Major Research Paper 2003-11

International Technology Spillovers and its Effects on China's Economic Growth

Seung Rok Park
Xinzhong Lee

KOREA ECONOMIC RESEARCH INSTITUTE

International Technology Spillovers and its Effects on China's Economic Growth

ISBN 89-8031-283-0

KOREA ECONOMIC RESEARCH INSTITUTE

FKI bldg., 28-1 Yeouido-dong, Yeongdeungpo-gu
Seoul, 150-756, Korea
Tel: (82-2)3771-0001
Fax: (82-2)785-0270~3

Preface

FDI into China has increased dramatically since 1978 when the government took special effort to open her doors to foreign investors. Only a quarter of a decade after, China has become the largest host country of FDI in the world. The impact of FDI inflows into China has been enormous and it is widely believed to be an important driving force behind the country's rapid economic growth.

Accompanying China's phenomenal growth, there has been a large volume of research that attempts to understand the main channels through which FDI have fostered China's economic growth? One approach is to emphasize technological spillovers of FDI to China, and this has recently become a very topical issue.

Specifically, following further market opening in the 1990s in China, it has become all the more important to better understand the externalities generated by FDI, especially in the terms of technological spillovers. In addition to capital inflows accruing to a host country brought by FDI, the potential and important benefits from FDI is its effects on economic growth in the host country, which depends much on whether foreign R&D can be transferred to local enterprises by FDI inflows and trade inflows.

However, despite the large number of studies, the relationship between FDI and technological spillovers in China has not yet been clearly defined. In this sense, this study entitled “International Technology Spillovers and Effects on China’s Economic Growth” attempts contribute to current literature by investigating the effects of technological spillovers of FDI on productivity and output of China’s provinces from both the theoretical and empirical perspectives. This paper begins by measuring China’s productivity at the provincial level using a translog production function, and then estimates the extent of technological spillovers through import-embodied and employee-embodied FDI inflows, as well as domestic R&D and human capital by measuring the change of total factor productivity(TFP) in China’s provinces. Variations in the models are used to show the effects of technological spillovers on productivity and output in China’s provinces.

This research is the joint effort of Dr. Seung Rok Park, a senior research fellow here at KERI, and Dr. Xinzhong Lee, a visiting Chinese researcher to KERI. I would like to express my gratitude to both for their enormous efforts in completing this study, which I believe that this study will be a good contribution to the various FDI and international trade studies regarding the international diffusion of technology in China. However, The views expressed here are those of the authors and do not necessarily represent the views of the Korea Economic Research Institute as a whole. However, the views expressed here are those of the authors and do not necessarily represent the views of the Korea Economic Research Institute as a whole.

Contents

Preface 3

Ⅰ. Introduction 11

Ⅱ. Literature Review of Previous Studies 14

Ⅲ. Technological Spillovers from FDI Enterprises and its Effects on Economic Growth 21

1. Review of Economic Growth Theories / 21
2. Role of Foreign Direct Investment in the Economic Growth / 23
3. Technological Spillovers from FDI Enterprises / 25

Ⅳ. Statistical Methodology 31

1. Measuring of Productivity in China's Provincial Data level / 31
2. Modeling of Effects of Technology spillovers from FDI on TFP and Economic Growth / 35
3. Data Description / 38

Ⅴ. Main Empirical Results of Models 40

Ⅵ. Conclusions 52

Appendix 54

References 78

Abstract 82

List of Tables

<Table 1> Estimation results of translog production function considering total fixed asset investment containing foreign and domestic fixed Asset Investment / 41

<Table 2> Estimation results of total factor productivity for China's provinces / 42

<Table 3> Effects of domestic R&D and technology spillovers of international R&D on productivity / 45

<Table 4> Effects of domestic and international R&D on output / 47

<Table 5> Effects of domestic R&D and technology spillovers of international R&D on productivity adding the interactive term / 49

<Table 6> Effects of domestic and international R&D on output adding the interactive term between human capital stock and FDI inflows stock / 51

International Technology Spillovers and its Effects on China's Economic Growth

Seung Rok PARK / Xinzhong LEE

◆ Seung Rok PARK

- Senior Research fellow at KERI
- e-mail psr@keri.org
- Homepage http://www.parksr.net
- Tel. +82-2-3771-0027
- Fax. +82-2-785-0272
- Address 12th Fl., FKI Bldg., 28-1 Yeouido-dong, Yeongdeungpo-gu, SEOUL 150-756 KOREA

◆ Xinzhong LEE

- Visiting Scholar at KERI

Ⅰ. Introduction

Technological spillovers of Foreign Direct Investment(FDI) to host country have recently become a very topical issue. Recent literature has attempted to understand better the determinants of the size and scope of spillover benefits to host countries among developed, developing and transition economies. However, a clear and consistent theory has yet to appear. Nonetheless, a clear understanding of the determinants of FDI technological spillovers and benefits is very important to policymakers of countries that aim to introduce FDI. The purpose of this study is to shed light on the FDI process and construct a framework to analyze the determinants of scope and magnitude of FDI technological spillovers to host countries.

In the case of China, following market opening in the 1990s, it has become very important to understand the externality features generated by FDI, especially in the form of technological spillovers. Besides the benefits of capital inflows accruing to a host country brought by FDI, the positive effects of FDI on economic growth in the host country is determined by whether foreign R&D can be transferred to local enterprises by FDI inflows and trade inflows. This study attempts to investigate the evidences towards the recognition of technological spillovers. The main channels of technological spillovers are considered such as labor-embodied and import-embodied FDI stock as well as domestic R&D expenditures and international trade.

This paper begins by measuring China's productivity at the provincial level using the translog production function, and then estimates the extent of technological spillovers through import-embodied and employee-embodied FDI inflows as well as domestic R&D and human capital. Later, models are constructed to show the effects of technological spillovers on productivity and output in China's provinces. Our study finds strong evidences that labor employed by foreign enterprises, human capital stock and domestic R&D have positive effects on productivity. But, domestic imports and FDI imports are found to have negative effects on productivity over the periods 1996 to 1999, and 2000 to 2001, hence very limited positive effects were evident. With regards to output effects of input factors, all variables were found to have robustly positive effects on Chinese provincial output. A robustly negative effect of imports-embodied in FDI inflows on final output was found. However, imports-embodied in FDI inflows have showed strong positive effects on output in recent times, for the period 2000 to 2001, suggesting that components of imports of domestic and foreign enterprises may have changed.

The remainder of this paper is organized as follows: Section 2 discusses recent studies and literature on international technological spillovers. Section 3 analyzes and summarizes the theories and interactions of technological spillovers and growth. Section 4 presents the methodology of measuring productivity, effects of technological spillovers on productivity and output of China's provinces. Section 5 describes the data sets for empirical analysis in the studies. Section 6 presents the empirical results of our econometric estimation, and Section 7 concludes.

Ⅱ. Literature Review of Previous Studies

Emma Xiaoqin Fan(2002) summarizes the main findings and missing aspects in existing studies involved on the effects of technological spillovers of FDI inflows in China including FDI patterns as well as determinants and impacts on growth. In general, evidences show that FDI has been beneficial to China's economic development, especially in terms of capital formation, output and income generation, and growth of exports. However, by investigating the technological transfer and adaptation in 36 FDI firms in the Dalian province of China, most FDI firms, except parts of FDI firms engaged in the transfer of advanced technology, have largely had relatively little impact in the transfer of advanced technology in real estate, commercial, tourism-related FDI, as well as labor-intensive manufacturing industries. The last category has been regarded as a low-level technologilcal field classified by the government as "non-productive". Despite the large number of studies, the relationship between FDI and technological spillovers in China is far from being clearly defined. In addition, due to difficulties in obtaining good sample data sets, the applicability of the derived conclusions by the small sample size is rather limited. Moreover, there have only been a few studies based on in-depth quantitative analysis in China;

most have been descriptive in nature and are helpful to gaining an intuitive understanding on the relationship between FDI and spillover effects.

J.F. Brun(2002) explored the existence of regional growth spillover effects as expected by Deng Xiao Peng's policy by using panel data for the period 1981-1998. He examines whether the growth of coastal provinces have affected the growth of inner provinces. The derived results showed that the spillover effects from growth of eastern provinces have been very limited, and waiting for spillover effects to sufficiently reduce disparities between Chinese provinces in the short run is not a wise choice.

Lee Branstete r(2000) examined the knowledge spillovers from Japan's FDI firms in the U. S. His research focused on the form of patent citations to measure the importance of FDI in mediating flows of knowledge spillover. The obtained evidences supported the proposition that FDI was indeed a significant channel of knowledge spillovers, both from investing firms to indigenous firms and from indigenous firms to investing firms. The results are quite different from the other micro-level studies. His work also showed that if the establishment of foreign-affiliated rivals in domestic markets increased the opportunity for knowledge spillovers, but also reduced the domestic firms' ability to appropriate the benefits of these knowledge spillovers through higher prices or higher sales volumes, then a TFP-based approach may fail to measure positive knowledge spillovers. Based on data sets at the firm level, Branstete r tested the hypothesis that FDI was a channel of knowledge spillovers for Japan's MNCs(multinational corporations) undertaking direct investment in the U.S. Results of the model showed that FDI increased the flow of knowledge spillovers both from and to the investing Japanese firms. Thus, FDI generally led to increased knowledge inflows in both directions. In some specifications, the impact of acquisition on knowledge flows from the Japanese parent firm to the American firm was actually larger than the corresponding impact of green-field investment.

Sarah Yueting Tong(2001) examined the effects of FDI and foreign technology on local Chinese firms. The empirical results indicated that knowledge inflows carried out mainly through FDI was an important conduit in promoting Chinese firms' exports. Furthermore, foreign knowledge was likely to increase local firms' total employment and production, especially in the short-run, and local non-affiliate firms could benefit through business dealings with those firms directly associated with foreign businesses. The possible contributing factors related to technology spillovers of FDI are mainly from such competition of domestic firms and enhanced education level of employees.

Brian J Aitken and Ann E. Harrison(1999) examined the effects of FDI firms on domestic firms in Venezuela using panel data at the plant level. The derived results showed that foreign equity participation was positively correlated with plant productivity(the "own-plant" effect). However, the relationship was only robust for small enterprises, while foreign investment negatively affected the productivity of domestically owned plants. Thus, the net impact of foreign investment, taking into account these two offsetting effects, was rather small.

Magnus Blomstrom and Steven Globerman(1999) summarized the main proximate determinants of the “equilibrium” value of technological spillovers, and attempted to identify the magnitude and nature of FDI spillovers by various direct and indirect approaches. The direct approach was to relate productivity measures of host country firms or industries to the extent of foreign ownership in host country, and the indirect approach examined the aspects of interaction between MNCs and host countries such as (1) technology licenses, (2) vertical linkages, (3) “copying” of technology introduced by foreign investors, (4) impact of FDI on host country market structure, especially competitiveness, (5) labor training, and (6) performance of research and development(R&D) by MNC affiliates in the host country. Blomstrom thought that the costs associated with absorbing foreign-developed technology should be negatively related to the technological competence of host country firms, while technological spillovers from MNCs should be positively related to the technological competence of host country firms.

Magnus Blomstrom and Ari Kokko(2001) discussed the relationship between FDI and human capital, and thought that the interaction between the two variables was complex and highly non-linear. Their study showed that FDI inflows created a potential for spillovers of knowledge to the local labor force. Besides, the level of human capital in host country determined how much FDI inflows it could attract and whether host country firms were able to absorb the potential spillover benefits. Especially human capital that was relatively of a high level in host country may be able to attract large amounts of FDI inflows with technology-intensive characteristics.

Yasuyuki Todo and Koji Miyamaoto(2002) examined the knowledge spillovers from MNCs based on data sets at the firm level in developed countries. The derived results did not clearly represent the general consensus on the presence of technological spillovers from MNCs. Todo thought that a possible reason for the mixed results is that active diffusion did not adequately address domestic and foreign efforts. But R&D activities and development of human resources conducted by MNCs stimulated knowledge diffusion from MNCs to firms of host country. In addition, R&D activities carried out by domestic firms also promoted knowledge diffusion from MNCs. Thus, knowledge diffusion from MNCs required domestic and foreign efforts in R&D and development of human resources.

Wilbur Chung(2002) identified technology transfer of FDI in U.S. manufacturing industries through examining the influence of industry conditions and investing firms' motives. The derived results indicated that the relatively less competitive industries experienced productivity growth, but productivity growth stagnated in more competitive industries.

Sonathan E. Haskel and Sonia C. Pereira(2002) examined productivity spillovers from FDI to domestic firms through using plant-level panel data covering the U.K. manufacturing from 1973 to 1992. The results showed that there exist significantly positive effects between domestic plant's TFP and the foreign share of employment in a particular plant's industry. Furthermore, evidences were found showing that FDI spillovers took time to permeate to domestic plants. Nevertheless, no significant effect was found between foreign plant's TFP and the foreign share of employment in the plant's industry.

Ali Ugur(2000) thought that FDI not only had significant direct effects on capital information, employment and trade in host country, but more importantly suggested that there were indirect effects for certain host countries in respect of the change of technological spillovers. Blomstrom also argued that the most important reason behind host country's efforts to attract more FDI today is the desire to acquire modern technology, and the extent of linkages between MNCs and local firms were an important indicator of potential indirect effects of FDI on the host economy. Thus, Ugur thought that the externalities(i.e. productivity spillovers) that MNCs' investment generates enhanced the productivity of indigenous firms. By examining the productivity spillovers from MNCs to local firms in Ireland, he measured the rate and direction of technical change and the extent of technical inefficiency using stochastic frontier production functions.

Donald J.S. Brean and Jerermy a. Ieonard(1998) thought that (R&D) and technological innovations that FDI yields are crucial to economic growth and prosperity, and also argued that R&D would be deficient without government support. Furthermore, tax incentives are thought to be an effective way in inducing more R&D, and the social economic benefits of tax-induced R&D are greater than the cost of the tax-incentive itself. His modeling results showed that nearly 70% of the observed growth of Canadian total factor productivity(TFP) from 1964 to 1986 was due to spillovers generated by U.S. R&D activities. With trade as the vehicle for international R&D spillovers, U.S. R&D efforts are almost as important for Canadian productivity as they are for the U.S. itself.

Simeon Djankov and Bernard Hoekman(2000), by estimating the production function and using TFP as a proxy measure for technology transfer, argue that foreign investment has the predicted positive impact on TFP growth of host firms, and the larger the MNCs is relative to the domestic industry, the easier the learning, which creates strong incentives to transfer technology to subsidiary as profits are expected to higher if more advanced technology is used.

