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Economic Growth in the Presence of FDI: The Perspective of Newly Industrialising Economies

by

Shujie Yao and Kailei Wei

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The Authors

Shujie Yao is Professor of Economics and Chinese Sustainable Development, University of Nottingham, UK, and Special Professor of Economics, Xian Jiaotong University, China.

Kailei Wei is a PhD student at Middlesex University Business School, UK.

Correspondence address:
Professor Shujie Yao
Institute of Contemporary Chinese Studies
University of Nottingham
Nottingham NG7 2RD, UK
E-mail: shujie.yao@nottingham.ac.uk

2. Kailei Wei
Ph.D candidate, Middlesex University Business School.
E-mail: k.wei@mdx.ac.uk

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Abstract

Although FDI is widely believed to have a positive effect on economic growth, the exact mechanism of how FDI impacts upon the development process of the newly industrialising economies is far from being well understood. This paper presents and tests two propositions on the role of FDI in economic growth from a newly industrialising economy's perspective. First, FDI is a mover of production efficiency because it helps reduce the gap between the actual level of production and a steady state production frontier. Second, FDI being embedded with advanced technologies and knowledge is a shifter of the host country's production frontier. Due to its dual role as a mover of production efficiency and a shifter of production frontier, FDI is a powerful driver of economic growth for a newly industrialising economy to catch up with the world's most advanced countries. China's economic success over the past decades provides an ideal example to test the hypotheses.

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Key words: FDI, economic growth, industrialisation, China

Outline

1. *Introduction*
2. *Propositions on the role of FDI in economic growth*
3. *Empirical models and regression results*
4. *Conclusions*

Non-Technical Summary

The role of foreign direct investment (FDI) in economic growth has been extensively studied in the literature. Endogenous growth theory emphasises the role of science and technology, human capital and externalities in economic development. It differs from the early post-Keynesian growth models which focused on savings and investment, and the neo-classical models which emphasised technical progress. This new growth theory is coincided with a rising trend of globalisation and integration in the world economy. Export and FDI have played an important role in this process.

Because FDI, export and economic growth has a close relationship, many empirical studies have focused on the linkage between exports and growth, or between FDI and growth, or examine the triangular relationship among FDI, export and growth. Existing studies provide useful insights and rich empirical evidence on the role of FDI in economic growth, but the exact mechanism of how FDI contributes to the growth process of a newly industrialising economy has not been well studied.

To understand why FDI is important in the growth process, it is necessary to compare the different roles of FDI and domestic investment (DI). FDI is different from DI in two important aspects although both can be treated as a basic physical input in the production process: FDI accelerates the speed of adoption of general purpose technologies (GPT) in the host countries; FDI is embedded with new technologies and know-how unavailable in the host countries.

This difference between FDI and DI is due to the motivation of multinational companies (MNCs) which seek to maximize profit for their investment in the host country. The second difference between FDI and DI is that FDI is embedded with advanced technologies that may not be available in the host country.

China provides an ideal example to test the propositions because of its fast economic growth with significant absorption of FDI for a long period of time. This paper constructs an augmented production function and uses a large panel dataset coving 29 Chinese provinces over 1979-2003 to test two hypotheses: (1) FDI is a mover of production efficiency, and (2) FDI is a shifter of the host country's production frontier. The empirical results show that FDI not only has a positive effect on production efficiency but also shifts China's production frontier equivalent to a Hick's natural technological progress of up to 1.5% per year, or about 30% of China's total technological progress over the data period. The impact of DFI on economic growth, however, exhibits a clear regional pattern with a 'water fall' shape from the East, to the Central and then to the Western part of the country. The results make a fresh contribution to the literature on economic growth and FDI, with important implications on regional economic and development policies.

Introduction

The role of foreign direct investment (FDI) in economic growth has been extensively studied in the literature, especially in recent years when China and India, the world's two most populous and fastest growing economies have been using FDI as a stimulus in the growth process. Different authors have studied the linkage between FDI and economic growth from different perspectives. Bhagwati (1994) proposes that the volume and efficacy of FDI inflows vary according to whether a country is following an export-push (EP) or an import substitution strategy (IS). Balasubramanyam, *et al*. (1996) prove that FDI plays a greater role in economic growth in EP countries than in IS economies. Both China and India have adopted an EP strategy, hence, it is possible for them to use FDI effectively to promote growth and reduce their income gap with the industrialized countries.

Endogenous growth theory emphasises the role of science and technology, human capital and externalities in economic development (Romer, 1986, 1987; Lucas, 1988). It differs from the early post-Keynesian growth models which focused on savings and investment, and the neo-classical models which emphasised technical progress (Solow, 1957). This new growth theory is coincided with a rising trend of globalisation and integration in the world economy. Export and FDI have played an important role in this process (Kreuger, 1975; Greenaway and Nam, 1988).

Because FDI, export and economic growth has a close relationship, many empirical studies have focused on the linkage between exports and growth (e.g. Greenaway and Sapsford, 1994), or between FDI and growth (Chuang and Hsu, 2004; Lardy, 1995), or examine the triangular relationship among FDI, export and growth (Yao, 2006). Existing studies provide useful insights and rich empirical evidence on the role of FDI in economic growth, but the exact mechanism of how FDI contributes to the growth process of a newly industrialising economy has not been well studied.

To understand why FDI is important in the growth process, it is necessary to compare the different roles of FDI and domestic investment (DI). In the post-Keynesian and neo-classical models, DI is a necessary condition for production growth and technical progress, but it may not enable a newly industrialising economy to take advantage of advanced technologies available in the developed world. FDI is different from DI in two important aspects although both can be treated as a basic physical input in the production process: FDI accelerates the speed of adoption of general purpose technologies (GPT) in the host countries; FDI is embedded with new technologies and know-how unavailable in the host countries.

A GPT is a technological invention, or breakthrough, that affects the entire system in the global economy. The most recent examples of GPTs include the computer, internet and mobile phone. Each GPT is capable of raising the aggregate productivity of labour and capital, but it takes a considerable amount of time for all countries to tap into its potential. Industrial countries tend to be front runners in the adoption of GPTs and their experiences are useful for the industrialising economies through FDI.

This difference between FDI and DI is due to the motivation of multinational companies (MNCs) which seek to maximize profit for their investment in the host country. According to Dunning's eclectic approach (Dunning, 1993), MNCs need to have three pre-conditions to invest abroad. First, they must process certain ownership advantage over indigenous firms. Second, they must have an advantage of internalising business activities. Third, the region of choice must have location-specific advantage. The ability of MNCs to combine these three advantages implies that they should be able to excel indigenous firms in performance. On the other hand, to be able to compete with MNCs, indigenous firms have to learn from them for their best practices in organisation and management through learning by watching. Increased competition between foreign and domestic invested firms can lead to more efficient use of resources, reducing the technical efficiency gap between realised output and a steady state production frontier.

The second difference between FDI and DI is that FDI is embedded with advanced technologies that may not be available in the host country. Such advanced technologies will be able to shift the host country's production frontier to a new level so that the same amount of material inputs can lead to a higher level of output. Of course, there are pre-conditions for this effect to take place. Such conditions may include an export-push development strategy, the accumulation of enough human capital, improved infrastructure and the like.

China provides an ideal example to test the propositions because of its fast economic growth and experiences of adopting an EP strategy with significant absorption of FDI for a long period of time. This paper is organised as follows. Section I presents a theoretical framework to outline two hypotheses on the role of FDI in the growth process of newly industrialising economies. Section II presents background information on the Chinese economy and FDI inflow. Section III uses empirical data which covers 29 provinces over the entire reform period 1979-2003 to test the propositions, while section IV concludes with policy implications and suggestions.

I. Propositions on the role of FDI in economic growth

Peter Mandelson, EU's trade commissioner, presented a seminar 'Can the EU compete with China?' in Brussels on 15 June 2005. He chose this topic because he just concluded a negotiation with his Chinese counterpart, Bo Xilai, on China's garment and textile exports to the EU, feeling the pinching challenge from China on the EU manufacturing sector. Twenty or even 10 years ago, the world's most powerful and advanced economic blocks, the US, Japan and the EU would not be so sure that China could become a real challenge to their economies so soon and so powerfully. Today, this uncertainty has become a reality, and the international economic order will look very different in another 20 years time as China has planned to quadruple its per capita GDP by then.

