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Technological Spillovers from Foreign Direct Investment —A Survey

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Foreword

The ERD Working Paper Series is a forum for ongoing and recently completed research and policy studies undertaken in the Asian Development Bank or on its behalf. The Series is a quick-disseminating, informal publication meant to stimulate discussion and elicit feedback. Papers published under this Series could subsequently be revised for publication as articles in professional journals or chapters in books.

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Abstract

The spillover effect has been identified as an important channel through which domestic firms benefit from foreign direct investment (FDI). It is also considered an important conduit through which FDI promotes growth in a host country. Realization of this and other benefits arising from FDI has prompted governments to encourage FDI inflow. The increased FDI flows have further stimulated intensive debate and research on the role of FDI on host economies. This paper surveys the substantial literature exploring FDI and spillover effects. Its purpose is to summarize the main findings from previous research, and identify missing aspects in existing studies and essential elements that should be included in future studies. The paper also reviews research on FDI in the People's Republic of China (PRC) alongside the general literature on FDI. Over the last two decades, the PRC has emerged as one of the largest hosts of FDI in the world. Studies on the PRC are particularly useful in illuminating the likely direction of FDI research in developing countries, especially the transition economies.

I. INTRODUCTION

Foreign direct investment (FDI)[1] can potentially benefit domestic firms. The benefits arise from foreign firms demonstrating new technologies, providing technological assistance to their local suppliers and customers, and training workers who may subsequently move to local firms. Local firms can also learn by watching. Moreover, the very presence of foreign-owned firms in an economy increases competition in the domestic market. The competitive pressure may spur local firms to operate more efficiently and introduce new technologies earlier than would otherwise have been the case. Because foreign firms are not able to extract the full value of these gains, this effect is commonly referred to as the spillover effect (Kokko 1994).

The spillover effect has been identified as an important benefit accruing to domestic firms. It is also considered an important mechanism through which FDI promotes growth in a host country. Realization of this and other benefits from FDI has prompted governments to allow and encourage FDI inflow. There have been increasing flows of direct investment across national borders over the past few decades. These have stimulated intensive debate and research on the role of FDI on host economies. A large number of studies have explored FDI and spillover effects.

People's Republic of China (PRC) is a particularly good case study to examine alongside the general literature on FDI. There is a rich corpus of studies on the impact of FDI on the PRC economy. As a former centrally planned economy, the PRC had long been closed to foreign trade and investment. Economic isolation resulted in stagnant economic development. The PRC overturned its policy of economic isolation in 1978 and implemented far reaching economic reforms. Attracting FDI constitutes an important component of the PRC's Open Door policy. A series of measures have been adopted to attract FDI, spurred on by the belief that this inflow will introduce modern technology and stimulate export-led growth. This has resulted in an accelerated increase of FDI inflow. Over the last two decades, the PRC has emerged as one of the largest hosts of FDI in the world. In 2000, it received US$38.4 billion in FDI inflow—making it by far the largest host among developing countries, and the fourth largest in the world after the United States, United Kingdom, and France.

This paper surveys the literature on FDI and spillover effects. It also reviews research on FDI in the PRC. The purpose is to present the main findings from previous research, and from this, identify missing aspects in existing studies and essential elements that should be included in future studies. Studies on the PRC are particularly useful in illuminating the likely direction of FDI research in developing countries, especially the transition economies.

[1] The International Monetary Fund (IMF) broadly defines FDI as the establishment of, or acquisition of, substantial ownership in an enterprise in a foreign country; and in a narrower sense, as enterprises in which nonresidents hold 25 percent or more of the voting share capital.

Given the vast amount of research in this area, this survey is by no means exhaustive. The survey begins with an examination of theoretical studies on spillover effects. Section III reviews the empirical evidence on spillover effects, followed by a survey of the evidence on FDI in the PRC in Section IV. Section V presents conclusions and policy implications.

II. THEORETICAL STUDIES ON THE SPILLOVER EFFECT

There is now a significant body of economic theory on FDI. Most theoretical models on FDI and spillovers lie within the framework of industrial organization theory. These models only started to emerge from the late 1970s.

A. Dependency Theory and Impact of Foreign Investment in Host Countries

Early theories on the impact of foreign capital and multinational corporations (MNCs) on host countries can be found in the writings of the "dependency school." The influential work of this school of thought includes the ontology of dependency; Karl Marx on development and underdevelopment; Paul Baran's analysis of economic backwardness and economic growth; Andre Gunder Frank's analysis of the development of underdevelopment; and Samir Amin on unequal development (see Ghosh 2001 and Brewer 1990 for reviews).

The dependency school theory views foreign investment from the developed countries at the core of the world economic system as harmful to the long-term economic growth of developing nations out in the periphery. It considers that the penetration of peripheral economies by large companies allowed them to control resources that might otherwise have been used for national development. It asserts that First World nations become wealthy by extracting labor and material resources from the Third World. This kind of capitalism perpetuates a global division of labor that causes distortion, hinders growth, and increases income inequality in developing economies. Dependency theorists argue that developing countries are inadequately compensated for their natural resources and are thereby sentenced to conditions of continuing poverty. Countries on the periphery cannot become fully modernized as long as they remain in the capitalist world system. To get out of this economically debilitating relationship, Third World nations must develop independently of foreign capital and goods.

Although the influence of the dependency theory peaked in the 1970s, debate on its validity continued beyond this decade. Bornschier and Chase-Dunn (1985), for example, consider that flows of foreign investment has short-run positive effects on economic growth, but accumulated stock of foreign capital has a long-term retardant effect on economic growth and is associated with greater income inequality. Firebaugh (1998), however, rejected this claim. He points out studies that found foreign investment harmful to poor nations have focused on the negative relationship between the investment capital stock ratio and the growth of per capita GDP. However, since capital stock is the denominator for the investment rate, the greater the stock, the lower the investment rate

for a given level of new investment. The negative coefficient for the capital stock variable found in dependency studies therefore does not indicate a harmful investment effect. Firebaugh (1998) find that LDCs with greater rates of foreign investment tend to exhibit faster rates of both long-run and short-run economic growth. Using data from 41 lower and upper middle income African, Central American, Latin American, East Asian, and Caribbean countries between the 1960s and 1970s, Hein (1992) does not find support for the dependency theory.

Most recent papers advocating dependency theory perspectives use qualitative methods or statistical methods with a limited number of explanatory variables. Omitting important variables leads to the potential for bias. Many do not distinguish types of foreign investment, although their criticisms imply they mean direct investment and multinational companies. The dependency theory was adopted by various countries in the 1970s, most noticeably Latin American countries. A number of them adopted an import substitution strategy and demonstrated a hostile attitude toward foreign investment. These inwardly oriented policies had a harmful effect on Latin American economies (Hein 1992). Their experiences contrast with those of some East and Southeast Asian economies that were designed to actively attract foreign investment into their domestic economies. These policies were accompanied by a period of rapid economic growth in East Asia during the 1970s and 1980s (Hein 1992). This reality largely curbed the popularity of the dependency theory, shifting attention to the study of FDI's contribution.

