THE CORRELATION BETWEEN FDI AND KNOWLEDGE TRANSFER, & THEIR EFFECT ON DOMESTIC INNOVATION -- EVIDENCE FROM CHINA

Hang Li

A Thesis
In
The John Molson School of Business

Presented in Partial Fulfillment of the Requirements
For the Degree of Master of Science in Administration at
Concordia University
Montreal, Quebec, Canada

July 2003

Your file Votre référence
ISBN: 0-612-83951-6
Our file Notre référence
ISBN: 0-612-83951-6

ABSTRACT

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This study attempts to explore the correlation between foreign direct investment (FDI) inflows and foreign knowledge transfer in China. More specifically, the study empirically investigates the feedback effect of foreign knowledge transfer from multinational corporations (MNCs) on FDI in the Chinese context. Also, the relationship between international knowledge transfer through FDI and indigenous firms' innovation is examined. Furthermore, in order to fill the gap in the literature, the study probes the impacts of WTO accession on FDI inflows to China and on domestic innovation development.

Using different methodologies, this paper conducts a longitudinal study based on a unique, country-level dataset (patent data) from China. The empirical evidence supports the view of FDI as a vehicle of foreign advanced technology inflowing to China. The more technologies transferred to China, the more investments MNCs make, which spurs the domestic firms to promote their own R&D activities. Accordingly, the improvement of domestic innovative capacity will attract more advanced technology and FDI inflows to China. Also, the WTO accession seems to have had positive effects on drawing FDI inflows and foreign knowledge transfer to China.

ACKNOWLEDGEMENTS

Acknowledgement must also be made of the contributions made by several people, who deserve special credit for their assistance in the creation of this thesis. First and foremost, I would like to express my special thanks to my supervisor, Professor Ramdas Chandra, for his constant support and invaluable guidance in the course of accomplishing this thesis, and for his careful, time-consuming reading of my work. His sense of quality and perfection, and his patience, has been a great help.

I am also indebted to the members of my thesis committee, Professor Christopher A. Ross and Professor Alan Hochstein, for their kind help and invaluable comments on the thesis. Moreover, I am very grateful to Shaojun Zhang and Mr. Ansheng Cao, who kindly provided the precious data from China for the study.

Furthermore, my greatest gratitude must be extended to my parents, Meijun Lu and Guangjun Li, to my lovely daughter, Yufei Wu, who just celebrated her 5th birthday, and to my husband, Lijian Wu, and all my family members in China, for their constant support and encouragement. Among other family members, I was particularly supported by my brother, Wensheng Li, and his wife, Ying Yu, for their technological assistance.

Finally, I appreciate very much the generous advice, knowledge and support given to me by many friends in Montreal, Canada. Mr. Richard James was a constant source of encouragement and assistance, and substantially contributed to the whole course of my study in Canada. I would also like to express my gratitude to Sarah Huang and Lucy Makdessian, for their constant help and important advice.

Hang Li
Montreal, Canada
July 2003

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INTRODUCTION

The role of foreign direct investment (FDI hereafter) in the growth process has for long been a topic of intense debate. Although this debate has provided rich insights into the relationship between FDI and economic growth, the existing literature has not yet delivered a clear judgement on this issue.

Some early studies using industry-level data find that foreign presence in an industry positively influences domestic labour productivity. More recent empirical studies suggest that FDI has a positive impact on growth (Borensztein et al., 1998; Balasubramanyam et al., 1996; Dees, 1998; Mello, 1996). By utilizing data on FDI flows from industrial countries to 69 developing countries over the last two decades, Borensztein et al. (1998) examine empirically the effect of FDI on economic growth in a cross-country regression framework. Their results strongly suggest that FDI is an important vehicle for the transfer of technology.

However, several firm-level studies have failed to find positive spillover from knowledge transfer via FDI to firms competing directly with subsidiaries of multinational corporations (MNCs hereafter). For example, while Djankov and Hoekman (2000) confirmed the positive effect of FDI on the total factor productivity (TFP hereafter) growth within joint venture or wholly owned foreign enterprises, they also found a negative spillover effect of knowledge transfer via FDI on domestic firms in Czech industries. Similarly, several studies cast doubts on the view that FDI generates positive spillovers of knowledge transfer for local firms (Aitken, Hanson, and Harrison, 1997; Haddad and Harrison, 1993).

Moreover, knowledge transfer has been described as the crux of FDI for several decades. With the widespread presence of MNCs, FDI by MNCs has long been recognized as an important channel of transferring technology to developing countries (Michalet, 1977; Lan, 1996; Borensztein et al., 1998; Blomström and Kokko, 1998).

The current phase of international linkage is centred on capital and technology flows, and investment crossing national boundaries is driven, or accompanied by a global exploitation of technology. Therefore, one of the most frequently questions about the impact of knowledge transfer via FDI on host countries is its contribution to the development of indigenous technological innovation. Many researchers have attempted to identify the role of FDI on technology development in host countries under various circumstances; among them are Steuer (1973), Frank (1980), OECD (1991), Smali (1985), UNCTC (1985, 1987), Roman (1986), and Blomstrom (1990).

Furthermore, in the existing literature, many studies have investigated the determinants of FDI to a developing country. Among those factors, labor quality, the stock of human capital, and the degree of industrialization of the host country are related to the technology skills of the host country; the source country's degree of innovation reflects the R&D competency of an MNC. However, none of the prior studies particularly examines the impact of technology skills of both MNCs and domestic firms on FDI inflows. Therefore, one of the objectives of the present study will be to tackle this issue empirically.

Additionally, Bosworth and Yang (2000) argue that IPR laws and their enforcement play a vital role in the process of economic development. While the earlier literature examined the impact of IPR protection on the volume of FDI, the results

showed that weak protection deters foreign investors in technology intensive sectors that rely heavily on IPRs (Mansfield, 1994; Smarzynska, 2002a).

Moreover, the theoretical literature has investigated the effect of IPR enforcement on knowledge transfer and FDI in several endogenous growth models. In principle, patent protection directly affects growth through inducements to innovation (Segerstrom et al., 1990; Grossman and Helpman, 1991; Helpman, 1993; Taylor, 1994).

Furthermore, Mansfield (1994) presents some evidence that IPR protection has a positive impact on investment in R&D and, subsequently, on economic growth in developing countries. Also, from a dynamic point of view, the introduction of IPRs stimulates innovation and thus increases future trade flows in the host country.

Nonetheless, although previous studies tackled the effects of IPR protection in a country on its FDI inflows, knowledge transfer, and indigenous innovation respectively, none of them uses IPR protection as a link to connect them together to examine the relationships among these variables in association with the effects of IPR protection in the host country.

In the Chinese context, the growth of FDI in China has been dramatic since the beginning of the economic reforms in 1978 (Lan, 1996). China is now almost surpassing the United States in being the largest recipient of foreign capital in the world. The expansion of FDI in China has been accompanied by a rapid economic growth and an increasing openness to the rest of the world, especially after its accession to the World Trade Organisation (WTO hereafter).

There are several positive impacts of FDI on the Chinese economy. First, since the early 1990s, FDI has brought about the import of advanced technology and equipment,

narrowing the technology gap between China and developed countries. Furthermore, via knowledge transfer, FDI has improved the Chinese total factor productivity (Liang and Zhu, 1996). The importance of technology is indispensable in improving Chinese technological competency and putting China on an equal footing with its Asian neighbours. Introducing modern technology to China is also a good way for MNCs to penetrate the Chinese internal market (Chen and Wong, 1995).

Furthermore, the reductions of barriers to FDI and policies to improve the investment environment have played a key role in attracting FDI to China (Tseng and Zebregs, 2002). From the beginning of the reform process, the Chinese authorities considered attracting FDI as an important goal, as it would introduce new technologies, know-how and capital, and help to develop the export sector. China's increasing openness to FDI has contributed importantly to its exceptional growth performance. Accession to the WTO broadens China's "opening up" policies and is expected to continue FDI's contributions to China's economy in the future.

However, a general picture of the impact of knowledge transfer to China via FDI on Chinese firms' technology development has not emerged from these studies. In this context, Lan (1996) has suggested that a longitudinal study which aims to reveal the general model of integration between inward technology and local technology in China will be helpful for understanding the development pattern of China in the whole economy. Moreover, to our knowledge, there is no empirical work studying the effects of WTO accession on a country's FDI inflows and its domestic innovation.

Therefore, the following questions draw our attention:

1. Is FDI positively correlated with foreign knowledge transfer to China?

2. Does foreign knowledge transfer through FDI spur the incentives for domestic innovation?
3. Whether or not WTO accession acts as a kind of catalyst to boost FDI inflows to China?
4. Does WTO accession also positively influence local firms' innovation?

With respect to the measurement of knowledge transfer or technology change, there are many different measures in the literature, such as labour productivity, total factor productivity (TFP hereafter), R&D expenditures, literacy, and patent data. In the present study, we use patent data as a proxy to measure the knowledge transfer and the development of innovation. The reason is partly because it reflects the degree of technology ability and partly because FDI is more significant in the more patent-sensitive sectors than in patent-insensitive sectors (Maskus and Penubarti, 1995).

Additionally, in the study, we add an indicator of openness measured by China's accession of the WTO to examine the effects of WTO accession on FDI inflows, as well as foreign knowledge transfer and domestic innovation. The reason is, to a developing country, membership of the WTO not only reflects the relative openness of the country, but also represents the degree and extent of protection and enforcement of its IPR regime.

Under the above background, therefore, we set up the major objectives for this study as follows:

1. While examining the impact of FDI on knowledge transfer to China, we will focus more on investigating the feedback effect of foreign knowledge transfer from MNCs on FDI in the Chinese context;

2. To go beyond the existing literature, we will shed some light on the relationship between international knowledge transfer through FDI and indigenous firms' innovation;
3. To fill the gap in the literature, we will probe if WTO accession boosts FDI inflows to China and aids domestic firms to promote their innovation development.

By conducting a longitudinal study based on a unique country-level dataset from China, we address the above questions empirically to accomplish our objectives in this study. Structurally, this study is organized as follows. In the next section, we review the related literature. The third section aims to bridge the existing literature and empirical study by developing a theoretical framework and formulating the hypotheses to be tested. Then we introduce our data and describe the methodology. In the following sections, we present the empirical results and discuss the findings. We conclude the study in the closing section.

LITERATURE REVIEW

The correlation between FDI and technological development

➢ General contribution of FDI to the host country

During the past decades, more and more studies are concerned with how to evaluate the contribution of foreign direct investment (FDI hereafter) to economic growth in host countries. For example, in his examination of development in Southeast Asia, Stewart (1987) identifies four contributions of FDI, which are supply capital, stimulate economic diversification, transfer technology and enhance employment opportunity. Yu (1990) has shown that, when a Korean researcher looks backward, he attributes the contribution of FDI to "promotion of economic co-operation with foreign country, improvement of the international competitiveness, and introduction of necessary advanced technology".

One report from the Organization for Economic Co-operation and Development (OECD hereafter) (1993) states that the biggest role of FDI in the developing countries is to help them make the transition from essential agricultural economies to industrial ones, because FDI is a source of additional capital, technology and management know-how, and an incentive to local companies to increase efficiency.

The existing literature on this subject is of four kinds in terms of the measures of the foreign presence and performance of local firms, as well as the relationship of both. First of all, much of the econometric literature focuses on productivity measures as proxies for measures of technology diffusion. On the one hand, early studies using

industry-level data find that foreign presence in an industry, measured by the foreign share of industry employment, positively influences domestic labour productivity. The drawback here is the difficulty in establishing the direction of the causality. It is possible that this positive association is caused by the fact that multinationals tend to locate in high productivity industries rather than by actual productivity spillovers. It may also be a result of FDI inflows forcing less productive domestic firms to exit and/or multinationals increasing their share of the host country market, both of which would raise the average productivity in the industry.

On the other hand, although the productivity of the economy increases, foreign investment sometimes generates negative externalities on domestic producers in the same industry. For instance, while Djankov and Hoekman (2000) confirmed the positive effect of FDI on the total factor productivity (TFP) growth within joint venture or wholly owned foreign enterprises, they also found a negative spillover effect of FDI on domestic firms in Czech industries. Similarly, several studies cast doubts on the view that FDI generates positive spillovers for local firms. For instance, Harrison (1996) suggests that in the short run FDI may adversely affect domestic firms, by taking away market share, and reducing capacity utilization for the firms.

Secondly, more recent studies using firm-level data are also less supportive of the existence of spillovers. Aitken, Hanson, and Harrison (1997) and Haddad and Harrison (1993) find that foreign investment has a negative effect on the performance of domestically owned firms. Harrison (1996) suggests that in imperfectly competitive markets entry by foreign investors implies that domestic incumbents lose market share, impeding their ability to attain scale economies. The result showing negative spillovers

contrasts with the findings of case-study literature and might, to some extent, reflect the omission of important variables.

Next, data on production, R&D spending, and worker training of foreign firms are used to characterize the presence and importance of FDI and to estimate the potential technology and skill spillovers of FDI for a sample of domestic firms. The effects of FDI on domestic firms are measured through frontier production function model estimates of the efficiency-enhancing effects of FDI on domestic firms, through aggregate measures of FDI presence, and through measures of the technological and training activities of foreign firms.

Finally, it appears that there is a positive impact of FDI on the growth of TFP in the host countries' manufacturing sectors. As an indirect measure of knowledge transfer, TFP was used by a number of previous studies in this field. For example, Djankov and Hoekman (2000) conducted a study by using firm-level data for the Czech Republic to show that, during 1992-1996, foreign investment had the predicted positive impact on the total factor productivity growth of recipient firms. This literature postulates that total factor productivity is higher when trade gives countries access to a wider, or more sophisticated, range of technologies.

Furthermore, more FDI associates with higher TFP in a sector, implying that there is a positive relationship between technological progress and FDI since the rate of technological progress is the prime determinant of rates of TFP growth in the long run (Cameron et al., 1999; Liu and Wang, 2003). This finding corroborates the result from a survey in which FDI or foreign-invested firms are found to play a more important role in

knowledge transfer than other factors, notably, licensing in China (Wang and Zhou, 1999).

Based on past studies in this field, it is noticeable that the role of FDI is mixed. In terms of the negative impact of FDI, high cost of payments for technology, technological dependence as well as inappropriate technology, and restraints to local firms are the central concerns in previous studies. Two aspects account for the high cost of FDI. First, royalty and other technology payments are too expensive. Secondly, it leads to diseconomy of externality. For example, Frank (1980) states that the new technology introduced by Multinational Corporations (MNCs hereafter) may be "highly capital-intensive" and thus "fail to utilize labour fully, even where unemployment is already widespread."

Moreover, scholars have explored technology dependence and inappropriate technology in the following contexts. The first is the repeat construction caused by FDI. Aggarwal (1984) argues that because of the knowledge transfer through MNCs, certain parallel industries may be developed. The second is the creation of a "Halo effect." Dunning (1988), based on his investigation in the UK, points out that new Japanese establishments may fail to undertake research in the host region, or may disband research organizations in cases of takeover, which causes the host country to be more technologically on foreign investment. During the process of local industrial development, coping with MNCs easily leads local firms to adopt inappropriate methods, such as imitating the product or productive process from the MNCs.

The third is helplessness or destroying innovation capability in local firms. Young (1988) states that many knowledge transfers are concentrated on standard technology,

assembly operations and mature sectors, which are helpless in promoting local technological development. Nonetheless, these findings do not imply that host countries have nothing significant to gain (or must lose) from FDI. The point is that the positive consequence that accompanies the entry of foreign firms may not be immediate.

Empirically, it does appear that there is some good evidence that FDI efficiency spillovers exist, although there is no strong consensus on the associated magnitudes (Blomstrom, Globerman, and Kokko, 2000). For developed countries, the limited evidence available indicates fairly consistently that the productivity of domestic firms is positively related to the presence of foreign firms (Caves, 1974; Globerman, 1979; Nadiri, 1991; Imbriani and Reganati, 1997). For developing countries, the results are also generally positive, although somewhat mixed as mentioned previously. While a number of studies showing a higher foreign presence increasing productivity in host country sectors, others point to limited or no efficiency spillovers, though that does not rule out positive spillovers over the longer run.

Actually, an overall optimistic view of FDI has been growing in recent years and would look to knowledge transfer as the mechanism through which FDI may affect growth. Theoretically, this view has been bolstered by recent developments in growth theory, which highlight the importance of improvements in technology, efficiency, and productivity in stimulating growth. In this regard, FDI's contribution to growth comes through its role as a conduit for transferring advanced technology from industrialized to developing economies.

At the economy-wide level, recent empirical work has also generally tended to find a positive correlation between FDI and economic growth. Dees (1998) finds that FDI

has been important in explaining China's economic growth; while De Mello (1996) finds a positive correlation for selected Latin American countries. By utilizing data on FDI flows from industrial countries to 69 developing countries over the last two decades, Borensztein et al. (1998) examine empirically the effect of FDI on economic growth in a cross-country regression framework. The results strongly suggest that FDI is an important vehicle for the transfer of technology. Furthermore, FDI contributes to economic growth only when sufficient absorptive capability of the advanced technologies is available in the host economy.

Hence, Young (1988) provides some criteria for evaluation of the impact of FDI on domestic industry as follows:

1. Sectional distribution of FDI,
2. Local R&D activities,
3. Forms of knowledge transfer (package/unpackaged; embodied/disembodied),
4. Terms of knowledge transfer,
5. The extent of technology diffusion,
6. Technology concentration and dependence,
7. Corporate/subsidiary strategies & coordination.