When the US, Japan and the EU feel the competitive pressure from China and see their trade deficits accumulate, their political leaders begin to blame for China's unwillingness to revalue its currency.[1] RMB (*ren ming bi*) was devalued in the 1980s and 1990s by the Chinese government to remove distortions in the exchange market and raise China's international competitiveness and attraction to MNCs. Nonetheless, China's comparative advantage in international trade is not because of its undervalued currency, but because of its ability to produce massive volumes of different industrial products and sell them to the west at low prices.[2] Western consumers have benefited from being able to buy these cheap products but producers may have suffered if they failed to improve their competitiveness through moving to a higher level of the production chain, or reduce their cost of production.

Although the rise of China and India may have threatened employment of low-skilled labour in the west, the impact of rapid growth in these two countries and some other emerging economies on the world economy is widely perceived to be positive. Some economic analysts suggest that one of the reasons why the sharp rise of oil price from 2004 has not resulted in a global recession or even high inflation in the industrialised world is because of the massive exports of cheap manufacturing goods from China and India to help mitigate inflation pressure in the USA, Japan and Europe.

For whatever reason, as along as the industrial economies feel the challenge or threat from the newly industrialising countries such as China or India, it implies that the latter are catching up with the former. In the literature of economic growth, this is the phenomenon of economic convergence between the poor and the rich, or between the developing and the developed economies. Romer (1986, 1987) and others suggest that economic convergence can be explained by the law of diminishing returns to capital. As rich countries have a higher capital/labour ratio than poor countries and further investment in the former will lead to a lower return to capital, MNCs will seek to invest in the latter where capital/labour ratio is low and potential return to capital is high. This process of international capital movement will lead to job creation in the developing world and a reduction in its gap of per capita income with the developed countries.

However, not all developing countries have been able to catch up with the developed economies (Islam, 1995; Sala-I-Martin, 1996). Even for the same countries such as China and India, they failed to catch up with the western economies before economic reforms and opening their doors to international trade and foreign investments. In other words, there are pre-conditions for a developing economy to be able to catch up with the industrialised world. According to Gregory Chow (2005), the necessary conditions for catching-up include the following: education and the accumulation of human capital, institutions and market liberalisation, and ability to create or adopt new technologies.

The new growth theory emphasises the importance of human capital because education and human capital is the most fundamental condition for a late comer of industrialisation to imitate the industrial world through 'learning by doing' and 'learning by watching'. Education and human capital is also the most fundamental condition for innovation and knowledge creation. In contrast with many other developing countries in Africa and Asia, China, India and the Southeast Asian countries have been successful in their development of education and the building up of human capital (World Bank, 1993; Yao and Zhang, 2003).

Institutions such as government policy and market liberalisation are also important conditions for catching-up. Before economic reforms, China failed to catch up with the west because it adopted a close-door, self-reliance and import-substitution policy although education was reasonably well developed. India did not perform well before 1990 because it stuck to its close-door and self-reliance policy as did China before 1978. Market liberalisation and policy reforms are key elements for the economic success of China since 1978 and India since 1991.

The third condition for catching-up is the ability to create and adopt new technologies. For a late comer of industrialisation, it is neither possible nor necessary to create all technologies required for modernisation. On the contrary, late comers have a tremendous advantage over developed countries in the sense that the former can acquire the same technologies in a much shorter time than the latter. This is particularly true because some of the most useful and latest technologies are in the information sector. Internet and telecommunication technologies can be easily imitated and adopted to have a quick and profound impact on economic growth. China and India are not inventors of many internet and telecommunication technologies but their people are now enjoying probably the world's most efficient and cheapest services because of their massive market size. Even in Africa, mobile phones and internets have become effective tools for transmitting price and marketing information between townships, which were subject to insurmountable communication and transportation barriers before.

But how can late comers acquire technologies that they do not innovate? One way is through direct import of technologies, but a more popular way is through FDI (Ethier and Markusen, 1996; Globerman, 1979). For investors, they have strong incentives to invest because they want to secure a market share for their products in the developing world, to produce their goods cheaply in the host countries in order to raise returns to capital, and to extend their competitive advantage beyond their traditional market (Blomstrom and Sjoholm, 1999; Chen *et al*., 1995). The incentives of investors constitute the push-factor of FDI. For host countries, FDI is the most direct and efficient way of acquiring technologies created in the most advanced economies, and hence an important mechanism of economic convergence. The incentives of host countries constitute the pull-factor of FDI.[3]

Most researchers consider FDI and exports as two sides of the same coin of openness, and few explain why FDI may be a different factor of openness from exports. Many liberal economists suggest that participation in international trade allow countries to become more specialised in areas where they have comparative advantage in the international division of labour. As a result, rising trade activities bring about mutual benefits for all parties. For poor countries, exports and foreign exchange earning are necessary conditions for importing foreign goods, services and even technologies. In this respect, export is a pre-condition for raising a country's production and allocative efficiency, but it may not be able to shift the country's production frontier. To a great extent, FDI plays a similar role in raising a country's production efficiency because FDI brings with the world's most advanced managerial and organisation skills provided by MNCs. For countries where lack of domestic capital is a key constraint on job creation and economic growth, FDI effectively makes up the shortfall of domestic investments. Hence, FDI can be regarded as a mover of economic growth.

What makes FDI differ from export is its role as a shifter of economic growth because it is embedded with advanced technologies which are not available in the host country. Although many studies find that export plays an important role in economic development, it is not a substitute of FDI, especially in the context of a newly industrialising country. This is easily apprehensible if one considers the following situation. Suppose China is able to export a lot of cheap and labour-intensive products such as garments and textiles to the US and then uses the foreign exchange earnings to import aircrafts and automobiles, as textiles and garments can be produced using indigenous technologies, the bilateral trade activities may not be able to change the level of technologies and know-how in China. However, if US carmakers, e.g. GM, Ford, or even aircraft manufacturers, e.g. Boeing, invest in China to produce and sell their vehicles and planes locally, domestic firms will be able to improve their technologies through learning by watching, or through supplying spare parts to foreign invested firms.

A typical example is the development of the automobile industry. Before 1978, China's motor industry was dominated by the Russian technology imported in the 1950s. The First Auto Work in Changchun was set up with help from the former USSR to produce the Jiefang Truck. From the 1950s up to 1978, the same model of truck was produced for almost three decades. Since economic reforms, foreign vehicle makers are allowed to set up joint ventures in China. The first western carmaker to enter China was VW, which dominated the local market for more than a decade before other world class makers realised the huge market potential. Today, almost all large foreign carmakers have established joint ventures in different parts of the country. Even Mercedes and BMW are now setting up production lines there. Through joint ventures, local firms have been able to imitate foreign technologies and started to produce their own models or supply parts to foreign carmakers. There is no doubt that FDI has not only helped improve the production efficiency of domestic firms but also helped push China's production frontier towards the world's most advanced levels.

Let us assume that there are only two countries in the world: one is an industrialised economy (A) and the other is a newly industrialising economy (B), and both countries follow a Cobb-Douglas production technology.

$$Y_{jt} = A_{jt} f(K_{jt}, L_{jt}) e^{g(z)} \tag{1}$$

Where Y, K, L are respectively GDP, capital and labour; j and t denote country (A, B) and time; g(z) a function of various factors affecting production efficiency and the production frontier, including exports, human capital, FDI, institutions and others. As country A is richer and has a higher K/L ratio than country B, country A tends to make investments in B in order to maximize returns to capital, as long as $\frac{\partial Y_{Bt}}{\partial K_{Bt}} > \frac{\partial Y_{At}}{\partial K_{At}}$ holds true.

In this two countries scenario, both countries must have mutual benefits for cross-border movement of capital to take place. The benefit for A is that it can maximize returns to its capital and has access to B's market. The benefit for B is that it can have access to A's technology and improve per capita income so that the income gap between A and B declines over time.

Another assumption is that both countries invest in science and technology to create knowledge and innovation. However, because A has better endowments in both physical and human capital, it is more able to innovate and hence produce a higher level of output given the same level of inputs in comparison with B. The only way for B to reduce this technological gap is through importation of A's technology embedded through FDI. Consequently, the role of FDI can be suggested by the following two propositions.

Proposition I: Given the same steady state of B's technology, FDI can improve B's production efficiency because foreign invested firms are front runners in the adoption of GPTs due to their superior human capital, management and organisational structure. Domestic firms can learn from foreign invested firms through learning by watching. They also have incentives to become more efficient and competitive because they fear losing out to foreign invested firms.