B. Industrialization Theory on FDI and Spillover Effects

Hymer's (1976) pioneering study on multinational companies (MNCs) drew attention to neglected aspects of MNCs' role as global industrial organizations. Hymer's view was a major departure from the orthodox theoretical economic literature. The standard neoclassical trade theory of Heckscher and Ohlin, for example, carried restrictive assumptions about the immobility of factors of production and identical production functions across national boundaries. It postulated that no international difference existed at the scientific and technological levels, not to mention technology transfer and spillovers. In the neoclassical financial theory of portfolio flows, multinational enterprises had been viewed as simply an arbitrageur of capital in response to changes in interest rate differentials. Capital is seen to flow from countries where returns are low to those where it is higher to earn arbitrage rents. This theory did not distinguish between the roles played in a country's development by portfolio and FDI capital inflows (Dunning and Rayman 1985, Teece 1985).

Hymer's major contribution was to shift attention away from neoclassical financial theory. In his view, FDI is more than a process by which assets are exchanged internationally. It also involves international production. By putting forward the idea that FDI represents not simply a transfer of capital, but the transfer of a "package" in which capital, management, and new technology are all combined, Hymer characterized FDI as an international extension of industrial organization theory.

Caves (1971, 1974) and Kindleberger (1984) further extended the industrial organization theory of FDI. Their theories emphasize the behavior of firms that deviate from perfect competition as the determinants of FDI. According to their perspective, multinational companies (MNCs) face disadvantages imposed by both geographic and cultural distance in comparison to domestic firms. In order for a firm to undertake FDI in a foreign country, it must possess some special ownership advantage over potential domestic competitors. Technological superiority or possession of some intangible, rent-yielding assets such as management skills and brands are believed to provide such advantages. Compared to portfolio investment, which only involves the cross-border flow of capital, FDI entails a cross-border transfer of a variety of resources, including process and product technology, managerial skills, marketing and distribution know how, and human capital. Viewed this way, FDI involves a transfer of intangible assets such as technological skills across nations. Neglect of the technological aspect can lead to a serious underestimation of the role of foreign-owned capital in the recipient country. However, early theorists neither calculated the benefits and costs of technology transfers, nor explicitly analyzed their impact on a host country through spillover effects.

Koizumi and Kopecky (1977) were the first to explicitly model FDI and technology transfer. They used a partial equilibrium framework to analyze technology transfer from a parent firm to its subsidiary. Technology transfer was assumed to be an increasing function of the country's capital stock owned by foreign residents. The transmission of foreign technology was viewed as "automatic" and technology was treated as a public good. The results showed that two countries with identical production functions could follow different time paths and reach a different level of steady state equilibrium. The analysis implied that an increase in a country's savings ratio would reduce foreign capital and, through its effect on technical efficiency, reduce its steady state capital intensity.

Findlay (1978) constructed a model to examine the relationship between FDI and technological change in a backward region. The rate of technological progress in the advanced region was postulated to increase at a constant rate. The rate of technological diffusion to the backward country was assumed to depend on two factors. First, following the hypothesis of Gerschenkron (1962), which states that the greater the relative disparity in development levels between the backward country and the industrialized part of the world, the faster the catch up rate, Findlay put forward the hypothesis that the rate of technological progress in a "backward" region is an increasing function of the technology gap between it and the "advanced" region. Therefore, for a given amount of foreign presence, the larger the technological gap between the foreign and domestic firms, the larger the spillovers. Second, Findlay followed Arrow (1971), to consider technological diffusion as analogous to the spread of a contagious disease. Therefore, technological innovations are most efficiently diffused when there is personal contact between those with the knowledge of the innovation and those who adopt it.

These considerations led to the hypothesis that the ratio of technical change in the backward region increases in proportion to the extent to which it opens up to FDI. The ratio of the capital stock of foreign-owned firms in the backward region to the capital stock of domestically owned

firms was used to measure the extent of foreign penetration. Findlay then considered the determinations of the relative growth rates of foreign and domestic capital. He showed the effects of changes in various parameters in the steady state, such as the backward region's saving propensity and the tax rate of foreign profit on the "backward" region's degree of "dependency" on foreign capital. However, the model did not provide an explanation for the forces that determine the transfer of technology from the "advanced" to the "backward" region.

Das (1987) utilized a price-leadership model from oligopoly theory to analyze the transfer of technology from the parent firm to its subsidiary abroad. This analysis recognized that domestic firms learn from MNCs and become more efficient. This increase in efficiency among domestic firms is assumed to be exogenous, and therefore costless to them. It is also assumed that the rate of increase in efficiency of the native firm is positively related to the level of activities of the MNC's subsidiary. The larger the scale of operation, the greater the opportunity for the native firm to learn from it. He then models the problem of choice the MNC faces due to the cost imposed by the "learning from watching" benefits flowing to the native firm. Along the optimal path, he concludes that the MNC benefits from the technology transfer from its parent company in spite of the leakage of knowledge in the host country, and the host country benefits unambiguously. Thus, in spite of the free insights competing domestic firms gain, it is still worthwhile for the MNC to import better technology. This model recognizes that the MNC affiliates are aware of the technology leakage, and determines technology transfer behavior based on this recognition. Yet, the behavior of the local firm is still not explicitly taken into account in any calculations.

Wang and Blomstrom (1992) developed a model in which international technology transfer through MNCs develops endogenously by means of the interaction between a foreign subsidiary and a host country firm. They also follow Findlay's assumption of a positive relationship between the technology gap and spillovers. This model is significant in that it is one of the few that recognizes the cost of transferring technology within MNCs. Since both the foreign subsidiary and the indigenous firm can make their own investment decisions to maximize profit, there is strategic interaction between them, where both firms solve their individual dynamic optimization problems subject to the other's actions in a game theory context. These considerations represent a major step forward compared with other models. The model also has important policy implications. These benefits make it worthy of more detailed consideration. Appendix A provides details on the structure of Wang's model.

By solving a dynamic optimization problem, Wang and Blomstrom found that:

(i) Technology transfer from a parent company to a subsidiary is positively related to the level and cost efficiency of a domestic firm's learning investment.

(ii) The lower the subsidiary's discount rate, the more rapid the technology transfer. The higher the operation risks—for example, political instability or low potential economic growth—the more reluctant foreign firms will be to transfer technology.

(iii) Some technology transfer proportional to the size of the technology gap always takes place irrespective of the subsidiary's active learning effort. The less costly the technology spillovers from the parent to subsidiary firms, the faster the technology transfer.

C. Assessment of Industrialization Theories of FDI and the Spillover Effect

In the models of Koizumi and Kopecky (1977), Findlay (1978), and Das (1987), the superior technology possessed by foreign firms is considered to be a "public good" in nature, and to be transferred automatically. However, the growing importance of international patent agreements and the licensing of technology suggests that technological knowledge is frequently a private rather than a public good, and that technology can rarely be automatically transferred. The contribution of Wang and Blomstrom's model lies in its highlighting of the essential role played by competing host country firms in increasing the rate at which MNCs transfer technology. Both the MNC affiliate and the local firm are able to influence the extent of the technology transfer through their investment decisions.