On the basis of the findings of previous studies, it seems that the main channel through which FDI contributes to economic growth is by stimulating technological progress. In other words, FDI may be the main channel through which advanced technology is transferred to developing countries. Therefore, the governments in many developing and transition economies place attracting FDI high on their agenda, expecting

FDI inflows to bring new technologies, know-how and thus contribute to increasing productivity and competitiveness of domestic industries.

➢ The impacts of FDI on knowledge transfer and the development of domestic technology

- ***Foreign knowledge transfer through FDI and spillover from knowledge transfer***

The UN (1987) defines knowledge transfer as a process of acquiring knowledge capability from abroad.

Empirical tests of the effect of FDI on knowledge transfer have generated mixed results. Some studies have found that FDI has a positive effect on productivity (Caves, 1974; Kokko, 1994; Oulton, 1998; Blomstrom and Sjoholm, 1999; Xu, 2000; Liu and Wang, 2003), while others have reported that there is an inverse relationship between FDI and industrial productivity in host countries (Haddad and Harrison 1993; Aitken and Harrison, 1999). Studying the impact of FDI on TFP for a cross sectional sample of Chinese industrial sectors, for instance, Liu and Wang (2003) confirm the view that attracting FDI is an effective way of introducing advanced technology to host countries.

Knowledge transfer can take place through a variety of channels that involve the transmission of ideas and new technologies. Imports of high-technology products, adoption of foreign technology and acquisition of human capital through various means are certainly important conduits for the international diffusion of technology.

Besides these channels, FDI by MNCs is presumably a major channel in international diffusion of knowledge and technology, as the effect of MNCs' entry on a host economy is beyond that of a simple import of capital into the country. FDI is not only a source of capital, but it also is a conduit for knowledge transfer and human skills

augmentation in host countries (Liu and Wang, 2003). In reality, of the technology flow within FDI firms, 85% show an obvious international technology flow (Lan, 1996).

Finally, the output sold by FDI firms on the local market, as Michalet (1977) states, is also a vehicle of technical knowledge flow between foreign investors and local buyers, no matter whether these buyers are consumers or enterprises.

In terms of the reasons for knowledge transfer, Lan (1996) summarized from the following two perspectives. From the standpoints of developed countries, there are two explanations for knowledge transfer. First, it is a tool or an instrument for their entering other countries, especially developing countries with a large market size.

Second, Baranson (1978) argues that developed countries use knowledge transfer or 'technology sharing' to avoid the risks of investing in developing countries resulting from economic and political issues. Oman's (1989) research confirms this opinion and states that new forms of foreign investment using more technology control than ownership control are widely welcomed by host countries, because it can conduct knowledge transfer.

Furthermore, Saggi (1999) proposes another view based on his two-period duopoly model. He argues that the reason for a foreign firm choosing licensing in the first-period instead of FDI is because the former could "avoid current competition with the domestic firm."

From the standpoint of the developing county, the necessity of knowledge transfer is that it is impossible or too expensive for them to develop technology by themselves. Meissner (1988) states that developing countries cannot afford to do basic research and development. It takes a longer time and more money for them to generate the same

technology developed by advanced countries. Thus, they must try to obtain technology by other means.

It is well known that MNCs conduct most of the world's R&D, and knowledge transferred from the parent firms to the affiliates might leak out to the host country, whereas developing countries typically have a weak domestic R&D sector and mainly acquire technologies internationally. This externality is called the spillover effect from FDI. Thus, FDI is widely seen as generating technology spillovers to indigenous firms in a transition economy (Sinani and Meyer, 2002).

As far as the spillover effect from knowledge transfer via FDI is concerned, it may take place when local firms improve their efficiency by copying technologies of foreign affiliates operating in the local market, either based on observation, or by hiring workers trained by the affiliates. Another kind of spillover occurs if multinational entry leads to more severe competition in the host country market and forces local firms to use their existing resources more efficiently or to search for new technologies (Blomström and Kokko, 1998).

Indeed, among the all kinds of technology spillovers mentioned above, FDI has long been recognized as a major source of technology and know-how to developing countries. Spillover effects have also been recognized as a major benefit accruing to host countries from FDI. It is widely recognized that technical progress accounts for a relatively low proportion of the growth experienced by developing countries in general (Shaw, 1992).

The earliest discussions of spillovers in the literature on FDI date back to the early 1960s. The first author to systematically include spillovers (or external effects) among

the possible consequences of FDI was MacDougall (1960), who analyzed the general welfare effects of foreign investment. Other early contributions include Corden (1967), who looked at the effects of FDI on optimum tariff policy, and Caves (1971), who examined the industrial pattern and welfare effects of FDI.

Although there have been a few earlier works estimating international knowledge spillovers, Coe and Helpman (1995) made the first and most widely quoted attempt to establish an empirical connection between international R&D spillovers and economic growth, where they focus on knowledge diffusion among OECD countries. Then, Coe, Helpman, and Hoffmaister (1997) extended this work to developing economies. Note that both studies use aggregate data to measure the impact of knowledge diffusion through trade flows. Moreover, Jaffe, Henderson, and Trajtenberg (1993) examine the geographic localization of knowledge spillovers by looking at patent citations. Eaton and Kortum (1996) analyze patterns of productivity and international patenting. On the basis of patent data they argue that 90% of growth in small OECD countries derives from foreign innovations.

Inspiringly, in both developing and industrial countries there is an increasing institutional awareness of the importance of knowledge for business performance, economic growth, and development. For instance, many analysts agree that knowledge could be the hidden factor of production that has driven Korea's growth (World Bank 1999; Rodriguez-Clare 1997).

In conclusion, the available empirical evidence supports the direct and indirect role of FDI in diffusing knowledge and suggests that it is particularly important for developing countries to trade with technologically rich countries. However, the major

concern in this study is what are the actual technological benefits of FDI to indigenous technology development? Since a distinguishing characteristic of FDI is that the control and ownership of the technologies used by the affiliates stay in the MNCs' possession, so the questions related to this issue will be: How does the diffusion of technology from MNCs through FDI stimulate local technological innovation?

- ***The effect of knowledge transfer via FDI on the technological development of domestic firms***

In the previous studies, one of the most frequently asked questions about the impact of FDI on host countries is its contribution to the development of indigenous technology capability. To answer this question, we need first to understand the role technology plays in a national economy as well as the impact of technology on the country's economy.

Various discussions in the literature tackle this issue from different angles and divide the main contributions of technology to economic development into the following aspects. Firstly, technology provides resources for creating new wealth and for increasing efficiency. One nation's economy can take off only when it masters certain technology (Rostow, 1962). Secondly, a constantly high rate of growth depends upon a continuous emergence of new inventions and innovations (Kuznets 1959).

In addition to qualitative analysis, quantitative measurement has repeatedly revealed the role of technology in creating economic growth (Abramovitz 1993, 1956; Scott 1993; Press 1987; Dension 1962; and Solow 1957). Kuznets (1966) finds that the rate and the focus of knowledge increase, markedly affects the rate and structure of economic growth. Although there is a time lag between them, economic systems are the result of past technical change (Heertje 1977).

Furthermore, new knowledge or technology benefits more than just the firms of origin. Other firms or industries can also improve their productivity by building on, and adding to, the cumulative stock of knowledge. Under this mechanism, technology innovation creates much larger social returns (TEP 1991, 1992). For instance, Katz (1969)

notes that the inflow of foreign capital into the Argentine manufacturing sector in the 1950s had a significant impact on the technologies used by local firms. He asserts that the technical progress takes place not only in the MNCs' own industries, but also in other sectors, because the foreign affiliates force domestic firms to modernize "by imposing on them minimum standards of quality, delivery dates, prices, etc. in their supplies of parts and raw materials."

Accordingly, the benefits gained by host countries through knowledge transfer are generalized as follows (OECD 1981; Smali 1985; Roman 1986; OECD 1989, 1993; TEP 1992):

1. Obtain more knowledge. During knowledge transfer, the technology supplier may provide more information, offer certain training, and serve as a vehicle to integrate knowledge. All of these increase the knowledge stock of receivers.
2. Make better utilization of resources. Inward technology can either strengthen the local production system, or strengthen other local capabilities.
3. Gain fast industrial processes. Since knowledge transfer could help to close the technological gap between developed and developing nations, and stimulate local R&D activity, it accelerates the technology development process.
4. Eliminate economic underdevelopment. The extra output or increased production resulting from knowledge transfer would facilitate a more competitive position for the host country in the international market, and the changes in trade may be translated into changes in employment and prices, which would lead to a better quality of life.

Besides the benefits to the recipients, knowledge transfer also has a positive impact on home countries. It is pointed to by many studies, such as strengthening technological bases (UNCTAD 1993, 1994; Dunning 1981, 1988, 1994; Rosenburg 1976, 1982, 1994). While technology supply is increasing, home countries are more concentrated on high value added products and advanced technology, which also leads to less dependency upon developing countries in raw materials. Also, when products and processes have become increasingly standardized across countries, MNCs attempt to safeguard their competitive position through the continuing differentiation of products and technology.

In terms of the impact of FDI on the host country's technology development, it has drawn many researchers' attention, such as Steuer (1973), Frank (1980), OECD (1981), Samli (1985), UNCTC (1985, 1987), Roman (1986), and Blomstrom (1990). Furthermore, some recent work on economic growth has highlighted the role of FDI in the technological progress of developing countries. Markusen and Venables (1999) show how FDI acts as a catalyst to lead to the development of local industry through linkage effects. Findlay (1978) postulates that FDI increases the rate of technical progress in the host country through a "contagion" effect from the more advanced technology, management practices, etc., used by the MNCs. Wang (1990) incorporates this idea into a model more in line with the neoclassical growth framework, by assuming that the increase in "knowledge" applied to production is determined as a function of FDI.

From the long list of benefits that host countries receive from FDI, Lan (1996) divided them into three categories: stimulating effect, short-cut effect, and spillover effect.

First is the stimulating effect. The stimulating role of FDI means that FDI forces indigenous existing firms to adopt more efficient methods, to increase their R&D, or to adopt some specific technology more quickly, either because the firms were not previously aware of the existence of the technology, or because it would not have been considered profitable for it to be acquired (Blomstrom, 1990). The mechanism of stimulation can be observed as stimulating domestic entrepreneurship through purchasing, subcontracting, or operational demonstration, and initiating competition by bringing competitive pressures to a local monopolist. MacDougall (1960) offers the same view, suggesting that domestic firms acquire "know-how" or they will be forced by foreign competition to adopt more efficient methods.

Secondly, the short-cut effect is much easy to understand, as in general FDI is more concentrated on new technology or on technology intensive sectors. For example, in a study of the Indonesian manufacturing sector, Sjoholm (1999) finds that local establishments in sectors lagging behind foreigners in technology seem to be enjoying the short-cut benefits of spillovers.

Finally, the spillover effect is the most complicated among these three effects. In its simplest form, a spillover can occur when a local firm improves its productivity by copying some technology used by multinational affiliates/corporations in the local market. Another type occurs when local firms are forced to use existing technology and resources more efficiently, or to search for more efficient technologies, because an MNC's entry has increased competitive pressure in the local market (Blomström and Kokko, 1998). In addition, spillovers can occur when an affiliate demonstrates new techniques and trains local workers, who later accept employment in local firms or start their own firms.

In this regard, Lim (2001) recognizes a determinant of the magnitude of spillovers, which is the size of the technology gap between domestic and foreign firms. Kokko, Tasini and Zejan (1996) use firm level data for Uruguayan manufacturing sector in examining how the productivity of individual plants is affected by foreign presence. Dividing the sample in two sub-samples by size of the technology gaps, they find that spillovers are significant only in industries with a small technology gap. If the gap is small, foreign technology appears to be more useful for local firms as they posses the skills needed to apply or learn the foreign technology. In contrast, Sjoholm (1999) finds evidence of spillovers to domestic firms only in a sub-sample with a large technology gap.

Moreover, spillover magnitude appears to depend on the host country's capability to "absorb" the foreign technology. Blomstrom (1986) indicates that foreign presence forces local firms to become more productive in sectors where "best practice technology lies within their grasp."

In practice, about 90% of FDI firms show a positive technological gap over local firms. This gap in skills can be bridged through FDI. The knowledge created in developed countries with their relatively high endowments of human capital can be transferred to developing countries through FDI. Admittedly, the knowledge transferred to developing countries is likely to be the preserve of the foreign entity undertaking the investment. Yet knowledge and technology could spillover from the foreign firms to the domestic firms through the training of labor and indigenous management and through links between foreign firms and local suppliers of components. In addition, local firms can learn-by-watching.

Moreover, the presence of foreign firms in the economy, with their superior endowments of technology, may compel local firms to invest in learning or R&D, if only to keep abreast of the competition. In turn, increased competition from local firms through their investments in innovation may push foreign firms to bring in superior quality technology and know-how. New growth theory, therefore, provides powerful support for the notion that FDI could be a potent factor in promoting growth.

The post-war experience in European countries and Japan shows, and proves, that knowledge transfer is an effective instrument for gradually bringing technology receiver countries to similar levels as the technology supplier countries (OECD 1981). For example, Hsiao (1986) identified two basic benefits gained by Japan from international technology flow. Firstly, it greatly facilitated the modernization and expansion of Japanese industries by substantially improving Japan's indigenous science and technology capability. Secondly, it brought about basic structural changes in Japanese industry over several decades, i.e. the development of the iron and steel industry in the 1950s, the machinery and the petrochemicals industries in the 1960s, the automobiles and the electronics in the 1970s, and the robotics and the computer industries in the early 1980s.

Hereby, a related issue is the speed of the adoption of foreign technology by local firms. At a more specific level, this absorptive capacity is conceived as a certain level of human capital. Here, the important factor appears to be the degree of competition introduced by the MNC. McFetridge (1987) finds that new technology is frequently introduced sooner by MNC affiliates, but that greater competition spurs quicker adoption of the innovation by local firms. Indeed, all the theoretical literature and the evidence

reviewed support the conclusion that inflows of technology are more beneficial to quicker learners, who are able to master new and complex knowledge.

Furthermore, the technology receiver needs to show not only its ability to master imported technology, but also the ability to introduce a degree of novelty in the production of products or the process. It is clear that the absorption level of imported technology is proportional to the technology creation capability of the technology receiver (TEP 1991; Yankey 1987; OECD 1988). Several studies, both theoretical and empirical, indicate that absorptive capacity in the host country is crucial for obtaining significant benefits from FDI. Without adequate human capital or investments in R&D, spillovers from FDI may simply be unfeasible.

Overall, the effects of FDI depend heavily on the absorptive capacity and the competitiveness of local firms. Spillovers will be larger if local firms are able to quickly adopt new imported technologies and to face the competition posed by more efficient foreign producers. Moreover, much of the evidence refers to the effects in developed countries, and it is impossible to disregard the risk that MNCs' entry into developing countries replaces local production and forces local firms out of business, rather than forcing them to become more efficient. Therefore, if FDI spurs innovation in the domestic industry by increasing competition, we do not view that as a 'spillover' from FDI as Saggi (2000) suggested, but rather "a benefit enjoyed by the host country that works its way through the price mechanism and the market equilibrium."

- ***The impact of technology skills of both MNCs and domestic firms on FDI inflows to host country***

The theory of FDI in the literature answers the question as to why a firm would want to produce in a foreign location instead of exporting to, or licensing a local firm. Dunning (1977, 1988) argues that three conditions must be satisfied for a firm to engage in FDI.

First, the firm must possess ownership of a firm-specific, tangible or intangible asset, or skill, which gives it an advantage over other firms – an ownership advantage. The entry of an MNC not only represents something more than a simple import of capital into a host country, but the MNC must also possess an asset, such as product and process technology or management skills, that can be used profitably in the foreign affiliate (Saggi, 2000). As Dees (1998) argued, the change in patents registered by the home country firms should have a positive effect on FDI. In general, the more innovative a country is, the more is it likely to invest abroad, because the firm needs to reap its investment from R&D in the global market.

Second, it must be more beneficial for the firm to use or exploit the firm-specific asset itself than to sell it/them, or lease and license it to other firms in order to prevent the asset from being replicated by competitors. Third, it must be more profitable to use these advantages in combination with some factor inputs located abroad – the location advantage.

In the existing literature, many researchers have investigated the determinants of FDI to a developing country. According to Zang (1995), in China, the sharp rise of FDI since 1987 has been due to the improvement of the investment environment and to the

impressive growth of the Chinese economy. Huang and Shirai (1994) suggest that the role of the authorities is highly important in revealing new information and in improving the investment environment. Crub et al. (1990) have used interviews and questionnaires to study the motivations of US firms investing in China. Among the positive variables, they find that potential market growth and cheap labour are the most important determinants of US investments.

Similarly, Shi (1996) shows that, initially, due to the location advantage, foreign investors in China from other developing countries were attracted by cheap labour because FDI was used to produce labour intensive goods in order to re-export them toward their traditional markets. However, since the early 1990s, foreign investors have attached more importance to the quality of workers in order to produce higher technological products. In this case, labour quality could be another determinant of FDI. This is consistent with the results provided by Mody, Dasgupta, and Sinha (1998). They find raw labor costs not to be an attractor of FDI, but labor quality is significant for U.S. and Japanese FDI in China.

