The Role of International Trade and Foreign Direct Investment in Technology Transfer and Wage Improvement in Vietnam

by

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Thesis submitted to the School of Economics, the University of Adelaide for fulfilment of the degree of Doctor of Philosophy.

THE UNIVERSITY OF ADELAIDE AUSTRALIA

September 2006

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List of Abbreviations

DC	Developed Countries
DIEs	Direct Investment Enterprises
FDI	Foreign Direct Investment
GDP	Gross Domestic Products
GSO	General Statistics Office of Vietnam
IMF	International Monetary Fund
LDC	Less Developed Countries
MNCs	Multinational Corporations
MNEs	Multinational Enterprises
MoLISA	Ministry of Labour, Invalids and Social Affairs of Vietnam
MoSTE	Ministry of Science, Technology and Environment of Vietnam
MPI	Ministry of Planning and Investment
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
R&D	Research and Development
TFP	Total Factor Productivity
UNCTAD	United Nations Conferences on Trade and Development
US$	US Dollar
VND	Vietnam Dong
VSIC	Vietnamese Standard Industrial Classification

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Abstract

This thesis is a theoretical and empirical study of the role of international trade and foreign direct investment (FDI) in technology transfer and wage improvement in Vietnam, and how the characteristics of the country influence the strength of technology transfer and wage improvement.

The starting point of this study or chapter 2 comprises a literature survey of theoretical models of international trade, FDI and technology transfer. This chapter improves our understanding of channels and determinants of technology transfer through trade and FDI, highlighting their implications for the growth performance of well-integrated economies relative to that of more autarchic economies. Theoretical models surveyed make reasonably clear prescriptions about the roles of trade and FDI in technology transfer and economic development. This paves the way for empirical work in the subsequent chapters aimed at identifying the actual mechanisms of technology spillovers through trade and FDI.

Using aggregate provincial data, chapter 3 is a first step in considering the extent to which the themes set out in chapter 2 apply to Vietnam. This chapter examines the relative importance of trade and FDI to technology transfer from both OECD countries and non-OECD countries. It is found in this chapter that international trade, particularly imports of capital goods, plays an important role in the transfer of technology to Vietnam. However, the importance of FDI as a channel for technology transfer in Vietnam is limited in that only FDI from non-OECD countries is a source of technology transfer. The chapter also finds that the skills of the labour force and

openness to trade are the most robust determinants of technology adoption at the provincial level.

With the availability of firm level data, chapter 4 takes into account specific factors of the country, industries, domestic firms as well as foreign firms, which have not been considered in chapter 3, to assess channels and determinants of technology spillovers at firm level. This chapter provides strong evidence that while domestic firms benefit from technology spillovers through vertical linkages with foreign firms, the horizontal presence of foreign firms in the same industry generates negative effects on the productivity of domestic firms. The existence and strength of technology spillovers from FDI depend on the characteristics of industries, domestic firms and foreign firms. This chapter reinforces the findings in chapter 3 that imports provide an important channel for technology spillovers; domestic firms benefit from foreign technology not only through direct imports of machinery and equipment, but also via vertical linkages with other firms in import-intensive sectors.

The role of FDI in the labour market and its impacts on wage levels of Vietnamese domestic firms are the subject of chapter 5. In a manner reflecting the concept of productivity spillovers, wage spillovers from FDI occur through horizontal presence of foreign firms in the same industry and through vertical linkages between domestic firms and foreign firms across industries. This chapter finds strong evidence that there are horizontal wage spillovers from foreign firms to domestic firms in Vietnam. Wage spillovers from the vertical linkages between foreign firms and domestic suppliers depend on the firms' specific characteristics. Training activities of both domestic and foreign firms are found to play a key role in facilitating wage spillovers.

Declaration

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and beliefs, contains no material previously published or written by another person, except where due reference has been made in the text.

I give consent to this copy of my thesis, when deposited in the University Library, being available for loan and photocopying.

Hoi Quoc Le, 18^{th} September 2006.

Acknowledgements

This arduous but deeply satisfying journey towards attempting to get a PhD owes a great deal from a number of people. First and foremost, I wish to express my deep and sincere thanks to my supervisor, Professor Richard Pomfret. His broad knowledge, insightful comments and suggestions regarding this work have been crucial to its development. The continuous encouragement and support I had from him were the utmost importance. I am fortunate to have been under his supervision. Without his faith, I would not have been able to finish this thesis at this juncture. Thanks are also owned to my adviser Dr. Raul Barreto for his constructive comments and invaluable suggestions on the thesis.

I would also like to express my thanks to the School of Economics, the University of Adelaide, for the support. Prof. Christopher Findlay and Dr. Ian Mclean, the current and former Dean of the School are owned special thanks for their help and encouragement. I need to mention other members of the School who have contributed to my learning process, including Prof. Daniel Leonard, Dr. Ralph Bayer, Dr. Mark Weder, Dr. Eran Binenbaum, and Mr. Tin Nguyen. I am grateful to my co-graduate students at the School of Economics who provided a stimulating environment and friendship. I would also like to acknowledge the contribution of participations at various Conferences and Workshops.

Thanks go to the government of Vietnam for awarding me the postgraduate scholarship in Australia. I also owe sincere thanks to Nguyen Thi Hong Hai and Nguyen Thi Mai. They have been so kind in helping me to collect data enthusiastically.

Finally, special thanks must go to my parents for their consistent love and encouragement. They always instilled in me the value of knowledge and education, and continue to love me whatever my age and wherever I may be.

Chapter 1

Introduction

In developing countries, the most important issues from an economic perspective to be confronted by government and policy-makers are the rate of economic growth and income improvement. Identifying the determining factors of economic growth and income improvement, and measures to affect these factors are thus crucial to developing countries. The accumulation of physical and human capital is considered as determining factors, but they cannot explain much of today's cross-country income differences (Prescott, 1998; Easterly and Levine, 2001). Recent studies have shown that the international diffusion of technology is important in explaining economic growth and income levels across countries (Eaton and Kortum, 1999; Keller, 2001).

From theoretical and empirical perspectives, both international trade and foreign direct investment (FDI) have long been recognized as factors that have a strong impact on technology diffusion and economic performance.

The literature has examined three main roles that trade plays in economic development through the channel of technology transfer. First, imports of capital goods and intermediate goods are the most direct mechanisms of technology transfer (Feenstra, Markusen and Zeile, 1992). Secondly, trade and market integration increase incentives to transfer more advanced technology to a country, giving rise to learning possibilities (Aghion and Howitt, 1998). Thirdly, trade increases the number of designs and production mechanisms that are accessible within a certain country. This allows the country to increase the degree of imitation and exposure to new technologies (Grossman and Helpman, 1991).

With the rapidly rising level of economic integration in recent years, FDI has been an important channel for the transfer of technology to developing countries. Since a large share of global research and development activities (R&D) is undertaken by multinational corporations (MNCs), FDI by MNCs is considered to be a potential way of gaining access to advanced technologies available in the global market. Local firms may benefit from the diffusion of new technology brought by MNCs through imitation or reverse engineering (Wang and Blomstrom, 1992; Glass and Saggi, 2002), backward and forward production linkages (Markusen and Venables, 1999), or labour turnover (Gorg and Strobl, 2002). Therefore, FDI creates technology spillovers in the form of externalities. Besides technology spillovers, FDI may generate wage spillovers to local firms (Lipsey and Sjoholm, 2001). Wage spillovers may come from competition effects of MNCs in the labour market, or from productivity spillovers that allow local firms to increase wages.

Since 1986, to deal with the economic crisis and the problem of underdevelopment in Vietnam, the government has conducted ambitious structural and institutional reforms. Now, after twenty years of renovation, Vietnam has obtained significant economic improvement while maintaining macroeconomic stability. International trade and FDI have been considered as engines of economic improvement and as leading mechanisms of technology diffusion. Understanding the effects of these channels on technology transfer, economic growth and income improvement in Vietnam is essential to firms and policy makers in the face of increasing globalization.

This thesis examines the role of international trade and foreign direct investment in technology transfer, economic growth and wage improvement in Vietnam, and how the characteristics of the country influence the degree of technology transfer and wage improvement. The research questions we broadly seek to answer are the following:

1. To what extent do international trade and FDI in Vietnam contribute to foreign technology transfer, and the growth rate of GDP?

2. What are the major determinants of technology transfer at the provincial level?

3. Is there any technology spillover from international trade and FDI to Vietnamese domestic firms? If there is, through which channels do spillover occur? Which types of spillover, intra-industry spillover, inter-industry spillover, imports or exports are significant?

4. To what extent and through which channels do FDI contribute to wage improvement in Vietnamese domestic firms?

The starting point of our analysis or chapter 2 comprises a literature survey of theoretical models of international trade, FDI, and technology transfer. This chapter presents an analysis of the major theoretical contributions in these three fields of research, highlighting their implications for the growth performance of globally integrated economies relative to that of more autarchic economies. The theoretical models in this chapter serve as basic models for our study in the subsequent empirical chapters. Although some of the main empirical findings in the literature are mentioned in this chapter, the empirical literature is reviewed more deeply in the individual later chapters.

Chapter 3 examines the manner in which the foreign technology that accompanies international trade and FDI affects the growth rate of Vietnamese provinces. This chapter tests the relative importance of trade and FDI to technology transfer and decides which is the most effective channel. The existing literature mainly considers technology transfer through trade and FDI from developed countries to developing countries, and ignores the role of technology transfer that may occur between developing countries. We add to the literature by considering technology transfers from both OECD countries and non-OECD countries to Vietnam. In this chapter, we also explore the similarities and differences between the adoption of technology from OECD and non-OECD countries in Vietnam.

In chapter 3, by using aggregated data, we consider the effects of technology transfer through trade and FDI at the provincial level and therefore it does not allow us to explore and compare the different impacts of technology transfer in different types of industries and firms. Chapter 4 uses firm-level data to examine how technology transfer through FDI, exports and imports affect the productivity of Vietnamese domestic firms. This chapter advances our understanding as to when, where, and under what conditions trade and FDI generate technology spillovers to domestic firms. In the context of technology spillovers from FDI, we distinguish between horizontal spillovers (between foreign firms and domestic firms within the same sector) and vertical spillovers (between foreign firms and their domestic suppliers). More importantly, we add to the literature by looking at the impacts of the characteristics of both foreign and domestic firms on the presence and strength of such spillovers. In the context of technology spillovers via international trade, this chapter contributes to the literature by shedding light on the argument that learning from imports not only occurs through direct imports of goods invented abroad, but also occurs among local suppliers upstream of import-intensive sectors. We suggest that linkages through vertical supply relationships are the relevant mechanism through which import-driven knowledge transfer occurs.

Chapter 5 addresses the impact of FDI on labour markets and the wages of domestic firms. The existing literature has so far only attempted to examine horizontal wage spillovers, by looking at the impact of the presence of foreign firms on the wage levels of domestic firms within the same industry. Here, we expand on the literature by examining vertical linkages between foreign firms and domestic firms as an additional conduit for wage spillovers. We argue that if there are positive productivity spillovers from foreign firms to domestic firms through vertical linkages, domestic firms will become more productive, therefore allowing them to pay higher wages. Similarly to chapter 4, we extend the analysis of FDI and wage spillovers by considering the effects of different characteristics of firms and industries on wage spillovers from foreign firms to domestic ones.

Finally, the conclusion of the thesis is given in chapter 6 where we summarise our main findings and discuss the contributions and limitations of the study, as well as giving policy implications for the Vietnamese government and firms.