However, some common features exist for all these models. These include the subject and object of technology transfer. There are two distinct processes in international technology transfer. One is technology transfer from the parent firm of a MNC to its subsidiary abroad. The second is technology transfer in the form of an externality from the subsidiary to native firms in the host country. Though recognized by some (Das 1987, Wang and Blomstrom 1992), all the models focus on technology transfer from a MNC to its own subsidiaries. Technology transfer from a subsidiary to domestic firms is taken for granted. In these models, a host country's production efficiency is formulated as an increasing function of the presence of foreign capital.

Furthermore, the assumption of Gerschenkron (1962), which suggests the wider the technology gap between the developed and developing country, the larger the potential for technological imitation, is incorporated into all the above models. To date, there remains ample scope for experiment and debate about the framework within which to analyze the relationship between the technological gap and the spillover effect. More and more evidence, however, shows that the assumption that technology transfers increase with a larger technology gap is not valid. For example, the dynamic game-theory model developed by Cheng (1984) shows a change in technological leadership is more likely to occur where the initial technological disparity between countries is small.

D. FDI and the Spillover Effect in a Growth Theoretic Framework

While the models described above explored FDI and technology transfer directly, another strand of models investigate the effect of FDI on growth using a growth theory framework. These models indirectly touch upon the role of FDI in transferring technology. However, compared with the intensive theoretical research conducted on the relationship between trade and growth, studies on FDI and growth are relatively scarce.

In traditional neoclassical growth models of the Solow (1956) type, with diminishing returns to physical capital, and technological change being exogenous, FDI cannot affect the long-run growth rate. In the absence of international factor mobility, these theories predict that countries with the same preferences and technology will converge to identical levels of income and an asymptotic

growth rate. Factor mobility reinforces this prediction. Capital will flow from capital-abundant countries to where it is scarce. In these circumstances, long-run equilibrium is characterized by the identical equalization of capital labor ratios and factor prices.

The new growth theories that have emerged since the mid-1980s have shifted attention away from the foci of earlier neoclassical modelling. Whereas the neoclassical theory treated technological progress as an exogenous process and focused on capital accumulation as the main source of growth, the new growth theory has focused on issues relating to the creation of technological knowledge and its transmission. It views innovation and imitation efforts that respond to economic incentives as major engines of growth. Therefore, it emphasizes the role of R&D, human capital accumulation, and externalities (Grossman and Helpman 1991, Lucas 1988, Romer 1990).

For a similar reason, technology transfer through trade has become a popular area of research (Krugman 1979). However, the fact that the interrelationship between FDI and growth has not been the subject of intensive studies is a surprising omission in light of the apparent empirical importance of the relationship. Externalities and their impact on long-run growth have been a common element in endogenous growth models. FDI can lead to increasing returns to scale in domestic production through spillovers. Despite the rarity of research in this area, the advent of endogenous growth theory has opened new research avenues to study the channels through which FDI can promote long-run growth.

While primarily dealing with international diffusion associated with trade in goods, Helpman (1993) briefly discusses the implication of international capital movements in the context of endogenous growth, focusing on how economies of scale interact with free capital movements. He observes that there may be agglomeration effects in capital accumulation in models where the externality comes from the capital stock. Technology transfer along with foreign investment is an explicit element in Helpman's discussion. This is done in a rather crude manner in that MNCs and producers in developing countries are identical. Helpman (1993) himself stresses the need for a more thorough treatment of MNCs with respect to growth.

In one of the few exceptions that deal with FDI and growth, Wang (1990) builds a dynamic two-country model to study the interaction between growth and international capital movement. Perfect capital mobility links the two regions. Human capital plays an important role in determining the effective rate of return for physical capital and hence affects the direction and magnitude of international capital movements. The analysis again takes account of FDI, in this case by incorporating Gerschenkron's (1962) hypothesis on technology transfer in that the rate of technological change in a less developed country is considered to be an increasing function of the amount of foreign capital operating there. With capital already moving internationally, the model predicts that the steady-state income gap is narrowed by an increase in the growth rate of human capital and the technology diffusion rate in the less developed country (LDC). One of the messages emerging from the analysis is that opening to FDI from more advanced countries has important beneficial implications for a developing country. Foreign investment facilitates domestic technological change, and hence increases the rate of income growth.

Walz (1997) incorporates FDI into an endogenous growth framework where MNCs play a critical role with respect to growth and specialization patterns. He extracts the idea of trade-related international knowledge spillovers used in Grossman and Helpman (1991) and applies them to FDI. Production activities of MNCs in the low-wage country improve the efficiency of potential innovations there. The knowledge spillover of MNCs' activities makes innovation in the low-wage country profitable. Allowing for imitation in the less developed country, the indirect transfer of technology through FDI provides the stimulus for active R&D and growth. Therefore, he predicts that policies promoting FDI will lead to faster growth.

These models using the growth theory framework primarily focus on technology transfer from the parent companies to subsidiaries. Technological spillover from a MNC subsidiary to domestic firms is assumed to be proportional to the presence of FDI in the host country. While this sort of epidemic diffusion model offers advantages in allowing one to relate the speed of diffusion to the amount of FDI inflow, the implicit assumption that technology spillover from a subsidiary to domestic firms is automatic is open to question.

III. EMPIRICAL STUDIES OF SPILLOVER

A. Case Studies

Compared to the relatively limited numbers of theoretical studies on the spillover effect, there is a rich body of empirical literature. Many investigations use case studies to examine individual spillover channels. Gershenberg (1987), Lim and Fong (1982), Mansfield and Romeo (1980), and Rhee and Belot (1990) are a few examples of these. These studies present mixed evidence on the role of foreign investment in generating technology transfer to domestic firms. In Mauritius and Bangladesh, the study of Rhee and Belot (1990) suggests that the entry of foreign firms led to the creation of a booming domestic textiles industry. However, in a survey of 15 multinationals, Mansfield and Romeo (1980) found that only a small share of FDI had accelerated the local competitors' access to new technology.

B. Econometric Studies Support the Spillover Hypothesis

Numerous studies employing econometric models started to appear from the early 1970s. Early econometric studies share some common features. They investigate the relationship between FDI and productivity. Spillovers were considered to exist if a positive correlation between productivity and FDI was found. The dependent variable in these models was generally labor productivity. The explanatory variables in these models included FDI, factor input, concentration ratio, and labor quality.

In the earliest analysis using econometric techniques, Caves (1974) tested the spillover benefits of FDI in the manufacturing sectors of Canada and Australia. His hypothesis for Canada

was that if FDI has the virtue of increasing allocation efficiency, the profit rate of domestic firms should be inversely related to the competitive pressure supplied by foreign firms. The results indicated profit in Canadian manufacturing industries did show a weak tendency to vary inversely with the foreign share. The 1966 data for 23 manufacturing industries enabled Caves to test the determinants of value-added per worker in the domestic sectors of Australian industries. Using foreign firms' share of industry employment as a proxy for foreign presence, Caves found that the higher the subsidiary share, the higher the productivity level in competing domestic firms. The results supported the hypothesis that spillovers were present.