The moving effect of FDI on production efficiency of B can be illustrated in Figure 1. PF_B denotes the production frontier of B. At a steady state when input is fixed at X_0, the actual level of domestic production is Y_{d0} without the effect of FDI. If FDI has a positive impact on production efficiency at this steady state, or $\frac{\partial Y_B}{\partial FDI_B} > 0$, the actual level of production will rise to Y_{f0}. The net moving effect of FDI on country B's production is $(Y_{f0}-Y_{d0})$.

[Figure 1 here]

Proposition II: FDI is a shifter of the domestic production frontier. If FDI does not have a shifting effect, the maximum output of B can never go above PF_B. If FDI has a shifting effect, country B's maximum potential output can be as high as those located on PF_A, which is the production frontier of A (Figure 1).

For instance, without a shifting effect, the actual level of production may move from Y_{f0} at the initial steady state to Y_{dt} at the new steady state with a new input mix X_t. The maximum possible output of B at the new level of input will be on PF_B or below. If FDI has a shifting effect, the actual level of output can go above PF_B, with a maximum potential output to be on PF_A. In Figure 1, if the new actual output is Y_{ft}, which is situated between the two frontiers, it means that the production frontier of B has been shifted towards PF_A from PF_B. This positive shifting effect can be expressed as $\frac{\partial Y_B}{\partial FDI} = f(t) > 0$, implying that the marginal product of FDI is an increasing function of time.

With propositions I and II, country B's production function can be re-written as

$$Y_{Bt} = A(FDI, Z_1)_{Bt} f(K_{Bt}, L_{Bt}) e^{g(t*FDI,\, t,\, Z_2)} \tag{2}$$

FDI is part of the multiplier A_{Bt} along with a set of other variables Z_1 which can also improve production efficiency. Besides, FDI enters the residual term to be a shifter of the production frontier along with other variables, including a time trend t, which captures the Hick's neutral technological progress in B in the absence of FDI or foreign technologies, t*FDI captures the additional technological progress that is attributed only to FDI.

The total effect of FDI on economic growth in country B can be expressed as

$$\frac{\partial Y_B}{\partial FDI} = \frac{\partial A(FDI, Z_1)}{\partial FDI} + e^{g(t*FDI,\, t,\, Z_2)} \left(\frac{\partial g(t*FDI, t, Z_2)}{\partial FDI} \right) \tag{3}$$

The first part on the right hand side of (3) measures the moving effect, and the second part the shifting effect of FDI on Y_B. If both effects are positive and significant, the above two propositions hold true. This is a task to be done below.

II. The Chinese economy with FDI

China's economic reforms have achieved remarkable success. Over the data period 1979-03, real per capita GDP increased more than eight-fold, registering an average annual growth of 9.41% (Table 1).

[Table 1 here]

The highest growth provinces are concentrated in the eastern coast which accounted for the lion's share of China's FDI and exports. In 1979, per capita GDP in the east was about 30% higher than in central China and 43% higher than in the west. By 2003, it was more than twice that in central China and almost three times that in the west. As a result, the east-central-west per capita real GDP ratio changed from 1:0.72:0.57 in 1979 to 1:0.50:0.35 in 2003.

China's economic growth has been powered by a number of factors: increased inputs of labour and investments, human capital, exports and FDI. Figure 2 shows the trends of real GDP, labour, investment, FDI and exports. All the variables are aggregated at the national level and converted into real values in 1990 prices. They are calculated in indexes (1990=100) and taken in natural logarithm.

Labour input increased steadily but significantly less than any other variable. The trends of GDP, exports and investment are close to each other. Only FDI grows remarkably more than all the other variables. It appears that exports, investment and labour are likely to have a log-linear relationship with GDP, but FDI is likely to have more than just a log-linear relationship.

[Figure 2 here]

In the literature, many studies show that openness, as reflected by rising international trade and FDI, has been an important element of China's economic miracle over the last 28 years of economic reforms (Pomfret, 1997; Yao and Zhang, 2001; Greenaway, 1998; Fleisher and Chen 1997; Choi, 2004). China's open door policy was implemented from 1978 on a gradual and pragmatic process along with its effort to transform from a centrally-planned to a market economy. The period 1978-1991 can be regarded as the first-phase of openness. In this period FDI was encouraged but largely concentrated in the special economic zones of Shenzhen, Xiamen, Zhuhai and Shantou, 14 other coastal cities and Hainan Island. During this period, the rate of growth was high but the level of inflow was low.

After Deng Xiaoping made his famous tour to South China in1992, the total inflow of FDI rose enormously, and in the following years, China quickly became the largest recipient of FDI among all the developing countries and the second largest recipient of the world by 1996 (Figure 3). FDI inflows into China continued to rise in recent years, reaching $52.7 billion by 2002, and $62 billion in 2004, accounting for over 10% of the world's total.

[Figure 3 here]

Buckley and Chen (2005) show that FDI inflows into China were directly linked to its export-push development strategy. Right from the early 1980s, one of the conditions for foreign firms to invest in China was that they had to sell a large proportion of their outputs to the international market. As a result, much of China's FDI was associated with exports (Sun, 1996; Zhang and Song, 2000). FDI inflows have contributed to the rapid growth of China's merchandise exports. In 1989, foreign invested firms accounted for less than 9% of China's total exports. By the end of 2003, they provided over 53%. In some high-tech sectors in 2000, the share of foreign invested firms in total exports was as high as 91% in electronic circuits and 96% in mobile phones (Buckley and Chen, 2005; UNCTAD, 2003). The latest data released by the World Trade Organisation (WTO, 2005) indicate that China's total exports in 2004 were $593 billion, and imports $561 billion, both surpassing the respective values of Japan's at $565 billion and $455 billion, making China the third largest trading partner in the world in both exports and imports. China's impressive annual growth in exports at 35% in both 2003 and 2004 was much higher than the world's average of 17% and 21% in nominal dollars.

The close link between FDI and export may give a false impression that MNCs only treat China as a manufacturing centre and do not transfer advanced technologies into the country. In reality, different investors have different motivations in China for FDI. Child and Faulkner (1998) argue that many overseas Chinese and some Japanese investors look for immediate profits through low-cost unskilled labour and land which are scarce resources in their own countries. Isobe *et al*. (2000) suggest that Japanese FDI in China is often resource seeking, with significant concentration on export and high technology. Zhang (2000) argues that the dominant motivation of the EU and US MNCs to invest in China is its huge domestic market which can provide good opportunities for long-term profits.

Whichever is the motivation of foreign investors, they have to consider three important factors in order to succeed in China. These factors include patented technology and know-how, closeness of the supply chain and proximity to clients, corresponding to Dunning's ownership, internalisation and location advantages (OIL). Of these three factors, superior technology and know-how is the most important factor that distinguishes foreign MNCs from domestic firms. Table 2 provides data on invention patents granted in China by domestic and foreign sources. During 1995-2003, invention patents granted in China increased over ten-fold. The number of invention patents granted to foreigners not only was greater but also increased much faster than that granted to domestic firms. Given that FDI constitutes less than 5% of total investment in China, foreign invention patents must have played a disproportionately significant and important role in propelling China's technological advance and knowledge creation.

[Table 2 here]

III. Empirical models and regression results

III.A Model specifications and panel cointegration tests

Previous empirical studies have proved that GDP can be determined by the following variables: labour and capital as basic physical inputs; export, FDI and foreign exchange rate policy as variables of openness; human capital and transportation as internal environmental variables. The following empirical model will include all these variables. Equation (2) is expanded and variables are all taken in natural logarithm as shown in equation (4).

$$y_{it} = \beta_0 + \beta_1 k_{it} + \beta_2 n_{it} + \beta_3 h_{it} + \beta_3 fdi_{it} + \beta_4 \exp_{it} + \beta_5 exc_t + \beta_6 tran_{it} + \beta_7 t + \beta_8 (t * fdi)_{it} + \beta_9 East + \beta_{10} Central + v_{it} \quad (4)$$

Where *i* (i = 1,2, …, 29) and *t* (t = 1979, …, 2003) denote province *i* and year *t*, *k* and *n* capital stock and labour in natural logarithm, human capital *h* = ln (number of students enrolled in higher education/population), *fdi* = ln(FDI/(DI+FDI)), *exp* = ln(Export/GDP), *exc* = ln(real exchange rate), *tran* = ln(equivalent highway mileage per 1000 km^2 of land area), *East* takes the value of 1 for an eastern region and 0 otherwise, *Central* takes the value of 1 for a central region and 0 otherwise.