Chapter 2

The Theories of Trade, FDI and Technology Transfer

2.1 Introduction

Growth literature has long been interested in searching for the causes and effects of the growth of income and why some countries grow faster than others. In the neoclassical growth models developed by Solow (1956) and Swan (1956), capital accumulation and technical progress are considered as the determinants of economic growth. The work of Solow and Swan has later been extended in many directions and in different economic fields. For example, Mankiw, Romer and Weil (1992) introduce human capital formation as an additional factor to the above-mentioned determinants of economic growth. The endogenous growth theory pioneered by Romer (1986) and Lucas (1988) has set a new paradigm for macroeconomic analysis. The endogenous growth models focus on the role of human capital, research and development (R&D) and externalities as endogenous factors of the economic system. In practice, all these determinant factors display their dominant impacts at certain stages of economic development.

Some theories of endogenous economic growth emphasize the importance of technology diffusion in explaining the pattern of long-run economic growth and cross-country income differences (Romer, 1990; Grossman and Helpman, 1991; and Aghion and Howitt, 1992). Technology diffusion may occur through international trade and foreign direct investment (FDI). On the one hand, technology spillovers may come from importing new capital goods used in R&D activities, so that an importing country's productivity would be improved by employing a wider variety of capital inputs or by using better capital inputs in final goods production. On the other hand, FDI often involves the transfer of knowledge from one country to another by setting up production units using advanced technologies in the recipient country (Borensztein, Gregorio and Lee, 1998); this makes it an important channel for international technology diffusion.

The literature on endogenous growth has reached various conclusions, depending on the main object of its analysis: international trade, FDI, or technology diffusion. This chapter surveys the major theoretical contributions on these three components of research. Its aim is to give an analysis of theoretical models, highlighting their implications for the growth performance of well-integrated economies relative to that of more autarchic economies. This will pave the way for empirical work aimed at identifying the more realistic of technology spillovers through trade and FDI.

The remainder of the chapter is organized as follows. Section 2.2 is a review of different schools of thought in international trade and growth, which focus on the role of trade in technology spillovers and economic growth. In section 2.2.1, the literature treats technology as exogenous, and trade does not have any growth effect. Section 2.2.2 considers dynamic models in which the evolution of technology is endogenous, and international trade plays an important role in technology diffusion. Section 2.3 contains models in which foreign direct investment is considered as a channel for technology transfer. Section 2.4 presents a review of another branch of economic growth, which focuses on the determinants of technology transfer. The last section presents a brief conclusion.

2.2 Trade, Technology and Growth

2.2.1 Exogenous growth theory and exogenous technology

Exogenous growth theory, which is also called neoclassical growth theory, was developed and dominated research on economic growth during the period from the 1950s to 1960s. The basic model for this branch of economic growth theory is the model which Solow (1956) and Swan (1956) developed independently from each other. They consider a closed economy with a production function as follows:

$$Y(t) = F(K(t), A(t)L(t)) \tag{2.1}$$

where $Y(t)$, $K(t)$, $A(t)$ and $L(t)$ are output, capital, knowledge and labour at time t respectively. In this model, the level of knowledge or technology $A(t)$ and labour force $L(t)$ are assumed to grow at constant exogenous rates:

$$\frac{\dot{A}(t)}{A(t)} = g \qquad (2.2) \qquad \text{and} \qquad \frac{\dot{L}(t)}{L(t)} = n \qquad (2.3)$$

Since the function F is homogeneous of degree one, output per capita can be yielded from (2.1) as follows:

$$\frac{Y(t)}{L(t)} = F\left(\frac{K(t)}{L(t)}, A(t)\right) \tag{2.4}$$

This expression implies that output per capita depends on capital intensity $\frac{K(t)}{L(t)}$ and the magnitude of knowledge $A(t)$. In this model knowledge A is treated as exogenous. The model therefore provides no insight as to which policy can be used for the progress of knowledge in order to consider the issue of differences in national income.

We now turn to consider the growth rate of the economy in the long run. Assume that the net increase in the stock of capital at a point in time equals gross investment less depreciation:

$$\dot{K}(t) = sY(t) - \delta K(t) \tag{2.5}$$

where s is the saving rate and δ is the rate of depreciation.

Under the neoclassical assumptions of competitive factor markets and constant return to scale, (2.1) and (2.5) can be written in intensive form:

$$y = \frac{Y(t)}{A(t)L(t)} = F(\frac{K(t)}{A(t)L(t)}, 1) = f(k) \tag{2.6}$$

$$\dot{k} = sf(k) - (n+g+\delta)k \tag{2.7}$$

where $y = \frac{Y(t)}{A(t)L(t)}$ and $k = \frac{K(t)}{A(t)L(t)}$ stand for income per effective worker and capital per effective worker respectively.

In the Solow-Swan model, the steady state corresponds to $\dot{k} = 0$. That is:

$sf(k) - (n+g+\delta)k = 0$ (2.8) or $sf(k)/k - (n+g+\delta) = 0$ (2.9)

Since the production function is assumed to exhibit diminishing returns to each input, the function $f(k)$ also exhibits diminishing returns to capital per effective worker k. This then produces a unique steady state at k^*, and k^* satisfies the following condition.

$$s\,f(k^*) = (n+g+\delta)k^* \tag{2.10}$$

At the steady state, k is constant, and y is also constant at the value $y = f(k^*)$. Hence, in the exogenous growth model, capital per effective worker and income per effective worker do not grow in the steady state. This implies that in the long run, both the growth rates of capital per worker and income per worker coincide with the growth rate of knowledge *(A)*. Without continuous progress in knowledge, long-run growth in per capita income is impossible. This is one of the important implications of the model about economic growth. The per capita outputs of an economy with fixed technology will not grow. Thus, government policies that do not affect the growth rate of technology will not change the steady state growth rate of the economy. For example, as mentioned by Lucas (1988), international trade will not have any growth effect as long as it does not affect the growth rate of technology.

Despite being incompletely explained, many empirical studies show that knowledge or technology is the main responsibility in explaining the differences in per capita income and labour productivity growth. For example, Solow (1957) tests his model and argues that most of the growth of the United States over the past one hundred year could not be explained by increases in labour and capital. He attributes nearly 90 percent of US per capita output growth to exogenous technical progress.

Hall and Jones (1999) examine the contribution of human capital, physical capital intensity and of technology to the income differences for 127 countries for the year 1988. They then compare the five richest countries and five poorest countries in the dataset, showing that while contribution of human capital and capital intensity just make up a factor of 1.8 and 2.2 to the income differences respectively, technology contributes by factor of 8.3.

Therefore, even though the Solow-Swan model makes a great contribution to growth theory, the main drawback of this model is that it leaves the source of long-run growth - knowledge or technology - unexplained. To go further, we need a theory that can explain the evolution of technology and why it affects economic growth. This is one of the motivations of endogenous growth theory.

2.2.2 Endogenous growth, technology and trade

Endogenous growth theory has been established by the works of Romer (1986), Lucas (1988) and Rebelo (1991). Their motivation is based on the desire to avoid the implication of the exogenous growth model that diminishing returns to capital make exogenous technical progress the only source of long-run growth in income per capita. They attempt to explain how private economic agents make decisions that drive long-run growth through increasing returns, technology spillovers and other non-traditional effects.

The literature on trade, technology and endogenous growth can be divided into two main streams. In the first one, trade may change the pattern of specialisation of a country, and endogenous growth is the result of a process of learning by doing. In the second stream, endogenous growth is determined by specific research activities carried out by profit maximizing agents, and trade in goods and factors of production may open new sources of technological spillovers.

2.2.2.1 Learning by doing

In models of learning by doing, comparative advantage and growth are closely related to trade. Trade may change the pattern of specialisation of a country in goods with different degrees of learning potential, and the effect of trade depends on the extent of learning externalities. In the case of intra-national spillovers, learning is faster if the country specialises in goods with higher learning potential because the increase in the level of production of these goods that are exported augments the relative efficiency of their production technology relative to that of other countries. In contrast, in the case of global learning externality, trade does not affect each country's specialisation, and there are no international knowledge spillovers.

The early work on learning by doing began with Arrow (1962). Arrow considers technological progress as a side product of economic activities and then shows that although new knowledge can be gained from doing a repetitive task, it is sharply decreasing. To make learning by doing a continuous process, it requires continuous stimuli. In this model, the continuous stimuli is brought about by a flow of new capital. New knowledge gained from working with existing capital is put into new capital. New capital is hence regarded as different from the existing capital in the sense that it is more productive. Accordingly, new investment is a source for learning by doing. This implies that new knowledge acquired from learning is just a side product of investment. Arrow also assumes that the arrival of new knowledge is outside the reckoning of an individual firm, since firms do not take into account the effects of their investment on the learning by doing process. This means that knowledge has the nature of a public good which is an unintentional product of an increase in investment. This also creates the possibility for the aggregate production function to exhibit increasing returns to scale even under conditions of perfect competition.

Krugman (1987) considers a world economy with two countries, namely Home and Foreign. He takes the production of each traded good in each country to be as follows:

$$X_i(t)=A_i(t)L_i(t) \qquad i=1,\ldots,n \qquad (2.11)$$

Where X_i is the output of traded good *i* in each country, L_i is labour devoted to that good's production. A_i is the productivity of resources in each industry and in each country, and depends on an index of cumulative experience, K_i:

$$A_i(t)=K_i(t)^{\varepsilon} \qquad 0<\varepsilon<1. \qquad (2.12)$$

The relative productivity of the home country to the foreign country is simply a function of the relative experience indices:

$$\frac{A_i^H(t)}{A_i^F(t)} = \left(\frac{K_i^H(t)}{K_i^F(t)}\right)^{\varepsilon} \tag{2.13}$$

where H and F denote home country and foreign country respectively.

Some goods are now produced exclusively in the home country, some exclusively in the foreign country. Over time, learning by doing makes the home producers more productive in each of the goods initially produced at home, while foreign producers gain no experience in these goods. Since the experience indices determine the relative productivity, the left hand side of equation (2.13) becomes larger over time. In other words, the relative productivity advantage of the home country in each of these industries grows over time. Similarly, foreign firms gain experience and knowledge in producing the range of goods initially manufactured abroad, while home firms learn nothing about these industries. As a result, the foreign relative productivity advantage of export sectors becomes larger. In this model, the determination of the long-run trade pattern depends not only on intrinsic ability, but also on the initial stock of industry knowledge in each country.

Lucas (1988) introduces a similar model, but with two goods (x and y) and a continuum of small countries. In his model, all countries have the same labour force L and the same intrinsic productivities, $1/a_x$ and $1/a_y$. They differ in their initial stock of knowledge (A). Then countries with the highest ratios A_x/A_y at time 0 initially produce good x and the remaining countries initially produce good y. In the countries that produce good x, the productivity of this good grows at the rate $\delta_x L/a_x$ (δ is a measure of the internationalisation of learning). If no country changes its sector of specialisation, world output of good x will grow at this same rate. Similarly, productivity grows at the rate $\delta_y L / a_y$ in the countries producing good y. Then, if $\delta_x / a_x > \delta_y / a_y$, the countries that specialise in producing goods x will grow faster than those that specialise in producing good y. The relative price of good x to good y is falling. This may induce some countries to change their patterns of specialisation from producing good y to producing good x. However, the decline in the rate of price never exceeds the rate at which productivity grows in sector x. Therefore, if these countries change their pattern of specialisation, they will lose their income until they have collected enough experience in the new pattern of specialisation. This model suggests that policies that temporarily alter the pattern of trade may affect the long-run specialisation of a country. Lucas's model has an interesting policy implication. In terms of the economy's growth, the right policy for a country is that its trade can only be liberalised when it has gained a comparative advantage in the fast growing good.