Using annual census data for four digit Canadian manufacturing industries in 1972, Globerman (1979) replicated the finding of Caves (1974). Globerman defined the dependent variable as the ratio of total value added per employee in domestically owned manufacturing plants. The explanatory variables sought to take into account factors that may influence labor productivity, including the foreign share of the industry; differences in the capital labour ratio between Canadian and comparable US industries; differences in labor quality measured by wage per worker in the affiliates and, alternatively, the share of male employees with tertiary education; and scale economies measured by average plant size related to the minimum efficiency scale in the US. The FDI variable was measured by the gross book value of depreciable assets at the end of 1971, divided by the total employees in 1972, in US industries. The results also provided support for the proposition that spillover efficiency benefits domestic firms.

Most of the empirical studies about developing countries use data from Mexico, which gathers manufacturing data by ownership type. For example, Blomstrom and Persson (1983) collected data for 215 four digit Mexican industries from the 1970 census to carry out their analysis. They also used labor productivity as a measure of technological efficiency. They related this to capital intensity, labor quality measured by the ratio of white-collar to blue-collar workers, economies of scale measured by the average gross production in the domestic firms to the estimated minimum efficiency scales (MES), FDI measured by the share of employees employed in plants with FDI, average effective work days during 1970, and the degree of competition measured by different concentration indices such as the Herfindal index. The study found strong support for the existence of spillover benefits from FDI.

Blomstrom (1986) tested spillovers based on an efficiency index defined as the ratio of the average value added per employee in an industry and that of the best practice. He used data for 230 four digit Mexican manufacturing industries in 1970 and 1975. The independent variables included the Herfindahl index, market growth variables, defined as the relative growth of employment of each industry in the period 1970 to 1975, the rate of technological progress, defined as the changes in labor productivity in the best-practice plants within each industry, and foreign share, defined as the share of employees in foreign plants. He found the entry of foreign firms had a significant effect on each industry's average productivity. However, it had no impact on technical progress in the least productive firms in each sector. He interpreted these findings as indicating that foreign entries into Mexico did not speed up technology transfer, but that FDI promoted efficiency by increasing competition.

Blomstrom and Wolff (1989) examined the difference between productivity growth in local and foreign firms in Mexican manufacturing industries from 1965 to 1984. They explored the extent to which the penetration of a sector by foreign-owned firms affects the productivity of local firms in that sector, and whether there is any evidence of convergence between that industry's productivity level and that of the US. The results show that productivity levels of locally owned firms in Mexico have converged to those of foreign-owned firms. Further, both the rate of productivity growth of local firms and their rate of catch-up to the multinationals are positively related to the degree of foreign ownership of an industry. The results thus provide support for the spillover hypothesis.

Most studies on spillover effect examine the impact of FDI on domestic firms' productivity growth. Some research tested the spillover hypothesis from a different angle. For example, Blomstrom, Kokko, and Zejan (1994) conducted studies to explicitly test the determinants of technology transfer. They analyzed how the technology imports of foreign firms are related to various industry characteristics. Their hypothesis, following Wang and Blomstrom's model, was that market rivalry and the availability of skilled labor may encourage the MNC to bring more technology to their foreign operations. Using data for Mexican manufacturing firms from 1970 to 1975, they used foreign firms' technology payments abroad to construct a proxy for total technology imports, which makes up the dependent variable. The share of white-collar employees in the labor force or the wage payments by foreign firms approximated the availability of skilled labor. The growth rate of domestic firms in the total capital stock and their market share served as proxies for local competition. Data on the domestic firms' expenditure on technology, the average license payments by US industries, and the advertising expenditure of Mexican industries were used to control for the variation that stems from basic technological differences. The results reveal that there was a significant relationship between the technology imported by foreign affiliates and the local competitors' investment and output growth, and labor skills. The estimation results thus provided strong support for their hypothesis regarding foreign firms' technology imports.

Using data from the manufacturing operations of US MNCs in 33 host countries in 1982, Kokko and Blomstrom (1995) conducted a similar test to examine how the technology imports of the US majority-owned foreign affiliates were related to proxies for the host countries requirement for technology transfer, level of competition, and learning capacities. The dependent variable is the affiliates technology imports from all sources including transfers between parent companies and affiliates. The independent variables included the share of affiliates that faced various quantitative performance requirements. The local competition was proxied by gross fixed capital formation per employee and gross fixed capital formation to gross output ratio. The results showed that the technology inputs of MNC affiliates increased with the competitive pressure of the host country. However, the payments of royalties and license fees were negatively related to performance requirements. Thus they found some support for the hypothesis proposed by Wang and Blomstrom (1992).

Using Taipei,China firm-level data from the 1991 Industrial and Commercial Census, Chuang and Lin (1999) found that FDI, local technology purchase, and outward foreign investment are substitutes for domestic firms' R&D activity. These results are mainly due to the significant

effect of industrywide technology spillovers. The major policy implications derived from this study was that governments in developing countries might be advised to initially adopt policies encouraging FDI to foster technology transfer and industrywide knowledge spillovers in the short run. However, once the country's technological capability is established, it appears critical to switch to policies that provide a favorable environment to stimulate R&D investment (for example, infrastructure improvement and protection of intellectual property rights). This point deserves a great deal of attention from a policy making point of view.

Most attempts to measure the spillover effects of multinational enterprises on host countries have been cross sectional and limited to labor productivity in manufacturing for a single country. Hejazi and Safarian (1999) extended this approach by adding FDI stocks to foreign trade as a channel linking total factor productivity (TFP) levels between countries. Using TFP levels from the period 1971 to 1990, they found three main results: the coefficient estimates for FDI are higher than those for trade in the standard model; the importance of the trade channel is greatly reduced once FDI is reduced; and overall spillover increases significantly with the inclusion of FDI. Their paper thus argued that technological spillovers are likely to be larger through multinational production and FDI than through international trade. Studies that ignore FDI as a channel of technological diffusion will be flawed in two aspects: the total spillovers will be underestimated, and the importance of international trade will be overestimated.

C. Econometric Studies Contradicting the Spillover Hypothesis

Existing empirical studies differ in their estimates of the overall size and significance of spillovers. Most studies suggest that foreign presence will create a spillover effect. However, some studies have concluded that no productivity growth can be attributed to FDI, or that FDI may even have a negative effect on domestic firms' output growth.

Using panel data on Venezuelan plants, Aitken and Harrison (1999) estimated the production function of a group of Venezuelan plants. They found that foreign equity participation is positively correlated with plants' productivity (the "own-plant" effect), but this relationship is only robust for small enterprises. When testing for spillovers from joint ventures to plants with no foreign investment, however, they found that FDI had an overwhelmingly negative effect on domestic firms' productivity growth. Thus, the gains from foreign investment appear to be entirely captured by joint ventures. They suggested less emphasis should be placed on the spillover effect.