The definition of FDI in the production model needs careful consideration. Because capital stock is the accumulation of fixed asset investment, which includes both domestic and foreign investments, the production function would be mis-specified if FDI, either measured as a flow or stock, were added as another explanatory variable along with capital stock. To avoid multi-collinearity and double accounting, FDI is defined as the ratio FDI/(DI+FDI). This definition has a clear advantage for discerning whether the role of FDI is different from DI. If they had exactly the same role in the growth process, this ratio would not have any significant effect in the production function. If FDI has a more important impact on production than DI, this ratio will have a positive and significant effect.

In the literature, export, human capital, exchange rate and transportation also have been found to be relevant variables in the production function. Like FDI, export is defined as the ratio Export/GDP instead of the absolute value of export to avoid the problem of multi-collinearity and crowding out the effect of labour and capital on output. Human capital can be defined in different ways, the ratio of the number of students enrolled in higher education over population, the ratio of the number of students enrolled in secondary education over population, or the ratio of the number of students enrolled in higher education to the number of students enrolled in secondary education. This paper chooses the ratio of the number of students enrolled to higher education over population for the reason to be explained below.

It is expected that all the explanatory variables in (4) will have a positive effect on the dependent variable. In particular, if both (*fdi*) and (*t*fdi*) are tested to have a positive and significant effect on y, the proposition that FDI is a mover of production efficiency, tested by the coefficient on *fdi*, and a shifter of the domestic production frontier, tested by the coefficient on *t*fdi*, will be supported.

Data are based on a panel of 29 provinces and municipalities for the period 1979-2003. China has 31 provinces and municipalities, but Tibet is excluded because it did not attract any significant FDI throughout the period. Chongqing became a central municipality out of Sichuan province in 1996. To maintain consistency, data for Chongqing are merged with Sichuan. Two principal data sources are available: *China Statistical Data 50 Years 1949-98* (NBS, 1999) and *China Statistical Yearbook* (NBS, various years, 1999-2004).

Data for GDP are gross domestic product and capital is calibrated below based on investment in fixed assets. All the variables are calculated in 1990 constant prices. GDP is derived from real GDP annual indexes by province. Labour is total labour force in each province. Human capital is the number of students enrolled in higher education in each province divided by its population. Other studies have used the enrolment rate of secondary schooling. In China, Yao and Zhang (2001) have proved that the variations in higher education have a more important impact on economic growth than secondary schooling. In this paper, we have also tried both indicators as human capital and found that higher education has a more important effect on economic growth. FDI is actually used FDI. Export is the total value of exports.

The values of exports and FDI are provided in US dollars in the official statistics. Since they are measured in US dollars, most economic analysts do not bother to deflate the values in current prices into values in constant prices (e.g. Liu, et al., 1997; Liu, 2000). It is important to conduct an appropriate deflation. One relevant deflator is the US consumer price index. The values of trade and FDI in nominal dollars are deflated by this index. The deflated values are converted into equivalent values in RMB by multiplying the value with the official exchange rate in 1990 ($1 = RBM 4.784). Since all the other variables in the model are measured in RBM, it is useful to change these two variables in RBM as well.

Exchange rate is real exchange rate, which is time-variant but location-invariant as all the provinces faced the same foreign exchange rate. Ideally, real exchange rate should be derived from the exchange rates and price indexes of China's main trading partners. However, since RBM follows the US dollar very closely, albeit not pegged to the dollar, only the dollar exchange rate and the US price index are used to calculate the real exchange rate. Real exchange rate is expected to have a positive effect on economic growth because it represents China's competitiveness in international trade and the extent of market liberalisation in the foreign exchange market (Yao and Zhang, 2001; Ding, 1998).

Transportation is measured as the equivalent mileages of railways, highways and waterways per 1000 squared kilometres. Highway is the dominant means of transportation in terms of mileages. The ratios of the lengths of railways, highways and waterways are 1.00/16.84/1.90 at the national level. The simplest way to measure transportation is to add the total lengths of these three different means of transportation (e.g. Liu, et. al., 1997; Fleisher and Chen, 1997). However, the tansportation capacity of one mile of railway is different from that of one mile of highway or waterway. As a result, it is necessary to convert railways and waterways into equivalent highways. The conversion ratios are derived from the volumes of transport per mile by each of the three means of transportation. At national average, the conversion ratios are 4.27/1.00/1.06. In other words, railways are multiplied by 4.27 and waterways by 1.06 to derive their equivalent lengths of highways. This method of conversion may not be perfect as the relative capacity of different transportation means may not be the same in different provinces. However, any possible conversion errors may be small because highways account for a predominant proportion of the total transportation volume.

The most difficult task is the calculation of capital stock as official publications do not provide any data on this variable. Most authors have tried various ways to measure capital stock. This paper follows Yao and Zhang (2001) by assuming the following equation.

$$K_{it} = (1-\delta)K_{it-1} + \lambda I_{it} \quad (5)$$

Where δ is the depreciation rate of capital stock, which is assumed to be 7.5%, and λ is the rate of capital formation from investment in fixed assets I_{it}. λ is assumed to be 95%, meaning a 5% wastage in the capital formation process.[4] Following Yao and Zhang (2001), the initial capital stock K_{i0} is calculated as two times the level of real GDP in the first year of the data period, 1979 in this case, implying a capital elasticity of 0.5 in that year. Given that the initial value of capital stock is relatively small for such a long time period, any other reasonable estimation of the initial level of capital will not have a significant effect on regression results.

Investment includes both domestic investment (DI) and FDI. It is calculated in 1990 prices using provincial price deflators. As price deflators for capital goods are not available, investment can be deflated either by an imputed GDP deflator, or a general consumer price index. As China has a high saving ratio, about 40% of GDP, GDP deflator is considered to be a better proxy of deflator for investment.

One important data issue is about the consistency of two different official publications, *China Statistical Yearbook (Yearbook)*, which is published every year, and *China Statistical Data of 50 Years 1949-98 (50 Years Book)*. Although the *Yearbook* provides more consistent data than the *50 Years Book*, the former does not provide complete data for the earlier years of the sample period. To deal with the inconsistency problem, the following procedure is followed. Firstly, whenever there is a difference between the two publications, data from the *Yearbook* will be used. Secondly, when data have to be taken from the *50 Years Book*, consistency checking is conducted. If abnormal changes of values between years are found, an artificial but reasonable smoothing or adjustment has to be applied.[5] Another problem is the unavailability of FDI data in the earlier years of the data period for some provinces which had little FDI. To avoid the problem of zero values in logarithm, some artificial small values are used to replace zero values. This may not be the best way to deal with such a data problem, but it should have little effect on the final results and have the benefit of keeping many observations in the regressions.[6] Table 3 gives the summary statistics of all the relevant variables to be used for the empirical models.

[Table 3 here]

Equation (4) is estimated in four different models. Three models are estimated with

OLS. The first OLS regression is run with a random effect where no provincial and regional dummy variables are included. In this model, provincial variations in production and production efficiency are left to be entirely explained by the explanatory variables, but the results are not satisfactory because the model does not pass Hausman's test. The preferred model is the second model where two regional dummy variables, East and Central, are included. The third model is to include all the provincial dummy variables using the first province, Beijing, as a benchmark province. As much of the variations in the dependent variable is explained by the provincial dummies, some important explanatory variables (export/GDP and FDI/(DI+FDI) become insignificant.

A number of empirical studies on China using similar datasets have found that all the variables included in equation (4) are non-stationary and integrated of degree 1, or I(1). Using a panel unit root test, Yao (2005) confirms that GDP, FDI, domestic investment, transportation, human capital, international trade are all I(1). The same finding is confirmed by Ljungwall (2006). As a result, a direct OLS estimation of equation (4) may lead to spurious results if the variables in their levels are not cointegrated.

An alternative estimation is by use of the GMM approach through the dynamic panel data estimation technique proposed by Arellano and Bond (1998). One advantage of the GMM approach is that it helps reduce the problems of multicollinearity among the explanatory variables and endogeneity between the dependent and explanatory variables. In the literature, some studies have pointed out that export and FDI may be seriously correlated. In addition, GDP and FDI (as well as export) may have a reversed causal relationship. In equation (4), export is defined as a ratio of export over GDP and FDI as a ratio of FDI over total investments. Although such definitions are intended to reduce the problems of multicollinearity and endogeneity, it is still useful to compare regression results of the GMM approach with those of the OLS regressions. If the results are not fundamentally different, we can be confident that the OLS regressions are not spurious.