Other models of trade with learning by doing have been suggested. Young (1991) develops a model of bounded learning by doing based on the framework of the Ricardian model of international trade. In his model, labour is the only factor of production, and trade is driven by differences in technology rather than differences in factor endowments. Young considers the effect of trade between two countries, a less developed country (LDC) and a developed one (DC), with the latter denoted by a star. Both countries produce any one of an infinite number of goods s, which is indexed along $[0, \infty)$, in terms of increasing technological sophistication, and under conditions of perfect competition. Technologies in two countries differ in terms of unit labour requirements. He assumes that there is a lower bound to the potential unit labour requirement for each good. In a special case of the Young model, potential unit labour requirements $\bar{a}(s)$ are exponentially decreasing in the degree of technological sophistication s.

$$\bar{a}(s) = \bar{a}.e^{-s} \qquad (2.14)$$

At each point in time t, actual unit labour requirements $a(s,t)$ are assumed to be increasing in s and given as follows.

$$a(s,t)=\bar{a}.e^{-s} \text{ for all } s \leq T(t)\text{, and } a(s,t)=\bar{a}.e^{-T(t)}.e^{s-T(t)} \text{ for all } s>T(t) \qquad (2.15)$$

where $T(t)$ denotes the most sophisticated good for which all potential for learning by doing has been exhausted and characterises the stock of technological knowledge.

Since there are externalities in learning by doing across goods, $T(t)$ rises at a rate depending on the economy-wide flow of skilled labour devoted to production of goods.

$$\frac{dT(t)}{dt} = \int_{T(t)}^{\infty} L(s,t)\, ds \qquad (2.16)$$

Representative consumers in each country maximise the intertemporal utility function:

$$U_t = \int_{t}^{\infty} e^{-\rho(\tau-t)}.\int_{0}^{\infty} \log[C(s,\tau)+1]\, ds\, d\tau \qquad (2.17)$$

where $C(s,\tau)$ denotes consumption of goods at time τ; ρ is the subjective rate of time preference.

In the absence of both trade and international spillovers of ideas, the growth rate of the economy depends on the rate of learning by doing on goods that potential unit labour requirement have not yet been attained. In equilibrium, Young shows that:

$$\frac{dT(t)}{dt} = \frac{L(t)}{2} \qquad (2.18)$$

This means that only half of labour force is devoted to the production of goods due to the symmetrical nature of demand around $T(t)$. Thus, under autarky the growth rate of the economy, like the rate of technical progress, is equal to $L(t)/2$.

In the absence of international spillovers of ideas, the two countries are assumed to be identical. They are only different in the size of labour force *L(t)* and the stock of technological knowledge $T(t)$. The key element that distinguishes the DC from the LDC in this model is that $T^*(t) > T(t)$. This assumption implies that relative unit labour requirement in the DC $a^*(s,t)/a(s,t)$ will be lowest in more sophisticated goods where it has greater opportunity to benefit from learning by doing. In contrast, relative unit labour requirement in the LDC $a(s,t)/a^*(s,t)$ will be lowest in less sophisticated goods. As a result, trade between two countries will induce the DC to specialise in more sophisticated goods where learning by doing still occurs. The LDC will specialise in least sophisticated goods where no learning by doing exists, resulting in poorer growth performance. An implication of Young's model is that in a world with two identical countries, temporary subsidies to high-tech industries in one country will give the country a permanent advantage.

Another finding of the Young model is that technology gap plays an important role in income convergence between the DC and the LDC. Equation (2.16) shows that the model is characterised by a scale effect because the rate of learning by doing in each country depends on the flow of skilled labour devoted to the production of goods. As a result, if the learning gap between two countries is small enough and the LDC's labour force sufficiently large relative to the DC's, the LDC will be able to exploit large economies of scale, and income per capita in the LDC will rise relative to that in the DC until the roles of LDC and DC are reversed.

Stokey (1991) develops a model of learning by doing with national spillovers in human capital accumulation. In her model, private investment in human capital raises the social stock of knowledge. International trade influences growth by affecting the incentive for schooling and other investments in human capital. Stokey shows that human capital can be substituted for learning by doing without significantly changing Young's conclusions. In particular, free trade reduces the incentive to accumulate human capital in a backward country, which in turn does not affect the growth rate of that country.

Both Young (1991) and Stokey (1991) have important contributions to the literature as they show clearly what happens when trade does not generate international knowledge flows. The findings of the models of Young and Stokey are too restrictive to derive policy implications for developing countries. These models, for example, may not account for the extraordinary growth of some East Asian countries during the 1970's and 1980's.

Matsuyama (1992) constructs a model of a small open economy with learning by doing to address the question of how the pattern of trade affects the long-run specialisation of the country. In his model, the economy is assumed to have two sectors, an agricultural sector using a constant technology, and an industrial sector using a technology characterised by learning by doing. Under these assumptions, the model shows that free trade can be detrimental to economic growth of a country with an initial comparative advantage in the agricultural sector and lagging in technological development. In particular, after free trade, the amount of resources employed in the industrial sector decreases compared to autarky, thereby reducing the rate of knowledge accumulation through learning by doing. As a result, the productivity of the manufacturing sector will be reduced, and then the growth rate of the economy will slow down in the long run.

In contrast to the models of Young, Stokey, and Matsuyama; Van and Wan (1997), in a model of growth with learning by doing, find that trade and learning by doing have a positive effect on the rate of growth of an integrated economy. Based on the contagion theory suggested by Findlay (1978), they show that technological progress, international trade and factor accumulation are complements in the growth of the economy. This implies that international trade provides a channel to the economy through which it learns from other economies.

Mountford (1998) analyses the growth and trade of an economy based on a two-country, two-sector overlapping generation structure with the standard Heckscher-Ohlin framework. This model shows that in the presence of national externalities, international trade forces a country trapped in low growth equilibrium to switch to its high growth equilibrium. International trade is also associated with convergence and overtaking dynamics, in which a country with relatively low output per capita can catch up and overtake output per capita of a country with relatively high output per capita.

A similar result is obtained by Goh and Olivier (2002) in a model of learning by doing and trade in capital goods. The model is a two-country overlapping generation model with an assumption that capital goods are to be traded. Under these hypotheses, trade in capital goods allows a country to gain access to cheaper capital goods, which raises investment, output per worker and learning by doing.

There are some implications of the learning by doing models for convergence and the overall growth effects. In the case of national externalities, international trade induces the specialisation of a country, which in turn increases the size of production within the given country and augments the positive effect of externalities on its productivity and economic growth. In the case of global externalities, international trade does not affect the country's specialisation and convergence. In both cases, the overall growth rate of the integrated country increases because of international trade.

2.2.2.2 Research and development (R&D) models

In the models of R&D, knowledge accumulation is introduced as an activity carried out by profit maximising firms. The R&D models rely on a hypothesis that the knowledge externality is dynamic. The rationale behind the hypothesis of dynamic spillovers comes from two fundamental characteristics of knowledge. First, knowledge is a non-rival good. This means that the use of knowledge from research activity by one firm or person does not preclude its use by another one. Secondly, knowledge can be made excludable by means of legal protection. But, it is likely that excludability is usually imperfect; knowledge and ideas can be copied or adapted. Therefore, research activity by one firm or person may generate positive spillovers for others undertaking the same activity.

One important model that is considered as a theoretical background for examining the international transmission of technology transfer is that of Rivera-Batiz and Romer (1991). We provide a brief description of this model because it is the basic theoretical model used for empirical studies.

Rivera-Batiz and Romer examine two models, which refer to two channels for transferring technological knowledge. The first one is the knowledge-driven R&D model in which the transmission of ideas can be traded independently from goods. The second one is the lab equipment model in which trade of intermediate inputs incorporates new ideas.

Final goods are produced with human capital, unskilled labour, and intermediate inputs as follows.

$$Y = H^{\alpha} L^{\beta} \int_{0}^{A} x(i)^{1-\alpha-\beta} \, di \tag{2.19}$$

where A denotes the index of the most recently invented goods.

In the knowledge-driven model, new designs for intermediate inputs are produced by the research sector, at a rate given by:

$$\dot{A} = \delta H A \tag{2.20}$$

In the lab equipment model, the specification of new designs is assumed to be the same as in the production of final goods.

$$\dot{A} = B H^{\alpha} L^{\beta} \int_{0}^{A} x(i)^{1-\alpha-\beta} \, di \tag{2.21}$$

where B denotes a constant scale factor.

This specification indicates that human capital, unskilled labour, and intermediate goods are productive in research, and knowledge per se has no direct productive value.

The balanced growth equilibrium for each of the two specifications of new designs can be calculated in terms of two linear relations between the rate of growth and the interest rate. As shown in Appendixes A.1 and A.2, the interest rates from the knowledge-driven model and the lab equipment model are respectively as follows:

$$r = (\delta H - g) / \Lambda \tag{2.22}$$

where $\Lambda = \alpha(\alpha + \beta)^{-1} (1 - \alpha - \beta)^{-1}$

and $r = \Gamma H^{\varepsilon} L^{\beta}$ (2.23)

where $\Gamma = B^{\alpha+\beta} (\alpha + \beta)^{\alpha+\beta} (1 - \alpha - \beta)^{2-\alpha-\beta}$

The other balanced growth relation between the interest rate and the rate of growth captures dynamic consumer optimization (Ramsey preference). The individual's lifetime utility is assumed to take the form of:

$$U = \int_0^{\infty} \frac{C^{1-\sigma} - 1}{1-\sigma} e^{-\rho t} dt \tag{2.24}$$

where ρ is the discount factor and σ is the risk aversion factor.

Under balanced growth, the rate of growth of consumption is equal to the rate of growth of output. Thus, the interest rate from the consumer's first order conditions for intertemporal optimization is as follows:

$$r = \rho + \sigma g \tag{2.25}$$

The balanced rate of growth for an economy under the knowledge-driven model is calculated from the relation between r and g determined in equations (2.22) and (2.25).

$$g = (\delta H - \Lambda \rho) / (\Lambda \sigma + 1) \tag{2.26}$$

Similarly, the balanced rate of growth for an economy under the lab equipment model is derived from equations (2.23) and (2.25).

$$g = (\Gamma H^{\alpha} L^{\beta} - \rho) / \sigma \tag{2.27}$$

Now suppose that international flows of goods and knowledge between the two countries are allowed. In the knowledge-driven model, the stock of ideas that can be used in research is now twice as large as it was prior to trade.

$$\dot{A} = \delta H(A + A^*) = 2\delta A \tag{2.28}$$

The balance rate of growth now is:

$$g = (2\delta H - \Lambda\rho)/(\Lambda\sigma + 1) \tag{2.29}$$

Thus, international trade has two effects on the economy equilibrium rate of growth in the knowledge-driven model. On the one hand, the increase in the stock of ideas has a direct positive effect on the rate of growth of the research sector. On the other hand, because productivity in the research sector increases, the growth rate of the economy will rise. In this model, although trade in intermediate inputs has no effect on the economy growth rate, it has important level effects on final goods and economic welfare.

In the lab equipment model, knowledge is diffused internationally only if there is trade in intermediate goods since knowledge is embodied in these goods. International trade in intermediate goods expands the variety of inputs that may be used in research and increases the marginal product of labour in research. Again, there are two effects on the economy's rate of growth in this model. First, there is a direct positive effect from the increase in the productivity of research. Secondly, there is an indirect positive effect through the incentive to engage in research. However, due to the fact that ideas in themselves do not affect the productivity of research, international flows of ideas alone have no effect on an economy's rate of growth.

The two models by Rivera-Batiz and Romer (1991) imply that there are different mechanisms of technology diffusion, and the form of knowledge diffusion plays an important role in determining the rate of growth. However, Rivera-Batiz and Romer (1991) focus only on symmetric countries. If two countries are not symmetric, the country with a larger stock of accumulated knowledge will have a comparative advantage, and research will concentrate in the country with larger endowment of human capital.