Ⅲ. Technological Spillovers from FDI Enterprises and its Effects on Economic Growth

1. Review of Economic Growth Theories

Since the concept of technological progress was first introduced into neoclassical growth models(Robert Solow, 1956, 1957 and T. Swan, 1956), the knowledge creation and technological progress have been regarded as central determinants of economic growth. However, in the neoclassical model, technological progress has been thought of as an exogenous factor, and also has received only a passing discussion. In addition, another significant feature of the neoclassical model is that the accumulation of labor, capital, and other production factors with diminishing returns to scale or constant returns to scale, allows the economy to converge to a steady state equilibrium, where the level of per capita income is determined by savings and investment, depreciation, and population growth. In such a scenario, there is no permanent income growth. Per capita income growth is thought to occur as the economy moves towards its steady state. On the other hand, increases in savings, investment and reduction in population growth rate shift the economy to a higher steady state income level. From the viewpoints of developing countries, low income and development levels are not only consequences but also causes of low savings and population growth rates. As a result, convergence in per capita income levels cannot occur unless technological progress convergence happens as well. In sum, the neo-classical model stresses the accumulation of capital, broadly defined, as the source of growth. An important prediction of this model is convergence, that is, the tendency for poor economies to catch up with rich ones. However, the model is less interesting in its predictions about long-run economic growth, which depends entirely on unexplained factors, specifically, the exogenous rate of technological progress.

In contrast, modern growth models regard technological progress as an endogenous variable with constant return or increasing return to reproducible factors as a result of the accumulation of knowledge. Thus, knowledge is a public goods to some extent, and R&D, education training, and other investments in knowledge creation is thought to help generate externalities which are the sources of increasing returns to scale for labor and physical capital.[1] Based on these assumptions, an economy may experience positive long-run growth instead of merely converging to the neoclassical steady state where per capita incomes remain unchanged. In sum, the new endogenous growth models focus on the origins of technological change, and stress technological advancement

1) See Romer(1989 and 1990), Lucas(1988) as well as Barro(1995).

amounting to the creation of new ideas. That is, some type of imperfect competition or even monopoly power over new products or processes is seen as necessary for motivating the discovery of better technologies. Numerous models have been developed along these lines, and have collectively been described as "endogenous growth models" because they determine within the model the rate of technological change and, consequently, the economy's long-term growth rate.

2. Role of Foreign Direct Investment in the Economic Growth

Many empirical studies indicate that technological change and transfers are important determinants of economic growth. MNCs are responsible for much of this technological accumulation, yet the neo-classical growth theory rarely acknowledges their important role. FDI does not only influence the long-run growth rate, but also the level of income. An exogenous increase in FDI generally tends to increase the amount of capital and output per person, but this would only be temporary, as diminishing returns on the marginal product of capital would impose a limit on growth. FDI can influence the long-run growth rate only through technological progress or growth of the labor force, which are both considered exogenous. In contrast, in the endogenous growth theories, knowledge and technology are expected to generate growth endogenously. Thus FDI influences economic growth through such variables as R&D and human capital. Via the form of subcontracting, joint ventures and strategic alliances, technological licensing, imports of capital goods and migration, the technological transfer and technology spillovers can occur. Thus, endogenous growth models suggest that FDI can speed up the development of new intermediate product varieties, raise product quality, facilitate international collaboration on R&D, and introduce new forms of human capital. That is, with the firms' accession to finance and a wider range of intermediate products, FDI can increase productivity directly in the foreign investment firms and indirectly in local enterprises through knowledge spillovers. As a result, the existence of technology transfer and local spillovers can prevent the unbounded decline of the marginal productivity of capital suggested in conventional growth theory, thereby making endogenously driven long-term growth possible.

Furthermore, while diminishing returns prevail inside the enterprise, various externalities outside the enterprise can provide the necessary positive feedback to sustain growth in the long run. MNCs can create such positive externalities for the local economy when they transfer new technology and organizational forms directly to their affiliate firms. Thus, the role of FDI in generating these externalities is important to promote growth. Especially, the new intermediate and capital goods in international trade lead to R&D spillovers and higher productivity growth. Some recent evidences show that the composition of imports appears to influence productivity growth, and domestic R&D also has a greater influence on productivity growth than foreign R&D. Recent studies based on the endogenous growth models show that technological transfer and technological spillovers from FDI tend to promote long-run growth, but in some cases this crucially depends on the stock of human capital and the absorptive capacity of firms in host countries. Some empirical studies also indicate that the scale effects found in industrial data show that direct transfer of technology to FDI firms may be more important than spillover effects from FDI firms to the domestic economy.

3. Technological Spillovers from FDI Enterprises

Numerous recent studies show that MNCs play an important role in transferring technology, especially concerning the most advanced countries. Furthermore, the environment of host country is an important factor for the effective diffusion of technology to host economy, and technological spillovers occur directly through linkages with the host country, labor market and degree of competitive pressure.

In general, technological transfers from FDI firms have two-way effect-direct or internal, and indirect or indirect spillovers. The former involves the ownership and control, while the latter concerns other firms in host economy. The two spillovers have positive effects on the diffusion of technology. MNCs can encourage technical change and technological learning directly through the transfer of new technology and organizational skills to their affiliates firms. The absorptive capacity is influenced by such factors as knowledge, skills and experiences of FDI firms and these determine the pace of technological accumulation within the enterprises. These direct effects can appear as changes in productivity, industrial structure, R&D expenditure and the composition of exports.

Technological spillovers can occur between firms that are vertically integrated with the MNCs by the inter-industry spill-overs or in direct competition with it(intra-industry spillovers). These can increase technical change and technological learning in at least four ways: 1) competition with the foreign affiliate can increase intra-industry spillovers by stimulating technical change and technological learning, 2) cooperation between FDI firms and upstream suppliers as well as downstream customers increases technological spillovers, 3) human capital can spill-over from FDI firms to host firms as skilled labor moves between employers, and 4) there is the demonstration or imitation spillovers.

Beside the technology spillovers aspects of FDI as described above, the training of MNCs' employees is also thought to be an important channel of technology spillovers of FDI. General and cognitive skills are particularly important determinant of the amount of training undertaken, since a relatively high level of education reduces the cost of further training while raising expected benefits. Competition is another important factor-firms that are protected from international or domestic competition are less likely to invest in costly training programs.

Productivity and technology spillovers are not automatic consequences of FDI, however. Rather, FDI and human capital interact in a complex manner(through some non-linear relationship between them), where FDI inflows create a potential for spillovers of knowledge to the local labor force, at the time as the host country's level of human capital determines how much FDI it attracts and whether local firms are able to absorb the potential spillover benefits.

However, not all MNCs activities lead to technological transfer and positive spillovers. MNCs can have a negative impact on the direct transfer of technology to FDI firms and reduce spillovers from FDI in the host economy in several ways. Especially, in some cases, FDI firms can even eliminate competition by crowding out the host product. It may also limit exports to competitors and confine production to the needs of MNCs.

In sum, past studies concerning technology spillovers of FDI mainly include the two aspects when identifying the magnitude and nature of technology spillovers. The direct approach is to relate productivity measures of host country firms, as well as the extent of foreign ownership in the host country. The indirect approach is to examine different aspects of the interaction between MNCs and host country residents that are possibly related to FDI spillovers, i.e. the nature of technology spillovers of FDI in host country firms. These natures include aspects as follows:

1) Technology licenses

Host country firms obtain the equivalent of spillover efficiency benefits when purchasing or licensing technology from FDI firms at a cost. By doing so, host country firms presumably gain from improvements in efficiency. In fact, foreign investors appear to regard foreign investment and licensing as direct alternatives. For instance, in China's DVD and VCD manufacturing sector, Chinese firms are required to pay an extra $10 for each DVD or VCD product sold in the international market as a compensation for technology licenses to foreign investors, because Chinese firms do not properly possess the crucial technology of building these products.

2) Vertical linkages

The closer linkages between MNCs and domestically owned firms are presumed to enhance spillovers in the host country. For example, it is presumed that closer commercial ties between MNCs affiliates and "upstream" suppliers and "downstream" customers lead to a greater transfer of technical and commercial information to suppliers and customers. So to an extent, closer vertical linkages are associated with larger spillovers to host country firms.

3) "Copy" of technology introduced by FDI

Related to issues of vertical linkages is the diffusion of technology associated with the early and successful introduction by MNCs affiliates. The successful introduction of new production techniques and new products reduces the subjective risk surrounding the adoption of the innovation and should therefore promote more widespread adoption throughout the population of potential adopters in the host country.

4) Impact of FDI on host country market structure, especially competitiveness

FDI could have important indirect impact by spillover efficiency benefits to the extent that it alters host county's market structures. Nevertheless, the failure to account explicitly for these indirect structural linkages may be a serious liability of existing literature.

5) Labor training

Generally, technology is embodied not only in machinery, equipment, patent rights and expatriate managers and technicians, but also in the human capital of the affiliates' local employees. In fact, MNCs may pay "efficiency wages" to productive employees in their affiliates in order to keep them from "defecting" to domestically owned competitors. For example, the mobility of employees from MNCs in the computer and software industries contributes to spillovers, both within the industry and elsewhere.

6) Performance of research and development(R&D) by MNCs' affiliates in the host country.

A long-standing policy concern about foreign ownership is that MNCs will centralize R&D in the parent company and leave their foreign affiliates to perform a very modest amount of R&D that focuses primarily on modifying the parent company technology for the foreign market. Domestically performed R&D expenditures have been found to generate significant spillover efficiency gains.

Modern growth theory is now largely built on models with constant or increasing returns to reproducible factors as a result of the accumulation of knowledge. The technological accumulations brought by FDI are considered endogenous, thereby differing from the approach of assuming exogenous increase of FDI on growth as in neo-classical models. Hence, technological progress generated by FDI is thought to be an important source of growth in the long run. Specifically, technical change and R&D are the most important determinants of economic growth.[2)]

2) See J. Temple(1999), "The New Growth Evidences", *Journal of Economic Literature,* 37 (1), pp.112-156.

Ⅳ. Statistical Methodology

The framework of models used here are mainly based on approaches in the literature including Ishaq Nadiri and Seongjun Kim's G-7 model(1996) of R&D spillovers integrating trade pattern and return rate of R&D investment, the GNP function approach suggested by Burgress(1974) and Kohli(1978), the technological spillover models proposed by Coe and Helpman(1995), Frank Lichtenberg(2001), Bernstein and Nadiri (1988), Bernstein and Mohnen(1994) and so on. Total factor productivity[3)] is measured by estimating the residual term of the production function.

1. Measuring of Productivity in China's Provincial Data level

Productivity is regarded as the residual of production function, which is used to estimate the effects on economic growth resulting from technological progress. Specification of the production function is used as a determinant in measuring

3) See Seng Rok Park, 2003, "Economic Performance of Korean Firms and Evaluation of Restructuring Tools during Financial Crisis", as well as Lee-in Chen Chiu, 1999, "Determinants of Total Factor Productivity of FDI in China: Implications for East Asia's Capability on International Production".

total factor productivity(TFP). In order to examine production efficiency, scale economies, and technological change, the production frontier approach as developed by Farrell(1957) is also adopted here. The early studies assume the frontier is an important determinant, and a stochastic frontier model is developed.

Based on the characteristics among the different production functions,[4] the translog production function, which is the more general and flexible functional form of Cobb and Douglas' production function(1928, 1934) extended by Christensen, Jorgenson and Lawrence J. Lau(1973), is applied in estimation of productivity in China's provinces. In this study, we use China's provincial panel and cross-section data to estimate production technology in order to examine and compare the effects under different frameworks.

The basic formula of the Cobb-Douglas production function is shown in equation (1).

$$Y = AK^{\alpha}L^{\beta} \tag{1}$$

where, Y denotes annual output of China's provinces; L denotes labor employed; K denotes capital stock. If $\alpha+\beta=1$, then this production technology is considered as exhibiting

4) In the results estimated by these models, not all the derived results are reasonable for interpretations of situations in China's provinces. So we decide to choice the better one from such as Solow model Cobb-Douglas function etc. in the estimated results - translog production function - to measure the productivity of China's provinces, this is mainly based on consideration that translog function has less constraining for the variables of models such as distribution of residual etc. these properties are very suitable to the processing of cross sectional data sets in the studies.

constant returns to scale. A, α and β are parameters determining the production technology, and respectively express scale economies, output elasticity of labor and capital. The general form of this production function may be expressed by equation (2).

$$Ln(Y) = \alpha_0 + \alpha_L Ln(L) + \alpha_K Ln(K) + (1/2)\alpha_{LL}(Ln(L))^2 + (1/2)\alpha_{KK}(Ln(K))^2 + \alpha_{LK}(Ln(K))(Ln(L)) \quad (2)$$

where, α_0 is the output elasticity for input factors used to measure TFP of China's provinces; L denotes labor employed of China's provinces[5] in ten thousand persons; K denotes total fixed asset investment of China's provinces consisting of domestic and foreign fixed asset investment, and is measured in 100 million Yuan RMB; Y denotes the output of China's provinces in 100 million Yuan RMB.

The form of production function above is called the transcendental logarithmic production function, or translog production function. Based on the special properties of this function, it is often used to quantitatively determine technological progress as well as other factors such as the effects of labor, human capital stock and other social capital stock on productivity.

5) This notion is different from the concept "Staff and Workers". Here, the labor employed expresses the persons employed in various units, such as fully-employed staff and workers, re-employed retirees, teachers in schools run by the local people, foreigners and Chinese compatriots(Hong Kong, Macao, Taiwan), part-time employees and employees of other units working temporarily at current posts as well as employees holding the second job, but exclude the staff and workers leaving their working units while keeping their employment relation. Thus, this indicator shows total laborers engaging in production or other operations in various units in China's provinces.

Solow(1957) measured the total factor productivity through examining the residual term of the Cobb-Douglas production function, and pointed out the well-known "Solow Residual term".[6] Recent literature following a similar fashion is Mankiw and Romer (1992). *Y*. Konishi and *Y*. Nishiyama(2002) found interesting relationships via comparing Japanese output elasticities of input factors over the period 1965 to 2001 between the Cobb-Douglas and Translog production function: production technology derived by the translog production function seems to have been changing over time, so that it is thought that not only the parameters, but also the functional form could also be different across time. In contrast, the labor and capital productivity show a surprisingly close mirror image, and the parameter associated with labor has been increasing, while that associated with capital has been decreasing. Their studies show that the Cobb-Douglas production function fits the data well over the time series, and has a clear mirror image, although the model is not assumed to exhibit constant returns to scale ($\alpha+\beta=1$). Because of the variation of the property of production technology over time, modeling of production technology based on the translog production function seems to be more reasonable, and the derived results of the Cobb-Douglas production function seems to be nested in the translog production function. Productivity

6) See Thijs ten Raa(2003), "Debreu's Coefficient of Resource Utilization, the Solow Residual, and TFP: The Connection by Leontief Preferences," *Working Paper Series*, Tilburg University, the Netherlands. For a similar method, see Alain Paquet and Benoit Robidoux(1997), "Issues on the Measurement of the Solow Residual and the Testing of its Exogeneity: a Tale of Two Countries."

derived by the translog production function can be expressed by equation (3) as follows.

$$TFP_i = \exp(Ln(Y_i) - Ln(\hat{Y}_i)) \tag{3}$$

where, $\hat{Y}_i$ is measured by translog production function; Y_i denotes the output of China's provinces with unit 100 million Yuan RMB. TEP_i denotes the total factors productivity estimated by the translog production function.