In an empirical study, Wei (1995) also finds a positive correlation between the inflow of FDI and the stock of human capital in the host country (measured by literacy). Borensztein et al. (1998) suggest that FDI itself may be influenced by innovations in the stochastic process governing economic growth rates.

Dees (1998) summarizes that Chinese inward FDI is established as a function of the Chinese domestic market size, the low cost of its labour force, its real exchange rate, its openness to the rest of the world and the source country's degree of innovation. In this regard, the World Bank (1994) finds that the most important determinants were the size

of the market, the cost of labor, and FDI policies. In general, technology-intensive sectors such as general machinery and electronics were the most sensitive to restrictive FDI policies.

In addition to the above determinants, FDI also appears to like to cluster, making infrastructure and a certain level of industrialization important determinants. Moran (1998) points out that once MNCs set up export-oriented FDIs, they tend to attract other foreign investors, including competitors, into the location in a "clustering" effect, which is referred to as an "agglomeration" effect. The reason is perhaps because of linkages among projects, creating incentives to locate close to other firms.

As evidence, Moran (1998) cites case study literature on Mexico's experience with the automotive industry and Asia's with the electronics/computer industry. Before 1979, the FDI-related automotive industry in Mexico had subscale plants producing mostly for the small domestic market. Once General Motors decided to use Mexico as a base for producing and exporting its engines, other major foreign car and auto parts companies followed suit, establishing their own export-oriented plants. The experience with FDIs in Asia has been roughly the same. Faced with Japanese competition, General Electric set up its first television parts plant in Asia in 1968, followed quickly by RCA and Zenith, Fairchild, Texas Instrument, National Semiconductor, and Motorola through 1973.

In a study of capital expenditures by U.S. manufacturing MNCs covering 42 developed and developing countries, Wheeler and Mody (1992) find significant evidence to confirm such an agglomeration effect. All three agglomeration-related variables – quality of infrastructure, the degree of industrialization, and the stock of FDI – had a

large impact on U.S. manufacturing FDI. Lim (2001) further confirms that the net impact of agglomeration effects on FDI is positive.

Moreover, as Aitken and Harrison (1999) have pointed out, data studies from different countries such as Australia, Canada, etc., lead strong support to the positive correlation between FDI and productivity in a sector or host country. This is also strongly supported by Lai (1998) whose study reveals that innovation is promoted along with FDI. It suggests that domestic innovative ability is one of the determinants drawing inflows of FDI.

Finally, the emerging view of FDI emphasizes that FDI is not only "pushed" by the firm-specific advantages of the investor, but may also be "pulled" towards centers of innovations located in recipient countries as a means for the investor to acquire and develop new resources and capabilities (Dunning, 1995; Shan and Song, 1997). Cantwell (1989), for example, performed a longitudinal analysis of the relationship between location of technology and FDI. He found that West German and American MNCs are positively attracted to locations that are important sites of innovative activities in their own industries.

In a historical analysis of patenting activities of leading MNCs, Cantwell (1995) noted the greater recent significance of overseas technology development activities, especially in countries of technological leadership. Kogut and Chang (1991) analyzed Japanese direct investments into the U.S. In their empirical study, Shan and Song (1997) find that FDI is drawn to American biotechnology firms with high levels of patent activity. Thus, by using industry-level data, these studies suggest that countries with technological advantages tend to attract FDI as well as generate outward FDI flows.

Thus, the literature above suggests a list of factors that may be important in affecting FDI, such as market size, business/investment climate and political, agglomeration effects, labor quality, the stock of human capital, source country degree of innovation, labor cost, economic distance/transport cost, economic stability, trade barriers/openness, and technological capability in the host country.

It is noticeable that the determinants such as labor quality, the stock of human capital, the degree of industrialization of the host country, and local technological advantages are all related to the technology skills of the host country, and the source country's degree of innovation reflects the R&D competency of an MNC. However, in the prior studies, although many researchers have discussed these factors on attracting FDI, none of them particularly examines the impact of technology skills of both MNCs and domestic firms on FDI inflows. Therefore, one of the objectives of the present study will be to tackle this issue empirically.

The impacts of IPRs on foreign knowledge transfer and domestic innovation

➢ General concepts of IPRs – Patent regime

Generally speaking, foreign companies always seek patent, trademark and other forms of Intellectual Property Rights (IPRs hereafter) protection as a prerequisite for subsequent licensing activity or conducting FDI, particularly in high technology sectors. Patents, as major components of IPRs, are generally linked with industrial innovation activity and are often the subject of technology licensing activities. Patents are also an important source of technical information that can be used in a country's own R&D activities.

In the IPRs regime, patents generally include three subcategories: patents for inventions, utility models, and designs. Designs relate to the configuration or shape of products. Utility models are aimed at more minor inventive activity and hence are often called "petty patents". In general, utility models are less widely used throughout the world, although a number of countries, such as Japan and China, have used them for many years. Moreover, utility models tend to be used more as a stimulus to domestic rather than foreign inventors. Patents for inventions, as an important index, indicate the achievements in science and technology for the features of high values on technology, more expenses on R&D, and internally recognized for comparison in technology.

The grant of IPRs in respect of technological innovation often occurs in the form of a patent, whereas the applications reflect the inventor's interest in obtaining protection and show his evaluation of the importance of his invention (Campbell and Nieves, 1979).

Thus, in order to limit the scope of this study, the patents mentioned here are only referring to patents for inventions.

A major reason for the creation of patents is to prevent unrestricted access to new knowledge. By granting innovators the exclusive rights to commercialize their intellectual assets over a certain period of time, IPRs offer an incentive for the production of knowledge as well as executing R&D activities. Without a patent, the use of the information that results from such activities cannot be restricted, and the researcher alone would bear the costs of the knowledge-creating activity while the profits would be widely spread. The "public good" character of the information, therefore, would lead to a "sub-optimal level" of production of such information. If law enforcement ensures the exclusive use of knowledge, such a disincentive to develop technological innovation will in consequence be taken away.

Interpreting by using market power, Vocke (1997) states further that the resulting market power of the patent holder will lead to "a rent transfer in favor of the producer", because this market power consists in the ability to raise prices above marginal costs; "Dynamic efficiency, at which the establishment of IPRs aims, can only be achieved at the expense of a redistribution of wealth." Therefore, the extent of IPR protection in a country reflects the country's attitude to the innovation and its own R&D capability, as well as its investment environment.

As is well known, MNCs undertake a major part of the world's research and development (R&D) efforts, and produce, own, and control most of the world's advanced technology. In the case of developing counties, formal R&D activity is limited, which reveals that most developing countries have not relied on IPRs protection as a major

mechanism to foster innovation. Therefore, although a multinational firm, through its FDI and licensing activities, expresses to developing countries a ready conduit through which technology can flow from the more advanced countries, the willingness of advanced countries' firms to exchange technology with developing countries often crucially depends on the existence of a legal framework of IPRs that protects locally the interests of technology owners.

Hence, Bosworth and Yang (2000) argue that IPR laws and their enforcement play a vital role in the process of economic development. Without such laws, the incentive for trade and FDI may be severely reduced, insofar as the related product can be copied by the importing or host nation. The potential barriers that an absence of appropriate IPR laws and weak enforcement impose on knowledge transfer through licensing and FDI are even more significant.

Finally, the distribution of IPRs in terms of regions around the world is unbalanced. Braga and Fink (1998) report that in both 1981-82 and 1994-95 the number of worldwide annual patents granted, increased 2-fold from 320,000to 670,000. Moreover, although the number of grants to 'residents only' has also gone up, and the same empirical pattern could point to an acceleration in the creation of new technologies, less than 5% of worldwide patents granted to 'residents only' in 1994-95 belonged to developing countries, and industrial designs, where less than 1% of domestic grants originated in the developing world.

Industrial property statistics also show a relatively stronger dominance of foreign residents in national grants for patents and trademarks in developing countries. In the

same period, only 21% of patents granted in developing countries were awarded to domestic residents, compared with 34% for developed countries.

In sum, these statistic figures reflect the situation of global innovative activities associated with the patent application.

➢ The impact of IPRs on FDI inflows and foreign knowledge transfer

In general, there are reasons to believe that IPRs are relevant to FDI. Many analysts have pointed out the existence of intangible assets as one of the main reasons for firms to become transnational firms instead of supplying a foreign market by an arm's length export relationship. These assets take the form of new technologies, know-how among employees, management skills, reputation for quality, and so on, and are often translated into explicit ownership of intellectual property. For example, 50 MNCs from developed countries accounted for 26% of all patents granted in the US between 1990 and 1996 (these estimates are based on World Bank data by Braga and Fink 1998).

Indeed, the relationship between IPR protection and FDI is quite complex. On the one hand, a weak IPR regime increases the probability of imitation, which makes a host country a less attractive location for foreign investors. On the other hand, strong protection may shift the preference of MNCs from FDI towards licensing.

In this regard, Vishwasrao (1994) provides a contrary example. By studying IPRs and the mode of knowledge transfer, Vishwasrao (1994) argues that a lack of patent protection, unlike in Chin and Grossman (1988), does not necessarily exclude the possibility of licensing technology. The reason is that transferring technology in an environment where patent protection is uncertain can pose significant risks to an innovating firm's ability to appropriate rents. The infringement of patent rights by a host country can generate significant losses on innovating firms, and alter their behaviour with respect to R&D and knowledge transfer to the host country. Thus, in the absence of patent protection, MNCs may opt for monopoly licensing or FDI due to fear of patent infringement.

Furthermore, using a sample of 33 political units over a period of 15 years, Kondo (1995) conducted three empirical tests to determine what, if any, effects on FDI occur from increased patent protection. No evidence is found that patent protection affects FDI.

However, most empirical evidences are in favour of the positive effect of IPR protection on attracting FDI, especially high-technology projects. As Lall (1997, p.244) points out, "the 'signalling value' of the intellectual property regime has become extremely important in recent years. In general, countries that seek to attract technology-intensive foreign investments also offer strong protection to those investments."

Concern about the IPR regime depends on the purpose of an investment project, being the highest in the case of R&D facilities and the lowest for projects focusing exclusively on sales and distribution (Mansfield, 1994 and 1995).

Empirical evidence indicates that the level of IPR protection in a country also affects the composition of FDI in two different ways (Lee and Mansfield, 1996; Smarzynska, 1999). First, for the industries in which IPRs are crucial (for example pharmaceuticals), firms may refrain from investing in countries with a weak regime of IPR protection. Second, regardless of the industry in question, MNCs are less likely to set up manufacturing and R&D facilities in countries without IPR regimes and more likely to set up sales and marketing ventures, since the latter run no risk of technology leakage. Mansfield (1994) finds that US firms, particularly in the chemical and pharmaceutical industries, limit FDI in countries with weak IPR protection.

By using a unique firm-level data set from Eastern Europe and the former Soviet Union, Smarzynska (2002a) conducted an empirical study to examine the effects of intellectual property protection on the composition of FDI inflows. The author confirms

that weak protection deters foreign investors in technology intensive sectors that rely heavily on IPRs. Moreover, the results indicate that a weak IP regime encourages investors to undertake projects focusing on distribution rather than local production.

Furthermore, protection of IPRs influences how knowledge is created and diffused within and between countries. Saggi (2000) suggests that if any policy variable should affect international knowledge transfer, it ought to be the host country's IPR regime. The theoretical literature has investigated the effect of IPR enforcement on knowledge transfer and FDI in several endogenous growth models.

Similarly, Cohen et al. (2002) argue that patents in particular are observed to play a more central role in diffusing information across rivals in Japan and appear to be a key reason for greater intra-industry R&D spillovers there, suggesting that patent policy can importantly affect information flows and plays an important role in generating intra-industry spillovers. Their analysis of the different channels through which firms might learn about the R&D activities of rivals show that of the five channels that are the most important in both countries, patent is the most important channel of R&D information flow in Japan.

In principle, patent protection directly affects growth through inducements to innovation. Returns to innovation could be influenced by variations in international patent laws, with a primary channel being decisions by firms to trade in different markets. Thus, IPR regimes could be an additional factor in the relationship between international trade and growth so as to further affect domestic innovation development (Segerstrom et al., 1990; Grossman and Helpman, 1991; Helpman, 1993; Taylor, 1994).

- **The effect of IPRs on domestic innovation**

In terms of the effect of IPRs on domestic innovation, an important question is whether IPR protection is always consistent with, and beneficial to the host country's innovation so as to increase economic growth.

Mansfield (1994) presents some evidence from his research that the protection of IPRs has a positive impact on investment in R&D and, subsequently, on economic growth in developing countries. Moreover, Gould and Gruben (1996) conducted an empirical study in examining the role of IPRs on economic growth. By utilizing cross-country data on patent protection, trade regime and country-specific characteristics, they concluded that IP protection is a significant determinant of economic growth. These effects appear to be slightly stronger in relatively open economies and are robust to both the measure of openness used and to other alternative model specifications. Thus, by creating an environment conducive to the accumulation of human knowledge, IPRs will tend to increase innovation and economic growth.

In closed regimes, however, the empirical work done by Braga and Willmore (1991) suggests that protecting IP may not increase innovation because the competitive framework is inadequate to stimulate much innovation. Rivera-Batiz and Romer (1991) offer a theoretical model, which suggests similar conclusions. That is, copying foreign technology is typically more profitable than innovating in a closed-trade regime. Since knowledge is non-rival in nature, it should be freely available (apart from the cost of transmitting knowledge). If this were the case, however, the market would under-invest in the production of new knowledge, because innovators would not be able to recover their costs.

In contrast, open trade regimes may exhibit a stronger linkage between IP protection and innovation. Open trade implies that local firms are more likely to face competition from foreign producers that use the latest technology, both in their production processes and in their products. Moreover, local firms that wish to meet this challenge by purchasing technology from abroad may find that weak IP protection at home impedes their efforts. In fact, some evidence suggests that foreign technology-producing firms often refuse to license or lease their latest innovations to firms in countries with weak IP protection in fear that the licensing contract will ultimately be unenforceable (Sherwood, 1990).

Furthermore, in larger markets, Taylor (1993) proposes a cost-reduction effect that would raise exports if a stronger patent law reduces the need of the foreign firm to undertake private expenditures so as to deter local imitation.

In terms of protection of IPRs and the relative law's enforcement, the difference between developed countries and developing countries is clear. To encourage the generation of new knowledge, historically, industrialized countries have elaborated systems of IPRs in place and conduct a majority of the world's R&D. Consequently, industrial countries have a tradition of reliance on IPRs that is alien to many developing economies. However, since developing countries spent much less money on R&D, formal R&D activity is limited in the developing countries. Moreover, there are also differences in the type and sectoral composition of R&D activity between developed and developing countries.

Survey evidence suggests that, at least in the United States, protection stimulates innovation (Mansfield, 1986) and the social rate of return appears to be considerably

higher than the rate of return to the innovator (Mansfield et al., 1977). In a Brazilian survey, 80% of 377 firms said they would invest more in internal research and would improve training for their employees if better legal protection were available (Sherwood, 1990).

Vessuri (1990) argues that transnational computer corporations located in Brazil were not interested in developing or absorbing local technology because they typically restricted their R&D to home country locations. Therefore, instead of protecting IP, Brazil attempts to foster local innovation by reserving a portion of its market for domestic producers of mini- and microcomputers and their peripherals.

From a dynamic point of view, the introduction of IPRs stimulates innovation in the host country and thus increases future trade flows as discussed in the previous section. The international recognition of IPRs can also be seen as an adjustment mechanism, which guarantees the functioning of dynamic competition between countries. Through IPRs, innovation-producing countries have an incentive to develop new technologies in which their next generation are manufactured by follower countries. This mechanism thus leads to continued technological progress and economic growth and is beneficial for both leaders and followers (Fisch and Speyer, 1995).

Finally, since patent rights restrict a local firm from producing a product invented by the foreign firm, but not from using the knowledge created due to R&D that is embodied in that product; as a result, as soon as a product is created, knowledge needed for its production becomes available to all and such knowledge spillovers ensure that neither domestic firms nor MNCs, can try to invent a higher quality version of the same product.

➢ Patent information as an indicator of technological progress

A frequently used measure of technological advantage or change is patenting activities. Although patents do not capture all the innovative activities of a firm, patenting activity has been found to be a good measure of the innovative capabilities of firm (Pavitt 1985).

The literature on patents may be listed under three main categories and research using patent statistics as a technology indicator falls into one of these categories (Basberg, 1987). Furthermore, studies that use patent statistics as a technology indicator can also be divided into three broad groups. One direction of research deals mainly with the relationship between technological change as measured by patent statistics, and economic development (Beggs, 1984; Graue, 1943; Jonason, 1982; Merton, 1935). Patent statistics have also been used to analyse the diffusion of technology from one country to another. Finally, a third group of studies are concerned with the analysis of the innovation process itself in order to assess and evaluate the output of research activity. This has often been done by looking at the relationship between R&D, patents and productivity (Griliches, 1984; Freeman, 1982; Leopold, 1977; Nelson, 1981; Scherer, 1965; 1981). Previous research has found a strong positive relationship between R&D investments and patents, which is empirically well documented (Basberg, 1987; Acs and Audretsch, 1998).

Moreover, patents are viewed as the intellectual capital of the high-tech industry and a cornerstone of a firm's ability to attract investment capital (Ernst and Young, 1993; Shan and Song, 1997). Likewise, in an overview of recent developments on the measurement of technological change by means of patent data and indicators derived from innovation surveys, Archibugi and Pianta (1996) point out that patent data is one

way to acquire information on the innovative activities of firms, because a wide variety of innovative activities can be documented by patent data. Thus, the patent system is one method firms use to protect their inventions. If they are duly processed, classified and organized, patents provide a unique source of information on industrial innovation (Archibugi and Pianta, 1996).