Devereux and Lapham (1994) consider the effect of international trade in goods between dissimilar countries in the knowledge-driven model of Rivera-Batiz and Romer (1991). They show that if countries start from different initial stocks of knowledge, the country with a smaller stock of knowledge will stop doing research and specialise in the production of goods because trade in goods creates an incentive for itself. As a result, all research is undertaken in the country with the large initial stock of knowledge. Devereux and Lapham then argue that the finding of Rivera-Batiz and Romer in the knowledge-driven model that international trade in goods per se does not affect the rate of growth is not robust. It holds only in the knife-edge case where pre-liberalisation stocks of knowledge are exactly equal across countries. Thus, trade in goods alone increases as long as there are even slight differences in the initial levels of national income between countries. These findings reinforce the importance of trade in goods and comparative advantage in the process of technology diffusion and economic growth when two countries integrate with each other.

In another study, Grossman and Helpman (1991) extend the framework of Rivera-Batiz and Romer (1991) to the case of asymmetric countries and the case in which there is more than one final good. In the Grossman and Helpman model, inputs are differentiated horizontally, and output is produced from an assortment of intermediate inputs with a greater number of inputs associated with more specialisation and refinement of each stage of production. A production function is as follows:

$$X = \left[\int_0^n z(j)^\alpha \, dj \right]^{1/\alpha} \quad , \qquad 0 < \alpha < 1 \tag{2.30}$$

where X and z denote final output and the inputs of intermediate good j; n is the number of intermediates employed.

Grossman and Helpman consider knowledge flows between two countries indexed by i, $i= A, B$. These countries have the same technologies for developing new blueprints and intermediate goods, but different sizes of their labour force ($L^A \geq L^B$). Two countries share common preferences and a common discount rate, ρ.

As shown in Appendix A.3, the long-run rate of innovation in the steady state satisfies the following:

$$(1-\alpha)\, V^i = \rho + g^i \tag{2.31}$$

where V is the aggregate value of innovations, g is the rate of innovation.

Equilibrium in the labour market requires:

$$g^i + \alpha\, V^i = \frac{L^i}{a} \tag{2.32}$$

where L represents the aggregate labour force.

Combining (2.31) and (2.32), the long-run rate of innovation in a closed economy is as follows:

$$g^i = (1-\alpha)\, \frac{L^i}{a} - \alpha\rho \tag{2.33}$$

Now suppose that international trade takes place between the two countries. Researchers in each country now learn not only from the R&D projects undertaken locally, but also from those that are carried out abroad. It is straightforward to derive the long-run rate of innovation in the world economy with international knowledge spillovers.

$$g^{i} = (1-\alpha)\frac{L^{A} + \varphi L^{B}}{a} - \alpha\rho \qquad (2.34)$$

where φ is the fraction of products available in country A that are not available in country B.

By comparing (2.33) and (2.34), Grossman and Helpman show that international spillovers stimulate innovation and growth in both countries. In each country, the rate and level of innovation produced under trade is larger than that of innovation experienced under autarky. In particular, international trade expands not only the range of intermediate inputs available to a producer of final goods, but also provides access to the general knowledge generated abroad.

Another finding from this model is that benefits from international trade are attenuated by any duplication of research effort. It is clear from equation (2.34) that the smaller the extent of overlap in the research project of the two countries (i.e. the greater the φ), the higher the common long-run rates of innovation and growth.

The Grossman and Helpman (1991) model has an implication for developing countries. If developing countries engage in international trade with developed countries, they will obtain a greater variety of intermediate inputs and knowledge, and therefore grow faster than they otherwise would. In other words, international trade may help raise the growth rates of developing countries.

In the models of Rivera-Batiz and Romer (1991), and Grossman and Helpman (1991), the effects of technology spillovers on growth are considered under steady-state conditions. Barro and Sala-i-Martin (1997) address this issue by introducing a model to analyse transitional paths and conditional convergence. The key element in their model is that imitation is typically cheaper than invention. Therefore, they argue that technology is diffused from a leading country, an innovator, to a follower country, an imitator. They show that the world growth rate in the long run is determined by inventions in the leading countries. The follower countries converge towards the leading countries because imitation and implementation of inventions are cheaper than innovation. They also show that this mechanism tends to generate a pattern of conditional convergence, as a tendency of an increase in copying costs reduces the growth rate of the follower country.

More recently, the framework of R&D models of growth has been extended to study the spatial dimension of economic development by merging endogenous spatial agglomeration and endogenous growth models. Martin and Ottaviano (2001) construct a model in which aggregate growth and spatial agglomeration are jointly determined. In their model, agglomeration fosters growth by making it possible to pay a lower price for an identical amount of intermediate inputs necessary for research. More specifically, if R&D activities use goods from imperfectly competitive industries as inputs, these industries will be attracted towards the location where the R&D activities take place. Due to the presence of transaction costs, this in turn lowers the cost of innovation and promotes the incentives to innovation and growth. This model implies that geography is a channel, through which trade can affect growth.

Baldwin and Forslid (2000) consider how agglomeration affects growth by extending the core-periphery model of Krugman (1991) with endogenous growth. They show that the presence of knowledge spillovers in the R&D sectors introduces growth linkage as a factor of circular causation that determines agglomeration. In their model, the integration of the R&D process is viewed as a lowering of the cost of trading information and goods. As a result, a reduction of the transport costs may not only increase concentration of all economic activities, but also guarantee a higher equilibrium rate of growth of total output for the global economy.

2.2.2.3 Comparing different types of models on endogenous growth, trade and technology, and their implications

We have examined two types of technological progress: learning by doing and R&D activities. These two types of technological progress affect the production and economic growth of an economy in different ways. On the one hand, models describing different types of technological progress vary a lot in terms of the underlying preferences, market structures, production technology, features of the research sector, the extent of technology spillovers, the role of trade, and so on. On the other hand, the growth rate of an economy is often measured in different ways. In some models, the growth rate of an economy is represented by the growth rate of per capita income or the growth rate of output. In other models, the growth of the number of varieties and the growth rate of the utility of a representative consumer are considered as measures of the growth of the economy. Consequently, the results obtained also vary a lot. Moreover, international trade affects technological progress and economic growth of an economy in different ways. For models on learning by doing, trade does not affect international knowledge spillovers. For R&D models, international trade induces an increase in the variety of intermediate inputs and knowledge, and therefore helps to raise the growth rate of an economy.

Although these models differ in their measures and economic interpretations, they have similar mathematical expressions, especially the expression for the growth rate of an economy. Specifically, the growth rate of the economy in a steady state can be measured as an increasing function of the employment engaged in the research activity.

These endogenous models have three major implications for the economic growth of the economy. The first implication is that endogenous growth theory points out the important role of technological progress in economic growth and income difference across countries. Romer (1990) shows that improvement in technology is the fundamental source of growth that makes output per hour worked in the US today 10 times as valuable as it was 100 years ago. Keller (2001) mentions that the fast development in new information and communication technologies is the reason to explain why the United States lead in per capita income over Japan has increased from 10% in 1990 to 20% by 1999.

The second implication is that an increase in the size of the R&D sector will increase the growth rate of the economy. This effect is called the scale effect of R&D and comes from the idea that the bigger the knowledge base, and the more resources devoted to research, the easier it is to accumulate more knowledge, and the higher the economic growth. However, existing empirical evidence does not support the implications of scale effects of R&D. Jones (1995a, 1995b) uses aggregate data on R&D inputs to test R&D based endogenous growth models in industrialized countries and finds no evidence of a relation between the growth rate of output and the relevant scale variables. Jones (1995a) shows that the growth rates in the US and other OECD countries are not proportional to economy-wide R&D investment in these countries. Using more sophisticated econometrics, Jones (1995b) further shows that while R&D input, measured by the number of scientists and engineers in the US, grows by more than five times from 1950 to 1998, the growth of productivity for the same period is constant or even negative.

Another implication of R&D models is the role of R&D spillovers in an international context. Coe and Helpman (1995) use a sample of OECD countries to examine the relation between international R&D spillovers and economic growth. They define foreign R&D capital stocks as the import share-weighted average of trade partners' domestic R&D capital stocks. Coe and Helpman find evidence that international R&D spillovers are an important source of productivity. In particular, the productivity level in a country is associated with past R&D investments of close trading partners, and international R&D is more important for small countries. Keller (1998) addresses the problem of foreign R&D measure in the study of Coe and Helpman, and calculates trade weights by considering only imports of machinery used in production in a given industry. Keller finds similar results that foreign R&D stocks have significant and positive effects on productivity. Coe, Helpman, and Hoffmaister (1997) confirm these results in their analysis of foreign R&D spillovers and economic growth in 77 developing countries. They also point out that openness to and trade with developed countries are key channels for developing countries to obtain access to foreign R&D. These three studies provide empirical evidence to reflect the role of R&D spillovers developed in the models of Rivera-Batiz and Romer (1991), and Grossman and Helpman (1991).

2.3 FDI and Technology Spillovers

2.3.1 Theoretical models on FDI and technology spillovers

Among the different ways of modelling international technology diffusion, technology transfer via foreign direct investment is an important research agenda. The literature on the role of FDI in technology transfer and its effects on the economic growth of host countries focuses on two distinct processes in international technology transfer. The first one is technology transfer from the parent firm of a multinational company to its subsidiary abroad. The second is technology transfer in the form of an externality from the subsidiary to domestic firms.

Koizumi and Kopecky (1977) are the first to explicitly model FDI and technology transfer. They develop a model of international capital movements and technology transfer in a small open economy context to analyse the role of international technology transfer. In their model, technology transfer is assumed to take place when foreign capital creates an externality in technology to the host country. Specifically, the technology level of the host country is assumed to be an increasing function of the stock of foreign capital per capita. Foreign capital and domestic capital are physically the same but foreign capital imparts spillovers in the form of technological transfers. As a result, while foreign capital and domestic capital are paid at the same world interest rate, the social marginal productivity of foreign capital is higher than that of domestic capital. They find that an increase in the savings rate of the country would reduce foreign capital and its steady state capital intensity through its effect on technical efficiency.

Findlay (1978) develops a model of international technology transfer by international corporations to examine the relationship between FDI and technology change in a backward region. In his model, the rate of technological diffusion to the backward country is assumed to depend on two factors, which are called the "relative backwardness" and the "contagious effect". The hypothesis of relative backwardness, which was introduced by Gerschenkron (1962), states that the larger the gap in development levels between advanced and backward countries, the faster the rate at which the backward country can catch up in technology. Findlay puts forward this hypothesis and shows that the rate of technological progress in the backward country is an increasing function of the technology gap between it and the advanced country. The contagion idea, following Arrow (1962), stresses the importance of personal contacts. That is, advanced technology is most efficiently diffused when there is personal contact between those who already have the technology and those who eventually adopt it. With the effect of contagion, Findlay argues that the rate of technology change in the backward country increases proportionally to the extent to which it opens up to FDI. This extent is measured by the ratio of foreign-owned capital stock to domestic-owned capital stock. He considers the effects of changes in various parameters in the steady state and shows that the economy approaches the steady state where it grows at the rate equal to the exogenous growth rate of foreign technology.

Das (1987) uses a price-leadership model from oligopoly theory to examine technology transfer from the parent firm to its subsidiary abroad. Domestic firms learn from subsidiaries and become more efficient. In her model, a domestic firm's production efficiency is assumed to be an increasing function of the level of activities of the subsidiaries. The larger the level of a subsidiary's operation, the greater the opportunity for the domestic firm to learn from it.

In another study, De Mello (1997) provides a model in which the existence of foreign direct investment creates externalities in the stock of technology of the host country. The stock of technology (H) is assumed to be a function of foreign-owned and domestic-owned physical capital stock.

$$H = \left[k_d \, k_w^{\alpha}\right]^{\eta} \qquad (2.35)$$

where α and η are the marginal and the intertemporal elasticities of substitution between foreign and domestic owned capital stocks.

A general growth accounting equation in this model is defined as follows

$$g_y = g_A + [\beta + \eta(1-\beta)]g_d + [\alpha\,\eta(1-\beta)]g_w \qquad (2.36)$$

By equation (2.36), De Mello argues that the effect of FDI on the growth performance of the host country is manifold. In his model, FDI is found to be a growth-determining factor where a higher growth rate of the economy is associated with a higher level of FDI.