Okamoto (1999) examined the spillover hypothesis using firm-level data for Japanese investment in the US auto parts industry from 1982 to 1992. The study made three major findings. First, contrary to expectation, Japanese-owned firms were found to be less productive than their US counterparts, at least in 1992. Firm-specific technological and/or managerial advantages were not revealed in the US market. Second, US-owned independent suppliers improved their performance steadily between 1982 and 1992. Third, technology transfer from Japanese assemblers to US-owned suppliers seems to explain only a small part of their improvement in performance. The improvement in productivity observed in the 1980s and in the early 1990s appears to have

been the result of increasing competitive pressure rather than technology transfer. Okamoto (1999), however, did not give a full explanation on the observed contradiction between the spillover hypothesis and the finding.

D. Econometric Studies that Differentiate between High and Low Technology Industries

Given the variation in conclusions about FDI and the spillover effect, it is not surprising that more recent studies have attempted to test the differences in spillovers among industries, usually by separating the sample into "high" and "low" technology groups and re-estimating the equation.

Cantwell (1989) found spillovers to be significant in industries where the technology gap between local and foreign firms was low. By analyzing the responses of local firms to the entry and presence of US multinationals in eight European countries from 1955 to 1975, he found the growth rate of output of local firms was catching up only in those industries or countries where local firms already possessed high technology levels. He therefore claimed that technological spillovers mainly took place in local firms that were initially strong, with the weaker local firms either being forced out of business, or confined to the limited segments of the market neglected by MNCs.

Haddad and Harrison (1991) investigated the relationship between productivity growth and FDI in 4,236 firms in 18 two digit Moroccan industries from 1985 to 1989. Using the share of foreign assets in total assets at the sector level to proxy FDI, they found that the influence of FDI in reducing the dispersion of productivity was greater in the low technology sectors[2]. They interpreted this as indicating that competition due to FDI was more important in pushing firms toward the best practice frontier than the transfer of technology. Furthermore, spillovers occurred only when the productivity gap between domestic and foreign firms was not too large.

Kokko (1994) argues that the variable findings of earlier studies suggest that host country characteristics may influence the incidence of spillovers. He conducted a test using the information for 230 four digit Mexican manufacturing industries in 1970. Kokko (1994) demonstrated that spillovers are related to various proxies for the complexity of MNC technology and the technology gap between locally owned firms and MNC affiliates. The foreign presence, measured by the ratio of foreign plants' employment to total employment in each industry, entered the equation along with other variables such as the capital labor ratio, the ratio of white-collar to blue-collar workers as a measure of labor quality, and the Herfindahl index, which was used to measure the concentration of each industry. Value added per worker was the dependent variable. Kokko (1994) divided the sample into groups with lower and higher technology gaps using three proxies[3]. The

[2] They defined the high technology sectors to include machinery, transport, equipment, electronics, scientific instruments, and chemicals.

[3] The first was the average patent fees per employee in each industry, the second was the average capital intensity of the foreign affiliate, and the third was the labor productivity gap between local and foreign firms.

result showed the existence of spillover effects in both groups. However, when the cross item between FDI and the technology gap was added to the model, the spillover in the group with the higher technology became insignificant. He concluded that this result implies spillovers do not generally occur in technologically complex industries. Based on the analysis, Kokko suggested that efforts to promote FDI by a host government should focus on industries where the local technological capacity is already relatively strong. Kokko, Tansini, and Zejan (1996) later conducted a similar test using data for 159 Uruguay firms from 1988 to 1990 and reached a similar conclusion.

Tsou and Liu (1994) analyzed the relationship between labor productivity, technical efficiency, and the spillover effect, using data from Taipei,China industrial and commercial census data collected in 1986 and 1991. They also divided the sample into a group with a relatively low technology gap between FDI and local firms, and a group with a higher technology gap between FDI and local firms, based on the average value of the ratio between value added per employee in local and foreign firms. The results showed a significant spillover effect in 1986 in the low technology group. In contrast, there was an insignificant relationship in the high technology industries. In 1991, the positive relationship in the low technology industry was not significant and still negative, and significant in the high technology industries. These results confirmed that domestic firms can only benefit from spillover effects when their technological capability is not greatly lower than that of the foreign counterpart. Therefore, a basic condition for domestic firms to benefit from spillover is to improve their technology capability.

Liu et al. (2000) examine intra-industry productivity spillovers from FDI in the UK manufacturing sector. They used panel data for 48 UK industries over the period of 1991-1995. They divided local UK firms into two groups: one having a “strong” capability, and one having a “weak” capability. The ratio of intangible assets per worker in locally owned firms to those in foreign-owned firms was used as a proxy for the technological capabilities of locally owned firms. The ratio of value added per worker in foreign subsidiaries to that in local UK firms in each industry was used as a proxy for the difference in the level of technology between foreign and UK-owned firms. The model employed a single equation and regressed labor productivity with other variables, such as capital labor ratio, and average size of UK-owned firms. The results indicated that the mere presence of FDI has a positive spillover impact on the productivity of UK-owned firms. It also showed that the extent to which local firms benefit from the introduction of advanced technology depends largely on their own technological capabilities as defined by UK firms’ capital intensity, learning efforts, and technological capabilities.

E. Assessment of Previous Empirical Studies

Some studies have argued that the link between FDI and productivity might arise from the fact that MNCs pursue higher productivity and capital formation from the outset. This raises the question of whether FDI happens prior to higher labor productivity and capital formation. The major problem with most previous attempts to measure spillover effects from foreign investment is that they do not investigate the correlation between FDI and growth in any detail. Although

this problem has been recognized by various studies, only a few address it directly rather than accept the convention that the direction of causality is from other variables, include FDI, to growth. The way this relationship is specified in almost all previous estimations has been to regress labor productivity on FDI, which implicitly assumed that FDI is causally prior to, or at least independent of, economic growth. But causation can run both ways. The inflow of foreign investment could potentially react to the vitality of the domestic economy. Bell and Pavitt observed that foreign direct investment has generally been a consequence, rather than a cause of rapid industrialization in developing countries.

Empirical evidence shows that firms increase investment in response to the expansion of sales associated with a rise in GDP. Bandera and White (1968) found a statistically significant correlation between US FDI to the European Union (EU) and EU incomes (GNP), and concluded that a motive to invest abroad can be summarized as a desire to penetrate a growing market defined in terms of the level and growth of GNP in host countries. In a large sample of developing economies, Renber et al. (1973) found that the flow of FDI into LDCs was correlated with their GDP. In spite of differences in assumptions, data, and specification of the variables, these studies came out in support of the proposition that FDI is positively dependent on output growth. Thus, it is possible that these studies may point either to a two-way process, with growth being fostered by FDI, and FDI itself induced by economic growth, or even a one-way process from growth to FDI. As a result, one could find positive spillovers from foreign investment where no spillover occurs. Most empirical studies on FDI and spillover effects have employed the single equation approach, but because of the simultaneity problem, this approach may not generate credible estimates, which are useful in policy analysis.

Kholdy (1995) employed the technique of Granger-Causality to investigate the direction of causation between FDI and spillover efficiency in some developing countries (Brazil, Chile, Mexico, Singapore, and Zambia) for the period 1970 to 1990. His findings do not support the efficiency spillover hypothesis, but rather, FDI is attributed to countries with higher factor endowments, an internal market, and more advanced technology in domestic production. The evidence on the direction of causality between FDI and growth highlights the importance of growth as a crucial determinant of FDI inflow.