2. Modeling of Effects of Technology spillovers from FDI on TFP and Economic Growth

In order to estimate the effects of FDI on TFP, we first construct a way to measure technological spillovers from FDI. International technological spillovers have no standard measuring method, and the existing quantitative analysis mainly focuses on the impact of FDI on domestic productivity growth. The measuring of technological spillovers is generally carried out via being either disembodied or embodied in the particular channels(Frank Lichtenberg, 2001). Thus, based on the available data sets in China's provinces, we can capture the technological spillovers of foreign enterprises through using FDI stock weighted the shares of international trade in GDP in host country(Coe & Helpman, 1995) and the shares of employees of foreign enterprises in total employees in host country(Brain J. Aitken and Ann E. Harrison, 1999). That is, FDI imports and employees of foreign enterprises are respectively embodied in

FDI stock so as to measure the technological spillovers of FDI. Domestic technological spillovers mainly are closely associated with domestic R&D expenditures and human capital stock (Duncan Mcvicar, 2002). Then, we can initially make the determinants affecting the technological spillovers, and construct the models of effects of domestic and foreign technological spillovers on productivity and economic growth in China's provinces(See model (4) and (5)). These variables are expected to have positive effects on productivity and output of China's provinces.

$$Ln(TFP_i) = \alpha_1 + \alpha_2 Ln(Drd_i) + \alpha_3 Ln(Dim_i) + \alpha_4 Ln(HC_i) + \alpha_5 Ln(Fimrd_i) + \alpha_6 Ln(Femrd_i) \quad (4)$$

And the effects of technology spillovers on output of China's provinces is as follows:

$$Ln(Y_i) = \beta_1 + \beta_2 Ln(Drd_i) + \beta_3 Ln(Dim_i) + \beta_4 Ln(HC_i) + \beta_5 Ln(Fimrd_i) + \beta_6 Ln(Femrd_i) \quad (5)$$

In order to demonstrate whether the level of accumulation of human capital stock in China's provinces has reached the level to adequately absorb the advanced technology brought and R&D performed by the developed countries via FDI inflows, we add their interactive term into the models. Then, the models of measuring the effects of technological spillovers on TFP and output in China's provinces are as follows:

$$Ln(TFP_i) = \alpha_1 + \alpha_2 Ln(Drd_i) + \alpha_3 Ln(Dim_i) + \alpha_4 Ln(HC_i) + \alpha_5 Ln(Fimrd_i) + \alpha_6 Ln(Femrd_i) + \alpha_7 Ln(Hfdi_i) \quad (6)$$

And then the effects of technology spillovers on output of China's provinces is such as:

$$Ln(Y_i) = \beta_1 + \beta_2 Ln(Drd_i) + \beta_3 Ln(Dim_i) + \beta_4 Ln(HC_i) + \beta_5 Ln(Fimrd_i) + \beta_6 Ln(Femrd_i) + \beta_7 Ln(Hfdi_i) \quad (7)$$

where, TEP_i denotes the productivity in China's provinces; Y_i denotes the output of China's provinces; Drd_i denotes the expenditures of research and development(R&D) of domestic enterprises in China's provinces, and are measured in ten thousand Yuan RMB; Dim_i denotes imports of domestic enterprises in ten thousand dollars; HC_i denotes human capital, which refer to the number of student enrollment in both secondary school and institution of higher education in persons; $Fimrd_i$ denotes the technological spillover of foreign enterprises by importing advanced products and technology or sophisticated equipment, and so on, and is expressed by the shares of imports of foreign enterprises in China's provincial GDP weighted foreign direct investment stock in ten thousand dollars; $Femrd_i$ denotes the technological spillovers generated by domestic workers absorbing the advanced technology through training and learning by doing in foreign enterprises expressed by the shares of employees of foreign enterprises in China's provincial total employment weighed foreign direct investment stock; $Hfdi_i$ denotes the interactive term of human capital stock and FDI stock in China's provinces.

3. Data Description

The data sets in this study are based on China's provincial level, and covers 31 provinces for the period 1992 to 2001. We measure productivity over the period 1992 to 2001 for China's provinces. However, because the data sets on domestic R&D and employment of foreign enterprises over 1992 to 1995 are unavailable, effects of domestic R&D and technological spillovers of foreign enterprises on productivity and output in China's provinces only can be estimated for the latter period of 1996 to 2001. Measuring the technological spillovers follows the approach of Coe and Helpman(1995), Lichtenberg(2000) and Aitken and Harrison(1999), and we also apply import-weighted and employment-weighted FDI inflows stock[7] in controlling for the effects of technological spillovers of foreign enterprises on productivity, and use domestic human capital stock, imports of domestic enterprises and R&D expenditures to depict their effects on productivity of China's provinces. Furthermore, the effects of interacting between human capital stock and FDI inflows stock are applied in measuring the essential conditions of technological spillovers of FDI inflows in China,[8] that is, whether or not human capital stock in host

7) Foreign direct investment inflows stock is measured based on the initial year of 1987.
8) This method of estimation is also used by E. Borensztein and J. De Gregorio(1998) as well as Benhabib and Spiegel(1994) et al. See their paper "How does Foreign Direct Investment Affect Economic Growth", *Journal of international Economics*,

country has reached the level that adequately absorbs the advanced technology from FDI firm to generate technology spillovers. Total fixed asset investment in the models contains domestic fixed asset investment and foreign fixed asset investment.[9] FDI inflows and total fixed asset investment in the models are all regarded as real variables, and the discount factors are also considered in the measure of real total fixed asset investment stock in China's provinces.[10] Human capital stock is based on the measure of the sum of student enrollment in total secondary school containing urban areas, counties and towns, as well as in institute of higher education.

1998, Vol.45, pp.115-135.

9) According to the data level released by national statistic bureau, total fixed asset investment is measured based on the initial year of 1988, which include both foreign and domestic fixed asset investment.

10) The consumer price index and fixed asset investment price index as well as discount value of fixed asset investment are considered in the measure of real variables and stock. These data sets are from www.cei.gov.cn collected and edited by National Statistic Bureau, National Planning Committee and National information Center in China.

V. Main Empirical Results of Models

Table 1 shows the results from the estimation by the translog production function. These derived results show strong positive effects, although not all are statistically significant. That is, nearly all coefficients for both labor and fixed asset investment capital stock in China's provinces have the characteristics of increasing marginal returns to scale from 1992 to 2001 except for the negative coefficient of capital stock in 1998. But, in the panel data analysis, which represents a synthesized result, the estimation indicates that the labor variable initially has features of increasing marginal returns to scale having a positive coefficient of 1.374 and is statistically significant at the 1% level. But this shifts to exhibit decreasing returns to scale having a negative coefficient value of -0.119 for latter periods; fixed asset investment capital stock variable exhibits increasing marginal returns to scale having coefficient 0.609 and 0.018, which are statistically significant at the 1% level. The output elasticities of labor inputs generally are over unity, and that of capital stock inputs are less than unity except for 1993, 1994, and 1995. These results suggest that labor inputs may have had a larger contribution to output than capital stock inputs in China. The former has a larger output elasticity of inputs than the latter. Results of the panel analysis also show similar results. Capital stock inputs in the near middle of the 1990s(1993-1995) have a larger contribution to output than in the late 1990s. The parameters of all the models from 1992 to 2001 as well as the panel model have an acceptable F-statistic and higher adjusted R squared value, which respectively run over 100 and 0.9.

<Table 1> Estimation results of translog production function considering total fixed asset investment containing foreign and domestic fixed Asset Investment

Dependent Variable : $Ln(Y_i)$, Method : Pooled Least Squares.

Variable	β_0	β_L	β_K	β_{LL}	β_{KK}	β_{LK}	Adj.R-sq.	F-statistic
Model92	-3.741[3]	1.082[2]	0.948[2]	-0.110	-0.076	0.022	0.986	403.328
t-Statistic	-3.973	2.309	2.196	-1.081	-0.837	0.327		
Model93	-5.302[3]	1.243[2]	1.241[3]	-0.190	-0.193[1]	0.088	0.981	297.325
t-Statistic	-4.730	2.571	2.986	-1.692	-1.892	1.062		
Model94	-3.277[3]	0.779	1.038[2]	-0.125	-0.141	0.082	0.981	304.218
t-Statistic	-2.917	1.563	2.455	-1.115	-1.501	1.055		
Model95	-3.559[3]	0.765	1.128[2]	-0.142	-0.164	0.098	0.980	287.159
t-Statistic	-2.929	1.491	2.459	-1.233	-1.704	1.257		
Model96	-5.366[3]	1.645[3]	0.789	-0.318[2]	-0.160	0.146[1]	0.978	261.903
t-Statistic	-4.027	2.961	1.554	-2.606	-1.574	1.807		
Model97	-4.868[3]	1.272[1]	0.985	-0.235	-0.148	0.113	0.977	243.920
t-Statistic	-3.278	1.939	1.683	-1.654	-1.413	1.339		
Model98	-3.002	2.105[1]	-0.298	-0.098	0.227[2]	-0.117	0.954	125.277
t-Statistic	-1.489	2.517	-0.429	-0.533	2.563	-1.346		
Model99	-3.217	1.719[1]	0.121	-0.119	0.115	-0.052	0.954	124.983
t-Statistic	-1.537	2.019	0.158	-0.652	0.985	-0.540		
Model2000	-3.517	1.319	0.558	-0.114	0.029	-0.012	0.950	116.105
t-Statistic	-1.558	1.484	0.642	-0.622	0.208	-0.113		
Model2001	-3.442	0.872	0.901	-0.109	-0.046	0.034	0.949	113.362
t-Statistic	-1.400	0.918	0.897	-0.568	-0.276	0.287		
Model1992-2001	-3.878[3]	1.374[3]	0.609[3]	-0.119[3]	0.018	-0.010	0.974	2239.567
t-Statistic	-8.141	8.115	5.664	-3.660	1.054	-0.669		

Note : 1) means "significant" at the level of 10%.
2) means "significant" at the level of 5%.
3) means "significant" at the level of 1%.
For the null hypothesis, H0 : Coefficient = 0.

<Table 2> Estimation results of total factor productivity for China's provinces

Provinces	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Beijing	0.991	0.977	0.965	0.993	0.951	0.929	0.937	0.933	0.896	0.905
Tianjin	1.076	1.097	1.157	1.191	1.215	1.203	1.430	1.379	1.350	1.316
Hebei	1.024	0.982	0.975	0.966	0.952	0.896	0.933	0.898	0.871	0.847
Shanxi	0.927	0.898	0.872	0.980	1.008	1.038	0.973	0.917	0.886	0.925
Inner Mongolia	1.051	0.982	0.980	0.966	0.976	0.986	1.080	1.089	1.082	1.117
Liaoning	1.251	1.246	1.131	1.007	0.984	1.048	1.248	1.288	1.305	1.297
Jilin	1.072	1.038	1.049	1.091	1.043	1.124	1.214	1.253	1.253	1.264
Heilongjiang	1.093	1.219	1.345	1.367	1.384	1.389	1.369	1.387	1.417	1.413
Shanghai	1.040	1.236	1.176	1.128	1.149	1.121	0.852	0.925	0.976	1.020
Jiangsu	1.114	1.147	1.131	1.106	1.063	1.044	1.075	1.071	1.090	1.081
Zhejiang	0.771	0.874	0.881	0.882	0.824	0.824	0.824	0.824	0.811	0.798
Anhui	0.928	0.970	1.135	1.182	1.131	1.112	1.008	1.043	1.008	1.040
Fujian	1.109	1.134	1.153	1.172	1.140	1.158	1.216	1.185	1.135	1.166
Jiangxi	0.973	0.976	0.995	1.042	1.138	1.221	1.106	1.138	1.230	1.351
Shandong	1.050	1.014	1.114	1.125	1.222	1.231	1.374	1.358	1.378	1.361
Henan	0.967	1.021	0.956	1.048	1.122	1.037	1.031	1.012	1.029	1.011
Hubei	1.271	1.173	1.078	1.004	1.039	1.081	1.178	1.138	1.138	1.104
Hunan	0.936	0.967	0.990	1.036	1.121	1.135	1.064	1.063	1.107	1.139
Guangdong	0.951	0.812	0.808	0.846	0.881	0.911	0.924	0.942	0.951	0.958
Guangxi	1.091	0.961	0.954	0.879	0.867	0.830	0.804	0.753	0.742	0.774
Hainan	0.922	0.751	0.752	0.745	0.768	0.761	0.920	0.870	0.824	0.817
Chongqin	n/a	n/a	n/a	n/a	n/a	n/a	1.442	1.502	1.525	1.391
Sichuan	0.957	1.025	0.960	0.958	0.819	0.806	0.843	0.846	0.810	0.788
Guizhou	1.036	1.079	1.050	0.976	0.919	0.871	0.584	0.649	0.676	0.672
Yunnan	0.934	0.871	0.901	0.772	0.843	0.824	0.771	0.760	0.753	0.748
Xizhang	1.033	0.969	1.032	0.960	1.014	1.049	1.012	1.086	1.119	1.190
Shaanxi	0.840	0.862	0.830	0.837	0.843	0.845	0.787	0.798	0.802	0.827
Gansu	0.869	0.874	0.894	0.926	0.934	0.931	0.802	0.823	0.817	0.812
Qinghai	0.992	1.137	1.058	1.104	1.022	1.026	0.961	0.931	0.930	0.887
Ningxia	1.017	1.098	1.043	1.109	1.104	1.031	0.925	0.876	0.863	0.832
Xingjiang	0.880	0.851	0.875	0.867	0.823	0.863	0.952	0.902	0.917	0.844

Table 2 presents the variation of productivity in China's provinces over the period 1992 to 2001 by estimation of the translog production function. The main coast and industrial cities or provinces in China such as Beijin, Tianjin, Liaoling, Inner Mongolia, Jinlin, Heilongjiang, Shanghai, Jiansu, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Guangdong, and Congqin, have larger values of over unity(or 0.9). In contrast, most of the provinces in western region have a smaller value of 0.7 to 0.9 than the main coast and industrial cities or provinces in China, such as Xingjiang, Qinhai, Gansu, Yunnan, Sichun, Guizhou, Guangxi, Shaanxi, and so on.

Table 3 presents the empirical results of the effects of domestic R&D, imports of domestic enterprises, human capital stock, import-embodied and employment-embodied foreign enterprises on the productivity of China's provinces. Parameters of the models from 1996 to 2001 as well as the panel analysis have acceptable F-statistic values and higher adjusted R squared values. F-statistic values generally are over 18, and adjusted R squared values are around 0.8 to 0.9, and 0.58 for the panel model. The results of the models show that domestic R&D expenditures have positive effects on productivity except for 2000, and parts of coefficients are statistically significant at the 1% or 5% level. But, domestic imports have negative effects on productivity except for 2000, and the coefficients are statistically significant at the level of 1%; for 2000, the parameter is positively significant at the 10% level and for 2001 is negative but not statistically significant. Human capital stock also has robustly positive effects on productivity, and the coefficients are all statistically significant at the 1% level, except for 2001. Import-embodied FDI stock has negative effects on productivity except for 2000, and the coefficients are statistically significant at the 1% level(except for 2000 which exhibit positive effect and for 2001 when parameter is not significant). The employment-embodied FDI stock show robustly positive effects on productivity, and all coefficients are statistically significant at the 1% level except for 2000 which is statistically significant at the 5% level. Thus, the results suggest that the growth of productivity of China mainly depends on domestic R&D expenditures, human capital stock and knowledge spillovers from employee trained by foreign enterprises. I contrast, imports of domestic and foreign enterprises generate adequate technological spillovers to increase productivity in China's provinces. These results suggest that the imitating ability by imported goods is rather limited. On the other hand, imports of foreign enterprises are mainly distributed in the initial commodity or lower technological intensive products, and this is consistent with the fact that most foreign enterprises use China primarily as a market or export-processing base, and carry out the export-oriented investment.