In the models of Koizumi and Kopecky (1977), Findlay (1978), Das (1987) and De Mello (1997), the advanced technology introduced by foreign firms is considered under the assumptions that it naturally is a public good and transferred automatically. However, as argued by Fan (2002, p6), "the growing importance of international patent agreements and the licensing of technology suggest that technological knowledge is frequently a private rather than a public good, and that technology can rarely be automatically transferred". As a result, these models do not raise or deal adequately with the issue of interaction between foreign subsidiaries of multinational firms and host country firms.

Wang and Blomstrom (1992) construct a model in which international technology transfer is examined in a game theory context. In particular, technology transfer in this model is assumed to be a process by which foreign subsidiaries of multinational firms obtain foreign technology, which is subject to diffusion to domestic firms. Both foreign subsidiaries and domestic firms solve their individual dynamic optimization problems subject to the others' action. The strategic decisions between firms then determine the rate of technology transfer. The model also shows that technology transfer via foreign direct investment is positively related to the level and cost efficiency of the domestic firm's learning investment.

More recently, Borensztein, Gregorio and Lee (1998) propose a model to address the question of how foreign direct investment affects the economic growth of developing countries through technology diffusion. Their model is based on the idea that the economic growth rates of developing countries are partly explained by a "catch- up" process in the level of technology. In particular, the extent of adoption and implementation of new technology that is already in use in leading countries will determine the economic growth rate of the developing country. In their model, technological progress takes the form of new types of intermediate goods introduced by foreign firms and available in the developing country. The existence of FDI lowers the cost of introducing new technology and thus raises the rate of technological changes and economic growth in the developing country.

The Borensztein et al. (1998) model considers the role of FDI in the process of technology diffusion and economic growth in developing countries. We now provide a full description of this model, as it is the theoretical background for the empirical studies in the thesis.

The model is based on the concept of an increase in the number of varieties of capital goods as in Romer (1990), Grossman and Helpman (1991), and Barro and Sala-i-Martin (1997). The production function of a developing country is as follows:

$$Y_t = A L_t^{\alpha} H_t^{\beta} X_t^{1-\alpha-\beta} \quad (2.37)$$

Where Y is output, A is a scalar productivity parameter denoting various control and policy influencing the level of productivity in the economy, L and H denote labour and human capital respectively, and X denotes physical capital that consists of a composite of different varieties of capital goods.

$$X = \{ \int_0^N x(j)^{1-\alpha-\beta} \, dj \}^{\frac{1}{1-\alpha-\beta}} \tag{2.38}$$

where $x(j)$ denotes each type of capital good; N is the total number of varieties of capital goods in the developing country. The domestic firms produce n varieties out of the total number N and the foreign firms produce n^* varieties.

$$N = n + n^* \tag{2.39}$$

Let F denote a setup cost when a new type of capital good is utilised in production. Thus, if the new capital comes from foreign countries, F may represent the cost of imitating or adapting the new capital.

Assume that the developing country, in imitating, begins with the easiest and cheapest invention that exists in developed countries, then F will increase with the increase in the number of capital varieties in the developing country (N) compared with that of developed countries (N^*).

$$\frac{\partial F}{\partial (N / N^*)} > 0 \tag{2.40}$$

This assumption is consistent with the fact that it is cheaper to imitate a product already in existence for some time than to create a new product at the frontier of innovation. Therefore, the level of technology of the developing country is the result of an increase in the number of capital goods that is invented in developed countries.

It is also assumed that $F(N/N^*) = 0$ is too small to encourage imitation in the country, and $F(N/N^*) = 1$ is large enough to discourage adoption or encourage imitation.

Also, assume that the setup cost depends negatively on the ratio of the number of capital goods produced by foreign firms operating in the country to the total number of capital goods (n^*/N). This means:

$$\frac{\partial F}{\partial (n^* / N)} < 0 \tag{2.41}$$

This assumption can be explained in many ways. First, the presence of foreign investors in the host country may motivate firms' imitation activities in the host country through demonstration, thereby reducing information costs. This is because new technology generally requires demonstration in the local environment before it can be transferred effectively (Findlay, 1978). Secondly, foreign investors are more familiar with their invention and hence may be better suited than local investors in adapting their invention in foreign countries. Thus, by making it easier to adopt the technology necessary to produce new capital varieties, foreign direct investment is considered as a channel of technology diffusion in this framework.

Let $m(j)$ denote the marginal product of each variety of capital goods.

$$m(j) = A(1-\alpha-\beta)\, L^{\alpha}\, H^{\beta}\, x(j)^{-\alpha-\beta} \tag{2.42}$$

The flow of revenues for the producer of a new variety of capital j is:

$$P = \int_{t}^{\infty} \{m(j)\, x(j) - x(j)\}.\, e^{-r(s-t)}\, ds \tag{2.43}$$

The profits for the producer from sales of a new variety of capital j are:

$$\Pi = -F(n^* / N, N / N^*) + \int_{t}^{\infty} \{m(j)\, x(j) - x(j)\}.\, e^{-r(s-t)}\, ds \tag{2.44}$$

Maximising (2.44) subject to equation (2.42) gives

$$A\,(1-\alpha-\beta)^2\; L^{\alpha}\; H^{\beta}\; x(j)^{-\alpha-\beta} = 1 \tag{2.45}$$

Rearranging (2.45) generates the following equilibrium level for the production of each capital good *x(j)*:

$$x(j) = A^{1/\alpha+\beta} L^{\alpha/\alpha+\beta} H^{\beta/\alpha+\beta} (1-\alpha-\beta)^{2/\alpha+\beta} \tag{2.46}$$

Substituting (2.46) into (2.42) and rearranging the result we have:

$$m(j) = 1/(1-\alpha-\beta) \tag{2.47}$$

We assume that there is free entry and hence profits are equal to zero. This means:

$$F(n^*/N, N/N^*) = \{m(j)\,x(j) - x(j)\}.\int_t^{\infty} e^{-r(s-t)}\,ds = \frac{\{m(j)\,x(j) - x(j)\}}{r} \tag{2.48}$$

(Because of the limited space, the proof of $\int_t^{\infty} e^{-r(s-t)}\,ds = \frac{1}{r}$ is shown in Appendix A.4)

Substituting (2.47) into (2.48) gives:

$$F(n^*/N, N/N^*) = \frac{\{(1/(1-\alpha-\beta) - 1).\,x(j)\}}{r} \tag{2.49}$$

Substituting (2.46) into (2.49) and rearranging the result, we have

$$r = (\alpha+\beta)(1-\alpha-\beta)^{(2-\alpha-\beta)/(\alpha+\beta)}\; A^{1/(\alpha+\beta)}\; F(n^*/N, N/N^*)^{-1}\; L^{\alpha/(\alpha+\beta)}\; H^{\beta/(\alpha+\beta)} \tag{2.50}$$

A representative household receives income from working wage and/or interest on rented assets and uses this income to purchase consumption goods and/or accumulate the assets. Each individual maximizes the following standard intertemporal utility function:

$$U_t = \int_t^{\infty} U(c)\,.\,e^{-\rho(s-t)}\,ds \quad \text{where} \quad U(c) = \frac{c^{1-\sigma} - 1}{1-\sigma} \tag{2.51}$$

subject to the income flow constraint:

$$\dot{a} = w + ra - c \qquad (2.52)$$

where a is the net assets of the individual under consideration; w and r are the wage rate and interest rate on rented assets respectively; ρ is the rate of time preferences; c is consumption. A positive value of ρ implies that an individual values future utility less than current utility.

The optimal consumption path is:

$$g(c) = \frac{\dot{c}}{c} = \frac{r - \rho}{\sigma} \qquad (2.53)$$

In a steady state equilibrium, the rate of growth of output is equal to the rate of growth of consumption. This means $g(c)=g(Y)$ (2.54)

Then, substituting (2.50) into (2.53) and using (2.54), we get:

$$g(Y) = \frac{1}{\sigma}[(\alpha+\beta)(1-\alpha-\beta)^{(2-\alpha-\beta)/(\alpha+\beta)} A^{1/(\alpha+\beta)} F(n^{*}/N, N/N^{*})^{-1} L^{\alpha/(\alpha+\beta)} H^{\beta/(\alpha+\beta)} - \rho] \qquad (2.55)$$

Equation (2.55) shows that the set up cost F is negatively related to the fraction of products produced by foreign firms in the total number of products (n^*/N), which is alternatively measured by the ratio of FDI to GDP. The theoretical positive impact of FDI on economic growth in equation (2.55) can be explained in the way that FDI reduces the costs of introducing new capital goods in the host country. In addition, countries that produce fewer varieties of capital goods than leading countries (lower N/N^*) have a lower cost of adoption of technology and tend to grow faster. In other words, a developing country can promote economic growth by increasing a variety of capital goods adopted from developed countries. The result also indicates that growth rate is positively related to human capital and labour force.

In addressing the question of how FDI affects local firms in the same industry, Markusen and Venables (1999) propose a model in which profits of local firms are explained by the effects of competition and backward linkages generated from FDI. On the one hand, the entry of foreign firms may increase the level of competition in the home country, which in turn reduces profits of local firms. On the other hand, FDI may lead to the establishment of backward linkages between foreign firms and local suppliers. Then, the linkages may reduce input costs and raise profits of domestic firms. This model provides a theoretical framework to assess the effects of technology spillovers via FDI at firm level.

2.3.2 Comparing the theoretical models on FDI and technology spillovers, and their implications

All the models focusing on FDI and technology spillovers have a common characteristic in terms of technology spillovers. Technology spillovers through FDI are in the form of an externality from multinational firms to local firms in the host country. In particular, technology is first transferred from multinational firms to their subsidiary abroad, and it is then diffused from the subsidiary to domestic firms.

However, these models differ in their interpretation of technology. In some models, technology introduced by foreign firms is assumed as a public good and therefore it is transferred automatically. As a result, a host country's production function efficiency is measured as an increasing function of the presence of foreign firms in these models. In other models, foreign technology is considered as a private good, and the adoption of new technology is costly. Consequently, the extent of technology transfer depends on the capacity of local firms and their interaction with foreign firms.

Based on these models, many empirical studies have used data at both national level and firm level to consider FDI as a mechanism of technology spillovers. The empirical results so far are inconclusive.

At the national level, Blomstrom et al. (1992) study the effect of FDI on economic growth of 78 developing countries, using data from 1970 to 1990. They find that FDI by multinational enterprises is positively associated with per capita income growth in the long run via technological upgrading and knowledge spillovers in those countries. Lichtenberg and Pottelsberghe (1996) examine the importance of FDI for technology spillovers in 13 OECD countries by adding both inward and outward FDI flows as additional channels of technology diffusion to the approach that Coe and Helpman (1995) and Keller (1998) use for trade. They find that a country's outward FDI is a channel for foreign technology in these countries. However, inward FDI does not contribute to the technology transfer in this study.

With the increasing availability of micro data, the study of FDI and technology transfer has increasingly turned to it. Aitken and Harrison (1999), using data on Venezuelan firms from 1976 to 1989, find that an increase in foreign ownership in an industry negatively affects productivity of domestic plants in the same industry. Similar results are found in studies on transition economies (Djankov and Hoeckman, 1998 on Czech; and Konings, 2001 on Bulgaria and Romania). In contrast, several studies find positive spillovers in the more developed countries such as the UK (Haskel et al., 2002) and the US (Keller and Yeaple, 2003). Recent studies on technology transfer through vertical linkages between foreign firms and domestic ones find strong evidence on the existence of technology spillovers (Blalock and Gertler, 2002; and Smarzynska, 2004). The findings from these studies are also consistent with the idea suggested by the above theoretical models that the extent of technology spillovers depends on the linkages between domestic firms and foreign firms.