A more reliable way to make sure that OLS regressions are not spurious is to test for panel unit roots of all the variables and panel cointegration between the dependent and explanatory variables. Both tests can follow the procedure proposed by Petroni (1999).

The common regression model for panel cointegration test is given in equation (6).

$$y_{it} = \alpha + \delta t + \sum_{j=1}^{M} \beta_j x_{jit} + e_{it}$$
$$\text{for } t = 1, ..., T; i = 1, ..., N; j = 1, ..., M \qquad (6)$$

where the left-hand side variable represents that of equation (4) and the right hand side variables represent all the right hand side variables in equation (4). T is the number of years and M is the number of provinces. Testing whether there is a cointegration vector is the same as testing whether the estimated error term e_{it} is stationary. This is done through testing whether $\hat{\gamma} < 1$, from an auxiliary regression of equation (7).

$$\hat{e}_{it} = \hat{\gamma}\, \hat{e}_{it-1} + v_{it} \qquad (7)$$

Equation (7) can be used to test for the existence of a unit root in any variable if the left-hand side variable in equation (6) is replaced by any variable and the third term in that equation is dropped. Hence, the same programme can be used for both panel unit root and panel cointegration tests. More details of the test procedure are in Petroni (1999).

Pedroni provides four standardised and normally distributed statistics for left tailed tests. This means that a negative value less than –1.96 will reject the null hypothesis of a unit root for a single variable. The results for all the variables involved in equation (4) are presented in Table 4.

[Table 4 here]

All the variables except human capital are found to be non-stationary. The first differences of all the variables are stationary, the results are not reported here to save space. This means that they are all I(1). A cointegration test is conducted for equation (4) and the test results are given in Table 5. All the test statistics except group-ρ show strong evidence of cointegration.

[Table 5 here]

Because equation (4) has passed the panel cointegration test, the long-run static models will not be spurious even although all the explanatory variables are found to be non-stationary. Following Johansen's (1988) testing procedure, a further cointegration test based on the λ_{max} and λ_{trace} statistics indicates that GDP, labor, capital, FDI/(FDI+DI), export/GDP， and human capital form at least one cointegration vector, providing further evidence for a meaningful long-run relationship in the regressions to be presented below.

Table 6 shows the regression results of the four models mentioned above. Most of the estimated coefficients are expected for their sign, size and significance. In particular, let us pay attention to three parameters of great interest: the coefficients on Time, ln(FDI/(DI+FDI)) and time*ln(FDI/(DI+FDI)). In all models, these coefficients are positive and statistically significant except for the time trend in the random effect model and ln(FDI/(DI+FDI)) in the fixed effect model. These results strongly support the two propositions presented at the beginning of this paper. Firstly, FDI plays a more important role than DI in stimulating production efficiency, which is now supported by the positive and significant coefficient on ln(FDI/(DI+FDI)) in all models. Secondly, FDI is also a shifter of the domestic production frontier, which is now supported by the positive and significant coefficient on the product term of a time trend and the FDI variable. It means that over time, FDI helps the domestic economy to move continuously onto a higher steady state of technology. This change in the domestic production frontier caused by FDI is an additional enforcement of the Hick's neutral technological progress represented by the coefficient on a time trend, which is positive and significant in all models except the random effect one.

[Table 6 here]

The second and the fourth models show that the rate of technological progress, without the effect from FDI, is about 3% per annum. With the effect of FDI, the total rate of technological progress is about 3.5-4.3%. This implies that up to 30% of the total technological progress in China could have been due to the effect of FDI. Given that FDI constitutes only 5% of total investment, its contribution to technological progress is highly important for China's economic success over the data period.

Apart from FDI, other variables are also important for China's economic growth. These variables include export, human capital and the real exchange rate. The estimated coefficient on ln(Export/GDP) is significant and positive in all but the fixed effect model. This means that export is a province specific variable. Once all the provincial dummy variables are included, the effect of export is reflected in the dummy variables. It also implies that export is an important factor explaining regional variations in production efficiency. Unlike FDI, the product term of time with export does not have a significant effect (results are not reported). This suggests that export can be used to stimulate production efficiency but it cannot become a shifter of the domestic production frontier. This result is easily apprehensible. Export is a dynamic force for improving the competitiveness of domestic firms but not embedded with advanced technologies from MNCs.

Human capital is another important variable. The estimated coefficient is positive and significant in all but the GMM model. If the ratio of higher education enrollment to population rises by 1%, the level of production will increase by 0.034-0.055%. Given that higher education has developed dramatically in China, human capital must have played a critical role in its economic progress. Real exchange rate reflects the extent of openness in the foreign exchange market. RMB used to be overvalued in the earlier years of economic reforms, and hence an important disincentive for foreign investors and exporters in China. The gradual devaluation of RMB improved China's international competitiveness. As a result it is expected to have a positive effect on economic growth. The regression results in Table 6 confirm this expectation. Similar result was also found in Yao and Zhang (2001).

Transportation is expected to have a positive effect on economic growth but the coefficient on transportation is not significant in Models 2 and 3, and only significant at the 10% level in Models 1 and 4 in Table 6. There are two possible explanations for the unexpected results on transportation. First, the government has invested heavily from 1998 in transportation and much of the investments have been allocated to the less developed regions. Consequently, the development of transportation may not have been related to the level of economic development at the provincial level. Second, the effect of transportation on economic growth may be dominated by the effects of export, FDI, human capital and real exchange rate. Some auxiliary regressions are conducted to include only the variables of labour, capital and transportation and it is found that transportation is significant and positive.

However, when transportation is included with all these variables, it becomes insignificant. A reasonable explanation is that transportation may not be as an important variable as FDI, export, human capital and foreign exchange in the production model. This is likely to be explained by the 'equalizing effect' of government policy on investment in transportation across regions.

Lastly, it is interesting to examine the values of labour and capital elasticities. Apart from the fixed effect model, the sum of these two values is close to unity, implying a constant return to scale economy. In the fixed effect model, the sum of these two elasticities is significantly less than unity, meaning a decreasing return to scale if all the provincial fixed effects are taken into account. The value of labour elasticity is less than half that of capital elasticity, suggesting that capital is a more important variable than labour.

III.B Regional differences

Rising regional inequality in income and growth between the coastal and inland areas has been an important economic and policy issue in China. It is also an issue of intensive research in the literature regarding its determination and consequence on further economic development. Fu (2004) suggests that exports and FDI are largely concentrated in the coastal areas and have limited spillovers to the inland provinces due to the following reasons. First, exports and FDI may function as engines of growth for the coastal regions but not for the inland regions. Second, exports and FDI may have limited forward and backward linkages because a significant proportion of export and FDI activities are concentrated in the export processing zones which have limited linkage to domestic firms. Moreover, high technology levels are 'enclaved' in wholly foreign owned enterprises or join ventures in which foreign partners hold majority equity shares. Advanced core technologies are often controlled by foreign investors in these firms (Huang 2001; Wang, 2000). Nolan (2002) argues that after more than a decade as a joint venture partner to VW, Shanghai Auto has no capability at all to compete as an independent carmaker. In some extreme cases, Hu and Jefferson (2002) find significant productivity depression rather than positive spillover effects of FDI on domestic firms.

To test whether the above case studies and arguments can be supported, the long-run models are estimated using regional data. Following the tradition of regional division as defined in Table1, equation (4) is re-estimated in four different versions by region. The first version is for the East, the second for the Central and the third for the West. The last model combines the Central and the West together to form the so-called Inland Region as opposed to the Coastal (East) region. The first three models are estimated with random effects and the last model with controlled random effects using a dummy variable for the Central provinces.

Table 7 reports the regression results. The results for the East (Coastal region) are consistent with those of the controlled random effect model in Table 4. All the variables have the expected sign and are statistically significant. One important difference is the values of estimated labour and capital elasticities. At the national level, labour elasticity is less than half of capital elasticity. In the East region model, there is no significant difference between the two, implying that the marginal product of labour in the East is substantially more than that in the rest of the country. Another difference is the estimated coefficient on transportation. At the national level, this coefficient is found to be statistically insignificant, but in the East, it is significant.

It is worth stressing that apart from labour and capital, all the environmental variables, including real exchange rate, human capital, FDI/(DI+FDI) and its product term with time, export/GDP and transportation are all significant at the 5% level or below. As the coefficients on the two FDI-related variables are significant and positive, the results confirm the two propositions presented at the beginning of this paper.