We explore the domestic and foreign factors influencing the productivity of China's provinces in model (3). In order to verify whether the variables in models of productivity have a similar nature as that in models of output in China's provinces, model (4) is constructed to present variation of effects of these variables affecting output in China's provinces. The results in Table 4 show that the models over the period 1996 to 2001 as well as the panel model by Generalized Least Squares(Cross Section Weights) have robust features, and all the models have acceptable F-statistic values, and adjusted R squared values are also over 0.9. Domestic R&D has positive effects on output in China's provinces, and the coefficients all are statistically

<Table 3> Effects of domestic R&D and technology spillovers of international R&D on productivity

Dependent Variable : $Ln(TFP_i)$, Method : GLS(Cross Section Weights)

Variable	β_1	β_2	β_3	β_4	β_5	β_6	Adj.R-sq.	F-statistic
Model1996-2001	0.082[1]	0.005	−0.072[3]	0.033[3]	−0.026[3]	0.075[3]	0.580	49.044
t-Statistic	1.850	1.362	−13.722	4.695	−5.864	13.174		
Model1996	0.133[3]	0.027[3]	−0.096[3]	0.052[3]	−0.103[3]	0.164[3]	0.845	31.496
t-Statistic	4.317	9.111	−27.198	7.641	−15.275	21.260		
Model1997	−0.143	0.017[2]	−0.075[3]	0.081[3]	−0.047[3]	0.101[3]	0.920	60.525
t-Statistic	−1.429	2.752	−10.341	5.746	−8.440	16.716		
Model1998	0.320[3]	0.006	−0.105[3]	0.006	−0.041[3]	0.113[3]	0.994	999.130
t-Statistic	6.337	0.718	−6.927	0.926	−6.593	9.724		
Model1999	−0.159[2]	0.002	−0.044[3]	0.071[3]	−0.059[3]	0.102[3]	0.935	84.235
t-Statistic	−2.567	0.173	−3.435	6.022	−13.436	12.883		
Model2000	−0.179	−0.040[3]	0.0004	0.055[3]	0.010[1]	0.015[1]	0.872	40.563
t-Statistic	−1.546	−3.734	−0.028	3.560	1.959	1.901		
Model2001	0.089	0.022	−0.070[3]	0.017	−0.011	0.054[3]	0.751	18.529
t-Statistic	1.199	1.148	−7.007	1.198	−0.856	4.371		

Note : 1) means "significant" at the level of 10%.
2) means "significant" at the level of 5%.
3) means "significant" at the level of 1%.
For the null hypothesis, H0 : Coefficient = 0.

significant at the 1% level, except for 2001 when coefficients are statistically significant at the 5% level. Domestic imports also have positive effects on output on China's provinces. The coefficients all are statistically significant at the 1% level, except for 1996 when it is statistically significant at the 5% level, and have an increasing tendency over the years. Human capital has positive effects on output as well, and the coefficients all are highly statistically significant at the 1% level. As with the models of productivity, import-embodied foreign enterprises also have negative effects on output of China's provinces in the period 1996 to 1999, and the coefficients of the panel model as well are statistically significant at the 1% level. But, negative effects appear for 2000 and 2001, and the coefficient in 2000 is statistically significant at the 1% level. This suggests that components of imports from foreign enterprises since 2000 have greatly changed, trending toward more sophisticated technological products such as advanced equipments and tool benefiting the output and productivity in China. This is consistent with the results in models of productivity for the years 2000 and 2001. Employment-embodied foreign enterprises also have positive effects on output of China's provinces as shown by the model of productivity. However, in 2000 and 2001, they have negative effects on output although contributions are very small, and their output elasticities are -0.009 and -0.041 respectively. Similar situation, as models of productivity in 2000 and 2001, with small output elasticities of 0.015 and 0.054, respectively, are displayed. This implies that amounts of MNCs inflows in China have had a significant growth along with China's economy increasingly being integrated into the world economy, in particular by China's accession to WTO. Foreign enterprises have willingly tended to become enterprises with sole foreign funds, thereby leading to variation of employment components in foreign enterprises, and this directly affects the contributions of

<Table 4> Effects of domestic and international R&D on output

Dependent Variable : $Ln(Y_i)$, Method : GLS(Cross Section Weights)

Variable	β_1	β_2	β_3	β_4	β_5	β_6	Adj.R-sq.	F-statistic
Model1996-2000	$3.585^{3)}$	$0.093^{3)}$	$0.087^{3)}$	$0.743^{3)}$	$-0.037^{3)}$	$0.118^{3)}$	0.999	67030.740
t-Statistic	92.645	9.676	12.392	78.699	-4.186	11.176		
Model1996	$3.321^{3)}$	$0.105^{3)}$	$0.056^{2)}$	$0.783^{3)}$	$-0.036^{2)}$	$0.126^{3)}$	1.000	72224035.00
t-Statistic	37.965	9.207	2.683	50.508	-2.481	9.805		
Model1997	$3.337^{3)}$	$0.113^{3)}$	$0.053^{3)}$	$0.814^{3)}$	$-0.088^{3)}$	$0.190^{3)}$	1.000	958886.400
t-Statistic	26.530	7.269	2.990	42.338	-17.065	30.128		
Model1998	$3.623^{3)}$	$0.136^{3)}$	$0.060^{3)}$	$0.741^{3)}$	$-0.054^{3)}$	$0.124^{3)}$	1.000	120180.300
t-Statistic	49.309	10.102	6.071	36.150	-4.982	7.809		
Model1999	$3.404^{3)}$	$0.099^{3)}$	$0.095^{3)}$	$0.788^{3)}$	$-0.089^{3)}$	$0.174^{3)}$	1.000	404628.100
t-Statistic	56.679	7.433	6.328	69.693	-4.712	7.223		
Model2000	$3.415^{3)}$	$0.070^{3)}$	$0.165^{3)}$	$0.720^{3)}$	$0.060^{3)}$	-0.009	1.000	270694.000
t-Statistic	37.872	5.363	10.874	34.000	10.085	-1.057		
Model2001	$3.576^{3)}$	$0.030^{2)}$	$0.209^{3)}$	$0.682^{3)}$	$0.098^{3)}$	$-0.041^{3)}$	1.000	59650.070
t-Statistic	37.950	2.264	19.341	34.096	7.089	-3.509		

Note : 1) means "significant" at the level of 10%.
2) means "significant" at the level of 5%.
3) means "significant" at the level of 1%.
For the null hypothesis, H0 : Coefficient = 0.

employment of foreign enterprises to China's economy.

In Table 5, on the basis of model (4), we add the interactive term between human capital stock and FDI inflows stock in model (6) to examine whether the domestic human capital stock have adequately absorptive ability of the advanced technology brought by FDI inflows to generate technological spillovers effects on productivity. The results are strikingly similar to results of model (4). That is, domestic R&D expenditure, employee-weighted FDI stock and human capital stock have positive effects on productivity, and coefficients are robust and statistically significant. Domestic imports and import-weighted FDI stock have negative effects on productivity, and most of the coefficients are statistically significant, except for 2000 and 2001. The interactive term between human capital stock and FDI stock present negative effects on productivity, and the coefficients are statistically significant at the 1% level. This suggests that domestic human capital stock have not reached the level sufficient to absorb technology spillovers from FDI firms to promote productivity in host country.

Similarly, in Table 6, on the basis of model (5), we also add the interactive term for human capital stock and FDR inflows stock in model (7) to examine whether limited technological spillovers can generate positive effects on the output of host country. The results are again similar to the results of model (5). That is, domestic R&D expenditure and imports, employee-weighted FDI stock and human capital stock have positive effects on domestic output, and coefficients are robust and statistically significant. Import-weighted

<Table 5> Effects of domestic R&D and technology spillovers of international R&D on productivity adding the interactive term between human capital stock and FDI inflows stock

Dependent Variable : $Ln(TFP_i)$, Method : GLS(Cross Section Weights)

Variable	β_1	β_2	β_3	β_4	β_5	β_6	β_7	Adj.R-sq.	F-statistic
Model1996-2001	1.834$^{3)}$	0.010$^{2)}$	-0.078$^{3)}$	0.321$^{3)}$	0.001	0.144$^{3)}$	-0.175$^{3)}$	0.613	46.935
t-Statistic	11.949	2.218	-11.494	14.324	0.192	16.150	-12.555		
Model1996	0.957$^{3)}$	0.030$^{3)}$	-0.102$^{3)}$	0.165$^{3)}$	-0.063$^{3)}$	0.165$^{3)}$	-0.079$^{3)}$	0.995	1024.530
t-Statistic	30.568	17.949	-41.985	20.845	-14.964	38.543	-20.497		
Model1997	2.466$^{3)}$	0.032$^{3)}$	-0.113$^{3)}$	0.392$^{3)}$	0.000	0.182$^{3)}$	-0.227$^{3)}$	0.957	97.810
t-Statistic	35.965	16.772	-72.176	33.611	0.162	48.418	-35.016		
Model1998	3.046$^{3)}$	-0.008	-0.091$^{3)}$	0.442$^{3)}$	0.049$^{3)}$	0.154$^{3)}$	-0.271$^{3)}$	0.997	1455.819
t-Statistic	7.317	-0.648	-5.897	6.559	2.875	10.056	-6.589		
Model1999	2.512$^{3)}$	0.002	-0.079$^{3)}$	0.422$^{3)}$	-0.014	0.195$^{3)}$	-0.236$^{3)}$	0.987	360.336
t-Statistic	5.398	0.220	-5.129	8.390	-0.722	8.751	-6.520		
Model2000	4.978$^{3)}$	-0.046$^{3)}$	-0.078$^{3)}$	0.781$^{3)}$	0.070$^{3)}$	0.232$^{3)}$	-0.464$^{3)}$	0.845	27.336
t-Statistic	15.640	-3.828	-4.756	21.330	6.032	13.322	-17.935		
Model2001	3.178$^{2)}$	0.034$^{1)}$	-0.100$^{3)}$	0.468$^{2)}$	0.078	0.118$^{3)}$	-0.292$^{2)}$	0.693	11.931
t-Statistic	2.461	2.068	-7.612	2.468	1.681	5.450	-2.373		

Note : 1) means "significant" at the level of 10%.
2) means "significant" at the level of 5%.
3) means "significant" at the level of 1%.
For the null hypothesis, H0 : Coefficient = 0.

FDI stock has negative effects on productivity, and coefficients are statistically significant at the 1% level, whereas import-weighted FDI stock in 2000 and 2001 have positive effects on output, and the coefficients are robust and statistically significant. This implies that the structure components of imports of FDI firms are possibly different from goods imports prior to 1999, becoming more sophisticated compared to the labor-intensive goods prior 1999. The interactive term between human capital stock and FDI stock also show negative effects on output although it is not robust, and most of the coefficients are only statistically significant at the 10% level. This suggests that the technology spillovers from FDI firms are very limited in enhancing the output in host country.

<Table 6> Effects of domestic and international R&D on output adding the interactive term between human capital stock and FDI inflows stock

Dependent Variable : $LN(Y_i)$, Method : GLS(Cross Section Weights)

Variable	β_1	β_2	β_3	β_4	β_5	β_6	β_7	Adj.R-sq.	F-statistic
Model1996-2001	3.488[3)]	0.094[3)]	0.092[3)]	0.723[3)]	-0.042[3)]	0.115[3)]	0.010	0.999	39684.290
t-Statistic	14.293	8.003	10.942	17.157	-4.142	7.358	0.415		
Model1996	4.321[3)]	0.125[3)]	0.034	0.936[3)]	-0.015	0.160[3)]	-0.098[2)]	1.000	217847.700
t-Statistic	10.310	10.939	1.548	15.980	-0.971	7.945	-2.605		
Model1997	4.611[3)]	0.150[3)]	0.045[2)]	0.996[3)]	-0.078[3)]	0.244[3)]	-0.123[3)]	1.000	449454.300
t-Statistic	15.580	8.956	2.146	23.271	-9.367	17.696	-4.190		
Model1998	6.463[3)]	0.141[3)]	0.065[2)]	1.178[3)]	0.015	0.195[3)]	-0.278[3)]	1.000	249574.500
t-Statistic	7.997	9.030	2.795	11.937	0.692	7.651	-4.072		
Model1999	4.852[3)]	0.121[3)]	0.097[3)]	0.982[3)]	-0.060[3)]	0.211[3)]	-0.134[3)]	1.000	1501915.000
t-Statistic	27.829	8.957	6.092	32.133	-3.757	8.214	-8.341		
Model2000	5.604[3)]	0.119[3)]	0.135[3)]	1.021[3)]	0.074[3)]	0.093[3)]	-0.200[3)]	1.000	249862.200
t-Statistic	8.715	3.138	4.851	9.648	5.784	3.012	-3.481		
Model2001	5.002[3)]	0.041	0.202[3)]	0.898[3)]	0.125[3)]	0.003	-0.138[1)]	1.000	1575540.000
t-Statistic	7.407	1.345	12.438	6.925	5.684	0.064	-1.892		

Note : 1) means "significant" at the level of 10%.
2) means "significant" at the level of 5%.
3) means "significant" at the level of 1%.
For the null hypothesis, H0 : Coefficient = 0.

Ⅵ. Conclusions

In this study, the results of the models present strong evidences on such output elasticities of labor and capital inputs, and the effects of technological spillovers on productivity and output of China's provinces. The derived results suggest that labor and fixed asset investment have strong and robust effects on output, and exhibit increasing marginal returns to scale.

The distribution of productivity in China's provinces tends to have higher values in the main coastal and important industrial cities or provinces. This demonstrates the effects of opening-door polices and move towards a market economy, which bring great benefits to the earlier opening-door cities and provinces, and have been helpful to promote their productivity and overall economic growth.

However, foreign enterprises were found to have very limited effects in enhancing productivity of China's provinces. Only employment brought by foreign enterprises has some positive effects on productivity, that is, employees trained by foreign enterprises, imitation and learning by doing can be the important channels of technological spillovers. This implies that technological spillovers from foreign enterprises have not reached a higher level to sufficiently stimulate the growth of productivity of China's provinces. The growth of productivity in China's provinces mainly depends on domestic R&D expenditures and human capital stock. But, imports of foreign enterprises have begun to generate positive effects on productivity in 2000, perhaps illustrating the effects of China's accession to the WTO that has allowed more MNCs inflows introducing advanced technology in China. This is in contrast with export-oriented investment from NICs that usually have labor-intensive industrial characteristics in the earlier period. Thus, the magnitudes of technological spillovers from FDI should exhibit an increasing tendency over time.

Furthermore, in respect to the effects of domestic and foreign enterprises on output of China's provinces, import-embodied FDI stock has a "crowding out" effect on output of China's provinces, that is, by importing raw material, equipments, or intermediate goods, foreign enterprises tend to occupy the domestic market displacing domestic enterprises. Other variables such as domestic R&D expenditures, imports of domestic enterprises, human capital stock and employment-embodied FDI stock have strong and robust positive effects.