2.4 Determinants of Technology Transfer

A different stream of the literature considers the different effects of technology adoption on the rates of growth across countries. This type of models is particularly suited to studying the determinants of technology adoption.

In a short paper in 1966, Nelson and Phelps introduce a new hypothesis of the role of human capital in technological diffusion. They formulate the change in the level of technological implementation in a country as follows:

$$\frac{\dot{A}(t)}{A(t)} = \phi(H(t)) \frac{T(t) - A(t)}{A(t)} \qquad (2.56)$$

where *A(t)* is level of technology in practice in the country in year *t*, *T* is the theoretical level of technology that is defined as the best practice level of technology that would prevail if technological diffusion were completely instantaneous, and *H* is level of human capital.

With this formulation, Nelson and Phelps argue that the rate of technology adoption depends on the technology gap between the leading country and the follower country. They also show that the rate at which the technology gap narrows depends on the level of human capital. In other words, the greater the rate of return to education, the more technologically progressive is the economy.

Wang (1989) develops a model of firm-level technology adoption in a developing country. The technology level of a firm in the country (*z*) is as follows:

$$z_{t+1} = z_t + I_t + \tau(I_t, \bar{g}_t) z_t \qquad (2.57)$$

where I_t denotes the amount of R&D expenditures, g_t is technology gap, $\tau(I_t, g_t)$ is a function that represents the capability of absorption. $\bar{z}_t$ is the size of technology level of the firm that is determined by the size of foreign existing technology and other factors influencing technology diffusion such as the degree of economic integration.

In this model, Wang shows that $\frac{\partial \tau}{\partial I_t} > 0$ and $\frac{\partial \partial \tau}{\partial g_t \partial I_t} > 0$. This implies that the absorptive capability of the firm increases with the amount of its own R&D, and the effect of its own R&D increases with the size of the technology gap.

Cohen and Levinthal (1989) consider many theoretical implications of the dual role of R&D. They argue that R&D not only generates new technologies, but also enhances a firm's ability to adopt existing technologies. Therefore, learning and technology adoption are affected by the characteristics of knowledge inputs. They also show that an innovation, which is purely capital-embodied, is less costly to adopt than a more disembodied innovation that requires more complementary internal effort and more pre-existing expertise in an area.

A further aspect of absorptive capacity has been emphasized in the literature recently. Parente and Prescott (1994) construct a model to explain the wide disparity in income per capita across countries. They consider the production function of a country as follows:

$$y = A.k^{\alpha} \qquad (2.58)$$

where y, k, and A are output per worker, capital per worker and technology level respectively.

In this model, they assume that the level of technology in the country depends on investment and the level of its technology relative to the level of world knowledge. In other words, the technology is not constant, but it varies through time and is defined as follows:

$$A = f(X)\left(A - \overline{A}\right) \tag{2.59}$$

where $f(X)$ is an increasing and bounded function, X is a set of exogenous variables, and $\overline{A}$ is the average level of world knowledge.

From equation (2.59), they argue that technological asymmetry between countries can be explained by the difference in the endowment of the factors in X. Countries with higher levels of capital and output per worker have a higher level of technology. Moreover, the rate of growth of output per worker is an increasing function of the distance between the country's technology and the world frontier.

Eaton and Kortum (1996) develop a model of technology diffusion and growth based on an R&D model of endogenous growth. In their model, the world level of knowledge is not exogenous and depends on the research activities of each country and on the degree of international knowledge diffusion. They show that the level of productivity of each country is determined by its ability to adopt new inventions. However, spillovers in R&D eventually bring countries to the same rate of growth. This implies that the productivity level is better than the growth rate in reflecting a country's ability to adopt new technology.

A similar result is obtained by Brecher, Choudhri and Schembri (1996), who build a model of monopolistically competitive industry in which the productivity of a country is determined by both national and international spillovers of knowledge. They show that in the long run, the growth rate of productivity is the same in each country, although the level of productivity can be lower in the smaller country. They also incorporate the role of openness into the model and show that spillovers of knowledge across international borders depend on the extent to which countries are open to international trade and FDI. The more open the countries, the greater the scope for international spillovers.

Basu and Weil (1998) introduce a model of appropriate technology. In their model, new technologies can only be implemented successfully by countries with the appropriate portfolio of endowments. In particular, a follower country can use the technology of a leading country if it has a sufficiently high level of development at which this technology is appropriate to its needs. They also show that technology spillovers are usually not symmetric between countries. A country that is the technology leader benefits less than its followers benefit from it.

In another line of interest, Parente and Prescott (1999) construct a model to explain why some countries do not adopt leading edge technologies. In their model, monopoly power is considered as the main institutional factor that acts as a barrier to adoption of foreign technologies. In particular, adopting new technologies depend on the monopoly power of endogenous rent-seeking coalitions of incumbent firms. In the absence of these monopoly rights, groups have no incentive to block the use of new technologies, and production is therefore efficient. This implies that more competitive economies are likely to benefit from spillovers to a larger extent, given that the presence of monopolies is the same.

Howitt and Mayer-Foulkes (2005) provide a model of R&D, implementation and stagnation, based on Schumpeterian growth theory, that considers the growth rate within three groups of countries: those carrying on leading edge R&D, those implementing efficiently the leading edge technologies developed abroad, and those implementing inefficiently the same leading edge technologies. This specification is based on the initial skill level of a country. Within this framework, they show that countries in the first two groups grow at the same rate in the long run as a result of technology transfer, but inequality of per capita income between these two groups increases during the transition to the steady state. Countries in the third group experience a slower rate, with relative incomes that fall asymptotically to zero. This suggests that economic policy aimed at fostering technology transfer should focus on skill acquisition and human capital investment.

Many empirical studies provide strong evidence on the role of human capital, R&D activity, technology gap, and other factors in technology transfer. Benhabib and Spiegel (1994), and Foster and Rozenzweig (1995) use cross-country data to investigate the Nelson-Phelps hypothesis and conclude that technology spillovers flow from leaders to followers and the rate of flow depend on levels of education. The empirical studies of Eaton and Kortum (1996), and Xu (2000) also confirm that human capital is a necessary condition for successful technology adoption.

Griffith, Reading, and Van Reenen (2000a,b) use industry-level data from 12 OECD countries from 1974 to 1990 to examine the importance of indigenous R&D in facilitating technology from abroad. They show that technology gap, which is measured by the difference between total factor productivity (TFP) of a given country and TFP of the leader country, is negatively related to TFP growth. In addition, the interaction between R&D and the technology gap is negative and significant. This implies that R&D enables a country to reduce the technology gap with the leader country and adopt foreign technology successfully. Kinoshita (2000) finds a similar result in the case of the Czech Republic. In particular, the effect of technology diffusion through FDI is conditional on a relatively high absorptive capacity of the country, which is measured by its own R&D investments.

2.5 Conclusion

In this chapter, we have surveyed the major models and issues of international trade, FDI, technology transfer and growth. The main conclusion coming from the theoretical literature surveyed is that international trade and FDI play a key role in technology transfer and economic growth. The models presented in this chapter have explained differences in technology adoption across countries by differences in technology gap and absorptive capacity measured by human capital or R&D activities. The literature on trade, FDI and technology transfer, with its diversity of results, suggests that no simple implication should be made without an understanding of the structure and the key characteristics of the country under consideration.

It is clear that the theoretical literature so far has improved our understanding of some channels and characteristics of technology transfer. The ways in which technology transfer through trade and FDI are modelled, however, still lack necessary empirical evidence to identify the actual mechanisms of technology transfer. Existing empirical studies on technology transfer focus more on developed countries than on developing countries, while the potential effects of technology transfer and better policy recommendations are far larger for the latter group. In addition, only a few of the technology spillover studies on developing countries have been undertaken for economies, which have little resemblance to the dynamic and export-oriented economies of East Asia. Therefore, more empirical analyses of technology transfer through trade and FDI for developing countries like Vietnam are still required. This is the subject of the subsequent chapters.

Chapter 3
Trade, FDI and Technology Transfer in Vietnam: A Provincial Level Analysis

3.1 Introduction

The theories of economic growth have identified technology improvement as a major driving force for economic growth. Technology improvements not only benefit the inventors but also contribute to the knowledge base which is publicly available. With the rapid development of economic integration in recent years, an increase in a country's economic growth depends not only on its domestic technology, but also on foreign technology through its interaction with foreign countries. Recent works by Keller (2001), and Klenow and Rodriguez (2004) have shown that the variations in international productivity are mainly explained by the differences in technological investment rates. They also find that countries benefit enormously from international technology transfer. International technology transfer facilitates domestic inventive activities and hence promotes economic growth.

As technology is a driving force for economic growth, a question of particular interest is: Through which channels does technology diffuse across countries? Although it is widely accepted that trade is an important channel for technology transfer (e.g., Grossman and Helpman, 1991; Coe and Helpman, 1995), it is still not clear whether or not it is the most important one. FDI is well examined as a channel of technology transfer in theoretical models (e.g., Borensztein et al. 1998; Markusen and Venables, 1999), but empirical studies provide mixed results. One shortcoming of the empirical literature is that researchers seldom examine technology diffusion in developing countries and they do not distinguish between the different effects of technology diffusion from developed countries and developing countries, via trade and FDI. Another issue of interest is to answer the question of what are the determinants of technology diffusion? Although the theoretical models for the determinants of technology transfer are developed, few empirical studies have explored this issue.

This chapter begins to examine the role of international trade and foreign direct investment as channels for foreign technology diffusion in Vietnam using aggregate provincial level data. The chapter is a first step in seeing the extent to which the themes set out in chapter 2 apply to Vietnam. In particular, we test the relative importance of trade and FDI to technology transfer and decide which is the more effective one. The similarities and differences between technology transfer from OECD countries and non-OECD countries to Vietnam are also investigated in this chapter. In addition, the major determinants of technology transfer in Vietnam are examined.

The remainder of the chapter is organised as follows. Section 3.2 provides a brief review of the Vietnamese economy and the role of trade and FDI in technology in the last twenty years. Section 3.3 reviews the literature on channels and determinants of technology transfer. The empirical tests and results of the effects of trade and FDI on technology transfer and economic growth in Vietnamese provinces are obtained in section 3.4. Section 3.5 empirically analyses the determinants of technology transfer at provincial level. Section 3.6 concludes the chapter.

3.2 Technology Transfer in Vietnam

3.2.1 The Vietnamese economy in the last two decades

The development of the Vietnamese economy can be divided into two stages: before and after 1986. Before 1986, Vietnam was a centralised economy, in which the government determined all economic policies and economic targets. Until the mid-1980's, the legacy of the wars and the central planning regime had led Vietnam to severe macroeconomic problems with widespread rural hunger and underdevelopment in almost all fields of the economy[1].

Since 1986, the government of Vietnam has carried out structural and institutional reforms that encompass the promotion of the domestic private and foreign sectors, liberalisation of prices and trading, improvement in fiscal and monetary policies and decollectivisation of agriculture. After twenty years of renovation, Vietnam has obtained significant economic improvement in all sectors and provinces of the country, despite the adverse influence of the Asian financial crisis in 1997. The average of annual GDP growth rates during the 1990s was 7% and GDP per capita in 2000 was double that in 1990 (World Bank, 2002). Since 1990 export has increased at the rate of over 30% annually, and poverty rate reduced from 70% in the end of the 1980s to 37% in 1998 (Le, 2005).

As well as reform in sectoral polices, the Vietnamese government carried out a macroeconomic stabilisation program that was based on a stabilisation-cum-liberalisation concept. Within this program, inflationary financing by the state bank had ceased in order to alleviate the dangers of generating inflation. Inflation has

[1] GDP per capita was approximately 290 USD in 1985, GDP growth rate was about 2-3% while inflation was at the recorded level of 287.8% annually in the period 1985-1988 (World Bank, 2001). Seven out of every ten Vietnamese were estimated to live in poverty (World Bank, 1999).

been cut to less than 10% since 1995 as a consequence of contractionary fiscal and monetary policies (Table 3.1).