Furthermore, although the quality of patents is not easily captured, the number of patents taken out by a firm seems to best indicate the firm's technological strength (Lerner, 1991; Shan and Song, 1997). In analyzing patent patterns in biotechnology, Spalding (1991) finds a strong correlation between number and quality of patents. Thus, Shan and Song (1997) conclude that the number of patents held by a firm appears to be the best "verifiable" information to evaluate a firm's technological capabilities in a high-technology industry.

Finally, patent data have been used to explore the relationship between technology and trade. Several studies have shown that sectoral specialization resulting from patens is generally associated with the industrial pattern of countries' exports (Soete, 1987; Fagerberg, 1987, 1988; Cantewell, 1989; Dosi et al., 1990; Amendola et al., 1993; Verspagen, 1993; Eto and Lee, 1993). For instance, Pavitt and Soete (1980) use data for foreign patenting in the US among others to analyze the relationship between technological change and foreign trade, and conclude, "technological performance is the most important trade explanatory variable... " (Soete, 1987).

Therefore, Archibugi and Pianta (1996) summarize the advantages of patent as a technological indicator. First, patents are a direct outcome of the inventive process, and more specifically of those inventions that are expected to have a commercial impact. As a

result, they are a particularly appropriate indicator for capturing the proprietary and competitive dimension of technological change. Second, since obtaining patent protection is time-consuming and costly, it is likely that applications are filed for those inventions that are expected to provide benefits over the costs. Third, patents are broken down by technical fields and thus provide information not only on the rate of inventive activity, but also on its direction. Fourth, patent statistics are available in large numbers and for a very long time series. Finally, patents are public documents so that everyone can approach the information.

Significance of WTO accession

As the only international body dealing with the rules of trade between nations, the World Trade Organization (WTO hereafter) is to help international trade flow as freely as possible, to achieve further liberalization gradually through negotiation, and to set up an impartial means of settling disputes; these are three main objectives of the WTO. On April 4, 2003, the membership of the WTO was raised 146 members. Thus, joining the WTO is a symbol to the country to liberalize its trade to the world.

The previous empirical literature implicitly assumes that any country opening its borders to trade, even the most advanced country, will benefit from a wider variety of technologies and from technologies that are, at least in some fields, superior to those available in the domestic market (Navaretti and Tarr, 2000).

Moreover, in terms of enhanced economic growth, Balasubramanyam et al., (1996) find that the beneficial effect of FDI is stronger in those countries that pursue an outwardly oriented trade policy than it is in those countries adopting an inwardly oriented policy. These results indicate that economic growth may also depend on the openness for developing countries, especially with regard to trade liberalization under the WTO. However, in the previous empirical studies, there is the difficulty of measuring openness.

In addition, in contemporary international business, ideas and knowledge are an increasingly important part of trade. Most of the value of new medicines and other high technology products lies in the amount of invention, innovation, research, design and testing involved. Many products that used to be traded as low-technology goods or commodities now contain a higher proportion of invention and design in their value. Therefore, with an increasing share of knowledge-intensive products in international

trade and the inclusion of trade-related IPRs on the agenda of the WTO, IPRs have become an important trade issue.

Since the extent of protection and enforcement of IPRs vary widely around the world, these differences become a source of tension in international economic relations. In order to narrow the gaps over the difference of IPRs protected around the world and to bring them under common international rules, Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS hereafter) has been injected into the international arena through the WTO. Under TRIPS, any countries intent on accessing world markets must within 5 years introduce and enforce IP protection of the same standard as developed countries (Zheng, 1996).

Furthermore, the TRIPS Agreement makes protection of IP as an integral part of the multilateral trading system as reflected in the WTO. This acknowledges the growing importance of IP in international competition in many areas of economic activity.

There are some likely effects on investment under TRIPS. Firstly, the protection of IPRs may increase investment in research and development activities. Secondly, FDI inflows may increase as a result of a more reliable legal framework and a better investment climate.

In this connection, Lim (2001) summarized that a friendlier business/investment climate lowers the additional costs of doing business in a foreign country, thus benefiting both horizontal and vertical FDI. Moreover, FDI inflows may decrease to the extent that they were needed to channel confidential knowledge within MNC networks into a country to serve a foreign market. Finally, if a country does not have the necessary administrative capacities to ensure an effective protection of IPRs, the amount of

resources needed to build up such capacities might absorb investment capital and reduce private investment.

On the other hand, a restrictive investment climate with various conditions tends to attract FDI that is likely to be less efficient and exhibit older technology, as well as experience slower rates of new knowledge transfer and lags in the utilization of advanced management systems (Moran, 1998).

In sum, to a developing country, membership of the WTO not only reflects the openness of the country's policy, but also represents the extent of protection and enforcement of its IPR regime. Such openness and strengthened IPR regime will, in return, help the country to attract more FDI inflows as well as international knowledge flows, so as to stimulate the domestic technology development in the host country.

Related to China

Due to its constant economy growth and remarkable success in the economic reformation, China provides a particularly interesting case to the world in studying the relationship between the promotion of technology flows through FDI and the promotion of an indigenous stock of knowledge to aid economic development.

- **General situation of FDI inflows into China**

Since the end of 1970s the attitude towards FDI in developing countries has experienced a radical change (OECD 1983, 1987, 1993; UNCTC 1985, 1987, 1990). Now FDI is widely regarded as a resource, which is particularly useful for the economic development of developing countries, especially for their industrial development. Many developing countries hope through inward flows of FDI to acquire the developed country's technology, to generate exports and/or reduce imports, to obtain hard currency, to gain advanced management skills and techniques, and to channel to world networks (Goulet 1989; Hoyle 1990). Particularly in China, since the late 1970s, the Chinese government had established a general policy of reform – opening its economy to the outside world. The encouragement and utilization of FDI, including its accompanying technology, capital, and expertise, have become both a principal focus of reform and the main economic objective in China.

Despite the foreign investment law adopted in China in 1979, the flow of FDI "has not been as rapid, nor has the outcome been as successful, as either the foreign investors or the Chinese officials had hoped" (Grub and Lin, 1991). Looking at the dynamic pattern of FDI in China since 1979, we can distinguish four different phases.

The first phase, from 1979 to 1983, was a period of sluggish increase. From 1984 to 1991, the inflows of FDI attained an increasing trend. Since 1992, the large-scale expansion of FDI had made China the second largest recipient of FDI in the world. Although FDI inflows declined slightly in 1999 due to the Asian financial crisis, they picked up again in 2000 and then reached another peak in 2002 after China's WTO accession, which made China surpass the United States to be the largest country attracting foreign investment in the world (MOFTEC, 2003).

With the increase of inward FDI in China, knowledge transfer from outside has been inflowing steadily as well. Since the 'open door' policy of late 1978, there has been a fifth wave of knowledge transfer. Observably, the current knowledge transfer differs from the previous stages not only in scope and method, but also in participants and channels. Given this background, more and more researchers are concerned about the linkage between FDI and China's rapid economic growth, as well as the effects of FDI on foreign knowledge transfer and domestic technological progress (Moser 1984; Casson et al. 1992; Li et al. 1991; Curry 1991, 1993; Zhan 1993; and Zhang 1994).

In this regard, there are many studies that describe the role FID played in certain regions of China (Pi 1989; Xiu 1991; Yao 1992). For example, Xiu (1991) discusses the formation of new industrial structure in Southern China and points out that there is a shift of industrial structure in Guangdong along with the inflow of FDI. He assumes that the technological gap between FDI and indigenous firms is the vital factor for advancing local industrial structure.

Furthermore, it has proven that FDI has contributed to GDP growth directly through the establishment of Foreign-funded enterprises (FFEs hereafter) and indirectly

by creating positive spillover effects from FFEs to domestic enterprises. FFEs tend to be the most dynamic and productive firms in China's economy. An output of FFEs in the industrial sector has expanded at four times the rate of other industrial enterprises during 1994-1997.

In addition, empirical research has found that domestic enterprises appear to have benefited from the presence of FFEs, both through increased sales and positive spillovers. The latter come about when FFEs introduce new technologies and management skills. These externalities are thought to have become progressively more important as more links began to develop between FFEs and domestic enterprises in the 1990s.

Thus, China's experience shows that FDI contributes to GDP growth. The effect is likely to be strongest if foreign enterprises develop close links with domestic enterprises, so that the impact of FDI on productivity growth is extended beyond the firms receiving FDI (Tseng and Zebregs, 2002).

The findings from the empirical studies confirm that not only does FDI represent the most important source of foreign capital in China, but also transfers a lot of high technology into indigenous firms. The former leader, Deng Xiaoping, promoted FDI reforms, acknowledging that foreign investment might absorb foreign capital, attract advanced technology and develop export products (Harding, 1987). The objectives of attracting FDI, as mentioned in various Chinese documents (Kamath, 1990), are to develop a diversified industrial base, introduce and transfer new technology, stimulate economic growth, upgrade managerial and labor skills, and increase exports; especially manufactured goods.

In his study, although Lan (1996) presents the fact that FDI keeps rapidly increasing in China as in other countries, technological gap and transferability of FDI in China do not show a decrease trend over time. He further notes that the technology content of FDI is still low in China. One of the factors he identified is the motive of international cooperation and economic environment.

Apparently, not many foreign investors are willing to bring their capital, technology, and market together into a developing country. Many studies have revealed that there is a trade-off between market orientation and the technology level of FDI (Germidis 1977; Frank 1980; UNCTC 1985, 1989, 1990; OECD 1981, 1989, 1991, 1993). Using less skilled manpower to supply products for export is usually conducted by FDI with a low technology level, while domestic oriented foreign investment is often a channel to transfer a comparatively high level technology, which was verified by Lan's (1996) case study conducted in Dalian, a northern city of China. This study discovered that the technology gap and knowledge transferability of FDI are much higher in market entry FDI than in cost saving FDI. Therefore, the trade off between exports requirements and the technology value of foreign investment becomes a focus of local policy over the control of FDI.

In 1983, for instance, with the extension of the legal framework and the enlarged flexibility given to investors in China, foreign investment grew faster. However, at that time, the FEEs had been too small, with low levels of capitalization and non-advanced technology. The economic environment had not encouraged foreign investors to build advanced-technology firms in China. The main reasons were the convertibility issue, the

incomplete legal system, the low quality of labor and the difficulties in obtaining some raw materials.

From 1992 the flow of FDI has increased dramatically, reaching $31.50 billion in 1994 and $42 billion in 1996 (World Bank, 1997). Shi (1996) showed that, initially, foreign investors (especially those from Hong Kong and Taiwan) were attracted by cheap labor. FDI was used to produce labor-intensive goods in order to re-export them toward their traditional markets. However, since the early 1990s, foreign investors have attached more importance to the quality of workers in order to produce higher technological products.

In fact, for a developing country, "idea gaps" are easier to solve than object gaps (Gould and Gruben, 1996). Hence, the diffusion of ideas by multinational firms allows a rapid convergence of developing countries toward the developed countries' standards. In the Chinese case, "the notion of a purely domestic response to policy reform misses the enormous flows of FDI that China has received since the latter half of the 1980s" (Romer, 1993). In other words, through the introduction of new ideas, FDI may raise technical progress and hence longevity in economic growth. Previous studies on FDI effects on growth suggest that inflow of new technology and working practices from MNCs create a significant potential for spillovers to domestic firms in the host country (Blomstrom and Kokko, 1996).

To other developing countries, China is perceived as having turned to industrialized countries for know-how and technology so as to modernize its economy and to enter international markets (Baker 1990). However, as UNCTC (1990) states, whatever degree of technological autonomy a developing country attains, it is achieved

through the foundation of a local scientific and technological infrastructure. Lan's (1996) study attests to the importance of local absorptive capabilities in knowledge transfer.

The survey conducted by Lan (1996) found that, at the present stage, every trade in China wants to update its technology by FDI, and the inflow of FDI is triggering more FDI for China. However, whether the continuous inflow of FDI will automatically form a network of technology and increase the whole technology capability of the host country is unclear. Presumably, after a period of accumulation, diffusing may be inevitable, since knowledge transfer - from the standpoint of the technology receiver - is the same as innovation. Such cumulative effects of minor technical change may be greater than the effects of major technical changes (Rosenburg, 1982). In this context, Lan (1996) has suggested that a longitudinal study which aims to reveal the general model of integration between inward technology and local technology in China will be helpful for understanding the development pattern of China in the whole economy.

Finally, with respect to the extant research on China, there are two major streams: one is conducted from outside China, and the other from inside. As for the studies outside China, lack of necessary information is a handicap. As Beamish (1988) comments, many 'insights' offered by outside observers have been based on very small samples and they tell more about the observer than about the observed. Conroy (1992) also notes that as no statistics are available for technology flows through FDI, there is no way to assess its role as a channel for knowledge transfer.

With respect to the studies inside China, the following two drawbacks are obvious. First, the lack of an international comparison makes the studies difficult to identify the characteristics of FDI operation in China. Like most developing countries, China needs

technology supplied by developed countries to update its technology. Second, the lack of concern over research methodology, which was displayed without a methodology section in most studies, makes their analysis superficial and inhibits further exploration of the issue.

- **Chinese IPR regime reformation and its domestic innovation**

The flows of intellectual properties, such as patents, designs, trademarks or utility models, into China from other countries are important, as they are the forerunners of knowledge transfer and licensing activities by foreign firms.

Bosworth and Yang (2000) conducted a study to explore the interrelationship between intellectual IPR laws and knowledge transfer via licensing activity in China. They argue that IPR laws and their enforcement play a crucial role in the process of economic development. Without such laws, the incentive for trade and FDI may be severely reduced, because the associated product can be copied by the importing or host nation. The potential barriers that an absence of appropriate IP laws and weak enforcement imposed on knowledge transfer through licensing and FDI are even more significant.

There is little doubt that, by the mid-1970s, the Chinese government had recognized the need to access new information and technologies in order to improve its international competitive power and, thereby, its rate of growth and development. The lessons of other countries that achieved rapid development, such as Singapore, illustrated quite vividly the contribution that knowledge transfer could make, particularly through FDI. Therefore, while greater market access and market size in China will have had a positive role to play in the international market, it is evident that China has been seeking to close the technology deficit created by years of political isolation, offering patent owners the chance to set up potentially lucrative licensing deals and alliances.

Since the 1990s there has been a gradual recognition by the Chinese government that IPRs would actually be to the advantage of Chinese business in the long run. In

January of 1992, China and the United States reached an agreement on intellectual property rights under which China pledged to make significant changes in its copyright and patent laws. China also promised to enact legislation governing the control of trade secrets (STAT-USA, US Department of Commerce). As a consequence, Chinese government officials began to speak up in favour of IPR and would condemn counterfeiting and copying. Some companies that have actively pursued the protection of their IPRs have seen some encouraging signs. The study conducted by Bosworth and Yang (2000) confirms that the introduction of numerous IP laws has clearly given rise to a rapid increase in the flows of patent, trademark and design activity to China by Western countries.

Moreover, after 1998, the Chinese government had strengthened the IPR protection and enforcement and started the preparation for the second revision of the Patent Law. As stated in the White Paper on the Intellectual Property Rights Protection in China in 1998 that "1998 was a significant year in the history of the development of the intellectual property system in China.....The legal framework for intellectual property - including patents, trademarks and copyright - was further implemented and perfected in China..... China has also made significant progress in cracking down on copyright infringement and piracy.....the relevant authorities undertook strong measures against infringement, piracy, and the manufacture and sale of illegal publications. China has further strengthened exchanges and cooperative relationships with other countries and international organizations with regard to intellectual property." As a whole, the awareness for the protection of intellectual property rights in Chinese society had risen

significantly since 1998, and "both the standards for, and the capacity of, protecting IPR by regions, departments and units throughout China were improved dramatically."

Furthermore, the domestic applications of patents for inventions had increased at an average annual growth rate of 13.3% in 16 years since the implementation of the Chinese Patent Law. There were over 440,000 patent applications in the China between 1984 and 1994, of which half were approved (Reuvid & Li, 1996). The statistics of patents was no longer a simple written index, the role of which was more and more important in economic and technological innovation.

The statistics of IPRs show that, on the one hand, with the further development of China's reform and opening up, foreign companies and institutes attach great importance to the huge market of China and expect to solidify and expand their market share through IP protection. Continuous increase of foreign applications of patents for inventions to China and the flowing support of capitals and high technology not only promote the leaping development of scientific research of the domestic firms, but also are conducive to the later advantages of China.

Nonetheless, although the amount of Chinese applications of patents to foreign countries and the exports of relevant rights continued increasing in recent years, foreign patents in China occupy most of the major high-tech fields. This reflects that there is still a great gap in terms of science and technology between developed countries and China, so the import of relevant rights would continue to increase over a rather long period.

In order to accommodate the international IP rules, China currently provides patent protection for pharmaceuticals and other chemical products in addition to providing process protection for those categories of goods. The length of patent

protection is 20 years. In addition, compulsory licenses are not generally allowed unless the proposed user has made reasonable efforts to obtain authorization from the rights' holder on reasonable commercial terms. Contracts for the licensing or assignment of patent rights held by a foreign entity to a Chinese entity are subject to the examination and approval of MOFETC or its local branches (STAT-USA, US Department of Commerce).