Overall, FDI and international trade have shown important impact on the output in China's provinces. FDI inflows are a main channel of technological spillovers, but imports currently have very limited effects productivity growth. The growth of productivity in China's provinces mainly depends on domestic R&D expenditures, human capital stock and employment of foreign enterprises.

Appendix

<Appendix 1> Imports of FDI Trade of China's Provinces

(10 thousand dollars)

Provinces	1993	1994	1995	1996	1997	1998	1999	2000	2001
Beijing	124063	147672	186628	224022	233856	281772	366197	489739	540603
Tianjin	109458	189617	301237	406855	435524	433255	536476	731364	723888
Hebei	48317	53892	67248	89623	56380	60779	65629	56907	66116
Shanxi	10884	6988	5354	5295	6404	7645	32841	26667	10769
Inner Mongolia	8051	7875	10041	7402	6564	4073	3841	4358	4958
Liaoning	159907	214465	262974	319087	387294	303372	389683	605234	590609
Jilin	34227	47939	65711	61045	45500	57211	61309	73077	10473
Heilongjiang	21633	28465	36517	48086	36586	21961	20990	20674	19296
Shanghai	405426	494631	719781	942116	959476	1005314	1232266	1914952	2083843
Jiangsu	307817	350171	487284	706739	748251	858550	977768	1572741	1754914
Zhejiang	105540	142807	195379	270804	224223	202419	233593	404142	477217
Anhui	20981	26136	26768	52581	43561	35535	53863	54786	56030
Fujian	357321	434621	468563	502316	524501	517316	545272	64602	674669
Jiangxi	32826	26692	15283	10129	7284	8871	18643	15516	16821
Shandong	176614	253187	362652	466395	448976	423077	433596	599802	702925
Henan	26333	31043	38092	40183	28409	22156	22424	26807	28303
Hubei	53935	49840	72753	84286	78273	69101	60303	61729	81661
Hunan	25355	22664	21644	25421	20646	16822	16960	29467	34706
Guangdong	1979877	2536046	2744113	3027696	3272863	3173178	3391787	4252685	4425844
Guangxi	41592	73032	60094	43459	32524	39368	26340	21228	21889
Hainan	55233	60323	51086	56898	26607	34453	10495	15529	50992
Chongqin						32192	17353	22723	22118
Sichuan	40077	43142	42401	101001	88862	18884	27177	37007	42737
Guizhou	4138	5093	5966	2616	3059	1671	1119	1678	1902
Yunnan	6897	16118	16759	21309	18482	10854	9744	11545	10238
Xizhang	216	1644	2454	6086	5886	1000	851	245	19
Shaanxi	18441	17557	16287	27418	23933	24129	23910	23823	25792
Gansu	4203	4340	3358	4202	3008	2746	1658	1824	3616
Qinghai	82	401	20	86	1	269	15	723	2174
Ningxia	674	1840	503	1659	1348	717	1787	1831	1539
Xingjiang	3202	5177	7321	5565	3854	3059	4471	2439	3702

<Appendix 2> Imports of China's Provinces

(10 thousand dollars)

Provinces	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Beijing	164177	254346	2093221	2678536	2119858	2077749	1999315	2445599	3765376	3975444
Tianjin	116422	192031	285408	397951	489323	508750	511510	626960	852822	867998
Hebei	51065	78236	85416	105214	111430	86426	111115	146081	152862	178172
Shanxi	17360	24617	18490	25973	23164	21250	21792	44799	52751	47274
Inner Mongolia	34282	50668	45041	49755	52918	41761	43715	75955	165188	140763
Liaoning	225921	335146	418433	495533	543188	574907	468903	551844	817516	879870
Jilin	83058	130070	142483	151031	113178	92126	90382	119357	131359	174514
Heilongjiang	113497	161335	118487	122005	136709	115584	111092	124116	153519	177234
Shanghai	518792	793464	890499	1139353	1411006	1473101	1542949	1981854	2935569	3326948
Jiangsu	295360	459352	507235	652062	909889	953275	1072161	1295159	1986953	2247739
Zhejiang	141282	240956	290216	381730	448933	415689	398765	543417	838987	982225
Anhui	29880	45424	52003	61496	90789	82969	81935	97237	117486	133771
Fujian	367207	488172	575933	653765	712990	792429	719502	726753	831439	870368
Jiangxi	31228	55332	50163	28121	26452	21845	22896	40776	42664	49190
Shandong	182587	307949	375414	578335	698278	667830	627004	669053	946092	1083304
Henan	34282	55878	61170	87159	72907	61036	54674	62155	78712	107685
Sichuan	68352	107448	129420	121045	197492	54772	92162	132996	115083	151644
Guizhou	10947	14305	16464	22158	13050	18503	23974	18983	23942	22468
Yunnan	33818	37512	66655	89050	80596	54382	52166	62556	63767	74472
Xizhang	9033	8479	60249	20854	15589	13816	7201	8018	1697	1054
Shaanxi	35807	57906	46226	41443	65947	50295	87480	85492	83003	95381
Gansu	13586	17997	15599	23925	20031	11904	10313	8924	15458	30256
Qinghai	984	2491	2626	2398	1455	1201	1369	2099	4773	5577
Ningxia	2316	3914	6371	5114	3507	3987	2858	7034	11555	18093
Xingjiang	18810	41084	43568	57935	46662	55388	77732	73801	105991	110299

<Appendix 3> FDI Inflows of China's Provinces

(10 thousand dollars)

Provinces	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Beijing	31846	27695	24495	34985	66694	137157	107999	155290	159286	216800	197525	168368	176818	172464
Tianjin	8134	3493	13261	10778	61368	101499	152093	215273	251135	211361	176399	116601	213348	158195
Hebei	2685	3935	5656	11309	39654	52340	54668	83022	110308	142868	104202	67923	66989	78271
Shanxi	882	340	380	5384	8643	3170	6383	13808	26893	24451	39129	22472	23393	21164
Inner Mongolia	n/a	1064	166	520	8526	4007	5781	7186	7325	9082	6456	10568	10703	17701
Liaoning	n/a	24373	36239	51642	127913	144014	142461	173782	236635	219045	106173	204446	251612	341168
Jilin	335	1760	3164	7534	27527	24192	40802	45155	40227	40917	30120	33701	33766	24468
Heilongjiang	2312	2449	2085	7217	23232	34759	51686	56691	73485	52639	31828	30086	34114	35511
Shanghai	42212	17401	14519	49361	316025	247309	289261	394094	422536	360150	283665	316014	429159	427229
Jiangsu	9464	12416	21922	146324	284371	376315	519082	521009	543511	663179	607756	642550	691482	1018960
Zhejiang	5181	4843	9229	23978	103175	115026	125806	152050	150345	131802	123262	161266	221162	307610
Anhui	478	961	1067	5466	25764	37000	48256	50661	43443	27673	26131	31847	33672	38375
Fujian	32880	29002	47116	142364	287444	371318	404390	408455	419710	421211	402403	343191	391804	383837
Jiangxi	587	621	1949	9972	20817	26168	28888	30126	48103	46496	32080	22724	39575	108197
Shandong	13132	15084	21639	100342	187413	255242	268898	263355	277556	220274	225878	297119	352093	473404
Henan	4266	1049	3799	5316	30491	38673	47855	52356	69204	61654	52135	56403	45729	40463
Hubei	2295	2900	4664	20313	54053	60186	62512	68079	84866	97294	91488	94368	118860	142665

Provinces	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Hunan	643	1116	2543	13271	43746	33114	50773	74530	91702	81816	65374	67833	81011	90022
Guangdong	115644	146000	194288	370111	755576	946343	1026011	1175407	1263495	1201994	1165750	1128091	1193203	1133400
Guangxi	4594	2866	3185	18201	88456	83633	67263	66313	88579	88613	63512	52466	38416	41726
Hainan	10707	10302	17672	45255	70710	91809	106207	78908	70554	71715	48449	43080	46691	51196
Chongqin	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	41802	43107	23893	24436	25649	19576
Sichuan	n/a	1604	8091	11214	57141	92174	54159	44090	24846	37248	34101	43694	58188	55583
Guizhou	747	468	1409	1979	4294	6363	5703	3138	4977	4535	4090	2501	2829	3821
Yunnan	740	261	351	2875	9702	6500	9769	6537	16566	14568	15385	12812	6457	11169
Xizhang	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Shaanxi	9719	4191	3176	4553	23430	23880	32407	32609	62816	30010	24197	28842	35174	36005
Gansu	17	85	478	35	1195	8776	6392	9002	4144	3864	4104	6235	7439	6121
Qinghai	n/a	n/a	n/a	68	324	241	164	100	247	n/a	459	n/a	3649	4726
Ningxia	233	25	18	35	1190	727	390	555	671	1856	5134	1741	1680	2200
Xingjiang	n/a	537	22	n/a	5300	4830	5490	6390	2472	2167	2404	1911	2035	1899

<Appendix 4> GDP of China's Provinces

(100 Million Yuan RMB)

Provinces	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
exchange rate	372.21	372.21	376.59	478.38	532.27	551.49	576.19	861.87	835.07	831.42	828.98	827.91	827.96	827.84	827.77
Beijing	326.82	410.22	455.96	500.82	598.9	709.1	863.54	1084.03	1394.89	1615.73	1810.09	2011.31	2174.46	2478.76	2845.65
Tianjin	220	259.64	283.34	310.95	342.75	411.24	536.1	725.14	920.11	1102.4	1235.28	1336.38	1450.06	1639.36	1840.1
Hebei	521.92	701.33	822.83	896.33	1072.07	1278.5	1690.84	2187.49	2849.52	3452.97	3953.78	4256.01	4569.19	5088.96	5577.78
Shanxi	257.2	316.7	376.3	429.3	468.5	570	704.7	853.77	1092.48	1308.01	1480.13	1486.08	1506.78	1643.81	1779.97
Inner Mongolia	212.27	270.81	292.69	319.31	359.66	421.68	532.71	681.92	832.88	984.78	1099.77	1192.29	1268.2	1401.01	1545.79
Liaoning	719.12	881.02	1003.81	1062.74	1200.1	1472.95	2010.82	2461.78	2793.37	3157.69	3582.46	3881.73	4171.69	4669.06	5033.08
Jilin	297.49	368.67	391.65	425.28	463.47	558.06	717.95	936.78	1129.2	1337.16	1446.91	1557.78	1660.91	1821.19	2032.48
Heilongjiang	454.6	551.98	630.61	715.23	824.23	864.04	1203.22	1618.63	2014.53	2402.58	2708.46	2798.89	2897.41	3253	3561
Shanghai	545.46	648.3	696.54	756.45	893.77	1114.32	1511.61	1971.92	2462.57	2902.2	3360.21	3688.2	4034.96	4551.15	4950.84
Jiangsu	922.33	1208.85	1321.85	1416.5	1601.38	2136.02	2998.16	4057.39	5155.25	6004.21	6680.34	7199.95	7697.82	8582.73	9511.91
Zhejiang	603.71	765.76	843.72	897.99	1081.75	1365.06	1909.49	2666.86	3524.79	4146.06	4638.24	4987.5	5364.89	6036.34	6748.15
Anhui	442.35	546.94	616.25	658.02	663.6	801.16	1069.84	1488.47	2003.58	2339.25	2669.95	2805.45	2908.58	3038.24	3290.13
Fujian	279.24	383.21	458.4	522.28	622.02	787.71	1133.49	1685.34	2160.52	2583.83	3000.36	3286.56	3550.24	3920.07	4253.68
Jiangxi	262.9	325.83	376.46	428.62	479.37	572.55	723.06	948.16	1205.11	1517.26	1715.18	1851.98	1853.65	2003.07	2175.68
Shandong	n/a	n/a	n/a	n/a	1810.54	2196.53	2779.49	3872.18	5002.34	5960.42	6650.02	7162.2	7662.1	8542.44	9438.31

Provinces	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Henan	609.6	749.09	850.71	934.65	1045.73	1279.75	1662.76	2224.43	3002.74	3661.18	4079.26	4356.6	4576.1	5137.66	5640.11
Hubei	517.77	626.52	717.08	824.38	913.38	1088.39	1424.38	1878.65	2391.42	2970.2	3450.24	3704.21	3857.99	4276.32	4662.28
Hunan	469.44	584.07	640.8	744.44	833.3	997.7	1278.28	1694.42	2195.7	2647.16	2993	3118.09	3326.75	3691.88	3983
Guangdong	n/a	n/a	n/a	n/a	1780.56	2293.54	3225.3	4240.56	5381.72	6519.14	7315.51	7919.12	8464.31	9662.23	10647.71
Guangxi	241.56	313.28	383.44	449.06	518.59	646.6	893.58	1241.83	1497.56	1697.9	1817.25	1903.04	1953.27	2050.14	2231.19
Hainan	57.3	77.13	91.4	102.49	120.51	181.71	258.08	330.95	364.17	389.53	409.86	438.92	471.23	518.48	545.96
Chongqin	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1179.09	1350.1	1429.26	1479.71	1589.34	1749.77
Sichuan	n/a	n/a	n/a	n/a	1382.96	1624.51	2096.48	2777.88	3534	2985.15	3320.11	3580.26	3711.61	4010.25	4421.76
Guizhou	165.5	211.79	235.84	260.14	295.9	339.91	416.07	521.17	630.07	713.7	792.98	841.88	911.86	993.53	1084.9
Yunnan	229.03	301.09	363.05	451.67	517.41	618.69	779.21	973.97	1206.68	1491.62	1644.23	1793.9	1855.74	1955.09	2074.71
Xizhang	17.71	20.25	21.86	27.7	30.53	33.29	37.28	45.84	55.98	64.76	76.98	91.18	105.61	117.46	138.73
Shaanxi	244.96	314.48	358.37	404.3	466.93	540.52	671.37	816.58	1000.03	1175.38	1300.03	1381.53	1487.61	1660.92	1844.27
Gansu	159.52	191.84	216.84	242.8	271.39	317.79	372.24	451.66	553.35	714.18	781.34	869.75	931.98	983.36	1072.51
Qinghai	43.38	54.96	60.37	69.94	75.1	87.52	109.62	138.24	165.31	183.57	202.05	220.16	238.39	263.59	300.95
Ningxia	39.63	50.29	59.21	64.84	71.78	83.14	103.82	133.97	169.75	193.62	210.92	227.46	241.49	265.57	298.38
Xingjiang	148.51	192.72	217.42	274.01	335.91	402.31	505.63	673.68	825.11	912.15	1050.14	1116.67	1168.55	1364.36	1485.48

<Appendix 5> Total Fixed Asset Investment of China's Provinces

(100 Million Yuan RMB)