Results of the Central region and the Inland region, which combines both the Central and the West, also show that all the key variables are statistically significant and have the right sign. The only exception is that both export/GDP and transportation are not significant, implying that export/GDP may not be a strong driver of economic growth in the Central provinces. However, two FDI-related variables are found to have the same positive and significant effects in the Central region as in the East and the whole country.

[Table 7 here]

Results of the West region are significantly different from the rest of the country. Most environmental variables are found to be insignificant except for the real exchange rate, export/GDP and the cross term of time with FDI/(DI+FDI). The coefficients on human capital, FDI/(DI+FDI), time, and transportation are all insignificant, implying that there is little domestic technological progress, that human capital and transportation are still two important constraints on economic growth, and that the effects of FDI and exports on economic growth are not as strong in the West as in the rest of the country.

The significant differences of regression results between the Central and West regions suggest that they are not a homogeneous group of provinces. Consequently, earlier studies which treat both regions as one homogeneous group may lead to misleading conclusions about the effects of FDI and export on economic growth. Nonetheless, despite the significant differences in the estimated coefficients of the explanatory variables among regions, it is important to stress that even in the West, export and FDI are found to have a significant impact on economic growth. This finding is different from the conclusion drawn by Fu (2004) who suggests that FDI and exports have little effect on economic growth in the inland region. The difference of the finding in this paper and that of Fu may be due to the use of different data and models. This paper emphasises the role of FDI as a mover of production efficiency and a shifter of the host country's production frontier. The regional level regressions suggest that the propositions are supported in both the East and the Central regions, and provide evidence that FDI is also a shifter of the local production frontier although it may not be a mover of production efficiency in the West region. One possible explanation is that the volume of FDI in the West is still small and it may take time for FDI to become an important and integrated part of local production. This finding has important policy implication on regional economic development.

The effects of explanatory variables on output are different across regions. The key differences can be summarised as follows. First, as two basic physical inputs, labour and capital play a rather different role in production. In the East, output is less elastic with respect to capital than in the rest of the country, implying that labour may be a constraint on economic growth. In the Central and West regions, output is twice as responsive to capital as to labour, implying that they have relative abundance of labour supply and scarcity of capital. The significant difference of labour and capital elasticities between regions implies that there exist barriers to free factor mobility in China among regions although there is evidence that labour migration from the inland to the coastal region takes place in large scale. Second, human capital plays a more important role in the East and Central regions than in the West, suggesting that economic growth in the latter was hampered by the lack of human resources, either due to emigration, or the fundamental deficiency of education caused by poor economic conditions. Third, technological progress caused by domestic innovation and knowledge is much faster in the East than in the Central, and faster in the Central than in the West. On an annual basis, the Hick's neutral technological progress was 2.8% in the East, 1.1% in the Central and 0.1% in the West. FDI-induced technological progress was about 1% in the East, 0.7% in the Central, and 0.2% in the West. Fourth, FDI helped the East and Central regions to improve their production efficiency but not the West. Export helped improve production efficiency in the East and West but not in the Central. It is worth noting that unlike FDI, export did not help shift the production frontier in all regions, confirming the theoretical discussion outlined in Section I. Finally, transportation plays an important role in the East but not in the other two regions. This implies that transportation is a key factor of production in the advanced region but still underdeveloped in the poor areas, pointing out the importance of infrastructure development in the inland provinces.

IV. Conclusions

This paper presents a theoretical framework to study the role of FDI in economic growth from the perspective of a newly industrialising economy. It presents two important propositions which have not been considered in the economic literature. First, FDI is a mover of production efficiency in the host economy. Second, FDI is a shifter of the steady state of the host country's production frontier.

As the largest and fastest industrialising economy in the world, China has maintained a long period of rapid economic growth. China's economic miracle over the past decades has been due to its open policy featuring with large inflows of FDI and exports. As a result, China provides an ideal example to test for the hypotheses.

The empirical models are based on an augmented Cobb-Douglas production function, which includes two basic input variables, labour and capital, and a set of environmental variables. FDI is calibrated into the production function along with export, human capital, transportation and the real exchange rate.

All the explanatory variables are found to have the expected results and output is positively influenced by labour, capital, export, FDI, human capital and real foreign exchange rate. At the national level, FDI as a proportion of total investment and its cross term with a time trend are found to have a significant and positive effect on production. In particular, it is important to note that technological progress played an important part in China's economic growth, contributing 3.5-4.3% of aggregate economic growth on an annual basis. FDI contributes up to 30% of total technological progress. Given that FDI constitutes about 5% of total investment, its contribution to gross technological progress in China is a potent support to the second proposition that FDI is a shifter of China's production frontier over time.

The models are also estimated using regional level data to see whether there are different effects of FDI and other environmental variables on economic performance across regions. Although the regression results disapprove that FDI and export have little impact on economic growth in the inland regions, there are strong evidences that the impact of FDI, export, transportation, human capital, technological progress on economic performance was asymmetric across regions. Most environmental variables (human capital, transportation, export and FDI) are found to have limited impact on production in the West region although FDI is found to have some effect on its technological progress.

The regional difference in technological progress deserves attention for both policy making and academic research. There exists a two-steps 'water-fall' shape of technological progress in China, starting from the highest level in the East, plummeting by more than a half to the Central and almost grounding to a halt in the West. The annual growth of technological progress, including both domestic and FDI-induced, was as high as 4% in the East, but less than 2% in the Central and less than 0.2% in the West. The real problem is not because FDI causes the widening gap between the East and the Inland areas, but because FDI has played a much less significant role in the latter than in the former. As a result, policy should not discourage export and FDI to move away from the Inland area, especially the West. Instead, inland provinces should be encouraged and supported to attract more FDI and stimulate exports. To achieve the full potential of FDI, conditions have to be created. Such conditions as education and transportation are essential, but other policies such as inter-regional migration and cross-regional investments are also important in the long match to reduce inter-regional disparity in income and production in China.

Endnotes

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1. The People's Bank of China decided to appreciate the value of RMB by 2% against the US dollar in July 2005. Before that, RBM was closely linked to the dollar although it is not entirely pegged with it. From July 2005, the central bank claimed that RMB would be adjusted based on a basket of hard currencies, rather than the dollar alone. In really, RMB has never been officially pegged to any currency or a basket of currencies.

2. In his visit to Japan in May 2006, Bo Xilai claimed that China's exports of textiles and garments were damaged by the appreciation of RMB against the dollar by over 3% in the past year. Since the profit margin of the Chinese textile industry was low, about 5%, even a relatively small appreciation of RMB will hurt China textile exports. However, Mr Bo did not mention whether the change in the exchange rate had hurt the exports of other industries. In 2005 and the first five months of 2006, China was still able to produce large trade surplus.

3. Some recent studies suggest (e.g. Love, 2003) that some type of FDI outflow is technology sourcing rather than exploitation. In other words, outward investments are used to acquire technology from rather than transfer technology to the host country. Lenovo's acquisition of IBM and Nanjing Automotive's acquisition of MG Rover can be regarded as China's technology sourcing strategy through direct foreign investments.

4. It is simplistic and somewhat naïve to assume constant depreciation and capital wastage rates throughout the data period and across all regions. An ideal solution should be to calibrate various rates for different years and regions but available data do not permit such exercises. An alternative approach is to do some sensitivity analyses to see whether

various depreciation and wastage rates may affect regression results. Such analyses were conducted and the results were robust, say if we change the depreciation rate from 7.5% to 5%, and the wastage rate from 5% to 10%. The main explanation for the robustness is probably due to the large scale of investments in China, making any small proportional changes in depreciation or wastage not significantly sensitive to regression results.

5. In the *China Statistical Data of 50 Years 1949-1998 (NBS, 1999),* there are a few places where figures looks spurious. This is obviously due to the compilation errors in the book. If we encounter such errors, we will examine the data in the neighbouring years or regions to derive reasonable estimates consistent within the relevant time series. Similarly, there are missing values in some places and we have to examine neighbouring figures so that reasonable estimates are made to fill in the gaps of the missing data points. For instance, if one data point on variable Y is missing in 1985 in province X, but we have data of variable Y for all the other years before and after 1985 in province X, we will take the average value of the figures three years before and three years after 1985 to represent the value in 1985. The number of missing and spurious values is very small (less than 2%) in the entire data set, but without correcting such data errors, some regression results could be ridiculous.

