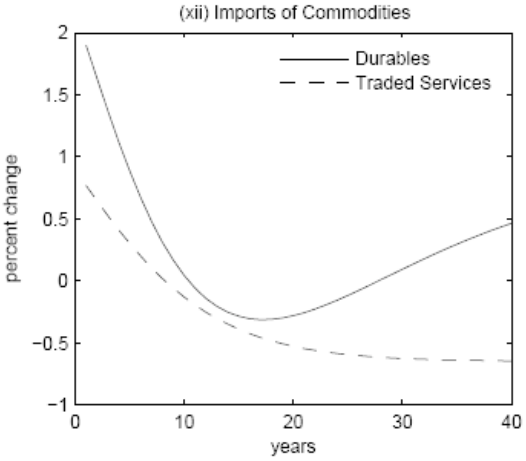

(xii) Imports of Commodities
percent change
years
Durables
Traded Services

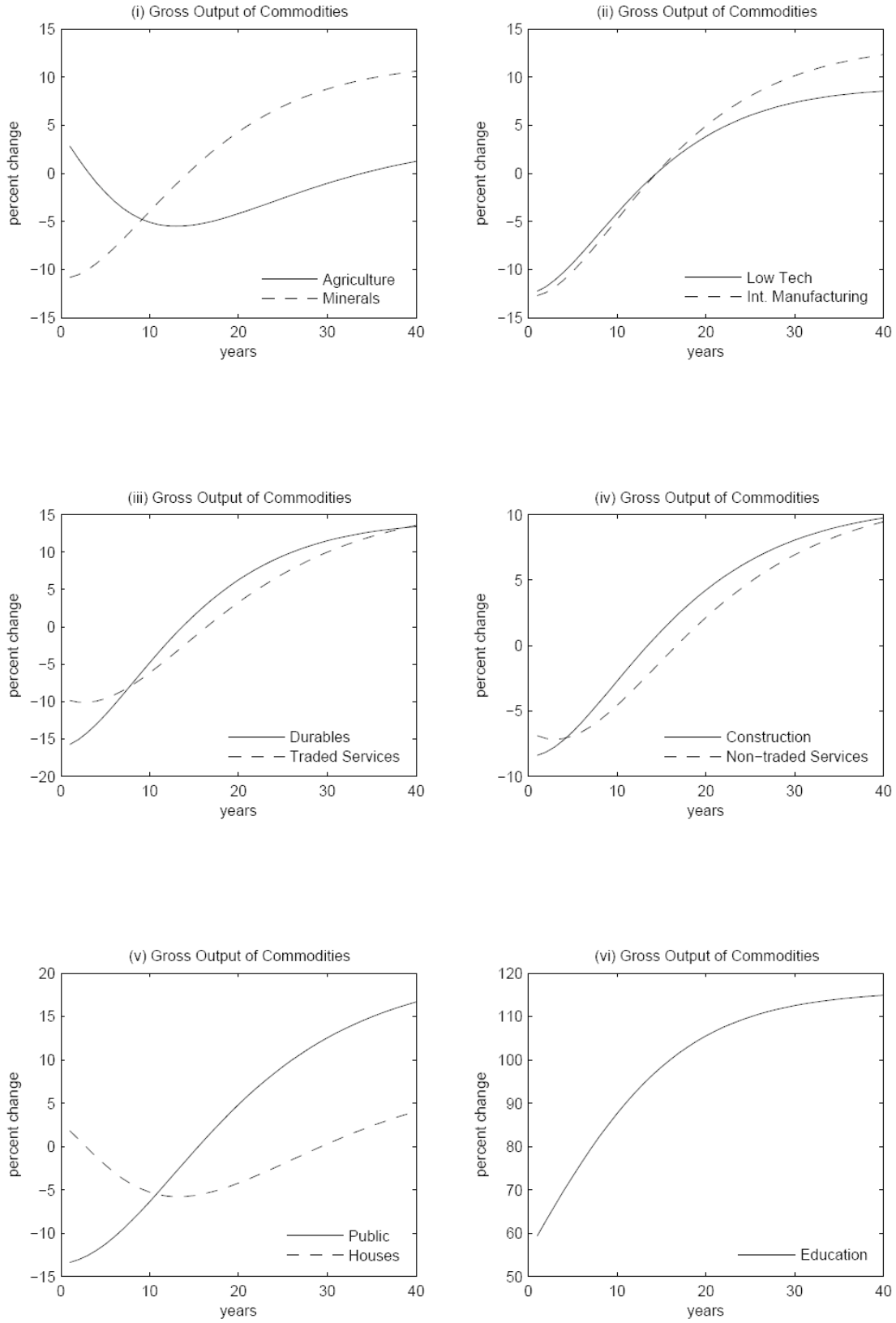
Table 7: Dynamic Simulation Effects on Aggregate Indicators (percent change) from Reduction in Skilled Labour Tax