Provinces	1993	1994	1995	1996	1997	1998	1999	2000	2001
Beijing	418.53	653.71	864.85	889.66	989.71	1124.62	1171.16	1280.46	1513.32
Tianjin	219.41	332.52	396.55	438.51	500.67	571.05	576.45	610.94	705
Hebei	471.88	671.39	907.75	1182.59	1425.98	1591.76	1770.47	1816.79	1912.53
Shanxi	235.07	276.16	270.64	311.77	376.74	454.93	477.57	548.16	663.58
Inner Mongolia	207.67	229.75	251.32	262.05	278.65	316.76	348.22	423.64	503.63
Liaoning	737.34	897.59	865.49	881.67	986.62	1057.7	1119.47	1267.68	1421.19
Jilin	264.12	302.21	320.27	362.99	361.17	431.78	500.02	603.51	701.7
Heilongjiang	338.59	412.27	517.62	568.64	669.86	770.05	751.66	832.64	963.58
Shanghai	708.14	1201.62	1597.89	1996.88	1981.48	1966.38	1855.76	1869.38	2004.64
Jiangsu	1155.52	1330.74	1764.76	1963.06	2174.97	2450.37	2441.88	2569.97	2823.2
Zhejiang	803.74	1115.51	1482.62	1611.44	1608.56	1801.74	1958.05	2349.95	2834.94
Anhui	294.02	375.57	476.1	609.79	677.85	722.61	703.45	803.97	893.37
Fujian	399.33	564.35	683.02	779.76	880.88	1053.01	1084.66	1112.2	1172.91
Jiangxi	201.29	246.03	282.54	317.32	329.45	400.6	454.44	516.08	631.84

Provinces	1993	1994	1995	1996	1997	1998	1999	2000	2001
Shandong	950.68	1129.07	1308.62	1528.5	1742.53	1935.58	2220.57	2531.1	2788.68
Henan	475.17	628.82	783.14	1039.41	1209.5	1289.7	1206.83	1377.74	1544.06
Hubei	392.74	578.78	785.09	935.22	1023.5	1156.76	1239.14	1339.2	1486.55
Hunan	344.38	455.02	523	684.14	667.39	796.89	883.94	1012.24	1174.3
Guangdong	1857.04	2416.56	2315.83	2363.18	2291.05	2644.13	2937.02	3145.13	3484.43
Guangxi	280.26	391.66	403.15	476.42	479.8	562.32	578.76	583.34	655.63
Hainan	201.82	218.77	182.08	181.01	161.48	173.37	194.78	198.87	213.32
Chongqin	n/a	n/a	n/a	n/a	375.57	492.97	525.26	572.59	697.03
Sichuan	591.34	744.45	901.42	1113.17	926.34	1145.33	1224.4	1418.04	1617.52
Guizhou	101.61	136.27	161.79	193.55	222.3	278.41	311.93	396.98	536.01
Yunnan	262.99	317.47	390.45	456.27	538.6	660.43	663.97	683.96	738.45
Xizhang	18.26	20.9	35.13	29.43	34.5	41.26	53.56	64.05	83.26
Shaanxi	222.42	249.57	310.18	343.71	393.16	517.57	587.79	653.67	773.43
Gansu	101.51	134.88	145.76	206.95	242.08	301.45	355.51	395.4	460.37
Qinghai	46.29	47.64	53.11	77.67	88.44	108.78	117.15	151.14	196.35
Ningxia	45.47	53.73	62.17	72.1	85.84	106.75	128.1	157.52	191.08
Xingjiang	261.65	293.57	331.97	388.67	446.99	514.77	526.65	610.39	706

<Appendix 6> Number of Students enrolled in Institute of post secondany Education of China's Provinces at the the end of 2002(Person)

Provinces	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Beijing	135974	143546	141562	139914	136940	139978	158906	175203	182173	190033	196082	212984	235140	280282	336484
Tianjin	50657	53071	52804	51039	49898	52127	60247	66672	68080	71354	73830	78651	90450	119117	153998
Hebei	69242	73047	75051	76018	74349	84083	104287	120297	126290	126645	135974	144383	176702	252571	350518
Shanxi	49121	49450	51203	51309	51516	55717	62156	66417	67420	68842	71138	76128	94120	125023	165034
Inner Mongolia	30654	32634	33112	32175	31107	31779	37290	38606	36715	38191	39474	42470	49732	71868	99613
Liaoning	113832	120510	122543	123314	124777	134671	155554	171284	179412	182684	188159	199223	235819	307931	372336
Jilin	68695	72933	73125	72806	72536	75686	86261	95242	100785	105026	110167	117892	139595	181019	217849
Heilongjiang	74678	78879	79224	79908	79340	85149	96343	108722	113523	116379	115767	125140	157063	210146	271435
Shanghai	122529	128163	126091	121251	116925	119532	131034	140396	144082	147926	154073	165123	186307	226798	279966
Jiangsu	140228	147705	147915	146894	144734	152716	180173	201534	208620	220575	239074	265953	329825	451844	585528
Zhejiang	60072	60419	61045	60327	59822	62226	73586	87428	92857	96480	102302	113543	138564	192371	293078
Anhui	61161	63139	64492	62448	61986	65947	80951	87088	86039	89414	96006	104944	133025	191824	252226
Fujian	54102	57059	56787	55624	54243	57179	64065	69255	71686	73401	78082	85147	102589	137859	167377
Jiangxi	52055	52152	53402	56608	56383	59294	70537	77976	81999	84592	88293	94103	110873	148589	196455
Shandong	95891	101281	103928	105822	107093	130188	151758	156879	160398	169184	176094	180795	213679	325317	449360

Provinces	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Henan	75747	79882	80119	80372	81790	89496	104367	117053	122388	127948	136120	146365	185486	273404	369149
Hubei	124116	130048	130386	130355	129889	137168	156023	170128	182703	189909	196771	210119	257875	357728	453277
Hunan	83364	87297	88833	88210	88626	95389	111036	123053	130363	135759	143654	156665	193553	265849	331301
Guangdong	92778	97224	100393	95929	92655	97432	116757	137458	151788	164017	174740	185047	220810	306019	381926
Guangxi	34523	37524	37757	37762	36868	42026	50951	57945	60032	63528	70561	77483	90286	123729	151604
Hainan	n/a	9133	9475	7652	7631	8498	10232	11719	12041	12452	12783	13532	14569	19193	26050
Chongqin	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	71189	83187	96569	126279	161648
Sichuan	133752	140760	140361	141007	141329	150139	177888	198407	200862	208435	150077	151905	180256	245648	316701
Guizhou	25975	27264	27636	26970	25741	26685	29305	32328	34676	35747	38472	42554	56454	79833	108159
Yunnan	41036	44985	45114	43525	43095	45357	49559	51331	51427	54043	57439	62368	73902	95893	119039
Xizhang	1801	1736	1973	2025	1961	2239	2813	3239	3878	3412	3200	3447	4021	5475	6793
Shaanxi	91792	97955	98647	95417	94300	100694	117307	126872	128285	134868	139308	148879	179447	244723	313718
Gansu	30985	33039	33186	32805	33048	34591	40514	45169	45480	47578	50678	54014	62637	82577	110898
Qinghai	6847	7012	6408	6202	6037	6315	6906	7170	7332	7780	8202	8691	9347	13485	17918
Ningxia	7317	7673	7878	7992	7898	8475	9604	10502	10686	10484	10958	11312	13121	17463	23154
Xingjiang	29801	30403	31661	31015	31145	33600	39107	43266	44409	44393	45695	46717	54058	81043	108066

<Appendix 7> Number of Students enrolled in Secondary School of China's Provinces at the end of 2002

(10 thousand persons)

Provinces	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Beijing	52.27	46.93	43.33	40.91	43.22	47.65	53.22	58.38	62.82	64.93	62.62	60.99	63.49	69.14	72.01
Tianjin	37.51	35.4	33.57	34.57	36.72	38.15	38.91	41.04	45.63	49.36	50.33	52.31	54.27	57.06	59.24
Hebei	243.69	225.44	207.98	207.61	222.21	239.26	247.76	273.6	310.24	350.09	389.35	416.08	447.43	481.75	501.76
Shanxi	163.76	161.17	149	145.08	143.36	142.26	138.44	142.52	150.97	161.33	170.09	177.4	186.86	199.75	214.31
Inner Mongolia	116.54	112.7	107.78	106.62	106.13	104.81	99.01	103.06	109.35	113.86	116.02	117.9	122.2	130.73	139.38
Liaoning	204.88	196.22	183.04	181.09	188.77	196.95	191.16	192.21	200.83	202.98	195.02	188.49	196.17	216.7	232.34
Jilin	133.45	129.77	120.18	119.57	124.02	129.8	129.46	126.64	128.74	128.71	129	127.89	133.68	143.12	148.81
Heilongjiang	206.3	199.1	185	180.1	179	176.1	166.4	168.5	179.1	188.6	198.1	215.2	235.65	248.74	252.06
Shanghai	48.21	45.68	46.1	48.31	51.24	54.77	57.69	65.56	72.4	76.23	74.43	73.85	77.46	80.35	81.08
Jiangsu	281.17	272.97	274.52	281.97	288.64	294.64	293.98	304.66	316.75	323.55	320.69	324.24	340.89	373.65	415.11
Zhejiang	182.95	169.74	163.34	169.62	180.75	188.38	185.02	194.02	210.54	223.65	222.74	217.67	228.15	249.55	263
Anhui	226.63	222.55	216.19	218.18	223.38	227.61	231.05	249.43	281.53	297.28	310.23	322.41	339.85	358.32	372.66
Fujian	118.32	107.47	100.64	104.85	113.13	123.36	127.97	136.21	155.25	181.85	207.36	220.05	228.14	233.5	238.3
Jiangxi	178.35	177.62	175.42	181.06	186.26	186.21	182.8	182.66	193.27	208.63	223.59	234.87	246.84	259.22	273.28
Shandong	379.54	373.53	363.74	367.3	372.98	382.49	395.28	427.15	470.46	512.22	541.38	571.54	620.43	678.6	702.18
Henan	373.51	362.64	349.05	352.56	357.66	359.78	362.96	384.8	417.86	454.48	480.21	512.51	568.86	638.15	683.39

Provinces	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Hubei	244.84	226.37	209.9	211.56	219.7	227.32	227.5	236.89	247.59	262.67	280.49	298.16	318.09	350.93	382.47
Hunan	267.17	251.88	249.62	253.78	257.03	252.87	250.45	265.35	285.41	305.22	323.24	336.23	356.05	391.73	425.59
Guangdong	252.6	244.23	235.73	234.03	238.28	255.02	277.19	307.38	339.46	373.19	400.85	423.61	443.91	460.69	489.7
Guangxi	130.63	131.43	131.91	140.88	149.08	159.83	164.11	176.69	194.05	216.35	235.28	252.37	267.02	285.63	288.69
Hainan	32.57	30.33	26.42	25.2	24.76	26.17	24.71	29.57	31.71	34.28	36.75	38.35	41.24	43.58	44.61
Chongqin	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	101.27	100.29	108.37	128.26	147.79	154.03
Sichuan	291.08	286.61	282.35	289.2	285.35	272.46	248.15	256.2	270.55	276.57	274.82	290.89	336.46	391.98	428.27
Guizhou	102.35	98.63	93.31	96.54	100.23	103.99	100.55	103.08	108.43	113.47	121.54	127.1	138.63	157.2	184.6
Yunnan	117.35	119.38	119.53	123.95	128.84	131.66	126.79	124.27	127.25	133.43	142.31	152.15	167.44	185.97	200.46
Xizhang	2.39	2.34	2.32	2.13	2.18	2.33	2.57	2.87	3.27	3.5	3.84	3.98	4.42	5.52	7.17
Shaanxi	179.71	161.32	135.6	132.64	135.07	137.33	129.62	134.24	145.07	157.21	169.01	183.6	204.41	230.52	254.75
Gansu	111.4	107.48	99.46	96.49	96.01	94.01	87.28	88	91.53	96.64	102.1	107.98	118.59	131.47	145.98
Qinghai	24.86	23.78	21.85	21.75	21.81	21.36	19.84	19.19	19.39	19.29	19.46	19.5	20.72	22.47	24.46
Ningxia	27.32	27.67	27.68	28.44	29.12	28.78	26.77	27.23	27.23	27.82	–	–	29.45	31.83	33.48
Xingjiang	104.64	99.37	89.32	86.31	80.67	78.31	71.86	72.36	74.98	80.39	87.67	95.84	106.24	113.29	122.86

<Appendix 8> Discount Value of Fixed Asset Investment of China's Provinces

(100 Million Yuan RMB)

Provinces	1978	1985	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Beijing	10.96	25.38	57.87	78.66	91.62	84.78	178.49	225.57	245.3	304.3	384.94	400.53	430.93	469.68
Tianjin	6.1	17.56	47.65	54.43	67.63	71.73	97.52	137.4	174	184.9	209.05	217.54	269.58	313.01
Hebei	20.81	44.17	98.31	129.76	159.88	187.51	258.96	296.37	397.7	513.9	568.08	651.67	717.61	797.47
Shanxi	13.04	26.09	60.27	76.44	98.87	104.03	108.4	134.58	160.9	176.2	200.09	197.15	213.5	237.78
Inner Mongolia	6.01	20.58	43.72	50.61	60.38	67.32	85.2	101.16	113.4	132	166.54	177.42	172.95	193.66
Liaoning	28.72	68.03	147.37	178.45	210.58	237.74	283.25	339.87	465	523.7	616.74	709.16	776.07	839.64
Jilin	9.68	24.79	57.5	69.15	80.72	91.03	119.47	160.5	185.3	237.6	251.39	269.4	325.76	343.22
Heilongjiang	17.12	51.61	104.86	112.31	156.67	139.92	198.65	276.98	343.1	386.9	411.97	435.87	422.94	550.96
Shanghai	10.6	26.16	92.93	126.62	160.36	158.49	241.31	332.29	364.2	407.7	489.77	580.89	635.73	722.64
Jiangsu	19.98	48.8	186.92	217.55	280.87	331.02	452.89	710.45	771.3	912.2	1034.88	1148.29	1303.16	1488.65
Zhejiang	11.3	35.07	89.08	106.59	137.05	170.63	257.66	299.86	346.7	439.3	487	572.71	767.78	875.99
Anhui	11.38	31.33	74.4	81.92	100.15	141.82	181.58	225.29	280.9	291.3	368.75	398.73	433.07	467.23
Fujian	5.85	18.38	51.27	63.37	79.88	115.61	157.39	233.83	290.3	352.5	397.48	433.03	496	560.82
Jiangxi	8.19	17.82	33.85	44.06	55.87	60.81	97.04	127.74	155.1	209.9	251.6	300.73	351.41	418.62
Shandong	22.72	71.22	182.12	220.78	266.92	385.99	561.55	655.73	827.8	1118.1	1317.45	1374.08	1616.66	1904.35
Henan	16.23	53.62	119.13	141.93	184.36	236.01	301.73	343.01	482.4	554.1	597.37	619.96	708.22	791.61
Hubei	13.7	29.26	97.92	122.35	152.36	137.74	170.66	283.65	369.9	525.5	613.56	685.77	669.88	701.65