Another problem with most of these studies is that they apply labor productivity as a proxy for technology. They test for the existence of spillovers by measuring the effect of foreign presence, generally expressed in terms of the share of employment in the foreign firms in each industry's total employment, on labor productivity in local firms. Although labor productivity provides one measure of technological advantage, it is a partial measure that varies with capital intensity as well as the level of other factor inputs.

A third problem is that by ignoring causality, many studies failed to include some important factors in the productivity equation. Most of the studies emphasized the importance of factor input and labor quality. However, factors such as R&D and trade intensity are often not considered. The results from models that omit such important variables are at best incomplete, and at worse misleading.

Most of the earlier empirical studies did not provide a careful analysis on the underlying causes for the potential negative or positive impact of FDI on domestic firms' production. Some more recent studies make useful attempts to tackle this issue by splitting samples into high and low technology groups. The overwhelming finding from these studies is that spillovers are more pronounced in low-tech industries where the technology gap between domestic and foreign firms is low. These conclusions do not support the basic Gerschenkron (1962) assumption used in most theoretical studies and upon which a number of government policies toward FDI are based. While many countries actively encourage the inflow of FDI in high tech industries, the findings of these recent studies suggest that, at least in light of the spillover effects, the benefit may be lower when the technology gap between domestic and foreign invested firms is too wide. Those designing FDI-related policies cannot ignore such implications.

Most studies tend to focus on simply testing the existence of spillover effects, and continue to pay insufficient attention to the mechanism through which spillovers take place. In particular, few studies explore the behavior and idiosyncrasies of domestic firms in determining the magnitude and eventuation of spillover effects. Furthermore, due to the complexity of this issue, the difficulty in measuring spillover effects, as well as data constraints, most studies focus on examining whether FDI variables are positively correlated to factors such as labor productivity. Few are able to produce quantitative estimates of the magnitude of spillover effects. The spillover effect from FDI thus remains an issue requiring further empirical attention.

IV. FDI STUDIES IN THE PRC

This section briefly reviews studies on FDI in the PRC. As noted above, the PRC is a good case study to use in conjunction with the general literature of FDI. The PRC has attracted an impressive amount of FDI since it embarked on economic reform more than two decades ago. Its utilization of FDI in the context of relatively controlled introduction of market forces into its economy from 1979 merits careful study, particularly for the possible lessons it holds for other transition economies.

FDI inflow in the PRC has attracted a great deal of interest within both academia and the policy-making arena. Existing studies on FDI in the PRC can broadly be classified into three categories. The first category examines the pattern of FDI in the PRC, including a quantitative description of FDI inflow, assessment of the investment environment, and changes in the PRC's economic policies. The second category examines the determinants of FDI in the PRC. The third category assesses the impact of FDI on industrial development and modernization in the PRC.

A. Studies on Patterns of FDI in the PRC

A large amount of research has been devoted to a constructing a general profile of FDI in the PRC. Kamath (1990 and 1994) and Pomfret (1991 and 1994) reviewed the experience of

the PRC's open door policy and discussed some of the lessons to be drawn from its experience with FDI. Zhang and Tracy (1994) looked at the size, rates of growth, location, and main features of FDI and addressed the question of whether the large inflow of FDI will continue. Eng and Lin (1996) investigated foreign investors' penetration of the PRC economy and their effort to build a competitive edge for operations in local and international markets. Fukasaku, Wall, and Wu (1994) provided a chronological evaluation of the PRC's foreign investment policy. Chi and Kao (1994) analyzed the general location and industrial distribution, sources, and types of FDI in the PRC by examining data from a sample of all foreign enterprises registered in 1991 over a period of 5 years. Wei (1995) investigated whether the PRC has reached its potential in attracting FDI. Freeman (1994) gave a qualitative profile by sector and region of FDI in the PRC and Viet Nam.

Efforts have also been made to assess the PRC's legal and policy framework with regard to FDI. Wu (1986) presented a critical overview of the PRC's policy on FDI since its inception. He analyzed the ideological change behind this, and assessed the legal-institutional framework of FDI in the PRC. Kwon (1989) analyzed the taxation framework for FDI in the PRC. Huang (1995) offered a careful study of FDI inflows and related policies. Hayter and Han (1998) discussed the economic dilemma posed by FDI in the formation of policies. They view the "open policy" as a geopolitical strategy of the government to enhance technological and industrial capability by seeking know-how from MNCs. Zhang (1994) argued that developing country governments can not only activate existing, but also create new, location-specific advantages by analyzing the performance of FDI in the PRC, especially Guangdong province. Potter (1995) reviewed the structure and performance of foreign investment laws and policies. He pointed out that, despite the fact that the Chinese legal regime for FDI has evolved significantly since its inception in 1978, in terms of basic laws relating to contract, taxation, foreign exchange, and other regulations, problems and inconsistencies still prevail.

B. Studies of the Determinants of FDI in the PRC

In contrast to the large number of studies on the patterns of FDI in the PRC, relatively little research has been done to test the determinants of FDI. Wang and Swain (1995) investigated the determinants of FDI from 1978 to 1982. The independent variables in their model included the size of the domestic market measured by GDP, the growth rate of GDP, wage rates, and imports. Using a single equation linear model, their study confirmed the positive effect of the market size variable on FDI inflow. The wage rate was negatively related to FDI, and a negative coefficient was found between imports and FDI. This study is one of the few that applies econometric techniques. However, it was criticized by Matyas and Korosi (1996) for inconsistencies in its numerical results and its limited degree of freedom. The degree of freedom is only 3, which is low for a model that estimates 12 unknown coefficients from 15 observations.

To increase the degree of freedom, Liu et al. (1997) analyzed the determinants of FDI in the PRC based on FDI inflow from 22 countries/regions from 1983 to 1994. The factors tested included market size measured by GDP and wage rates. Their study showed a positive relationship

between the market size variable and FDI inflow, and a negative relationship between the wage rate and FDI inflow.

Broadman and Sun (1997) focused on the geographical and sectoral distribution of FDI within the PRC and developed an econometric model of locational determinants. These determinants include market size proxied by regional GDP, labor costs, and human capital. The results showed that regional GDP is the most important factor in determining foreign investors' location choice in the PRC. Adult literacy has a small, though significant, positive effect on the destination of FDI, while labor costs were not a strong determinant of the location of FDI within the PRC.

Head and Ries (1995) developed a model in which tax incentives, infrastructure, labor costs, and self-reinforcing agglomeration effects determine the location of FDI. The monopolistic-competition model predicts that the arrival of FDI in a city will stimulate entry by local suppliers, creating upstream growth, which, in turn, makes the city more attractive to foreign investors. The hypothesis is supported by estimation results using data on 931 investments in 54 cities from 1984 to 1991.