Furthermore, at present there are three forces creating a more favorable environment for western MNCs to do new business in China by transferring new technology. First, growing overcapacity means that China not only requires traditional turnkey factories, but the technology that will enable local teams to manage a process of innovation and improvement. Second, is a changing attitude by all levels of the Chinese government toward demanding state-of-the-art technology, including software instead of previous generation technology, and to technology management and commercial implementation. Third, IPRs have slowly become better respected than before.

Since the late 1970s, the Chinese government had clearly recognized that a policy of direct government control was not consistent with attracting investment and technology inflows, and that the formation of a formal system to protect IPRs was a prerequisite for further economic development. In addition, the Chinese government further demonstrated its desire to improve and modernize its IPR protection regime by joining a number of international IP organisations and by signing up to various international conventions. In particular, in order to meet the requirement of TRIPs for joining the WTO, a few relevant laws were amended before 2001 and some are in process

of being amended. Taken together, these actions indicate the positive attitude of China toward improving the degree of legal protection for IP.

Finally, China's participation in the WTO not only brings a market of 1.3 billion people into the global trading system, but also benefit for a lot of Chinese companies involved in international competitive opportunities. After China's accession to the WTO, more and more Chinese companies have their own technological exports that will be subject to copying from companies in other countries. It is worthwhile addressing how to carry out knowledge transfer successfully, in order to manage the whole process of introducing and developing technology in China.

- **WTO Membership**

Countries in transition have considered membership in the World Trade Organization (WTO) as an important step toward integration in the international economic system. After several years of negotiations, on 11 December 2001, China finally gained its membership and became the 143rd member country in the WTO, which significantly changed China in terms of IP practice, protection and enforcement.

After its WTO entry, China seriously performed its obligations, and abided by the WTO regulations. Consistent with the provisions of the TRIP Agreement administered by the WTO, the Chinese government amended some Chinese Patent Laws and revised the Implementing Rules for the Patent Law on August 25th, 2000, which became effective on July 1st, 2001. After such amendments, the scope of Chinese patent protection was expanded, the enforcement of patent rights strengthened, and the various procedures in the course of application and examination were simplified. Apart from amending the Chinese Patent Law, China is in the process of revising various laws to meet its WTO commitments.

Furthermore, along with the development of international and domestic situations, the role and status of IPRs in the Chinese economy, science and technology, and social life, have become more important. It demonstrates that, after the signing of the Sino-US bilateral agreement on China's entry into the WTO on November 17th, 1999, it has incurred increasing domestic patent applications.

Finally, many researchers feel confident that FDI will continue to contribute to China's economic development, as WTO accession is expected to lead to a continuation of these contributions. Tseng and Zebregs (2002) predict that FDI will continue to be an

important source of growth in China and will help offset potential output losses and create employment opportunities for workers that have become redundant in state enterprise and banking reforms. In sum, Membership of the WTO will boost more FDI inflows into China and FDI can be expected to continue to play an important role in China's reform process for some time to come.

THEORETICAL FRAMEWORK

In the previous section a series of issues associated with the role of FDI, knowledge transfer to developing countries through FDI, and the significance of WTO accession were reviewed. However, a general picture of the effect of such knowledge transfer to China through FDI on domestic technology development, and a suitable method used to measure the knowledge transferability of inward investment in current China, do not emerge from the prior studies. This section attempts to bridge the literature's investigation and empirical study by means of building a theoretical framework.

Given the study background, the main objective of the current research, based on the country-level data, is focused on analyzing and investigating the effect of knowledge transfer to China through FDI on Chinese domestic technology development of a national scope. Moreover, while FDI has been widely regarded by a lot of researchers as a key pillar of China's "opening up" policies, China's accession to the WTO would be a stepping-stone for indigenous enterprises to enter global trade and participate in international market competition. Accordingly, this would prompt indigenous firms to improve their own technological competency and spur incentives for their R&D.

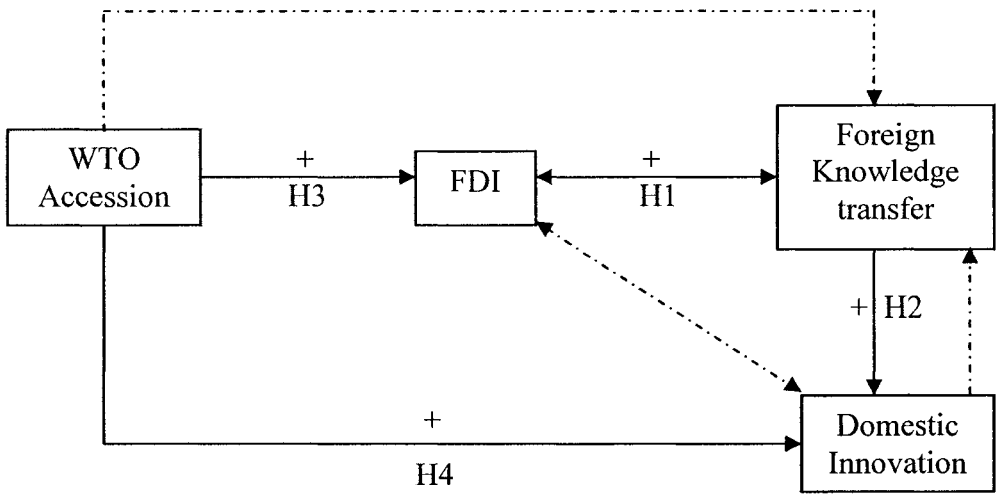
Therefore, the first priority of this study is to systematically examine the results of foreign knowledge transfer through FDI on promoting technological progress in China, in order to show a picture of the contributions of FDI to China's current technology development from one angle. Then, the impact of WTO accession will be investigated so as to provide some instructive suggestions to other developing countries.

On the basis of the above views, as well as the preceding literature review, the following **research questions** are brought about:

1. **Is FDI positively correlated to foreign knowledge transfer to China?**
2. **Does foreign knowledge transfer through FDI spur the incentives for domestic innovation?**
3. **Whether WTO accession acts as a kind of catalyst to boost FDI inflows to China?**
4. **Does WTO accession also positively influence local firms' innovation?**

In order to answer the above four research questions, a research model (see Figure 1) is graphed below:

Figure 1 – Research Model



Based on this research model, the relevant hypotheses were formulated to realize the study objectives.

H1. The FDI inflowing is positively correlated with foreign knowledge transfer to the host country.

We set up this hypothesis for the following reasons:

1. It has been well documented by the previous studies that FDI is a vehicle for knowledge transfer.
2. It is commonly argued that MNCs rely heavily on intangible assets such as superior technology, to successfully compete with local firms who are better acquainted with the host country environment. The reason for this is because, while MNCs invest in a foreign country, they will transfer the intensive competition to the local market. Consequently, the intensive competition will force the MNCs to bring in their advanced technology to vie with domestic firms. Thus, FDI is "pushed" by such firm-specific advantages of MNCs (Shan and Song, 1997). Meanwhile, the technology that is transferred to the subsidiaries might leak out to the domestic firms, thereby increasing the competition facing the subsidiaries even more. Therefore, the tougher the competition, the more technology will be brought in by the MNC to guarantee the technological advantage of its invested project.

3. Generally, the flows of IPRs, such as patents, are generally linked with industrial innovation and also an important source of technical information into the host country from MNCs, are the forerunners of the ensuing FDI activities. In particular, for those transnational firms that pursue productive FDI involving high technology in the host country, it is necessary to transfer the technology, or knowledge, to the host country before realizing the FDI project. There are some reasons for MNCs applying for a patent in the host country. Firstly, such a patent might protect existing or a potential market (Basberg, 1987). Secondly, licensed production will very often have a patent as a precondition (Scher, 1954, pp.52). Foreign patents are used as technology indicators because, on average, they are expected to be of a higher quality than

domestic patents. Thus, the more foreign patent registered in the host country, the more advanced knowledge transfer to the local market; as a result more FDI projects would flow in to the market.

4. As is well known, MNCs are concentrated on industries that exhibit a high ratio of R&D relative to sales and a large share of technical and professional workers (Markusen, 1995). Therefore, from the MNCs' perspective, the knowledge or technology they invented is not only to help them increase productivity in the home country, but also to reap the investment on those costly R&D activities so as to maximize their profits from the knowledge transferred. By licensing the technology, or investing directly in a foreign country with the inventive technology, the MNCs inevitably transfer their sophisticated technology to the host country.
5. As noted in the literature review section, an FDI project related to R&D activity is put at the highest level. This implies that that when MNCs bring their R&D centres into a host country, not only will they take advantage of local raw materials and low cost technical staff, but they will also bring more advanced technology projects to the host country. Moreover, once they achieve certain innovations based on local raw materials and technical staff from the R&D activities in the host country, MNCs will invest more projects in the local market based on the invented technologies. Furthermore, by setting up their R&D centres in the host country, MNCs also stimulate the local R&D activities so as to help domestic firms develop their technological innovation indirectly.

   In this connection, China gives a good example. Given the large number of R&D institutions and the large supply of capable but low-cost scientists and researchers in

China, FDI in R&D activities has been increasing. MNCs such as Microsoft, Motorola, GM, GE, JVC, Lucent-Bell, Samsung, Nortel, IBM, Intel, Du Pont, P&G, Ericsson, Nokia, Panasonic, Mitsubishi, AT&T, and Siemens have helped build over 100 R&D centres in China. What FDI into medium- and high-tech manufacturing is on the increase reflects that foreign affiliates in China have played an important role in supporting the country's rapid pace of industrial development, economic growth and skills enhancement (UNCTAD, 2002).

6. As noted in the literature review, FDI appears to like to cluster, and this seems to be determined partly by the degree and level of the MNCs' innovation, thereby creating a significant draw to FDI from foreign innovation. Moreover, such an agglomeration effect of FDI can be also explained by the severe competition among MNCs, or between MNCs and domestic firms in terms of technology. Wang and Blomstrom (1992) argue that MNCs respond to local competition by introducing newer technologies faster. The survey conducted by Lan (1996) found that at the present stage, every trade in China wanted to update its technology by FDI, and the inflow of FDI is triggering more FDI coming to China.

H2. Foreign knowledge transfer through FDI positively affects the development of domestic innovation

The second hypothesis stems from:

1. Based on the literature review, we notice that by encouraging FDI, developing countries hope not only to import more efficient foreign technologies, but also to

generate technological spillover for local firms so as to eventually develop the domestic firms' technological innovation capability.

2. Empirical research has found that domestic firms appear to have benefited from the presence of MNCs through positive spillovers (Zebregs 2001). Such spillovers come about when MNCs introduce new technologies and management skills. In the debate on the role of MNCs in international knowledge transfer, it has been strongly suggested in the extant literature that the most significant channel for the dissemination of modern, advanced technology is knowledge spillover through FDI, rather than formal knowledge transfer arrangements (Blomström, 1989).
3. Blomström and Kokko (1996) summarize three types of spillover through FDI to improve the domestic firm's productivity. The simplest example of a spillover is perhaps the case where a local firm improves its productivity by copying some technology used by MNC affiliates operating in the local market. Outlining a comparison of local and MNCs' technologies, Jenkins (1990, p. 213) notes that, "over time, where foreign and local firms are in competition with each other, producing similar products on the same scale and for the same market, there is a tendency for local firms to adopt similar production techniques to those of the MNCs. Indeed this is part of a general survival strategy whereby, in order to compete successfully with the MNCs, local capital attempts to imitate the behaviour of the MNCs." Another kind of spillover occurs if the entry of an MNC leads to more severe competition in the host economy. Sinani and Meyer (2002) argue that such spillover of knowledge transfer benefits to domestic firms from competition of foreign firms, as the competitive pressure induces domestic firms to use more efficiently their existing

technologies, or search for new ones so that they are able to maintain their market shares. The third type of spillover effect takes place when MNCs train domestic employees who may leave for the domestic firms or through backward forward linkages.

4. In the model of Wang and Blomstrom (1992), knowledge transfer channeled through FDI is considered as an endogenous equilibrium phenomenon that results from strategic interaction between foreign firms and local firms. The magnitude of spillovers depends on the extent to which local firms respond positively to the technology gap and invest in 'learning activities' (Liu and Wang, 2003).
5. Some research suggests that FDI contributes to economic growth only when a sufficient absorptive capability of the advanced technologies is available in the host economy. Wang and Blomstrom (1992) highlight the importance of learning efforts (absorptive capacity) of a local firm in increasing the rate of knowledge transfer. Furthermore, in order to be able to absorb the advanced technology of foreign firms, Kamien and Zang (2000) show through a game theoretical framework that a local firm should invest in R&D. Cohen and Levinthal (1989) argue that there are two 'faces' of R&D in the domestic firm: it not only simulates innovation but also increases firm's absorptive capacity. Thus, all these points demonstrate that foreign knowledge transferred in the host country require domestic firms to accelerate local technological development and upgrade the indigenous innovative capabilities so as to narrow the technology gaps between the MNCs and domestic firms.

6. Conducting an economic study on the interrelationship among FDI, licensing and incentives for innovation, Saggi (1999) proposed a two-period duopoly model. In formulation of this model, he assumed a series of scenarios:

   (1) If the foreign firm opts for licensing in the first period to transfer the knowledge to a domestic firm, the domestic firm is forced to invest more in R&D in order to improve its ability to absorb the foreign firm's technology, eliminate the technology gap with the foreign firm, and increase its competitive ability in the future by making any improvements to the licensed technology. Thus, initial licensing increases the domestic firm's incentive for innovation as the knowledge transfer under first-period licensing provides the domestic firm with a springboard upon which to base its second-period R&D.

   (2) Under second-period licensing, since the domestic firm employs the technology developed by the foreign firm, it also has an incentive for R&D to lower the costs of knowledge transfer by bridging the technology gap between the foreign firm and itself (costs of knowledge transfer are assumed to increase with the technology gap between the two firms).

   (3) If, initially, the foreign firm chooses FDI to reduce knowledge spillovers to the domestic firm relative to licensing, second-period FDI will also force the domestic firm to compete with the foreign firm by using its own technology.

   Accordingly, Saggi (1999) summarized that the domestic firm's technological development would receive a strong boost from foreign knowledge transfer no matter whether the foreign firm engages in licensing or FDI initially, or follows the licensing or FDI in the second period. Furthermore, since FDI forces the domestic firm to

compete with the foreign firm by using its own technology, the domestic firm's incentive for innovation is stimulated by the competitive incentive of inward FDI. The empirical result is that the local firm would have the strongest incentive for innovation if the foreign firm were to follow initial licensing by FDI.

7. According to the analysis of Djankov and Hoekman (2000), if the learning of domestic firms is proportional to the output of the MNC, the MNC has an incentive to transfer technologies to its subsidiary, since more advanced technologies raise profits. The greater output of the subsidiary then induces local firms to learn and adopt foreign technologies at a faster rate. Foreign firms again transfer technologies at a higher rate if domestic firms invest more in learning activities. Blomstrom, Kokko, and Zejan (1994) find some empirical support for this prediction.

H3. WTO accession positively influences FDI inflowing to the host country

The reason for using WTO accession as the proxy to measure the relative openness in this study is because firstly, it has been recognized by prior studies that it is difficult to measure openness, and so far in the literature, there has been no good measurement of this issue. Moreover, as the only international organization dealing with the rules of trade between nations, the WTO is there to help a nation join global markets so as to further achieve its liberalization gradually. In order to enter the WTO, on the other hand, the nation has to open its own market to the world. Thus, it has been generally acknowledged that joining the WTO is a sign to the country to liberalize its trade to the world.

In terms of the rationale in proposing this hypothesis, firstly it comes from one study of the OECD (1991), which claims that abolishing or reducing discrimination in the host country is more attractive to FDI than offering other incentives. Thus, WTO accession would reduce the trade barriers to FDI and improve the relevant FDI policies as well as the investment environment; as a result, a membership of the WTO would help the country attract more FDI from the MNCs.

Secondly, as noted in the literature review, the beneficial effect of FDI is stronger in those countries pursuing an outwardly oriented trade policy than it is in those countries adopting an inwardly oriented policy (Balasubramanyam, Salisu, and Sapsford, 1996). In particular, export-oriented FDI will increase with greater openness in the host country. Moreover, quite a few cross-country studies have found that closed economies grow less than outward-orientated economies (Krueger, 1978; Bhagwati, 1978; World Bank, 1987; De Long and Summers, 1991; Michaely et al., 1991; Edwards, 1992; and Roubini and Sala-i-Martin, 1992).

Thirdly, it has been proven that there is a positive link between IPR protection and trade flows. Since the MNCs usually seek IPR protection as a prerequisite for their following FDI activities, a weak IPR regime in the host country deters foreign investors in high technology sectors where intellectual property rights play an important role (Smarzynska, 2002a). In their study, for instance, Lee and Mansfield (1996) find that a country's system of IP protection influences the volume and composition of US firms' FDI. Therefore, if a country intends to join the WTO, it has to make substantial commitments in trade and investment liberalization, such as adherence to WTO rules on

IPRs and the elimination of various requirements on FDI, thereby strengthening investors' confidence.

Furthermore, such attributes associated with WTO accession also brings in a scale effect. For example, numerous studies on the Chinese economy have found a strong persistency in FDI flows (Cheng and Kwan, 2000; Head and Ries, 1996). The results of these studies support that once a country has attracted a critical mass of FDI, due to abiding by the WTO provision of IPR protection, it will find it easier to attract more FDI as foreign investors perceive the strengthened IPR regime and the presence of other foreign investors as positive signals.