Provinces	1978	1985	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Hunan	12.78	28.23	58.88	75.18	100.15	132.9	177.69	240.05	341.6	407.8	415.79	433.88	578.46	600.74
Guangdong	22.36	63.54	172.81	215.25	294.7	397.84	550.53	782.34	1020.1	1126.6	1251.72	1436.78	1641.14	1731.46
Guangxi	7.26	16.09	41.51	50.03	60.53	67.3	86.86	134.5	158.2	187.1	188.03	194.97	215.33	258.06
Hainan	n/a	n/a	8.94	10.8	17.5	29.16	34.31	45.86	54.7	64.7	68.01	73.65	83.49	88.64
Chongqin	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	207.25	226.32	261.39	268.91
Sichuan	31.79	67.38	128.66	161.39	226.3	261.74	349.67	437.99	490.1	464.7	574.33	612.28	642.46	734.68
Guizhou	3.94	11.36	29.6	32.63	39.72	45.32	54.11	71.82	81	90.5	98.53	113.6	128.72	160.1
Yunnan	3.42	9.03	36.28	50.57	64.47	87.21	114.54	131.95	199.8	217.3	215.43	283.71	287.11	319.34
Xizhang	n/a	1.04	2.12	2.3	2.24	2.92	3.85	6.08	6.4	11.4	27.87	24.13	28.85	32.05
Shaanxi	8.02	16.85	48.97	55.01	70.22	90.22	106.74	137.31	155.6	185.2	197.14	241.44	267.26	332.74
Gansu	5.54	14.32	23.67	27.13	38.06	46.65	58.2	70.82	92.3	101.2	108.19	118.06	186.02	192.61
Qinghai	1.52	3.21	9.86	7.38	14.32	14.57	19.37	26.48	25.7	32.3	34.95	38.74	59.91	54.34
Ningxia	1.84	4.36	9.52	10.68	12.84	15.28	18.8	25.79	28.5	33.4	37.46	43.37	49.73	58
Xingjiang	3.08	8.03	26.85	32.75	46.51	64.83	80.46	121.06	154.6	172.8	189.88	195.18	231.3	270.63

<Appendix 9> Number of Total Employee of China's Provinces

(10 thousand persons)

Provinces	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Beijing	–	–	–	–	659.3	668.6	659	681.7	669.5	661	661	624.3	621.9	622.1	629.5
Tianjin	–	–	–	–	471.6	472.1	478	490.5	489.7	485	492	427	421.1	406.7	410.5
Hebei	–	–	–	–	3109.8	3179.3	3241	3303.7	3367.3	3391	3415	3382.9	3399.9	3441.2	3379.6
Shanxi	–	–	–	–	1373.7	1402.7	1414	1447.9	1460.4	1478	1483	1429	1434.3	1419.1	1412.9
Inner Mongolia	891	909.7	910.3	924.6	963	979.4	999	1012.1	1024.5	1043	1050	1006.8	1017	1016.6	1013.3
Liaoning	1835.4	1858.6	1874.8	1897.3	1932.6	1954.1	1952	2009.2	2034	2031	2063	1818.2	1796.4	1812.6	1833.4
Jilin	–	–	–	–	1185.9	1224.5	1230	1250.2	1254.5	1258	1237	1127.4	1102.8	1078.9	1057.2
Heilongjiang	1333.3	1358.6	1395	1436.2	1476.1	1477.1	1492	1524.3	1552.4	1567	1659	1723	1679.9	1635	1631
Shanghai	–	–	–	–	773	764.1	740	763.2	768	764	770	670	677.3	673.1	692.4
Jiangsu	–	–	–	–	3720	3729.4	3743	3756.4	3765.4	3748	3746	3635	3595.8	3558.8	3565.4
Zhejiang	–	–	–	–	2595.9	2625.2	2659	2694	2700.7	2702	2700	2651.1	2660.9	2700.5	2772
Anhui	2563.3	2665.9	2723.9	2807.6	2891.2	2982.7	3049	3119.4	3206.8	3246	3322	3311	3312.5	3372.9	3389.7
Fujian	1237.7	1281.1	1301.8	1348.4	1436.5	1489.9	1521	1551.6	1567	1594	1613	1621.9	1630.9	1660.2	1677.8
Jiangxi	–	–	–	–	1844.9	1870.3	1893	2008.4	2059.2	2064	2078	1971.3	1961.3	1935.3	1933.1
Shandong	3766	3887	3940.3	4043.2	4310.1	4405.1	4473	4546.3	4625.4	4650	4707	4657.2	4698.6	4661.8	4671.6
Henan	–	–	–	–	4274.2	4386.6	4481	4608.9	4696.7	4829	5017	4999.6	5205	5571.7	5516.6
Hubei	–	–	–	–	2556.8	2567	2607	2672.8	2707	2692	2709	2616.3	2572.4	2507.8	2452.5
Hunan	–	–	–	–	3251.5	3308.8	3361	3440.2	3506.1	3547	3591	3498.5	3496.1	3462.1	3438.8

Provinces	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Guangdong	–	–	–	–	3324.9	3397	3480	3569.1	3656.8	3691	3784	3737.4	3760.5	3861	3962.9
Guangxi	1961	2012	2046	2109	2170.8	2217.4	2277	2336.4	2382.5	2417	2452	2470.9	2481.5	2530.4	2543.4
Hainan	280.8	292	298.4	304.6	316.1	321.2	320	335.5	335.3	335	331	320.8	326.2	333.7	339.7
Chongqin	–	–	–	–	–	–	–	–	–	–	1690	1645.1	1639.4	1636.5	1624
Sichuan	–	–	–	–	6075.4	6202.5	6221	6256.8	6335.3	6295	4618	4534.7	4482.3	4435.8	4414.6
Guizhou	1435.9	1501.3	1570.8	1651.8	1701.4	1741.8	1770	1825.6	1857.1	1892	1927	1946.3	1975.9	2045.9	2068.2
Yunnan	–	–	–	–	2021.2	2065.2	2106	2147.3	2186.3	2214	2248	2270.3	2273.4	2295.4	2322.5
Xizhang	107.8	107.2	107.6	107.9	109.7	111	113	112.7	113.7	118	120	118.4	122.2	123.4	124.6
Shaanxi	–	–	–	–	1668.7	1699.6	1718	1746.7	1774.4	1798	1812	1802	1780.9	1812.8	1784.6
Gansu	–	–	–	–	1091.7	1112.7	1131	1151	1159.4	1175	1186	1175.6	1185.6	1182.1	1187.2
Qinghai	–	–	–	–	211.6	216	217	222.9	226	232	235	230.4	241.2	238.6	240.3
Ningxia	190.9	197.4	203.5	211.2	218.7	224.4	230	235.5	243.6	250	260	259.5	270.8	274.4	278
Xingjiang	–	–	–	–	624.2	635.7	646	649.7	662.2	672	691	678.3	669.6	672.5	685.4

<Appendix 10> Consumer Price Index of China's Provinces(%)

Provinces	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Beijing	108.6	120.4	117.2	105.4	111.9	109.9	119	124.9	117.3	111.6	105.3	102.4	100.6	103.5	103.1
Tianjin	106.8	116.9	114.7	103	110.2	111.4	117.6	124	115.3	109	103.1	99.5	98.9	99.6	101.2
Hebei	107.8	118	118.7	100.6	103.4	106.1	113.8	122.6	115.2	107.1	103.5	98.4	98.1	99.7	100.5
Shanxi	107.4	120.9	119.5	102.2	104.8	107.3	115.1	125.2	116.9	107.9	103.1	98.6	99.6	103.9	99.8
Inner Mongolia	107.8	116.3	115.3	102.3	104.6	107.4	114.1	122.9	117.5	107.6	104.5	99.3	99.8	101.3	100.6
Liaoning	108.6	119.3	118.2	103.3	105.6	106.7	115.2	124.3	116.1	107.9	103.1	99.3	98.6	99.9	100
Jilin	107.6	120.3	117.2	104.9	106.8	108	112.6	120.6	115.2	107.2	103.7	99.2	98	98.6	101.3
Heilongjiang	109.4	118	114.6	105.7	107.4	109.2	114.8	121.9	116.1	107.1	104.4	100.4	96.8	98.3	100.8
Shanghai	108.1	120.1	115.9	106.3	110.5	110	120.2	123.9	118.7	109.2	102.8	100	101.5	102.5	100
Jiangsu	109.2	121.9	117.1	103.2	104.9	106.6	118.2	123.2	115.8	109.3	101.7	99.4	98.7	100.1	100.8
Zhejiang	108.8	121.5	118.2	102.1	103.5	107.5	119.8	124.8	116.6	107.9	102.8	99.7	98.8	101	99.8
Anhui	109.1	120.9	117.2	102.7	106.1	108.2	114.7	126.9	114.8	109.9	101.3	100	97.8	100.7	100.5
Fujian	109.4	126.5	118.9	99.3	103.5	105.9	115.4	125.3	115.2	105.9	101.7	99.7	99.1	102.1	98.7
Jiangxi	106.6	121.8	118.5	102.1	102.8	105.7	114.6	126.9	116.9	108.4	102	101	98.6	100.3	99.5
Shandong	108.2	118.7	117.3	103.4	104.9	106.8	112.7	123.4	117.6	109.6	102.8	99.4	99.3	100.2	101.8
Henan	106.3	119.4	118.7	100.7	102.3	105.4	110.4	125.2	116.5	110.5	103.5	97.5	96.9	99.2	100.7
Hubei	107.5	119	116.3	104.2	104.9	109.6	118.4	125.3	120	109.4	103.2	98.4	97.8	99	100.3
Hunan	109.8	125.6	118.2	100.4	104.4	110.7	116.8	125.3	119	107.7	102.8	100.2	100.5	101.4	99.1

Provinces	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Guangdong	111.2	129.4	122.1	97.5	101.2	107.3	121.6	121.7	114	107	101.9	98.2	98.2	101.4	99.3
Guangxi	108.2	120.8	121.1	101.1	102.8	105.9	122	126	118.4	106.5	100.8	97	97.7	99.7	100.6
Hainan	109.8	128.1	128.4	102.1	103.9	108.7	123.3	126.7	113.5	104.3	100.8	97.3	98.3	101.1	98.5
Chongqin	–	–	–	–	–	100	100	100	100	100	103.1	96.4	99.3	96.7	101.7
Sichuan	107.6	119.9	119.8	103.8	103	107.4	116.8	124.6	118.5	109.3	105.1	99.6	98.5	100.1	102.1
Guizhou	107.1	119.8	118.3	101.8	104.4	107.8	116	122.8	121.4	109.1	103.4	100.1	99.2	99.5	101.8
Yunnan	107	119.8	118.6	102.8	103.1	108.9	121.3	119.2	121.3	108.7	104.3	101.7	99.7	97.9	99.1
Xizhang	–	–	–	–	–	100	113.4	100	100	100	100	100	100	99.9	100.1
Shaanxi	–	–	–	102.4	106.6	110.3	113.1	126.7	119	109.7	104.8	98.4	97.8	99.5	101
Gansu	107.6	119.1	117.9	103.2	104.9	107.2	115.4	123.7	119.8	110.2	102.9	99	97.6	99.5	104
Qinghai	–	–	–	105.1	107.6	108	113.2	121.8	118	110.8	104.8	100.7	99.5	99.5	102.6
Ningxia	107.3	117.1	117.2	107.1	106.3	108.3	114.3	123.1	117.1	106.8	103.8	100	98.7	99.6	101.6
Xingjiang	107.2	114.7	116	105	108.6	108.6	113	126.7	119.7	110.5	103.7	100.2	97.4	99.4	104

<Appendix 11> Fixed Asset Investment Price Index of China's Provinces(%)

Provinces	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Beijing	107.3	112.2	126.6	116.2	113.9	108.2	102.7	100.8	99.9	101	100.6
Tianjin	–	119.4	122.9	111.9	107.6	102.5	100.8	98.9	99.2	99.9	99.7
Hebei	106.8	129.3	124.8	110	106.9	103.9	101.5	97.8	99.4	101.1	99.9
Shanxi	107.8	116.8	124.8	108.3	106.8	104.9	101.5	98.8	99.7	101.8	101.7
Inner Mongolia	107.1	109.3	124.5	106.7	103.9	105.3	99.7	101.7	101.9	101.9	100.8
Liaoning	108.2	120.9	136.4	117.4	104.9	102.2	102.3	99.8	100	101.1	100.4
Jilin	111.9	116.4	128.8	107.3	109.6	102.9	104.4	100.8	102.2	102	101.1
Heilongjiang	107.6	113.5	127.9	109	106.5	103.4	102.7	100.8	99.7	101.5	100.1
Shanghai	107.3	112.9	131.4	108.8	103.1	106.9	100.5	98.4	98.1	100	100.7
Jiangsu	104.5	112.1	138.8	114.6	107.4	103.2	99.2	98.4	98.3	101.1	100.8
Zhejiang	–	–	138.8	112.4	107.2	101.3	99.5	97.6	98.2	100.3	100.4
Anhui	114.8	119.8	123	120.1	106.5	103.4	101.3	100	99.3	101.6	99.5
Fujian	108.6	114.9	134.1	107.3	104.8	104.7	101.1	98	98.5	100.2	99.5
Jiangxi	110.4	110.1	129.8	114.6	107.2	105.8	101.4	102.1	98.6	101.4	98.9
Shandong	112.4	119.4	122.1	115.8	106.6	103.1	100.4	99.2	99.6	102.4	101.4
Henan	109.4	119.8	126.7	106	105.9	103.9	102.9	98.7	98	102.9	100.4

Provinces	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Hubei	108.3	117	127.4	107.9	105	104	102.1	100.5	99.5	101.7	100.1
Hunan	108.1	116.4	129.5	113.5	109.5	104.9	101.8	102.7	100.5	102.3	101.3
Guangdong	–	124.6	–	–	–	–	–	–	–	–	100.2
Guangxi	101.7	117.9	131.2	112.3	103.4	103.6	100.3	99.9	96.1	101.4	102
Hainan	–	–	–	–	–	–	–	–	–	101.8	100.3
Chongqin	–	–	–	–	–	–	101.7	98.7	100.5	102.5	100.8
Sichuan	108.1	113.9	133.2	107.3	101.2	104.8	102.2	97.5	100.5	100.9	101.5
Guizhou	110.6	120.2	126.9	113.1	107.6	105.4	101.4	100	99.4	102.2	100.4
Yunnan	112.1	117.6	135.4	113.6	104	104.3	105.4	101.8	100.7	101.6	101
Xizhang	–	–	–	–	–	–	–	–	–	–	–
Shaanxi	112.9	119.1	129.5	111.7	107.9	107.8	105.3	101.8	101.2	103.6	103.6
Gansu	116.5	117.4	126.2	112.6	109.4	104.9	102.7	100.3	101	103.3	102
Qinghai	–	115.1	125.9	108.4	105.3	103.5	103	98.5	100.1	101.6	100.3
Ningxia	110.4	117.3	123	112.6	109.3	107.4	102.2	102.1	99.7	104.5	101.5
Xingjiang	114.8	116.9	126.5	112.3	106.2	105.6	103.2	102	99	103.6	102.5

<Appendix 12> Expenditures of Domestic Research & Development(R&D) of China's Provinces

(10 thousand Yuan RMB)