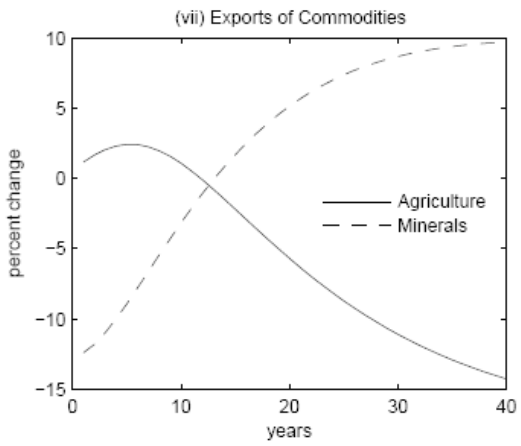
	Year 1	Year 5	Year 10	Year 20	Steady State/Long Run
Indicators					
Real GDP per capita	-8.25	-7.64	-4.59	2.50	11.32
Real Consumption per capita	7.01	-0.61	-6.17	-6.07	6.82
Exports	-16.66	-11.39	-3.57	5.84	6.96
Imports	5.85	1.60	-1.89	-2.02	6.01
Terms of Trade	-2.45	-1.06	0.31	0.85	-1.15
Ls/Lu	0.64	13.52	30.15	61.72	131.44
Number of Students	59.33	73.10	87.63	105.52	114.57
Endowments					
Machinery &Equipment	0.00	-5.55	-4.64	1.95	10.30
Structures	0.00	-2.84	-2.95	0.86	10.03
Residential Housing	0.00	-2.74	-5.28	-4.23	11.06
Skilled Labour	0.00	11.91	27.07	52.60	114.52
Unskilled Labour	-0.63	-1.41	-2.37	-3.91	-7.31
Real Factor Returns					
Machinery & Equipment	-6.67	-1.35	1.00	0.15	-1.77
Structures	-4.49	-1.88	0.18	0.40	-2.77
Residential Housing	8.86	0.75	-2.88	-1.34	-2.72
Skilled Labour	72.52	41.04	13.66	-16.56	-41.54
Unskilled Labour	-3.70	-2.95	-0.79	3.72	10.30
Land	-0.57	-3.55	-4.66	-1.57	7.99
Natural Resources	-6.18	-5.71	-3.63	1.17	7.69
Ws/Wu	79.15	45.33	14.56	-19.55	-47.00

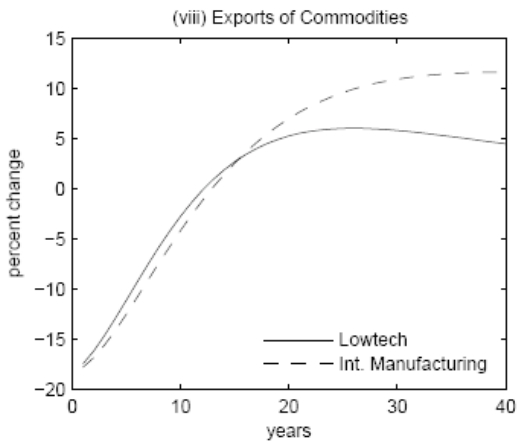
Table 8: Steady State/Long Run Simulation Effects on Sectoral Indicators (percent change) from Reduction in Skilled Labour Tax