Finally, as for the case of China, several researchers predict that FDI will continue to contribute to China's economic development after China joins the WTO, which is expected to lead to a big jump in the inflow volume of inward FDI. As an UNCTAD report (2002) highlighted, the global economic slowdown did not affect most respondents' investment plans in China: 9 out of 10 companies already operating in China intended to expand their operations, and 6 out of 10 companies without any operation in China would consider investing in China in the first 1 to 3 years after the country's WTO accession. This report implies that the membership of the WTO strengthens foreign investors' confidence in investing in China. Therefore, we propose that a country's WTO accession positively affects the inflows of FDI into the country.

H4. WTO accession stimulates the development of domestic innovation

This hypothesis is based on the following concerns:

1. When a country joins the WTO, not only does its own market open to the world, but it also has more opportunities to enter international markets, which enable domestic enterprises to participate in international competition by exporting their products or technologies. In turn, exporting technologies to the other countries or global markets would be an incentive to domestic firms to deepen their innovative capabilities. Balasubramanyam et al. (1996) also supports that view, suggesting that exports like FDI are likely to result in a higher rate of technological innovation and dynamic learning from abroad.
2. In order to meet WTO requirements, especially on IPR protection, the country must reinforce its own IPR protection and enforcement. By doing so, while it strikes at the infringement caused by imitating foreign technologies, it also protects domestic state-of-the-art technologies so as to encourage indigenous firms to pursue more innovative activities. As Bosworth and Yang (2000) note, "a country's preparedness to continue copying during its early development is mollified by the importance to economic growth of participating in world trade, in terms of both imports of technology and exports to advanced countries."
3. Applying this to China's case, from the introduction of its "open door" policy in the early 1980s, China's exports have gained great attention; especially exports of technology. With the growing importance of technology exports, IPR protection has become crucial in protecting China's indigenously developed technology. In this connection, Bosworth and Yang (2000) illustrate two reasons. First, according to Jiang (1995), 70-80% of the technology exported from China was destined for developing countries, many of which, for various reasons possessed weak IPR

protection themselves. Meanwhile, Chinese state-owned enterprises had not yet acquired appreciable experience of exporting technology. Although foreign-invested enterprises will have made a significant contribution to China's export performance in this regard, the fact that technology exports have increased significantly in recent years not only suggests there has been an upsurge in indigenous technology production, but also indicates that an opening policy is conducive to the improvement of local technological capabilities as well as the development of domestic innovation.

4. After China's accession of the WTO, many Chinese firms will have more and more opportunities to export their high technology or high technological products to other countries, and not only stick to the exports of labour-intensive final products, such as textiles and other consumer goods. This would require Chinese firms to invest more on their R&D activities to upgrade their technological competency and promote their own innovation capability to be able to compete with foreign MNCs in global markets.

DATA & METHODOLOGY

Empirical Data

This empirical study employs two unique country-level datasets based on the statistics of the Chinese Intellectual Property Right Office, including the numbers of foreign patent applications and the numbers of domestic patent applications in China between 1994 and 2002, and the FDI data obtained from the Ministry of Foreign Trade and Economy of China (MOFTEC) between 1994 and 2002.

In detail, the first dataset is on a quarterly base from 1994 to 2002, which is called the long-term dataset. The second dataset is on a monthly base from 1999 to 2002, because since 1999 Chinese government has been collecting and publishing the FDI data by month; as a result, we call this dataset as the short-term dataset. These two datasets are plotted as Figure 2 and Figure 3, respectively.

Figure 2 – Long-term dataset (quarterly data)

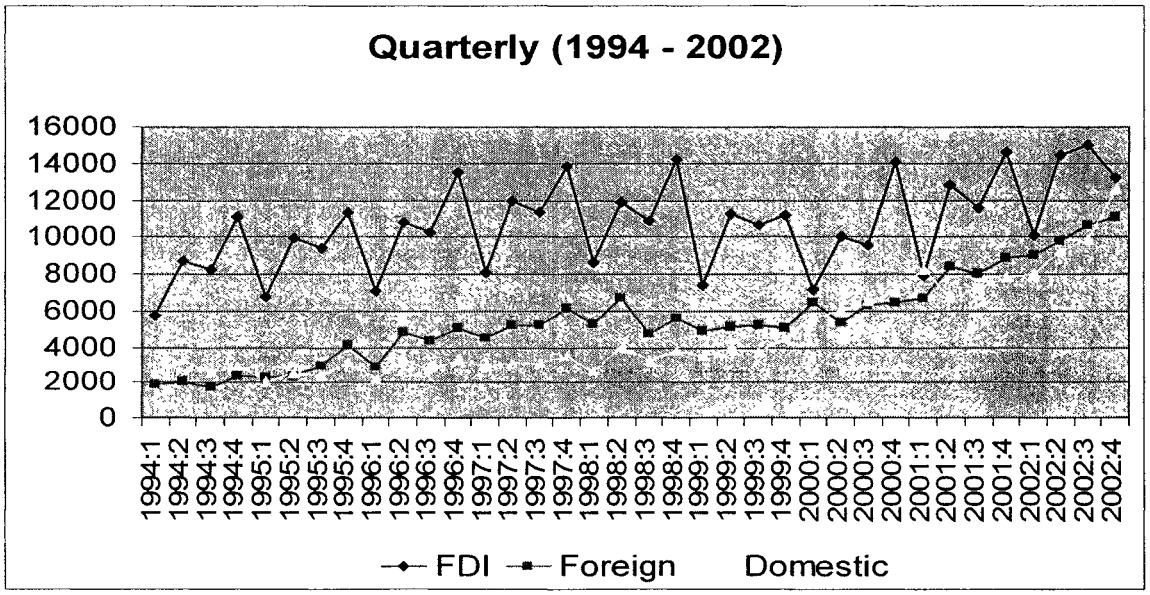
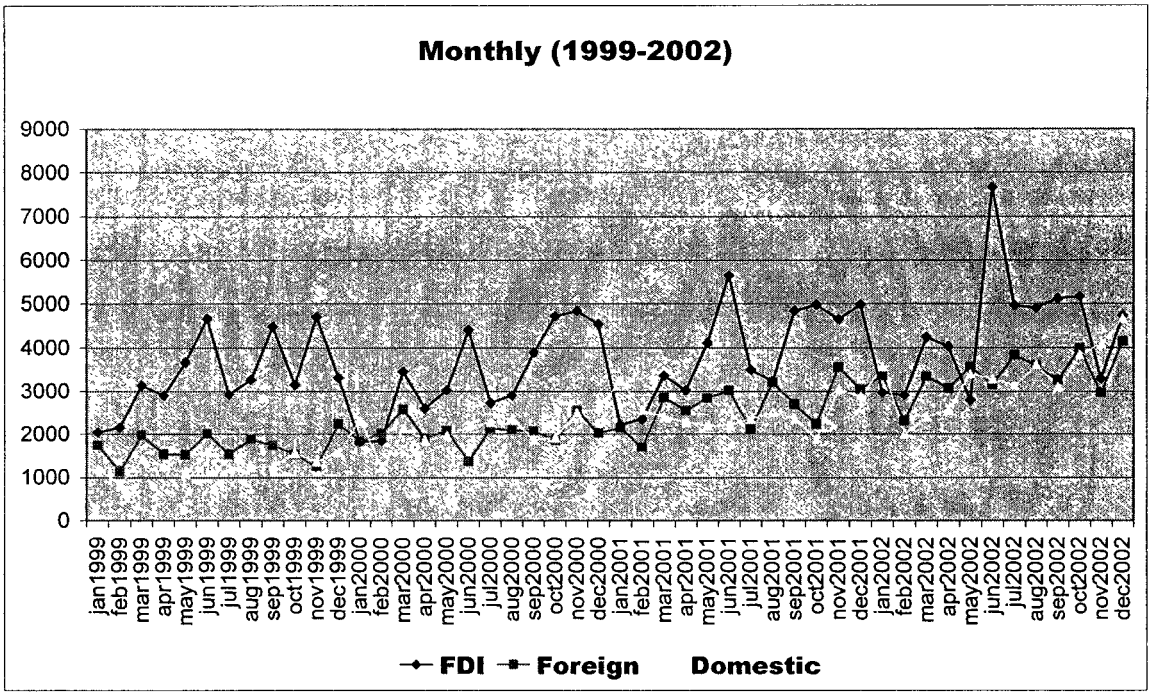


Figure 3 – Short-term dataset (monthly data)



Meanwhile, in order to examine the effect of China's WTO accession on the FDI inflow as well as the technology spillover, we specify a dummy variable that is equal to 0 before November 15th, 1999 when China signed the Sino-US bilateral agreement with the United States on China's entry into the WTO, and equal to 1 thereafter.

Empirical Approach

To empirically test the research model in this study, we use time series regression analysis.

First of all, from Figure 2 and Figure 3, we can notice that the data we use in the study are indexed in real time, and a natural ordering exists in terms of prior and subsequent observations. Thus, the order of the data is of considerable importance in this case, so that most classical statistical techniques are not relevant.

In general, there are two time-based approaches – cross-sectional studies and longitudinal studies. A cross-sectional study is one in which the data are collected at one point in time and an answer to the research question applies only to the phenomenon at the particular time it is studied. On the other hand, a longitudinal study involves data collection at different points in time in order to track down the changes in the future situation of certain study. Thus, longitudinal study conducts research over time in which time is a variable (McTavish and Loether, 2002; Del Balso and Lewis, 2001).

Since cross-sectional data are indexed by an integer index set and there exists no natural ordering in which the observations may be arranged relative to the index (Dhrymes, 1998), whereas data in the form of time series are a sequence of observations taken at regular intervals of time such as on a monthly or quarterly base as our case, thus, a longitudinal study is appropriate for our study.

In terms of time series regression, Granger and Newbold (1986) describe a time series as "a sequence of observations ordered by a time parameter." Time series are realizations of underlying data-generating processes over a time span, occurring at

regular points in time. As such, time series have identifiable stochastic or deterministic components (Yaffee, 2000).

Moreover, in regressions of one series on another, each of which is driven with stochastic trend, a spurious regression with an inflated coefficient of determination may result. Null hypotheses with T and F test will tend to be over-rejected, suggesting false positive relationships (Granger and Newbold, 1986; Greene, 1997). Thus, regressions involving highly persistent, unrelated series can produce spuriously large correlations and thereby incorrectly appearing to be related (Yule, 1926; Granger and Newbold, 1974). By using time series, one possible source of spurious relationship is removed (Granger and Newbold, 1986).

Furthermore, as Ostrom (1990) noted that the great advantage of time series regression analysis is "the possibility for both explaining the past and predicting the future behavior of variables of interest." Thus, both of these efforts are predicted upon being able to correctly postulate a model and estimate its parameters. Such regression approaches to the analysis of time series data in which the modeler makes an initial specification of a causal structure and then analyzes the data to determine whether there is any empirical support for the specification.

In addition, in time series analysis, researchers often prefer to use multiple-input dynamic regression models to explain processes of interest (Yaffee, 2000). The main objective of multivariate time series analysis is ascertaining the leading, lagging, and feedback relationships among several series. Therefore, by exploiting multivariate time series analysis in this study, not only can we test four hypotheses proposed in the

framework, but it also enables us to go beyond the scope of the study to examine some feedback relationships among these variables.

Given a multivariate time series in the present study, a Vector Error Correction Model (VECM) is used with non-stationary data and allows the short-term and long-term relationships to be modeled simultaneously as long as the variables are cointegrated. Therefore, before using VECM, we need to test the stationarity of each individual variable, and then examine the cointegration between variables. By doing so, we use the VARMAX procedure in SAS, which enables you to model both the dynamic relationship between the dependent variables and between the dependent and independent variables.

Basically, Time series may be stationary or nonstationary. Stationary series are characterized by a kind of statistical equilibrium around a constant mean level as well as a constant dispersion around that mean level (Box and Jenkins, 1976). A stationary series is the observations fluctuate about a fixed mean level with constant variance over the observational period. In other words, the overall behavior of the series remains the same over time (Pena et al., 2001). Thus, a stationary series appears be quite stationary with a mean level close to zero over time. In contrast, the nonstationary series does not have a mean level and exhibits a drifting or wandering behavior.

If a series is stationary, the magnitude of the autocorrelation attenuates fairly rapidly; whereas if the series is nonstationary or integrated, the autocorrelation diminishes gradually over time. Many macroeconomic series are integrated or nonstationary. Nonstationary series that lack mean stationarity have no mean attractor toward which the level tends over time. Nonstationary series are characterized by random walk, drift, trend, or changing variance (Yaffee, 2000).

For situations where the stationarity of the time series is in question, the VARMAX procedure provides Dickey-Fuller test to aid in determining the presence of unit roots and then Johansen cointegration test to determine cointegration of the variables. Moreover, the VARMAX procedure also provides a Granger-Causality test to determine the Granger-causal relationships between two distinct groups of variables.

Therefore, the first step is to carry out the Dickey-Fuller test for a unit root by testing the null hypothesis of non-stationary for the series, using the t-statistic on the parameter of the variable. The t-statistic is compared with specific values constructed by Dickey and Fuller (1979, 1981). If there is strong evidence in favour of the null hypothesis of non-stationarity, we could conclude that a non-stationary model may be more appropriate to such vector time series; as a result, we would use Vector Error Correction Model for the next steps, because a VECM can lead to a better understanding of the nature of any non-stationarity among the different component series.

The second step is to test for cointegration. The concept of cointegration, as developed by Granger and others, examines the presence or absence of an equilibrium relationship between two variables over time (Engle and Granger, 1987; Granger, 1986). Thus, understanding cointegration is necessary to facilitate the development of the error correction model.

In general, two time series variables can be considered cointegrated if they have the same order of integration and the error process from the regression performed on the untransformed variable is stationary. A long-run equilibrium relationship can be said to exist between the two series, while short-run deviations between them are stationary.

Johansen (1988), and Johansen and Juselius (1990) provide a procedure to examine the question of cointegration in a multivariate setting. The procedure is based on maximum likelihood techniques and involves two test statistics to test the null hypothesis that there are at most r cointegrating vectors, which is called the cointegration rank of the series. These two tests, Trace Test and Maximum Eigenvalue Test, are provided by the VARMAX procedure to examine various hypothesis tests of long-run effects.

Finally, once two time series variables are proved as cointegrated, we would conduct the Granger causality test to determine the extent to which the lag process in one variable explains current values of another variable. In any multivariate setting, researchers are interested in testing for the exogeneity of a variable. Such testing is closely related to the concepts of causality.

Causality in the sense defined by Granger (1969) and Sims (1980) is inferred when lagged values of a variable, say x_t, have explanatory power in a regression of a variable y_t on lagged values of y_t and x_t. Consequently, the researcher may wish to determine if a causal relationship exist between x_t and y_t, and if there is reverse causality, i.e., y_t causing x_t, and so on. The Vector Autoregressive (VAR) model can be used to test the hypothesis. Tests of the restrictions can be based on Wald's F tests in the single equations of the VAR model.

Measurement

- FDI is measured as the volume of realized foreign direct investment inflow into China at USD million;
- The key variables in this study are proxies for foreign knowledge transfer and domestic technology progress. How to measure knowledge transfer and technological change has concerned economists, economic historians, historians of technology and research analysts for a long time. However, no widely accepted method has been developed so far. Much of the econometric literature has focused on productivity measures as proxies for measures of technology diffusion, such as the study done by Blomstrom and Person (1983). More recent studies, for instance Djankov and Hoekman (2000), estimate production functions using total factor productivity as a proxy for knowledge transfer. As discussed in the literature section, finally, the use of patenting as an indicator of technological innovation has grown steadily over the past decade. A large body of literature has used patent-based indicators either at country or industry level in order to link technology to patterns in science, R&D, production and exports. Therefore, in this study, we exploit the last method. Namely, using the number of foreign patents registered in China in a certain period measures the knowledge transfer from foreign investors, and using the number of Chinese domestic patents registered in a certain period measures the technology change or innovation development of Chinese firms;

- We create the zero-one dummy variable, because, as discussed in the theoretical framework section, we believe that a country's accession to the WTO not only spurs more FDI inflows to the country, but also stimulates indigenous firms' R&D, or innovation development. In turn, it would further encourage MNCs to bring more advanced technology into the host country through FDI. Therefore, in order to investigate the impact of China's WTO accession on its FDI inflows, and foreign knowledge transfer, as well as domestic innovation, we conduct a causality test on these variables.

It is worth noting that, to the best our knowledge, none of the previous studies on this topic has used patent data in a developing or host country to examine the knowledge spillover or knowledge transfer to the host country through FDI.

EMPIRICAL RESULTS

Vector Autoregressive Model

To test the hypotheses, a vector autoregressive model is set up as the following form:

$$Y_t = A + BY_{t-1} + E_t$$

Where:

Y_t = (FDI, Foreign, Domestic)$_t$ = a vector including the volume of FDI inflow in China at time *t*, the numbers of foreign patents registered in China at time *t*, the numbers of domestic patent registered at time *t*;

A = the constant unobserved influences;

Y_{t-1} = (FDI, Foreign, Domestic)$_{t-1}$ = a vector including the volume of FDI inflow in China at time *t-1*, the numbers of foreign patent registered in China at time *t-1*, the numbers of domestic patent registered at time *t-1*;

B = the corresponding vector of coefficients of Y_{t-1}, which is expected to be positive sign on all including variables;

E_t = a normal disturbance term with mean zero, which takes into account all other unidentified variables.