Provinces	1995	1996	1997	1998	1999	2000	2001
Beijing	1135114	1303334	1405060	1415218	1558821	1591280	1556635
Tianjin	131243	136856	142431	138114	133855	116187	246931
Hebei	72233	86092	73798	63254	89876	102239	262738
Shanxi	57495	64472	48493	54978	55361	59076	98942
Inner Mongolia	28706	32206	29389	26662	24943	26545	33444
Liaoning	200837	225886	219947	226236	224847	227326	416934
Jilin	99806	116256	104093	94316	98484	102005	133741
Heilongjiang	66362	73836	72561	78559	75185	68578	149414
Shanghai	483859	552838	488060	440453	407084	460333	736146
Jiangsu	250861	308574	244998	262177	275662	331475	729995
Zhejiang	67003	73986	75076	85369	89793	95658	335171
Anhui	57038	61687	52405	54632	56177	92213	200215
Fujian	26054	28094	29436	32668	39382	41722	211918

Provinces	1995	1996	1997	1998	1999	2000	2001
Jiangxi	46996	45891	31688	36978	43390	44647	81882
Shandong	137635	142448	133250	138880	149595	151968	519501
Henan	132274	144748	118619	132470	110969	126391	248024
Hubei	200349	213895	242208	257293	259123	195954	348239
Hunan	130601	145905	105993	96901	96571	84864	192442
Guangdong	215392	225702	230409	227309	235726	187144	1071166
Guangxi	58449	55563	38932	40122	36211	41117	83597
Hainan	10772	9554	8685	10033	11468	12262	8306
Chongqin			40035	44455	54204	57412	101294
Sichuan	371985	421603	341785	330584	358959	366260	448848
Guizhou	21432	22608	21163	20522	21233	23370	41774
Yunnan	58960	72942	76595	73947	72811	64392	67995
Xizhang	2373	2884	3220	3108	3139	3124	2412
Shaanxi	237233	259742	288519	298979	273508	363665	494570
Gansu	237233	89987	80153	72450	77981	64404	72565
Qinghai	7498	8646	9957	10414	11587	10959	12937
Ningxia	12461	13821	9246	9498	9251	7204	16488
Xingjiang	21454	25759	23232	24660	29001	34933	32381

<Appendix 13> Number of Employee in Hong Kong, Macao, Taiwan Firms of China's Provinces

(10 thousand persons)

Provinces	1996	1997	1998	1999	2000	2001
Beijing	10.1	10.2	13.1	13.5	14.2	12.9
Tianjin	6.4	8.5	8	10.4	10.7	11.2
Hebei	8.5	7.6	6.2	5.9	5	5.4
Shanxi	1.4	1.4	2	1.7	1.7	1.7
Inner Mongolia	1.9	2.1	2.3	2	1.7	1.6
Liaoning	8.2	8.7	9.5	10.2	10.2	8.1
Jilin	1.7	1.8	2	2.4	2.4	2.4
Heilongjiang	4.4	4.6	4.4	4.1	3.5	3.6
Shanghai	13.7	13.8	16.9	22	23.3	17.6
Jiangsu	19.5	20.6	20.1	19.8	20	20.8
Zhejiang	12.4	13	15.5	15.2	15.9	16.8
Anhui	2.2	2.3	2.1	2.3	2.1	1.8
Fujian	37.9	44.1	47.6	49.1	51.5	61.3
Jiangxi	2.7	2.4	3.3	2.9	2.6	3.5
Shandong	12.7	13	11	11.1	11.9	12.6
Henan	8.9	8.7	9.2	9	9.6	7.6
Hubei	5.9	5.4	4.7	4.1	4.1	4.2
Hunan	2.6	3	2.8	2.8	2.7	2.8
Guangdong	89.6	96.4	99	102.7	102.7	104.9
Guangxi	2.3	2.1	2.8	2.7	3	2.8
Hainan	1.9	1.9	1.7	1.6	1.7	1.5
Chongqin		1.8	2	2.2	2	2.1
Sichuan	3.4	1.8	2.6	2.8	2.6	2.3
Guizhou	0.7	0.6	0.6	0.6	0.6	0.7
Yunnan	1.8	1.9	1.8	2	1.7	1.6
Xizhang		0				
Shaanxi	1.2	0.8	1.1	1.3	1.3	1.5
Gansu	0.7	0.3	0.4	0.4	0.3	0.6
Qinghai		0.2	0.2	0.2	0.1	0.03
Ningxia	0.3	0.3	0.4	0.3	0.3	0.3
Xingjiang	1.5	1.3	0.9	1	0.9	0.9

<Appendix 14> Number of Employee in Foreign Firms without Hong Kong, Macao, Taiwan Firms of China's Provinces

(10 thousand persons)

Provinces	1995	1996	1997	1998	1999	2000	2001
Beijing	18.1	20.7	21.2	21.2	20.6	23.8	22.4
Tianjin	12.9	15	18.2	18.2	22.2	24.6	25.9
Hebei	7.2	8	8.1	7.3	6.7	6.9	7.3
Shanxi	1.9	1.9	1.8	1.1	1	0.9	1.2
Inner Mongolia	2.2	2.7	2.8	1.7	2.1	2.2	1.7
Liaoning	17.8	17.2	19.1	19.9	18.9	20.9	20.7
Jilin	6.2	7.2	7.4	5.5	5.7	5.9	6.1
Heilongjiang	5.5	4.6	4.7	3.8	3.6	3.4	3.6
Shanghai	22.2	27.1	29.8	35.5	36.8	40.3	33.2
Jiangsu	18	22.1	23.8	26.4	28.6	31.4	32.4
Zhejiang	12.7	14.4	14.8	11	12.3	13.9	14
Anhui	3.8	3.5	4	3.4	4	3.6	4.1
Fujian	16.4	28.4	32.2	35.9	36.5	40.3	35
Jiangxi	1.9	1.6	2.5	2.4	2	1.4	1.4
Shandong	24.7	25.9	28.9	28	33.9	38.7	41.7
Henan	7.6	7.3	7.2	6.2	5.8	5.5	5.4
Hubei	4.2	4.1	4.7	4.6	3.5	4.7	5.6
Hunan	3.2	3.3	3.6	3.4	2.8	2.9	2.3
Guangdong	35.8	40.3	42.6	38.7	40.5	43	46
Guangxi	5.7	5.4	6.6	4.9	4.1	3.8	3.7
Hainan	1.8	1.9	2.2	1.5	1.6	1.7	1.7
Chongqin			2.8	2	2.2	2.6	2.6
Sichuan	5.1	6	3.6	3.8	3.8	3.3	3
Guizhou	1.5	1.2	1.4	1.3	1.3	1.2	1
Yunnan	1	1.2	1.5	1.3	1.2	1.3	1.3
Xizhang			0.1				0.02
Shaanxi	1.2	1.2	1.3	1.7	1.6	1.6	2.2
Gansu	1.1	1.2	1.1	0.8	0.9	0.9	1.4
Qinghai	0.1	0.2	0.1				
Ningxia	0.9	1	1.1	1	1	1	0.8
Xingjiang	0.5	0.6	0.6	0.6	0.5	0.5	0.5

References

Adams, James D., "Endogenous R&D Spillovers and Industrial Research Productivity," *Working Paper* 7484, NBER, Cambridge, MA, January 2000.

Aitken, Brian J. and Ann E. Harrison, "Do Domestic Firms Benefit from Direct Foreign Investment? Evidence from Venezuela," *The American Economic Review*, 1999. 6, pp.605-618.

Aitken, Brian J. and Ann Harrison, "Are there Spillovers from Foreign Direct Investment? Evidence from Panel Data for Venezuela," Mimeo, MIT and the World Bank, 1991.

Aitken, Brian J., Gordon H. Hanson, and Ann E. Harrison, "Spillovers, Foreign Investment, and Export Behavior," *Journal of International Economics*, Vol.43, 1997, pp.103-132.

Baldwin, Richard E. and Braconier, Henrik et al., "Multinationals, Endogenous Growth and Technological Spillovers: Theory and Evidence," *Working Paper Series*, Research Institute of Industrial Economic(IUI) workshop, Stockholm, Sweden, August 1999.

Baldwin, Richard E., Henrik Braconier, and Rikard Forslid, "Multinationals, Endogenous Growth and Technological Spillovers: Theory and Evidence," CEPR Discussion Paper, 1999.

Blomstrom, M. and Globerman, Steven et al., "The determinants of Host Country Spillovers from Foreign Direct Investment: A Review and Synthesis of the Literature," *Working Paper* No. 76, Stockholm School of Economics and NBER, September 1999.

Blomstrom, M. and Kokko, Ari, "FDI and Human Capital: A Research Agenda," *Working Paper Series*, Stockholm School of Economics, Sweden, December 2001.

Blomstrom, M. and Kokko, Ari, "Multinational Corporations and Spillovers," *Journal of Economic Surveys*, Vol.12, 1998, pp.247-277.

Blomstrom, Magnus, "Multinational Corporations and Productivity Convertgence in Mexico," *Working Paper* No.3141, NBER, Cambridge, MA, October 1989.

Bloom, David E. and Canning, David et al., "Technological Diffusion, Conditional Convergence, and Economic Growth," NBER *Working Paper* 8713, Cambridge, MA, the U.S., January 2002.

Branstetter, Lee, "Is Foreign Direct Investment a Channel of Knowledge Spillovers? Evidence from Japan's FDI in the United States," *Working Paper* 8015, National Bureau of Economic Research, Cambridge, MA, the U.S., 2000.

Campos, Nauro F., and Yuko Kinoshita, "Foreign Direct Investment as Technology Transferred: Some Panel Evidence from the Transition Economies," The Manchester, 2002.

Chen, Chung, Lawrence Chang, and Yimin Zhang, "The Role of Foreign Direct Investment in China's Post - 1978 Economic Development," World Development, Vol.23, No.4, 1995, pp. 691-703.

Chen, Yu, "Foreign Direct Investment and Manufacturing Productivity in China," Research Report, CEPII project, Paris, France, April 2002.

Chiu, Lee-in Chen, "Determinants of Total Factor Productivity of FDI in China: Implication for East Asia's Capability on International Production," Research Report, Chung-hua Institution for Economic Research, Taipei, Taiwan, 2001.

Chung, Wilbur, "Identifying Technology transfer in Foreign Direct Investment: Influence of Industry Conditions and Investing firm Motives," *Journal of International Business Studies*, 2001, 32(2), pp.211-229.

Coe, D. and Helpman, E., "International R&D spillovers," *European Economic Review*, 1995, 35(5), pp.859-887.

Driffield, Nigel and Kaylor, Karl, "Spillovers from FDI and Skill

Structures of Host-country Firms," Paper at Royal Economic Society Conference, Department of Economics, University of Leicester, England, April 2001.

Eeckhout, Jan and Jovanovic, Boyan, "Knowledge Spillovers and Inequality," *The American Economic Review*, December, 2002, Vol.92(5), pp.1290-1307.

Fan, Emma Xiaoqin, "Technological Spillovers from Foreign Direct Investment - A Survey," ERD *Working Paper* N0.33, Asian Development Bank, Manila, Philippines, December 2002.

Harris, Richard and Robinson, Catherine, "The Effect of Foreign Acquisitions on Total Factor Productivity: Plant-level Evidence from U. K. Manufacturing, 1987-1992," *The Review of Economics and Statistics*, August 2002, 84(3), pp.562-568.

Haskel, Jonathan E. and Pereira, Sonia C. et al., "Does Inward Foreign Direct Investment Boost the productivity of Domestic Firms?" *Working Paper Series* No.452, Wueen Mary University of London, U.K., February 2002.

Jones, Charles I., "Time Series of Endogenous Growth Models," *Quarterly Journal of Economics*, Vol.110, November 1995, pp.495-523.

Keller, Wolfgang, "International Technological Difussion," NBER *Working Paper Series*, Cambridge, MA, October 2001.

Konings, Jozef, "The Effects of Foreign Direct Investment on Domestic Firms," Economics of Transition, Vol.9(3), 2001, pp.619-633.

Lee, Xinzhong, et al., "Does Variation in Fixed Asset Investment by Foreign Firms Explain Part of the Variation in Economic Growth Across Chinese Provinces," *Working Paper Series*, ICSEAD, Kitakyushu, Japan, June 2002.

Lichtenberg, Frank and Bruno van Potterlsberghe de la Potterie, "International R&D Spillovers: A Re-examination," NBER *Working Paper* 5668, National Bureau of Economic Research, Cambridge, MA, the U.S., 1996.

Mcvicar, Duncan, "Spillovers and Foreign Direct Investment in U.K. manufacturing," Applied Economics Letters, 2002. 9, pp.297-300.

Nakanishi, Yasuo, "Empirical Evidence of Inter-Industry R&D Spillover in Japan," *Journal of Economic Research*, July 2002, pp.91-104.

Paquet, Alain and Benoit Robidoux, "Issues on the Measurement of the Solow Residual and the Testing of its Exogeneity: a Tale of Two Countries," *Working Paper Series* No.5, CREFE, Downtown Station, Montreal(Canada) Quebec, 1997.

Park, Seung-Rok, "A Review of Total Factor Productivity Studies in Korea and A Discussion of Limits to National and Corporate Technology Strategies," *International Journal of Technology Management*, Vol.22, No.5/6, 2001.

Park, Seung-Rok, *Economic Performance of Korean Firms and Evaluation of Restructuring Tools during Financial Crisis*, Korea Economic Research Institute, Seoul, Korea, April 2003.

Potterie, Bruno van Potterlsberghe de la and Frank Lichtenberg, "Does Foreign Direct investment Transfer Technology across Borders?" *The Review of Economics and Statistics*, 83(3), August 2001, pp.490-497.

Raa, Thijs ten, "Debreu's Coefficient of Resource Utilization, the Solow Residual, and TFP: The Connection by Leontief Preferences," *Working Paper Series*, Tilburg University, the Netherlands, Jan. 2003.

Temple, J., "The New Growth Evidences," *Journal of Economic Literature*, 37(1), March 1999, pp.112-156.

Todo, Yasuyuuki and Miyamoto, Koji, "Knowledge Diffusion from Multinational Enterprises: The Role of Domestic and Foreign Knowledge-Enhancing Activities," *Working Paper Series*, Department of Economics, Tokyo Metropolitan University, Japan, July 2002.

Y. Konishi and Y.Nishiyama, "Nonparametric Test for Translog Specification of Production Function in Japanese Manufacturing Industry," *Working Paper Series*, Graduate School of Economics, Nagoya University, 2002, pp.597-602.

Abstract

By measuring the change of total factor productivity(TFP) in China's provinces, this paper develops a framework of modeling technology spillovers. Both theoretical and empirical analyses of the potential channels of international technology spillovers as well as the determinants affecting TFP in China are carried out. The derived results show that domestic research and development(R&D) expenditures, human capital stock and employees brought by foreign enterprise have significantly positive effects on output and growth of TFP. The study identifies R&D performed by advanced countries transferred to host country via training of employee or learning-by-doing in FDI firms. FDI inflows are found to be an important channel of international technology spillovers, but domestic imports and imports of FDI firms do not seem to have generated adequate technology spillovers needed to stimulate productivity growth. Moreover, the effects of interaction between human capital stock in host country and FDI stock are found to have had rather limited effects on productivity. This suggests that human capital stock have not adequately reached a level where it can absorb advanced technology from

FDI firms through technology spillovers. This study helps better understand the impacts of activities associated with Multi-national corporations(MNCs), FDI and international trade regarding the international diffusion of technology in China.

*** Key words**

Technological spillovers, Foreign direct investment, Research and development(R&D), Total factor productivity(TFP), China.