C. FDI, Technology Transfer, and Growth

Many authors have documented the overall economic outcome of FDI inflow. It is now commonly agreed that FDI has been beneficial to the PRC's economic development. For example, Lardy (1996) concluded that FDI has contributed to the PRC's rapid export growth. Kueh (1992), considered the impact of FDI on the coastal provinces, and concluded it had contributed to capital formation, output and income generation, and export growth. Hiemenz (1989) discussed the impact of FDI on economic development, regional growth, and trade. He suggested that the better economic performance of the PRC in the 1980s was achieved by more efficient use of resources than by increasing investment.

Chen, Chang, and Zhang (1995) critically assessed the role of FDI in the PRC's economic development since 1978 in terms of GDP, domestic savings, fixed asset investment, foreign trade, and the transition to a market economy. They concluded that FDI had contributed to the PRC's post-1978 economic growth by augmenting the resources available for capital formation and by increasing export earnings.

In an attempt to analyze the relationship between FDI and growth in the PRC, Shan et al. (1997) tested an FDI-led growth hypothesis. They constructed a vector auto-regression (VAR) model on the basis of quarterly time series data over the period 1985 to 1996. The result indicates that there is two-way causality between FDI and growth.

Assessments differ over FDI's contribution to technology transfer in the PRC. Huang (1995) stated that FDI introduced advanced technologies. Lan and Yong (1996) studied technology transfer and adaptation in the northeast city of Dalian by interviewing 36 firms, concluding that FDI had transferred advanced technology. However, many others have argued that relatively little advanced technology had been transferred. (Kamath 1990), for example, argues that given the preponderance of real estate, commercial, tourism-related FDI, and FDI in labor-intensive manufacturing industries,

the major transfer has been low-level technology in areas classified by the government as "non-productive."

Despite the large number of studies, the relationship between FDI and technological spillovers in the PRC is far from clearly defined. Due to the difficulties in obtaining data and the complexities of defining the relationships, work based on in-depth quantitative analysis in the PRC is scarce. Most studies are based on intuitive reasoning and are descriptive in nature. These descriptive studies help to shed light on the relationship between FDI and spillover effect in the PRC, but more systematic empirical studies are needed.

There is also a lack of comparative studies between firms in different ownership categories and industries in the PRC. One exception is Pan and Parker (1997), who compared management attitudes in three kinds of firms in the PRC. However, their study was based on only 16 enterprises in Shanghai and Nanjing.[4] Therefore, the applicability of their conclusions may be limited by the small sample size.

V. FDI AND THE SPILLOVER EFFECT: THE REMAINING ISSUES

The postwar era has witnessed an increasing flow of direct investment across national borders. This has stimulated intense debate and research on the role of FDI on host economies. Research has greatly improved our understanding of various aspects of FDI. However, there are still issues that need to be addressed, both at the intellectual level and the policy-making level.

A. FDI Research and Policy Issues

Various theoretical studies have shown that FDI can serve as a channel for transferring technology to a host country. Focusing on technology transfer from parent to subsidiary firms, recent models, such as that of Wang and Blomstrom (1992), not only argued for FDI as a vehicle for the diffusion of technology, but also used rigorous analysis to prove that the learning investment and cost efficiency of FDI firms operating locally had a significant bearing on the magnitude of spillover effects. Furthermore, political stability and high growth potential in a host economy will also make MNCs more willing to transfer technology. These conclusions have important policy implications.

While theoretical studies focus on technology transfer from a parent company to its subsidiary, most empirical studies aim to test the hypothesis that FDI leads to technological advancement and efficiency improvement in domestic firms. Many studies provide evidence of the existence of spillover effects, suggesting that FDI can act as a vehicle through which new ideas, technologies, and working practices can be transferred to domestic firms. However, some case studies and empirical research find little evidence of a spillover effect arising from FDI inflow. This mixed empirical evidence suggests that spillover benefits cannot be assumed, but rather, research needs to identify conditions under which spillovers actually occur.

Some studies have specifically investigated the relationship between the technology gap between MNCs and domestic firms and the spillover effect. Their overwhelming conclusion is that spillovers are strongest in industries where the gap between domestic firms and foreign firms is low. This conclusion does not support policies pursued by many countries in seeking to attract FDI in high-tech industries. The PRC government, for example, provides many incentives for FDI in advanced industries, including priority for Bank of China loans, exemption of profits remitted abroad from a 10 percent remittance tax normally placed on such profit flows by foreign investors, extended reduction period for income tax, and additional tax benefits for reinvested profits. If the joint venture uses part of its profits to reinvest in a technologically advanced project, it can receive a full refund on income tax paid on the reinvested funds in previous years, and gain permission to sell products in domestic markets.

Numerous studies have explored issues relating to FDI inflow in the PRC. They generally confirm that FDI has greatly contributed to the PRC's economic development since the beginning of the era of economic reform. Statistics concurs with these findings. In 1999, FDI firms produced 26.1 percent of gross industrial output, accounted for about 20.0 percent of net fixed capital asset, and generated over US$10 billion of tax revenue. There were more than 5,500,000 people employed in FDI firms. The inflow of FDI has also enhanced interaction between the PRCand the outside world. Export share of foreign-invested firms reached 31.5 percent in 1995, and further increased to 54.8 percent in 1999. This has greatly enhanced the PRC's position as a trading nation. From 1980 to 1999, the PRC has moved from the 26th largest exporter in the world to the 9th.

More controversy, however, exists regarding the role of FDI in transferring technology to the PRC. While some studies find that FDI transfers advanced technology to the PRC, others state that FDI has not fully met expectations in this regard because FDI in the PRC is mainly distributed in labor-intensive industries (Freeman 1994, Li and Su 1996). Given that one of the most important motivations for the PRC government to attract FDI inflow was, and still is, to improve the PRC's overall level of technology, a careful study of the relationship between FDI and technology spillover in the PRC is needed. In light of the findings from theoretical studies and the mixed empirical results, the value of spillovers in the PRC needs to be more specifically integrated into domestic policy framework considerations and assessment of firms' behavior. Such analysis can shed light on the mechanisms through which spillovers take place. An understanding of these issues is important for maximizing the benefits of FDI to the Chinese economy. The lessons to be derived from this exercise will also provide useful indicators on the direction and likely success of FDI policies in other developing countries.

Until now, policy frameworks in most developing countries have tended to focus predominantly on attracting FDI, particularly in high-technology areas. Policy initiatives have largely bypassed measures to specifically enhance the spillover benefits from FDI. There are now a large number of empirical studies that suggest it is difficult for domestic firms to extract the potential benefits of spillovers when a large technology gap exists between domestic and FDI firms. FDI policy should thus be placed in a broader economic policy context in order for the host economies to maximize the benefit they derive from FDI inflow. Government policy can play a role by investing

in basic infrastructure, education and training, and encouraging domestic firms themselves to invest in technological development. These policies can all help to increase domestic technological capability.