6. One referee suggests that we drop data in those years which do not have FDI for all individual provinces. This is a very valuable suggestion but it implies that we have to exclude 7 years data from the sample. To test whether the results are significantly changed, we used two different data samples, one covering all the years as presented in this paper and the other only for 1986-2003. The results derived from these two samples using the same models are not much different, especially the effects of the key variables (FDI and other environmental variables) remaining essentially unchanged. This implies that the way we have treated FDI in this paper is acceptable with an obvious advantage that it gains many more data points which are useful in different model specifications, especially for the regional models where the sample size would be too small if we eliminated many years from the data set.

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Figure 1 Production frontiers of A and B, and the role of FDI in B

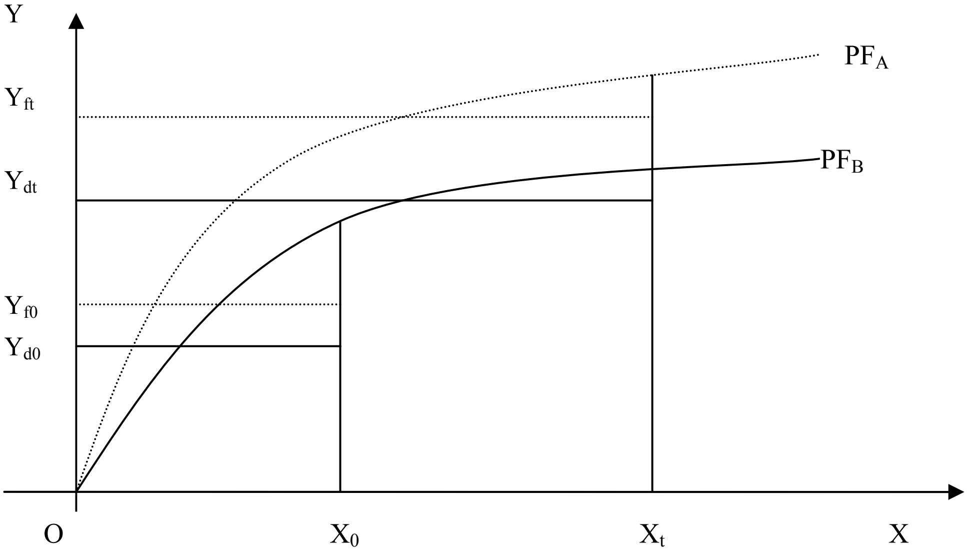
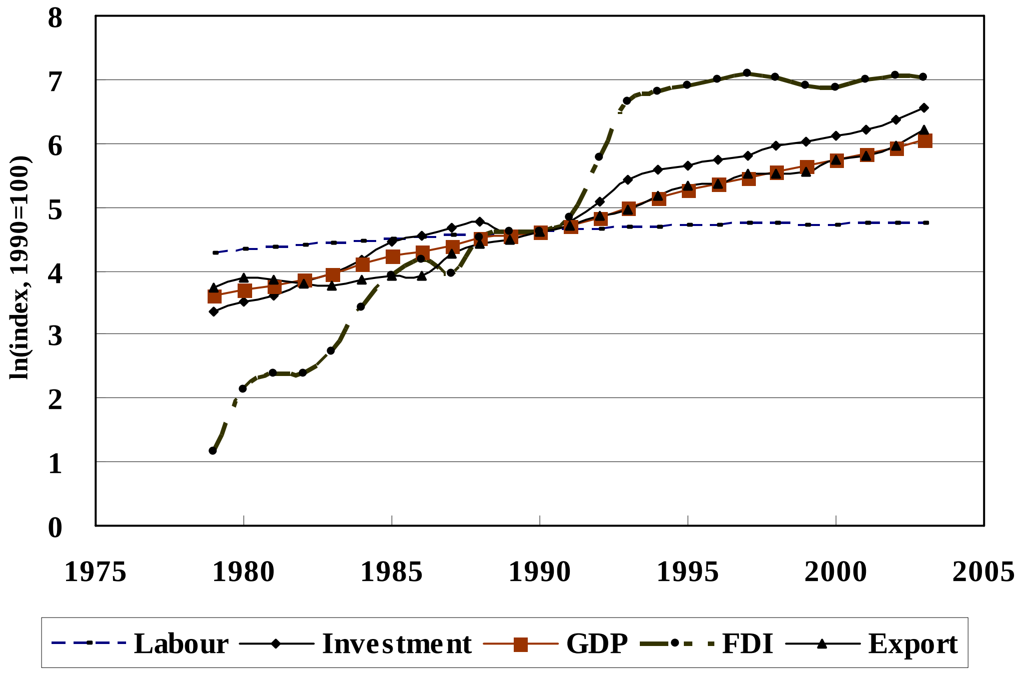


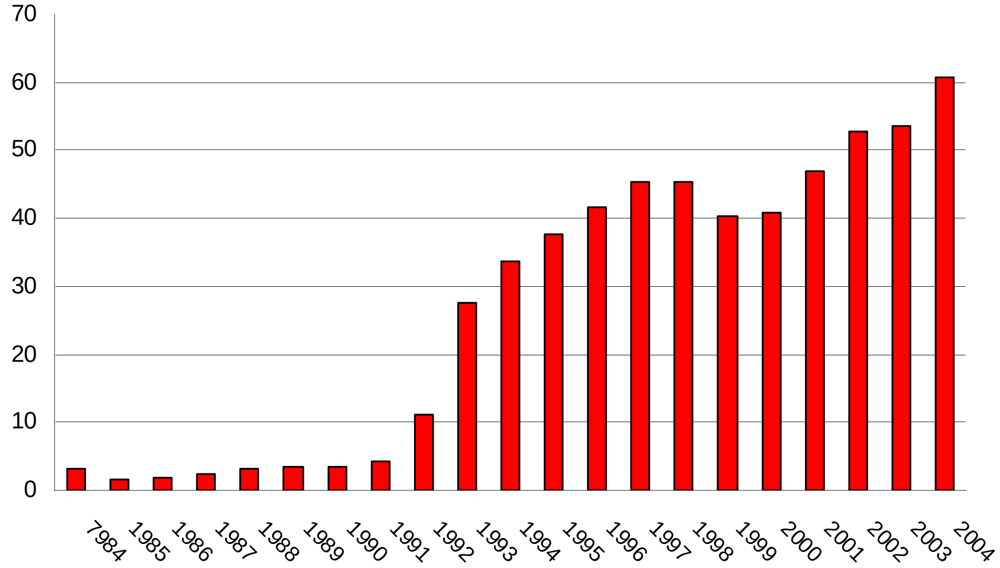
Figure 2 Trends of real GDP, investment, export and FDI in 1979-2003



Notes: FDI in this figure and throughout this paper refers to the actual use of FDI, which is different from contracted FDI and excludes foreign loans and portfolio investments.

Sources: *China Statistical Data for 50 Years 1949-98* (NBS, 1999) and *Statistical Yearbook of China* (NBS, 1998-2004, various issues).

Figure 3 FDI inflows in China, 1979-2004 ($billion)



Source: *China Statistical Yearbook,* NBS, 1987-2004

Table 1 Economic growth in China 1979-2003 (yuan, 1990 prices)

	GDP per capita in 1990 prices			Annual Growth rates (%)		
provinces	1979	1992	2003	1979-92	1992-03	1979-03
Beijing	2156	5441	13132	7.38	8.34	7.82
Tianjin	1898	4189	13237	6.28	11.03	8.43
Liaoning	1267	3194	8304	7.37	9.08	8.15
Shanghai	3030	7213	19054	6.90	9.23	7.96
Jiangsu	767	2788	9945	10.44	12.26	11.27
Zhejiang	713	2937	11000	11.51	12.75	12.08
Fujian	600	2340	8466	11.04	12.40	11.66
Shandong	712	2360	8440	9.65	12.28	10.85
Guangdong	780	3467	10770	12.16	10.85	11.56
Guangxi	586	1367	3636	6.73	9.30	7.90
Hainan	617	2459	5406	11.22	7.42	9.46
Hebei	703	1833	5876	7.65	11.17	9.25
East China	877	2768	8961	9.24	11.27	10.17
Shanxi	746	1709	4376	6.58	8.93	7.65
Inner Mongolia	618	1727	4891	8.22	9.93	9.00
Jilin	737	2043	5569	8.16	9.55	8.79
Heilongjiang	1056	2263	5586	6.04	8.56	7.19
Anhui	518	1309	4184	7.40	11.14	9.10
Jiangxi	549	1369	4152	7.28	10.61	8.79
Henan	449	1282	3800	8.40	10.38	9.30
Hubei	697	1797	5482	7.55	10.67	8.97
Hunan	637	1454	3947	6.56	9.50	7.90
Central China	633	1573	4489	7.25	10.00	8.50
Sichuan	525	1360	3583	7.60	9.20	8.33
Guizhou	367	914	2015	7.27	7.46	7.35
Yunnan	487	1394	3139	8.43	7.66	8.08

Shaanxi	517	1395	3466	7.93	8.63	8.25
Gansu	505	1229	3029	7.08	8.55	7.75
Qinghai	805	1706	4051	5.94	8.18	6.96
Ningxia	661	1530	3463	6.67	7.71	7.14
Xinjiang	713	2243	4647	9.22	6.85	8.12
West China	514	1364	3292	7.80	8.34	8.05
All China	711	2036	6151	8.43	10.57	9.41

Sources: *China Statistical Data for 50 Years 1949-98* (NBS, 1999) and *Statistical Yearbook of China* (NBS, 1998-2004, various issues).