Table 3.1: Macroeconomic Indicators of Vietnam

Year	Growth rate of GDP	Growth rate of GDP per capita	Inflation (GDP-deflator)	Exchange rate (VND per US$)
1986	2.78	0.43	398.1	-
1987	3.58	1.06	362.5	-
1988	5.13	2.62	411.1	-
1989	7.36	4.85	69.7	-
1990	5.10	2.83	42.1	6,483
1991	5.96	3.75	72.5	-
1992	8.64	6.46	32.6	-
1993	8.07	5.98	17.4	10.641
1994	8.83	6.81	16.9	11,045
1995	9.54	7.58	17.0	11,038
1996	9.34	7.39	8.7	11,033
1997	8.15	6.48	6.6	11,706
1998	5.76	4.29	8.8	13,297
1999	4.77	3.42	5.7	13,944
2000	6.78	5.41	3.4	14,170
2001	6.89	5.59	1.9	14,725
2002	7.04	5.80	4.1	15,280
2003	7.24	6.07	5.3	15,517

Source: World Bank, 2004; IMF, 2003.

The exchange rate has been maintained at relatively stable levels during the 1990s despite the Asian financial crisis in 1997-1998. Exchange rates were depreciated to be equal to the parallel market rate in 1992 and were maintained stable henceforth. In addition, export revenue, official development aid (ODA), and FDI disbursement played cental roles in controlling the balance of payment deficit and reducing pressures for depreciating the Vietnamese Dong (VND). The exchange rate regime was a crawling peg during 1990s.

3.2.2 Trade, FDI and technology transfer in Vietnam

3.2.2.1 Trade and technology transfer

Technology transfer through trade in Vietnam has been undertaken by imports of machinery and equipment. As can be seen from Table 3.2, capital goods imports were volatile during the 1986-1992 period and collapsed in 1991 due to the collapse of the Soviet bloc, cutting Vietnam off from its major source of international trade and technical assistance. During the period 1986-1992, capital goods imports accounted for a small share of GDP. Since 1992 Vietnam has carried out trade reforms, which open itself to the world and allow the country to integrate to international organizations. Thus, capital goods imports have increased dramatically and played an important role in technology transfer. Capital goods imports accounted for around 30% of total import during the period 1993-2003 (Table 3.2).

Table 3.2: Capital goods imports of Vietnam, 1986-2003

Year	Total imports of capital goods			
	Value Million US$	Growth rate	As % of GDP	As % of total imports
1986	704.2	-	6.17	32.67
1987	801.3	13.78	6.80	32.63
1988	631.7	-21.17	5.09	22.91
1989	620.7	-1.73	4.66	24.19
1990	741.8	19.50	5.30	26.95
1991	450.1	-39.32	3.03	19.24
1992	471.7	4.82	2.93	18.56
1993	1,324.4	180.73	7.61	33.75
1994	1,996.0	50.70	10.54	34.26
1995	2,343.3	17.40	11.30	28.73
1996	3,400.3	45.10	14.99	30.51
1997	3,432.6	0.95	13.99	29.61
1998	3,487.3	1.59	13.44	30.32
1999	3,452.7	-0.99	12.70	29.40
2000	4,711.0	36.44	16.23	30.12
2001	4,865.1	3.27	15.68	29.99
2002	5,757.6	18.34	17.34	29.15
2003	7,921.5	37.58	22.24	31.36

Source: The Vietnamese General Statistics Office, 2004.

In the period 1996-2003, capital goods imports were mostly concentrated in Red River Delta and South East, which account for 30.6% and 44.9% of total imports of capital goods respectively (Table 3.3).

Technology imports from non-OECD countries accounted for a larger share of total imports than from OECD countries in Vietnam. While 57.54% of machinery and equipment were imported from developing countries, 42.46% were imported from OECD countries (Table 3.3). It is likely that foreign technology transfer to Vietnam comes from both developed countries and developing countries.

Table 3.3: Structure of capital goods imports by region, 1996-2003

Region	Total machinery and equipment imports		Machinery and equipment imports from OECD countries		Machinery and equipment imports from non-OECD countries	
	Value (Million US$)	As % of total machinery and equipment import	Value (Million US$)	As % of total machinery and equipment imports	Value (Million US$)	As % of total machinery and equipment imports
North Mountain and Midlands	231.92	7.18	18.81	0.58	213.12	6.60
Red River Delta	988.28	30.61	454.05	14.06	534.22	16.55
North Central Coast	99.96	3.09	51.04	1.58	48.91	1.51
South Central Coast	247.99	7.68	115.77	3.58	132.22	4.10
Cental Highland	12.86	0.39	3.97	0.12	8.88	0.27
South East	1,451.09	44.95	644.64	19.97	806.40	24.98
Mekong River Delta	195.63	6.06	83.25	2.57	112.38	3.49
Total	3,227.74	100	1,371.53	42.46	1,856.21	57.54

Source: The Vietnamese General Statistics Office, 2004.

3.2.2.2 FDI and technology transfer

FDI inflows to Vietnam began in 1988 after the Law on foreign investment was launched in December 1987. FDI flows to Vietnam can be divided into two periods: pre and post the Asian financial crisis. In the former, together with the world trend of capital flowing to emerging and transitional economies, net FDI flows into Vietnam increased consistently with an annual growth rate of 28% and reached its peak of US$ 2.4 billion in 1996 (Table 3.4). However, after the Asian financial crisis, net FDI flows to Vietnam declined sharply. The main reasons are the Asian financial crisis and the unattractiveness of Vietnam's investment environment relative to other countries in the region. From 2000 to the present, FDI flows into Vietnam began to recover and increase albeit at a low rate. The recovery of FDI inflows in this period resulted mainly from the improvement in the investment environment provided by the revision of the Law on foreign investment.

Table 3.4: Net FDI inflows to Vietnam, 1988-2003

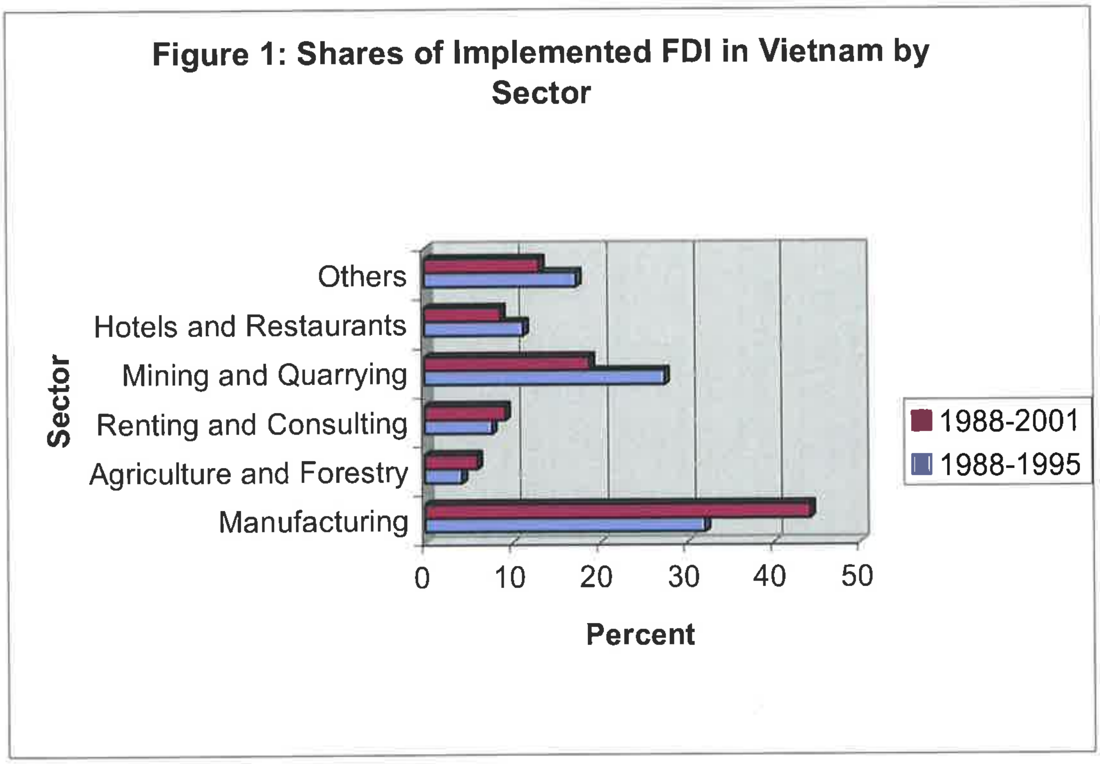
Year	Net FDI inflows			
	Value (1000 US$)	Growth rate (%)	As % of total capital formation	As % of GDP
1988	8,000	-	0.17	0.03
1989	4,000	-50.0	0.43	0.06
1990	180,000	4400.0	22.13	2.78
1991	375,200	108.4	25.89	3.90
1992	474,000	26.3	27.23	4.80
1993	926,300	95.4	28.97	7.02
1994	1,944,500	109.9	46.80	11.93
1995	1,780,400	-8.4	31.60	8.58
1996	2,395,000	34.5	34.56	9.71
1997	2,220,000	-7.3	29.22	8.27
1998	1,671,000	-24.7	21.14	6.14
1999	1,412,000	-15.4	17.81	4.92
2000	1,298,000	-8.1	14.06	4.16
2001	1,300,000	0.1	12.75	3.97
2002	1,400,000	7.6	12.43	3.99
2003	1,450,000	3.5	11.60	3.85

Source: World Bank, 2004.

Trade regimes in Vietnam influence strategies of inward investors. In the early stage of economic renovation, FDI was predominant in import-substitution sectors, generally as joint ventures with state ownership firms due to high levels of protection in these sectors. More recently, as the trade policy regime has been liberalized and the FDI regime relaxed, Vietnam has attracted more export-oriented FDI. Thus, the shift in the composition of FDI from domestic-market orientated production to export-oriented production or from rent-seeking FDI to efficiency-seeking FDI has closely reflected the changes in the trade policy regime.

The sectoral structure of FDI has been shifting in a positive way towards the promotion of industrialisation and modernisation in Vietnam. In the 1988-1995 period, FDI was concentrated largely on manufacturing, oil exploration, and hotel construction. After 1995, FDI expanded to a wide range of new sectors, such as real estate and other different industrial activities. As percentage of total implemented FDI[2], FDI in manufacturing increased from 32.05% in 1995 to 44.19% in 2001, FDI in agriculture and forestry from 4.22% to 5.95%, and in renting and consulting from 7.65% to 9.23% (Figure 1).

[2] Implemented FDI is defined as the amount of FDI that is disbursed.



Source: Department for Monitoring Foreign Investment Projects, MPI, 2002.

Up to the end of 2003, Vietnam had attracted investors from 64 countries. It can be seen from Figure 2 that most FDI comes from Asian countries, which account for the largest proportion of FDI (68%), followed by European countries (25.7%), American countries (3.2%) and Australia (1.3%). Singapore is the largest foreign investor with 288 projects and US$ 7,370 million of registered capital[3], followed by Taiwan (1,086 projects and US$ 5,998 million), Japan (418 projects and US$ 4,480 million), South Korea (662 projects and US$ 4,161 million), and Hong Kong (288 projects and US$ 2,975 million)[4]. Since the signing of the US-Vietnam Bilateral Trade Agreement in July 2000, FDI from Western countries such as France, Netherlands and the US has been increasing.