B. Areas for Future Research

Existing studies have greatly improved our understanding of the role of FDI in host economies. However, there are still lacunae that need to be addressed by future research. Most of the existing theoretical models focus on technology transfer from a parent company to its subsidiary, while spillovers from a subsidiary to domestic firms have been assumed to be automatic. There is little theoretical discussion on the relationship between FDI and domestic firms. Moreover, most studies incorporate the Gerschenkron (1962) assumption, which considers that the greater the relative disparity in technology level between firms/countries, the faster spillover takes place. Some later studies suggest this may not be a valid assumption. FDI has not been given an important role in the literature of growth theory. More rigorous theoretical work is needed to explore the relationship between FDI and spillovers, FDI and domestic firms, and the role of FDI in promoting growth.

At the empirical level, much has been learned about spillovers from research conducted over the last two decades. However, many studies suffer from the problem of omitted variables. The vast majority of studies employ a single equation OLS model to regress labor productivity on FDI. The possible two-way causality between FDI and productivity growth is therefore ignored. More importantly, few provide careful analysis of the underlying causes for the potential negative or positive impact of FDI on domestic firms' production or productivity, and examine under what conditions spillover benefits are most pronounced. More work is needed to understand the process of technology spillovers from FDI, in particular, to help evaluate the mechanism of spillovers.

While the literature on FDI in the PRC has grown rapidly, most is of a descriptive nature. Because of methodological difficulties, as well as the lack of data, little careful empirical investigation has been conducted to analyze the relationship between FDI and domestic firms. To provide a comprehensive analysis on FDI and domestic firms in the PRC, it is necessary to not only carefully study the behavior of foreign-invested firms, but also domestic firms and policies. Studies combining theoretical investigation, empirical analysis, and detailed case studies are needed in the future to flesh out the remaining gaps in our understanding of the interaction between the PRC economy and foreign investment.

Appendix A: Derivation of the Model of Wang and Blomstrom (1992)

Wang and Blomstrom start by assuming that technology affects demand. Consumers' preference is represented by the utility function

$$U(Y) = U(\sum_i G_i Y_i), \tag{1}$$

where Y is an industry output index, Y_i is firm i's output, and the weight G_i reflects the attractiveness of firm i's products. G_i increases in relation to the firm's technology level K_i. Moreover, the authors assume the utility function is logarithmic, and $G_i(K_i)$ is of the form K_i^a, where a is a positive constant. Then, $U(Y)$ can be expressed as

$$\begin{aligned} U(Y) &= U(K_d^a Y_d + K_f^a Y_f) \\ &= U(K_d^a (Y_d + (K_f^a / K_d^a) Y_f). \end{aligned} \tag{2}$$

A monotonic transformation also means that the utility function can take the following form:

$$(2') \qquad U(Y) = aLnK_d + Ln(Y_d + k^a Y_f),$$

where k is the technology gap, defined as the ratio of the foreign firm's technology level to that of the local firm, and subscript d and f refer to domestic and foreign, respectively.

The price of each product is set proportionally to its marginal utility in equilibrium. Setting the marginal utility of money equal to 1, it follows from (2') that the prices facing the local and foreign firms are

$$P_d(k, Y_d, Y_f) = \partial U(Y) / \partial Y_d = (Y_d + k^a Y_f)^{-1}, \tag{3}$$

and

$$P_f(k, Y_d, Y_f) = \partial U(Y) / \partial Y_f = k^a (Y_d + k^a Y_f)^{-1}. \tag{4}$$

These equations show that the prices for both firms' products depend on the quantities of both goods and on the relative attractiveness of the products, which is determined by the technology gap between the two firms. It can also be shown that

$$\partial P_d / \partial k = (-ak^{(a-1)} Y_f) / (Y_d + k^a Y_f)^2 < 0, \tag{5}$$

but

$$\partial P_f / \partial k = (ak^{(a-1)} Y_d) / (Y_d + k^a Y_f)^2 > 0 . \quad (6)$$

That is, the prices of the MNC affiliate's products increase with the technology gap, whereas the prices of the local firm's products move in the opposite direction.

Wang and Blomstrom break down each firm's decision into two steps. Each firm chooses its output to maximize its profit on the basis of the status quo of both firms' technological level and its competitor's current output. Intertemporally, each firm chooses its technological investment to maximize the present value of its profit stream.

The quasi-rent function of firm i, given P_i as above, is then

$$R_i(k) = Max\{P_i(k, Y_i, Y_j^*)Y_i - \bar{c}_i Y_i | Y_i \text{ is feasible}\} , \quad (7)$$

where $\bar{c}_i$ is the firm's marginal cost, and Y_j^* is the Cournot-Nash equilibrium output of the other firm.

It is assumed that the MNC affiliates can increase their level of technology K_f by investing resources I_f to import technology from their parent company. The speed of the technology transfer is proportional to the MNC's commitment to the transferring activity. For simplicity, the marginal productivity of I_f is assumed to be constant and equal to 1. Hence,

$$DK_f = I_f K_f , \quad (8)$$

where D marks the time derivative, that is $DK_f = dK_f / dt$. The local firm's technological development is expressed as

$$DK_d = f(I_d) k K_d , \quad \text{with}$$
$$f' > 0,\ f'' < 0,\ f(0) = v > 0 , \quad (9)$$

where the constant v is the rate of costless technology spillovers. The technological level of the local firm increases in response to its learning investment I_d, and the return of the investment diminishes as the learning effort increases. The technological progress of the local firm is an increasing function of the technology gap, following the hypothesis of Gerschenkron (1962).

Taken together, equations (8) and (9) define the changes in the technology gap:

$$\begin{aligned} Dk &= D(K_f / K_d) \\ &= (K_d * DK_f - K_f * DK_d) / K_d^2 \\ &= (K_d I_f K_f - K_f * f(I_d k K_d) / K_d{}^2) \\ &= (I_f - f(I_d)k)k \,. \end{aligned} \tag{10}$$

The foreign firm's objective is to choose $I_{f(t)}$ to maximize the discounted value of its profit stream subject to the transfer absorption process, given the learning effort of the domestic firm. The dynamic optimization problem involves (a/the following) trade-off between current and future profit:

$$\begin{aligned} &max\, V^f = \int_0^\infty e^{-rt}(R_f(k) - C_f(I_f))dt \\ &s.t.\ Dk = (I_f - f(I_d k))k \end{aligned} \tag{11}$$

where r is the discount rate used by the MNC affiliate, $R_{f(k)}$ is the quasi-rent function, $C_f(I_f)$ is the cost for technology transfer, and C_f is assumed to be strictly convex in I_f.

The domestic firm faces the problem of choosing I_d subject to equation (10) and the choices of the affiliates. That yields the function

$$\begin{aligned} &max\, V^d = \int_0^\infty e^{-\rho t}(R_d(k) - \theta C_d(I_d))dt \\ &s.t.\ Dk = (I_f - f(I_d k))k \,, \end{aligned} \tag{12}$$

where C_d is the domestic firm's learning cost, and it is assumed to be strictly convex in I_d. ρ is the domestic firm's discount rate, and θ is a shifting parameter representing the cost efficiency of the firm's learning investment. The smaller the value for θ, the more cost-effective the domestic firm's learning activities are.

Equations (11) and (12) describe a differential game situation that can be solved by defining the steady-state equilibrium conditions for each firm's optimal control problem, given the decisions of the other player.

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