In order to compare the effect of FDI on knowledge transfer to China in a long time period with FDI in a short time (especially before and after Chinese joining the WTO), we test and analyze two datasets separately.

The Long-term Dataset Test

The first test is based on the long-term dataset: quarterly data from 1994 Q1 to 2002 Q4. Moreover, from Figure 2 we notice that the quarterly data of FDI display a strong seasonal behavior. We also assume that the effects of all variables have impacts on the others with a one-year lag. In terms of the order of this autoregressive (AR) model, we specify a first-order AR model.

As noted previously, we first need to determine the stationarity of all the series by using the Dickey-Fuller test. Table 1 shows the output of Dickey Fuller Unit Root Tests. Since all the t-ratio results for all the variables are beyond the critical values at both 5% and 10% significant levels, unit root tests show that we would not reject the null hypothesis of a unit root. As a result, each variable is non-stationary, suggesting that a VECM model is most appropriate for the following tests.

Table 1 - Dickey Fuller Unit Root Tests for the Quarterly Data

Variable	Type	Tau	Prob<Tau
FDI	**Single Mean**	-2.57	0.1078
Foreign	**Single Mean**	1.38	0.9985
Domestic	**Single Mean**	3.49	0.9999
	Critical Values	*-2.965 at 5%*	
		-2.61 at 10%	

Note that in the long-term relationship there is a constant included in the error correction model so that the model has an intercept term, but there is no constant in the short-term relationship.

Next, we investigate the cointegration of all the time series as well as the cointegration rank of two cointegrating vectors, FDI-Foreign and FDI-Domestic. Table 2 demonstrates the results of Trace Test and Maximum Eigenvalue Test. The outputs of these two tests indicate that all the time series are cointegrated with rank 1 at a 0.05 significance level.

Table 2 - Johansen Cointegration Test for the Quarterly Data

	Hypotheses		**Trace test**	**Maximal Eigen**
	Null	**Alternative**	**(critical value)**	**(critical value)**
Foreign	**r=0**	**r>0**	*46.30*(15.34)	*46.30*(14.07)
	r=1	**r>1**	0(3.84)	0(3.76)
Domestic	**r=0**	**r>0**	*39.71*(15.34)	*36.74*(14.07)
	r=1	**r>1**	2.97(3.84)	2.97(3.76)

Finally, we carry out the Granger causality tests to determine the long run, causal relationships among all the variables. Additionally, in order to examine the impacts of China's WTO accession on the FDI inflows and knowledge transfer, in this step we involve WTO as a dummy variable, which takes a value as 1 between 2000 Q1 and 2002 Q4 and a value as 0 between 1994 Q1 and 1999 Q4.

Table 3 displays the results of the Granger causality tests for all the variables. From the outputs, we can see that, apart from the directions from FDI to Domestic, from Foreign to Domestic, and from WTO to Domestic, the F values show statistically significant for all the other causality tests. This means that there appears to be the long-term, causal relationships among FDI, foreign knowledge transfer, domestic innovation

development, and the WTO accession in China. Moreover, the causality appears to run in both directions for FDI and foreign knowledge transfer, but only one way from domestic innovation development to FDI and from domestic innovation development to foreign knowledge transfer. Surprisingly, the results suggest that China's WTO accession does not encourage domestic innovation development, which means that hypothesis 4 is not supported in this test. Likewise, as expected, hypothesis 2 partly fails, because the results do not confirm that foreign knowledge transfer affects domestic innovation development.

Table 3 - Granger Causality Tests for the Quarterly Data

			Wald's *F* Statistic (p values)
FDI	→	**Foreign**	4.00 (0.0456)
Foreign	→	**FDI**	22.76 (<.0001)
FDI	→	***Domestic***	*0.68 (0.4095)*
Domestic	→	**FDI**	9.56 (0.0020)
Domestic	→	**Foreign**	3.55 (0.0595)
Foreign	→	***Domestic***	*0.49 (0.4855)*
WTO	→	**FDI**	6.60 (0.0102)
WTO	→	**Foreign**	2.24 (0.1343)
WTO	→	***Domestic***	*0.18 (0.6727)*

The Short-term Dataset Test

The second test is based on the monthly data from 1999-01 to 2002-12. Different from the long-term dataset, the monthly data in Figure 3 do not display a seasonal pattern. Likewise, we still assume that the effects of all variables have impacts on the others with a year lag. In terms of the order of this autoregressive (AR) model, we also specify a first-order AR model.

In the same way as the long-term dataset test, we examine the stationarity of all the series. Table 4 shows the outputs of the Dickey Fuller Unit Root Tests. Similarly, as all the *t* statistics for all the variables are beyond the critical values at both 5% and 10% significant levels, unit root tests show that all the series are non-stationary; as a result, we will use a VECM model for the subsequent tests. Contrary to the long-term dataset test, however, there is no constant in the short-term dataset test.

Table 4 - Dickey Fuller Unit Root Tests for the Monthly Data

Variable	Type	Tau	Prob<Tau
FDI	**Zero Mean**	-1.30	0.1426
Foreign	**Zero Mean**	2.17	0.9882
Domestic	**Zero Mean**	1.29	0.9257
	Critical Values	***-1.95 at 5%***	
		-1.60 at 10%	

As for the Johansen Cointegration Test, the results of Trace Test and Maximum Eigenvalue Test in Table 5 indicate that all the time series are cointegrated with rank 1 at a 0.05 significance level as well.

Table 5 - Johansen Cointegration Test for the Monthly Data

	Hypotheses		Trace test	Maximal Eigen
	Null	**Alternative**	(critical value)	(critical value)
Foreign	**r=0**	**r>0**	*26.92* (12.21)	*26.92* (11.44)
	r=1	**r>1**	0 (4.14)	0 (3.84)
Domestic	**r=0**	**r>0**	*18.78* (12.21)	*18.54* (11.44)
	r=1	**r>1**	0.24 (4.14)	0.24 (3.84)

Finally, in terms of the Granger causality tests, we also involve WTO as a dummy variable, which takes a value as 1 between 1999-12 and 2002-12 and a value as 0 between 1999-01 and 1999-11.

Table 6 displays the results of the Granger causality tests for all the variables. In contrast with the outputs of the long-term dataset test, all the *F* ratios are statistically significant for all the causality tests. As expected in the previous sections, they present the long run, causal relationships among FDI, foreign knowledge transfer, domestic innovation development, and WTO accession in China.

Moreover, the causality appears to run in both directions not only between FDI and foreign knowledge transfer, but also between FDI and domestic innovation development, as well as between foreign knowledge transfer and domestic innovation development. Furthermore, the results suggest that China's WTO accession does cause more FDI inflows and more foreign knowledge transfer to China, and also affects the domestic innovation development as expected. Therefore, all the hypotheses are consistent with the results in this test.

Table 6 - Granger Causality Tests for the Monthly Data

			Wald's *F* Statistic (p values)
FDI	→	**Foreign**	6.29 (0.0122)
Foreign	→	**FDI**	18.52 (<.0001)
FDI	→	**Domestic**	9.00 (0.0027)
Domestic	→	**FDI**	10.74 (0.0010)
Domestic	→	**Foreign**	4.92 (0.0266)
Foreign	→	**Domestic**	3.59 (0.0582)
WTO	→	**FDI**	4.18 (0.0409)
WTO	→	**Foreign**	3.31 (0.0687)
WTO	→	**Domestic**	2.68 (0.1017)

DISCUSSION

The causal relationship between the FDI inflow and foreign knowledge transfer

In both tests for hypothesis 1, the empirical results of the causal tests on the volume of FDI inflows into China and the numbers of foreign patents filed in China, are statistically significant in both directions, suggesting that, as predicted inflows of FDI and foreign knowledge transfer interplay with each other with a one year lag.

Our empirical evidence indicates that not only do inflows of FDI positively affect foreign knowledge transfer to the host country, but also the more foreign technologies are transferred to the host country, the more FDI projects will be brought into the local market. Moreover, such correlation between the inflows of FDI and foreign knowledge transfer is consistent with the previous theoretical framework. The findings provide full support for hypothesis 1 regarding the direction of effects.

The policy implication here suggests that a country should relax the relevant policies to encourage more high-tech FDI inflows. Moreover, given that foreign firms opt to produce in the host country, FDI seems to be the preferred route and is therefore a prominent channel of knowledge transfer. Under this context, the IPR protection is very important to a host country. By improving the laws of IPR protection and strengthening the enforcement of IPR law, the host country will appeal to more advanced technology inflows from MNCs. Accordingly, from the dynamic point of view, FDI projects will also be brought in more and more.

Hence, our result is in accordance with Balasubramanyam et al. (1996) who found that FDI has long been recognized as a major source of technology and know-how to developing countries, and with Dees (1998) who found that the change in patent registration by MNCs has a positive effect on their FDI, indicating that innovation in the home country is a determinant to investing abroad. This is also consistent with Lan (1996), who found from his case study on China that FDI has emerged as the most important channel for Chinese firms to contact outside technology the 1990s, accounting for about 60% of inward projects and about 70% investment.

The relationship between foreign knowledge transfer and domestic innovation development

The results of hypothesis 2 are exceeded expectations. Both long-term dataset tests and short-term dataset tests provide us two different results in examining hypothesis 2, though the results are the same in both tests on examining the direction from domestic innovation to foreign knowledge transfer.

First of all, we will discuss the impact of domestic innovation on foreign knowledge transfer. The results on both tests are consistent with the literature review and all display a positive influence of the numbers of domestic patent applications on the numbers of foreign patent applications in China.

As noted in the literature review, the reason for this effect is that when domestic firms improve their technological competence by increasing the numbers of their patent applications and speeding up their innovation rate, the products and processes have been increasingly enhanced in the host country. It suggests that the technology gap between domestic firms and foreign firms has been narrowed, and the adaptive capacity of the

domestic firms has been improved or increased. As a result, if MNCs attempt to maintain their competitive position and their technological advantage in the local market, they have to bring in more advanced technology to the host country so that they will be able to compete with the promoted domestic firms.

This finding strongly supports the view that the development of domestic technological innovation does positively affect foreign technology progress and more advanced knowledge transfer to the host country.

With respect to examining hypothesis 2, the results from both tests are inconsistent. Although the result of the short-term dataset test significantly confirms the hypothesis, the result in the long-term dataset test does not tend to support it. The reasons of this surprising result are complicated and we will firstly discuss the background of these data.

First and foremost, before 1998 there was a lack of focus among Chinese firms on foreign knowledge transfer in China. One reason for this is that foreign knowledge transfer itself was quite a new issue to most Chinese firms, who had not recognized the importance of foreign knowledge transfer via FDI. As Ball et al. (1993) state: "the term knowledge transfer is only widely known by the Chinese in the recent years."

Moreover, most Chinese enterprises did not care about their own R&D, because the separation of production from technology development was generally the case for most Chinese firms. Under the planned economy, most enterprises obtained technology from associated research institutes instead of developing it themselves (Lan, 1996).

Secondly, with such attitude toward R&D activity, domestic firms inevitably paid less attention to IPRs and just imitated the technology from MNCs. As De Melto et al.

(1980) argue that MNC presence in the host country probably facilitates imitation of MNC's technology. Thus, it is likely that domestic firms may adopt technologies introduced by MNCs through imitation or reverse engineering – the practice of taking apart and analyzing products – to learn about the technologies embodied in them.

Meanwhile, although China already had set up the Patent Law before 1998, the enforcement and protection of Patent Law were not implemented strongly. From 1998, the Chinese government strengthened a variety of IPR protection and enforcement and began preparation for the second revision of the Patent Law.

Furthermore, as of the end of 1999, Regulations on Patent Protection were promulgated and implemented consecutively in many major Chinese cities. The promulgation and implementation of these regulations at the local level was to help intensify law enforcement and protect more effectively the legislative rights and interests of patent holders. In accordance with Chinese Patent Law and related international agreements on intellectual property, such as the Sino-US Agreement on IPR Protection, China seriously cracked down on activities related to passing off patents.

Therefore, under this circumstance, awareness for the protection of IPRs in Chinese society had risen significantly since 1998. As a result, most Chinese firms had begun to invest in their own R&D activities, because under the strong IPR regime, firms would have less opportunity to imitate. Moreover, according to Saggi's two-period duopoly model (1999), for many domestic firms, the licensed technology from MNCs in the early 1990s had practically expired. Thus, in order to safeguard their market shares and compete with MNCs in the local market, domestic firms had to develop their own

innovation based on the previous licensed technology. By doing so, indigenous firms would also push MNCs to bring in relatively new and sophisticated technologies to China.

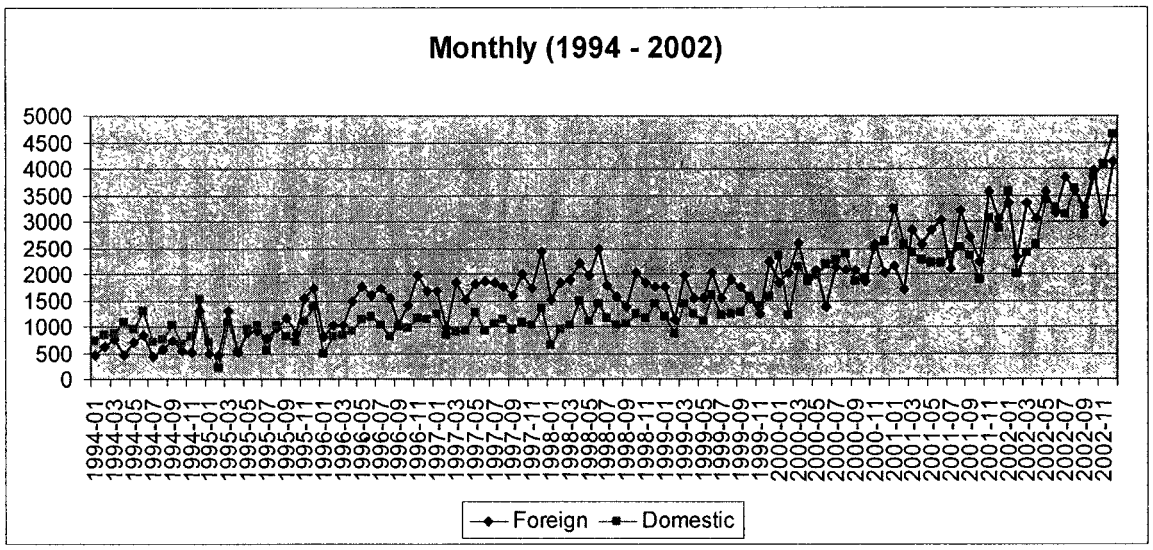
Another reason about domestic innovation development is that after 1999, more and more Chinese firms sought to export their products to the world. In order to compete with MNCs in global markets, Chinese firms have to promote their innovation and produce more high-tech products to obtain their international competitiveness. This view is supported by Balasubramanyam et al., (1996), who suggest that exports are likely to result in a higher rate of technological innovation and dynamic learning from abroad.

Based on the above background analysis, we can identify that the major reason for those different results is the difference of the range in time used in the two tests. In the long-term dataset test, the data spanned from 1994 to 2002 on a quarterly basis, whereas the data used in the short-term dataset test only began in 1999 and ended in 2002 on a monthly basis. As analyzed above, since 1998 most Chinese firms had just become aware of the importance of IPRs and started to invest in their own R&D. Consequently, the domestic patent applications began to increase dramatically in January 2000, as shown in Figure 4.

Therefore, we could find that the data used in the long-term dataset test have 66.67% observation numbers (24 out of 36) before 2000, but only 33.33% (12 out of 36) after 2000; in contrast, the data used in the short-term dataset test starting from January 1999 and have only 25% numbers (12 out of 48) before 2000, but 75% (36 out of 48) after 2000. The disparity of the data used in these two tests is mainly responsible for the contradictory results. Since the data in the long-term dataset test has 3 times the observation numbers before 2000 than those after 2000, the unanticipated result is

understandable. Also, another possible explanation for our different results could be a bias caused by limited data.

Figure 4 – Foreign & domestic patent applications (monthly data)



Finally, the result from the short-term dataset test is consistent with the idea that the flow of advanced technology brought along by FDI can increase the growth rate of the host technology development, a finding supported by other researchers as well. For example, Dees (1998) believes that through trade and FDI, China can develop its own productivity level via technological transfer. Moreover, post-war experiences in European countries and Japan also confirm our empirical findings. Furthermore, based on the above analysis and this confirmative result of hypothesis 2, we can see the importance of IPR protection in a country, as well as its significant impact on developing domestic technology and attracting foreign technology.

The policy implications involved in examining the relationship between foreign knowledge transfer and domestic innovation development are the following three points. First, to any developing countries who wish to improve their own technology, they need

to set up a series of IPR laws, enforce IPR laws strongly, and protect the owners of the IPRs. Second, based on the IPR laws, developing countries should make some favorable policies to encourage MNCs to transfer their advanced technology to the host country. It is crucial for the government to adopt a combined strategy that obtains knowledge transfer from FDI, while at the same time moves towards developing domestic industries' technological capabilities since technological progress is the driving force sustaining economic growth in the long run. Third, in order to absorb the foreign technology and close the technology gap with developed countries, the developing countries needs to take the lead in fostering innovation in industrial sectors by allocating more resources to support domestic R&D activities. As Hill (1995) suggests, increasing domestic educational attainment, rising employment of scientific personnel and increasing R&D expenditures will contribute to increased domestic technological capability.