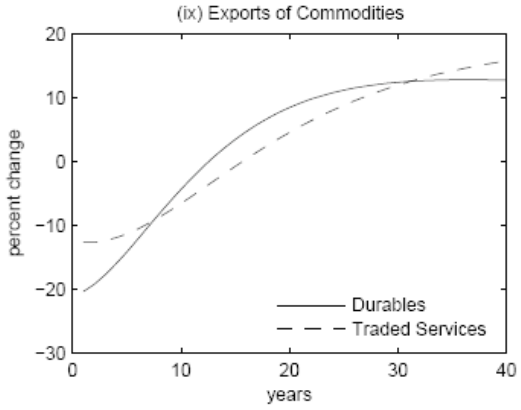
	Gross Output	**Export Volume**	**Import Volume**
Agriculture	3.85	-18.27	27.67
Minerals	11.98	9.78	17.22
Low Tech	9.13	1.60	9.31
Inter. Manufacturing	14.12	11.10	2.41
Durables	14.71	11.73	2.67
Traded Services	17.34	19.78	-2.25
Construction	11.22		
Non-Traded Services	12.02		
Public	21.28		
House	9.06		
Education	114.57		

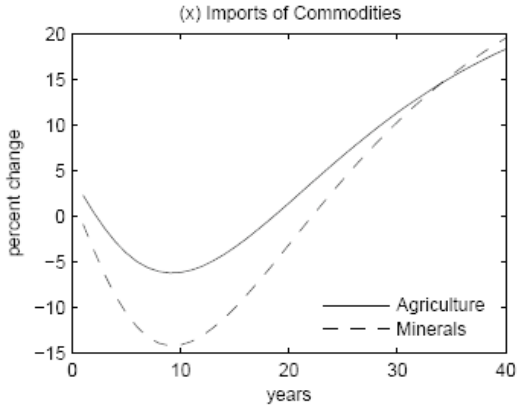
Figure 4: Dynamic Simulations on Sectors from Reduction in Skilled Labour Tax

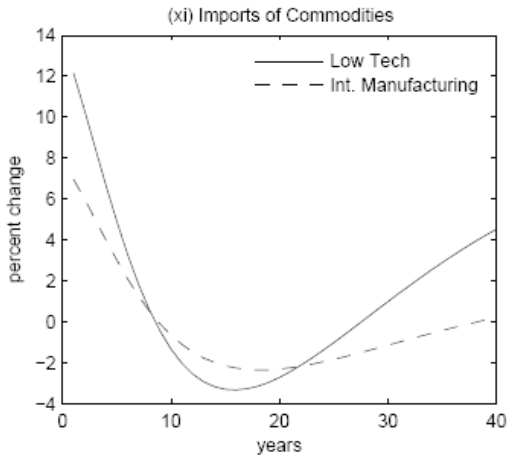


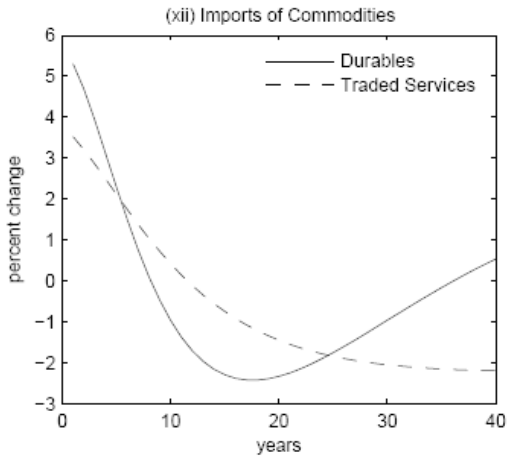

(vii) Exports of Commodities
percent change
years
Agriculture
Minerals


(viii) Exports of Commodities
percent change
years
Lowtech
Int. Manufacturing


(ix) Exports of Commodities
percent change
years
Durables
Traded Services


(x) Imports of Commodities
percent change
years
Agriculture
Minerals


(xi) Imports of Commodities
percent change
years
Low Tech
Int. Manufacturing


(xii) Imports of Commodities
percent change
years
Durables
Traded Services

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