Table 2 Invention patents granted in China

Year	Domestic (000)	Foreign (000)
1995	1.53	1.86
1996	1.38	1.59
1997	1.53	1.96
1998	1.66	3.08
1999	3.10	4.54
2000	6.18	6.51
2001	5.40	10.90
2002	5.87	15.61
2003	11.40	25.75

Source: NBS (2004), *China Science and Technology Statistical Yearbook*.

Table 3 Summary statistics (25 years, 29 provinces, 1979-2003)

Symbols	Definition	Minimum	Maximum	Mean	S.D.
y	Ln(GDP)	7.863	13.661	11.003	1.090
k	Ln(capital)	8.525	14.204	11.545	1.039
n	Ln(labour)	0.382	4.020	2.645	0.853
fdi	Ln(FDI/(DI+FDI))	-5.108	3.810	0.182	1.961
exp	Ln(Export/GDP)	-0.746	4.467	1.981	0.908
h	Ln(human capital)	-3.110	1.138	-1.469	0.814
exc	Ln(Real exchange)	0.616	1.832	1.466	0.314
tran	Ln(Transport)	2.699	7.357	5.572	0.877
*t*fdi*	*time*fdi*	-56.990	66.930	10.092	23.968
*t*exp*	*time*exp*	-1.312	97.488	24.950	18.265

Notes: S.D. = standard deviation. All the values are measured in 1990 prices in million RMB (GDP, capital, FDI, DI, export); in percentage (FDI/(DI+FDI)), Export/GDP, human capital (higher education enrollment/population); in million people (labour); in km/1000KM^2 (transport); and in yuan/$ (real exchange rate).

Sources: *China Statistical Years Book* (NBS, 1999-04, various issues), and *China Statistical Data of 50 Years 1949-1998* (NBS, 1999).

Table 4 Panel unit root tests for individual variables (29 provinces,1979-2003)

	Levin-Lin ρ	Levin-Lin t-ρ	Levin-Lin ADF	IPS ADF
Capital assets	2.21	6.15	3.65	5.66
Human capital	-3.12	-5.10	-0.88	-0.65
Employment	2.55	2.01	2.78	4.11
Exports/GDP	2.13	1.49	2.11	2.32
FDI/(DI+FDI)	-0.61	1.11	2.09	-1.00
GDP	3.22	4.33	7.16	9.02
Transportation	4.16	4.04	5.22	5.92
Exchange rate	0.80	3.12	3.03	2.23

Notes: Human capital = enrolment rate of higher education students as a proportion of secondary school graduates. The critical value is –1.96 to reject the null hypothesis of a unit root at the 5% significance level as all the statistics are left-tailed tests.

Table 5 Cointegration tests for the empirical model, equation (4)

Panel-pp	-1.14
Panel-ADF	-1.28
Group-ρ	-2.03
Group-pp	0.61
Group-ADF	-0.32

Notes: The critical value is –1.96 to reject the null hypothesis of no cointegration at the 5% significance level as all the statistics are left-tailed tests.

Table 6 Panel data Regression results (29 provinces, 1979-2003)

	Random effect model		Controlled random		Fixed effect model		Controlled GMM	
	Beta	t-values	Beta	t-values	Beta	t-values	Beta	t-values
Constant	1.084*	6.5	1.868*	10.7	3.460*	11.4	1.995*	3.6
ln(labour)	0.258*	22.2	0.298*	25.6	0.208*	5.9	0.310*	4.6
ln(capital)	0.726*	47.4	0.657*	41.2	0.512*	23.1	0.652*	11.9
ln(real exchange rate)	0.049*	7.4	0.039*	6.2	0.041*	7.4	0.039*	4.5
ln(human capital)	0.034*	4.5	0.055*	7.3	0.050*	4.9	0.021	1.2
ln(FDI/(DI+FDI))	***0.015****	***2.2***	***0.019****	***2.8***	***0.010***	***1.6***	***0.026****	***2.6***
time trend	***0.002***	***0.3***	***0.030****	***3.1***	***0.022****	***8.6***	***0.031****	***3.1***
time*ln(FDI/(DI+FDI))	***0.058****	***8.0***	***0.043****	***6.2***	***0.053****	***8.9***	***0.021****	***2.0***
ln(export/GDP)	0.036*	6.2	0.026*	4.3	0.004	0.7	0.031*	2.5
ln(transport)	0.003	1.6	0.024	0.5	0.015	0.6	0.038	1.7
East	No		0.057	8.1	No		0.223	2.2
Central	No		0.049	10.6	No		0.072	1.5
Provincial dummies	No		No		Yes		No	
Diagnosis	Adj-R^2=0.992		Adj-R^2=0.993		Adj-R^2=0.996		Wald test (p=0.00)	

				Sargan test (p=0.00) First-order (p=0.17) Second-order (p=0.98)

Notes: (1) Dependent variable = ln(GDP), '*' signifies significance at 5% critical level or below. (2) DI = domestic investment, FDI = foreign direct investment. (3) The first three models are run in OLS and the last model is run in DPD, using the following instruments, labour (2,3), capital (2,3), labour(-1), capital(-1), ln(FDI/(DI+FDI)), ln(human capital) and ln(transport). (4) East and Central are dummy variables for the east and Central provinces of China, regional definitions are in Table 1. (5) All the variables are measured in constant 1990 prices.

Sources: NBS (1999) *China Statistical Data 50 Years*; and NBS (1999-2004) *China Statistical Yearbook* (various issues).

Table 7 Panel data regression results by region, random and controlled effect models

	East region		Central region		West Region		Central&West Regions	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
Constant	2.355*	9.5	1.953*	6.3	1.328*	3.9	1.722*	6.9
ln(labour)	0.548*	20.2	0.339*	10.4	0.365*	12.9	0.357*	16.7
ln(capital)	0.515*	17.4	0.695*	24.1	0.732*	22.2	0.705*	29.4
ln(real exchange rate)	0.112*	3.5	0.147*	3.9	0.166*	4.5	0.164*	5.6
ln(human capital)	0.084*	6.3	0.108*	4.8	0.010	0.6	0.068*	4.5
ln(FDI/(DI+FDI))	***0.013****	***2.4***	***0.040****	***2.5***	***-0.001***	***-0.1***	***0.019****	***2.2***
time trend	***0.028****	***5.1***	***0.011****	***2.1***	***0.001***	***0.3***	***0.010****	***2.9***
time*ln(FDI/(DI+FDI))	***0.051****	***3.5***	***0.043****	***3.4***	***0.011****	***1.9***	***0.035****	***4.8***
ln(export/GDP)	0.048*	5.3	0.013	0.8	0.028*	3.7	0.015*	2.5
ln(transport)	0.057*	5.2	0.001	0.1	-0.033	-1.5	-0.028	-1.1
Central	----	----	----	----	----	----	0.059*	9.4
Diagnosis	Adj-R^2=0.994		Adj-R^2=0.990		Adj-R^2=0.995		Adj-R^2=0.993	
	T=24		t=24		t=24		t=24	
	n=288		n=216		n=192		n=408	

Notes: (1) Dependent variable = ln(GDP), '*' signifies significance at 5% critical level or below. (2) DI = domestic investment, FDI = foreign direct investment. (3) All models are estimated with random effect, or controlled random effect (for the Central & West regions combined). Central is a dummy variable for the Central provinces of China, regional definitions are in Table 1. (5) All the variables are measured in constant 1990 prices.

Sources: NBS (1999) *China Statistical Data 50 Years*; and NBS (1999-2004) *China Statistical Yearbook* (various issues).