The relationship between FDI and domestic innovation

Although we did not hypothesize the direct relationship between FDI and domestic technological development in the theoretical framework, both tests have examined this relationship and the results are also contradictory.

First of all, in terms of the causality test from domestic technology development to FDI, both empirical findings have the same confirmative results. They suggest that, with the growth of the numbers of domestic patents registered in the host country, the more FDI projects are attracted to the host county. The major reason for this is that while domestic firms apply for more patent rights, they prove to the MNCs their technology competency and exhibit their technological capability ability to shorten the technology

gap between both sides. This phenomenon encourages MNCs to invest more in the host country with even more advanced technologies. Thus, such finding confirms the view of Shan and Song (1997) that FDI may be "pulled" towards centers of domestic innovations as a means for the foreign investor to acquire and develop new resources and capabilities. Moreover, as stated in the framework section, one of determinants for MNCs investing a foreign country is the technological skill of domestic firms.

Furthermore, this finding could be interpreted that the domestic technological competence is a very important variable for attracting high technology FDI. The host economy must be capable of absorbing the new technology manifested in the FDI (Blomstrom et al., 1994). Therefore, the higher the level of human capital stock in the host economy, the more FDI projects will be attracted, and the greater is the impact of FDI.

As for the direction from FDI to domestic innovation development, contrary to the result in the long-term dataset test, the result in the short-term dataset test is statistically significant. Indeed, such contradictory results in this regard are understandable.

The first reason is the data limitation as stated in the last part. Therefore, this part shares the same explanation of the unexpected result as mentioned in the last part.

Second, according to Lan (1996), to a technology receiver, two qualities are crucial for knowledge transfer – the willingness to obtain inward technology and the capability to absorb contacted technology. Thus, it is clear that before the technology receivers start to develop their own technology, they have to be willing to obtain the

technology from outsiders and have certain absorbing technology ability, and then they may be able to move to create their own technology eventually.

Before 1998 the situation in China was that some local firms did not aim to get any knowledge transfer from foreign investors by setting up an international cooperation project, but aimed to get favorable policies offered by the Chinese government. Since after employing the opening-up policy, a Chinese firm possessing the status of an FDI enterprise could get a lot of benefits, such as tax reduction, a privilege to do the business of imports and exports, or even a better opportunity to get loans from banks.

Therefore, it is quite reasonable that before 1998, FDI did not spur domestic technology development through foreign knowledge transfer. This reason generates an alternative explanation for the contradictory result in this study. A similar result appeared in Lan's study. He discussed the finding of his study that "Chinese partners are not so serious in getting capital" and other benefits from FDI, but only in obtaining an FDI enterprise identity.

Finally, after the signing of the Sino-US bilateral agreement on China's entry into the WTO in November 1999, the numbers of domestic patents filed have increased since December 1999 and reached 1572 applications in December, which was 14.66% growth of the last month; in January 2000, the numbers of domestic patent applications even jumped to 2344 cases, which was almost 50% more than December of 1999. Since then, the numbers of domestic patent applications have been increasing constantly, which is shown in Figure 4. Thus, the confirmative result from the short-term dataset test indicates that an increase in FDI is associated with a faster growth of the numbers of domestic patent applications.

The empirical findings of the causal test between FDI and domestic technology development engender the following policy implications.

First, in addition to setting up IPR laws to protect owners' rights, the Chinese government should also revise relevant FDI policy to impede fake FDIs. Second, the most important and significant finding in the present study is the positive effect of domestic technology development on the inflows of FDI, suggesting that the technology competence of the domestic firms is a major determinant in attracting high technology level FDI. Thus, the government should encourage domestic firms to improve their R&D capacity. It is only that when the technological skills of domestic firms reach a certain level, FDI could maximize its benefits to the host country for upgrading their technology.

The impacts of WTO accession on the FDI inflows, on foreign knowledge transfer, and on domestic innovation

In terms of hypothesis 3, as anticipated, all our empirical results significantly support this hypothesis in both dataset tests. It indicates that WTO accession does have a positive effect on the inflows of FDI into the host country. As many researchers predict, China's accession to the WTO promises further trade liberalization, including the reduction of trade barriers to FDI, enhancement of IPR protection, and improvement of the investment environment, etc., which further encourage more inward FDI from the world. Moreover, our results are consistent with a number of recent surveys, which suggest a positive impact on FDI in China as a result of its WTO accession. Therefore, we can conclude that WTO accession has played a key role in attracting FDI to China recently.

Regarding the effect of WTO accession on foreign knowledge transfer, although we did not formulate a specific hypothesis in the framework, our empirical results, based on both dataset tests, display that China's accession to the WTO also positively influences foreign knowledge transfer to the country.

This finding is easy to understand. Since FDI is connected with technology, and based on the result of hypothesis 3, WTO accession has a significant effect on the inflows of FDI into China. Given this situation, WTO accession would certainly assist foreign knowledge transfer to China via FDI.

An UNCTAD report (2002) states that after China's accession to the WTO, technology-intensive industries have been attracting more and more FDI. Also, given the large number of R&D institutions and the large supply of capable, but low-cost, scientists and researchers in China, FDI in R&D activities have been increasing. Thus, all of these evidences confirm that by investing more technology-intensive projects and conducting R&D activities directly in China, MNCs have transferred more and more high technology to China. This view is consistent with our empirical finding.

Finally, in reference to the test for hypothesis 4, the results are similar to those examining the impact of foreign knowledge transfer on domestic innovation development, as well as the impact of the inflows of FDI on domestic innovation development. More specially, in the long-term dataset test, the result rejects the hypothesis, whereas the result of the short-term dataset test supports the hypothesis.

To the surprising result, we think that the explanation in the other two cases is applicable to this finding. Moreover, China signed the Sino-US bilateral agreement with the United States on China's entry into the WTO on November 15, 1999, and formally

joined the WTO on December 11, 2001. Thus, the lack of data causes the major bias of the result as our empirical data end up in 2002. Therefore, it is will warrant some further study on this issue.

As for the confirmative result, it confirms the positive impact of WTO accession on domestic innovation progress. Moreover, this finding supports the view that the inflow of FDI in China is expected to increase domestic firms' innovation. Foreign affiliates in China have played an important role in supporting the country's rapid pace of industrial development, economic growth and skills enhancement (Katz, 1969; Smarzynska, 2002b; Blomström and Kokko, 1996). As before, we find positive correlations between the inflows of FDI and domestic innovation and between foreign knowledge transfer and domestic innovation.

Furthermore, under an open market, such as in the WTO, we might expect competitive forces to stimulate innovation and IP protection to induce even more of it. Thus, after China joined the WTO, the more FDI flows to China and the more high foreign knowledge transfer to China, the more and faster domestic firms promote their innovation.

Finally, this result indirectly confirms the previous findings, which are the positive correlations among the inflows of FDI, foreign knowledge transfer, and domestic innovation development, and the positive impact of WTO accession on the inflows of FDI and foreign knowledge transfer to the host country. Moreover, our empirical result will be conducive to other developing countries that attempt to pursue WTO accession.

A confirmation test on the relationship between foreign knowledge transfer and domestic innovation development

After analyzing all the results in this study, we find that all insignificant results are related to variable "domestic innovation development" and occur in the long-term dataset test. All results in the short-term dataset test are significant. As emphasized before, the most probable explanation for our different results based on different datasets could be a bias caused by limited data. Moreover, account also should be taken of the short-term frame on which this the study is focused. Knowledge transfer may require more time to affect the level of domestic innovation.

To further test the robustness of the findings from the short-term dataset test, an additional test is performed. Basically, this test uses the same VECM model to repeat the causal test on examining the relationship between foreign knowledge transfer and domestic innovation development. Yet the new dataset used only includes the numbers of foreign and domestic patent applications in China from 1994 to 2002 on a monthly basis. Since prior to 1999 China did not publish FDI data monthly, and Chinese membership of the WTO was effective after 2001, it is impossible for us to examine the relationship between FDI and domestic innovation, and the impact of WTO accession on domestic innovation with a large dataset. Moreover, this dataset is plotted in Figure 4.

After carrying out the Granger Causality test, we find that the results are statistically significant in both directions, and hypothesis 2 is significantly supported by this dataset. They confirm that the findings of the short-term dataset test are quite robust. The results are displayed in Table 7.

Table 7 - Granger Causality Tests for the Confirmation Test

			Wald's *F* Statistic (p values)
Domestic	→	**Foreign**	4.71 (0.0300)
Foreign	→	**Domestic**	3.12 (0.0775)

Our empirical finding suggests that, as predicted, foreign knowledge transfer and domestic innovation development do interplay with each other with a one-year lag. Thus, such a positive correlation between foreign knowledge transfer and domestic innovation development is a very important finding for this study.

Finally, the results here imply that a large dataset is necessary to conduct a study like the present one. A further study is worth carrying out in this direction, but should be based on a large dataset.

Theoretical Implications

In terms of theoretical implications, our research model not only confirms the positive effect of FDI on foreign knowledge transfer by using patent data, but it also is the first time in an attempt to investigate the feedback effect of foreign knowledge transfer on the inflows of FDI to the host country. The results significantly support such a positive correlation between those two variables.

Also for the first time, we empirically examine the impacts of WTO accession on a country's FDI inflows, foreign knowledge transfer to the country, and domestic technology progress.

Moreover, by incorporating the effect of IPR protection into our research model, we highlight the important role of a country's IPR protection in attracting FDI inflows, in

transferring foreign technology, and in affecting domestic innovation, as well as examine the relationships among these variables in association with the effects of IPR laws in the host country.

Furthermore, we also set up the relationship between foreign knowledge transfer and domestic innovation development. Our results successfully reveal such positive correlation existing, thereby contributing to existing literature in this field.

Finally, one of contributions in the research model is that we intend to explore the effects of domestic innovation on FDI inflows and foreign knowledge transfer. Our findings significantly support these two casual relationships.

Policy Implications

The results of this study reveal important policy implications for governments in other developing countries. First, FDI seems a prominent channel of foreign knowledge transfer; therefore, a country should relax the relevant policies to encourage more high-tech FDI inflows.

Second, transferring more advanced technology from MNCs to a developing country not only spurs more FDI inflows to the country, but also stimulates domestic firms to develop their technological innovation.

Third, a country may increase the inflows of FDI and the advanced technology from the MNCs by encouraging indigenous innovation. Thus, the priorities of national policy should be focused on improving their own R&D activities and developing domestic innovatory capability. However, if a country has very low technological capability per se so as to be unable to absorb the advanced knowledge from the foreign firms, or lacks institutional factors, our findings cannot be applied to such country.

Furthermore, our findings also imply that the IPR protection is very important to a host country. First, to any developing countries who wish to improve their own technology, they need to set up a series of IPR laws, enforce IPR laws strongly, and protect the owners of the IPRs. Second, based on the IPR laws, developing countries should make some favorable policies to encourage MNCs to transfer their advanced technology to the host country. It is crucial for the government to adopt a combined strategy which obtains knowledge transfer from FDI, while at the same time moves towards developing domestic industries' technological capabilities since technological progress is the driving force sustaining economic growth in the long run. Third, in order to absorb the foreign technology and close the technology gap with developed countries, the developing countries needs to take the lead in fostering innovation in industrial sectors by allocating more resources to support domestic R&D activities. As Hill (1995) suggests, increasing domestic educational attainment, rising employment of scientific personnel and increasing R&D expenditures will contribute to increased domestic technological capability.

Finally, joining the WTO could thus liberalize the trade policy of a country so as to attract more FDI inflows and transfer more advanced technology to the country.

CONCLUSION

Summary

Market-oriented reforms and the "opening up" policy pursued by China have produced high economic growth and a dramatic economic transformation. The huge amounts of FDI that China has accumulated since the 1990s have helped domestic firms close the technology gap more rapidly with developed countries so as to improve Chinese productivity. Moreover, on 11 December 2001, China successfully joined the WTO and became its 143rd member country. All these facts make China a particularly interesting case to the world and have drawn much attention of researchers.

Therefore, this paper mainly aims to assess the correlation between the inflows of FDI in China and foreign knowledge transfer, as well as the effect of knowledge transfer on domestic innovation development. After presenting a variety of previous work in this field, an empirical study has been implemented, extending the previous ones, with a different dataset (more recent) and with different methodologies.

Through the theoretical framework and by using a time series model, we have investigated the role of FDI in knowledge transfers and its effect on indigenous technical progress. By conducting causality tests, we have examined the correlations between FDI and domestic innovation development, and between foreign knowledge transfer and domestic innovation development. In addition, we have also added an indicator of openness measured by China's accession of the WTO to probe the impacts of WTO accession on FDI inflows, as well as foreign knowledge transfer and domestic technology progress.

Our empirical results not only strongly validate the view of FDI as a vehicle of the foreign advanced technology inflowing to the host country, but also reveal that foreign knowledge transfer positively affects the inflows of FDI to the host country. Moreover, the study finds that foreign knowledge transfer positively spurs domestic technological development. Interestingly, going beyond the existing studies, we have successfully proven that a developing country may increase the inflows of FDI and the advanced technology from MNCs by promoting domestic innovation capacity. Finally, our empirical findings also shed light on the positive impacts of WTO accession on FDI inflows and foreign knowledge transfer in the Chinese context.

Contribution of the Study

While the earlier literature examined the impact of FDI on foreign knowledge transfer, little is known about the feedback effect of foreign knowledge transfer on the inflows of FDI to the host country. This paper addresses this question empirically, using a unique country-level dataset from China. In particular, this study is the first empirical work in an attempt to investigate the correlation between FDI and foreign knowledge transfer by using patent data, and the results significantly support such a positive correlation.

Also for the first time, we empirically examine the impacts of WTO accession on a country's FDI inflows, foreign knowledge transfer to the country, and domestic technology progress.

Moreover, by incorporating the effect of IPR protection into our research model, we highlight the important role of a country's IPR protection in attracting FDI inflows, in transferring foreign technology, and in affecting domestic innovation, as well as examine

the relationships among these variables in association with the effects of IPR laws in the host country.

Furthermore, by using the time series and Vector Error Correlation Model, we conduct a longitudinal study to investigate the general model of integration among inward FDI, knowledge transfer, and local technology development. To the best of knowledge, it is the only longitudinal study on the present topic.

Finally, we also successfully discover the positive correlation between foreign knowledge transfer and domestic innovation development, thereby contributing to existing literature in this field.

Limitation of the Study

Like all studies, however, this study is not exempt from limitations.

First, due to the limitations of the research data, particularly for the data of FDI in the beginning of 1990s, we cannot get a very clear picture of whether improving domestic innovation would help the host country draw more FDI inflows. Future research needs to further explore this direction with a sufficiently large dataset.

Likewise, since China's joining the WTO only happened recently, the range of time for examining the effects of WTO accession is too short. Thus, this will also warrant some attention for future study in other countries.

Second, our proxy for domestic technology innovation may be subject to measurement error. We may ignore some variables, such as the data of R&D in China or the data of technology exports, which also reflects the level and extent of the development of domestic innovation. Therefore, this factor is worth including in future studies.

Moreover, although the numbers of patents reflects the degree of technology ability in a country, and also because FDI is more significant in the more patent-sensitive sectors than in patent-insensitive sectors (Maskus and Penubarti, 1995), only using patent data to measure foreign knowledge transfer may be not sufficient or comprehensive. As Blomstrom and Kokko (1996) suggest, the measure of technology, for which the numbers of new patents provides a proxy, does not cover other parts of technology and technical production, such as R&D expenditures, payments of licenses and loyalties, stocks of capital equipment, and so forth. Likewise, Shan and Song (1997) suggest that the R&D ratio may be the best measure of technological capabilities of a firm. Thus, this issue is worthy of research in future study.

Furthermore, the patent data we used in this study are only related to application activities. All patent applications are not necessarily granted later. Granted patents are more affected by the speed of operation of the administrative system and involve more technological examination for novelty and innovation than filed patents, so certainly take more time to obtain and broadly reflect the real value of technology.

Third, for the FDI data we include in our study only inward FDI from the whole world to China, but do not distinguish the source countries in terms of the region. Similarly, for the patent data, we also examine them as a whole, but do not separate the data based on industries or sectors. Therefore, studying the relationship between the source country of the inward FDI and transferred technology based on industry would be an interesting topic and could be further investigated in the future.

Finally, as no other similar study has been undertaken, to the best of our knowledge, it is difficult to carry out a thorough comparison with previous research,

either in the measurement of the three factors' effects, or in the analysis of technology flow at each component's level. In this context, what lessons or experiences can be drawn by China from other countries, especially those that have 'upgraded' their technology through FDI such as Japan, Korea or Singapore? It is apparent that only a more comparative international work can provide the answer to this question.

Future Research

The results of this paper, as well as the limitations generated, suggest some directions for further research.

(1) The present study only investigates the correlations of FDI, foreign knowledge transfer, and domestic innovation in China alone. The same study is also worthy of being conducted in other developing countries;

(2) Due to the data limitation in the present study, examining the impacts of WTO accession on the FDI inflows and knowledge transfer and domestic innovation merit more investigation. Likewise, the relationship of FDI and domestic innovation progress needs to be tested further over a longer time period;

(3) Future research should introduce the source country as a variable to investigate regionalization in terms of the relationship between the volume of FDI and knowledge transfer;

(4) Our study is based on country-level data. It would be good to use industry-level data or firm-level data in any future study;

(5) Regarding the development of domestic innovation, future research could involve the data of technology exports to measure domestic technological capacity.

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