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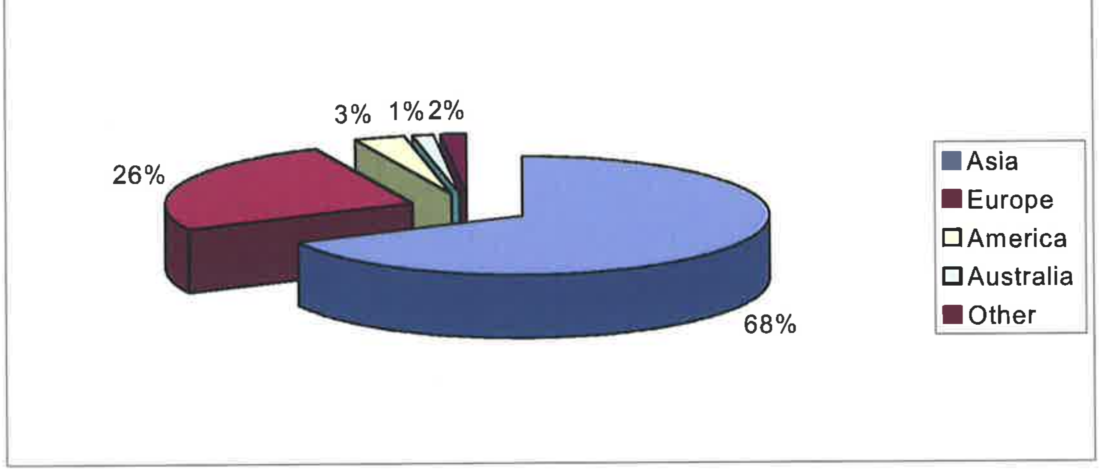
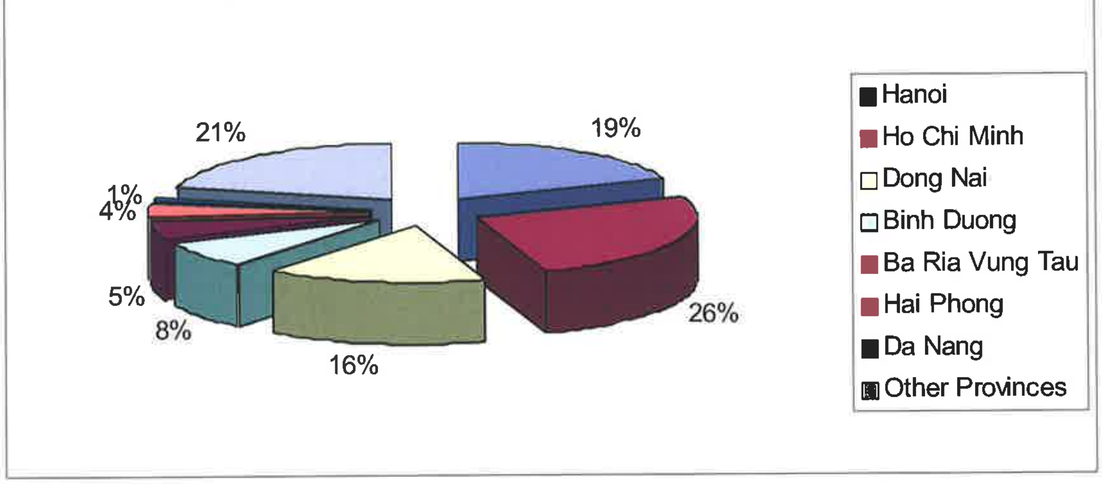
[3] Registered capital includes new investment and supplementary capital to the projects in previous years.
[4] Source: Department for Monitoring Foreign Investment Projects, MPI, 2004.

Figure 2: FDI in Vietnam 1988-2003 by Country



Source: Department for Foreign Investment, MPI, 2004.

Figure 3: FDI in Vietnam 1988-2003 by Province



Source: Department for Foreign Investment, MPI, 2004.

Recent FDI in Vietnam has spread to all provinces. In terms of registered investment, 61 provinces out of 64 provinces of Vietnam have received FDI. But FDI is mainly concentrated on urban areas, especially Hanoi and Ho Chi Minh City with 19% and 26% of total FDI inflows during the period 1988-2003 respectively (Figure 3). Other provinces with high FDI, namely Dong Nai, Binh Duong and Ba Ria Vung Tau, are located in the Southeast region. The Southeast region takes more than half of FDI inflows because of rich natural resources and quick institutional reforms of the local government. FDI in poor and remote areas like North Mountain and Midlands, Central Highlands, and North Central Coast remains sparse, despite the economic potential of these regions.

Attracting FDI is one aim of the transfer of foreign technology in Vietnam. To promote technology transfer through FDI, the Vietnamese government has been trying to attract FDI into high technology sectors and to encourage foreign investors to bring updated technology through using tax incentives. From the statutory Decree 10/1998/ND-CP dated January 23, 1998 and then replaced by the statutory Decree 24/2000/ND-CP dated July 31, 2000, FDI in new materials, high technology and in R&D is especially encouraged. Direct investment enterprises (DIEs) in these fields are granted a preferential corporate income tax rate of 10% for a ten-year period, a four-year tax holiday on corporate income tax from their profitable operations and 50% reduction of corporate income tax for the following four years. In addition, these DIEs are granted a preferential rate of 3% on repatriated profits and are exempted from import duty with respect to raw materials used for production for a five-year period starting from the beginning of production. Specifically, FDI in high quality steel, precise mechanical equipment, communication and telecommunication, electronic equipment and informatics technology industries are encouraged. DIEs in these industries are subject to a preferential corporate income tax rate of 15% for a twelve-year period starting from the beginning of operation of business and production, a two-year tax holiday on corporate income tax from their profitable operation and a 50% reduction of corporate income tax for the following three years.

In Vietnam, FDI in some high-technology industries has been stipulated by the form of investment and performance criteria. In some high-technology industries like telecommunications and oil exploration, foreign investors had to invest in the form of business co-operation contract. In other lower-tech industries, foreign investors have been required to invest in the form of a joint venture.

Technology transfer through FDI differs in different sectors and industries of the Vietnamese economy. In manufacturing, technology transfer does occur, as there is a gap between technology brought by foreign investors and that currently used in Vietnam. Due to capital constraints, most domestic industrial enterprises either use outdated machinery or obsolete equipment provided by the former Soviet Union and China during the 1970s and 1980s, while DIEs use technologies at a higher level, which have been transferred through FDI. In general, most technology used in DIEs is at the intermediate level of the world (Bui, 2000). The reason for the adoption of the intermediate level of technology is to match it with the intermediate level of local human capital, and relative to simple integration and stand alone strategies of transnational corporations.

In agriculture, forestry and fishery, technology transfer has been under the form of demonstrating and diffusing new seeds, new cultivation and production methods, and new kinds of activities such as planting and processing fruits and vegetables or planting forests and processing paper. Despite the small amount of FDI in agriculture, forestry and fishery, technology transfer has a significant contribution to these sectors as exports of DIEs in these sectors increased sharply in the second half of the 1990s.

In the services sector, technology transfer is clear. Foreign investors in hotels and restaurants, banking and auditing have brought and used their managerial and organisational skills in conducting services activities, which are similar to those in their home countries. These managerial and organisational skills are quite novel to

Vietnam as the country was closed for a long time. Though technology transfer in services may be limited by existing constraints regarding FDI in the aforementioned services, it is important to Vietnam in the current integration and development process.

3.2.3 Data description

This study employs panel data for 59 Vietnamese provinces for the 1996-2003 period. This time period is selected because the data on educational attainment and government R&D expenditures in each province are only available since 1996. The definitions and sources of all variables are reported in Appendix B.1.

Most data, including GDP growth rate, domestic investment, inflation rate, exports, imports, FDI and capital goods imports, are obtained from the General Statistical Office of Vietnam. Data on research and development expenditures, and the number of telephones are collected from the Ministry of Science, Technology and Environment of Vietnam. Data on labour force, the level of education and skills of labour force are from the Ministry of Labour, Invalids and Social Affairs of Vietnam.

3.3 Literature Review

The empirical literature on the effects of international trade and FDI on technology transfer and economic growth has been diversifying in terms of objectives, research scopes and methodology, and has resulted with various conclusions.

Coe and Helpman (1995) (CH hereafter) start the empirical debate on the effects of technology diffusion through trade and examine the international R&D

diffusion among 21 OECD countries and Israel for the period 1971-1990. They provide evidence that trade is an important channel for transferring technology, and trade-weighted foreign R&D stock has a positive and significant impact on a country's total factor productivity. Their results suggest that foreign R&D capital stocks are a more important source of productivity than domestic R&D. They also find that domestic R&D is more important in larger countries than in smaller countries. A contribution of the CH model is a measure of foreign R&D capital stock. The R&D capital stocks of a country's trade partners are weighted by import shares, reflecting the importance of a trade partner in determining the foreign capital stock. This measure is considered as a basic specification for models dealing with international knowledge spillovers.

A drawback of the CH study is that it does not consider the important effects of human capital on technology diffusion. Coe, Helpman and Hoffmaister (1997) extend the CH model to investigate the effect of trade as a vehicle for technological spillovers in 77 developing countries and examine the importance of human capital that directly influences productivity and increases absorptive capacity. Their findings support the hypothesis that total factor productivity (TFP) in developing countries is positively and significantly related to the R&D of their industrial trade partners. Their large and positive coefficient on human capital indicates the important effect of human capital for total factor productivity. However, human capital independently influences TFP growth as the interaction term between human capital and foreign R&D stock turns out to be statistically insignificant. A restriction of the CHH model is that they do not include domestic R&D stock. This is a conceptual problem as developing countries might conduct R&D at a low level, and differences in domestic R&D level between these countries may have a potentially large effect on their productivity.

Lichtenberg and Pottelsberghe (LP) (1998) criticise the measurement by which CH estimate their foreign R&D capital stock and the way they estimate its effects on TFP. LP argue that CH's specification does not reflect the intensity of research in a country, and they use the ratio of research to GDP as a measure of research intensity to avoid an aggregation bias. Using this alternative specification and repeating CH's regression, LP point out that their results have a better fit than CH's results. LP also include the import-GDP ratio as a measure for openness with their foreign R&D measure. Correcting an indexation bias, they show that the elasticity of TFP with respect to foreign R&D stock depends on a country's openness to trade. Specifically, the results confirm that the more open a country is to trade, the more likely it is to benefit from foreign R&D. However, as human capital is not included in the LP model, the role of human capital is not examined in a process of technology diffusion.

Instead of using foreign R&D capital stock, Mayer (2001) uses a dataset on machinery imports from countries that have a substantial ratio of R&D to GDP to assess technology transfer to 53 developing countries. He finds that machinery imports are important for developing countries in gaining new technology. He also shows that imports of general-purpose machinery have a significantly stronger positive impact on economic growth than imports of specialized machinery. In addition, machinery imports combined with human capital have a positive and statistically significant impact on cross-country growth differences in the transition to the steady state. This supports the earlier findings in the literature that human capital plays a main role in facilitating technology transfer.

Xu and Wang (1999) examine R&D spillovers through capital goods trade and compare it with the effect of non-capital goods trade in 21 OECD countries. Their results show that capital goods trade makes a more significant contribution to international R&D diffusion than non-capital goods trade due to their higher content of technology. They also suggest that the majority of the R&D spillovers in the OECD countries are transferred through other unknown channels.

Based on international patent data for 75 countries from 1965 to 1990, Connolly (2003) presents evidence that high technology imports positively affect both domestic innovation and imitation. Moreover, the effect of technology imports is greater for developing countries than for developed ones. This implies that developing countries rely more heavily than developed ones on trade in goods for access to foreign technology. This study also finds that high technology goods imports from developed countries benefit less developed countries via both static effects and dynamic externalities. Trade in high technology goods not only directly affects GDP growth, but also leads to an increase in domestic innovation and imitation.

Other evidence on the importance of trade for international technology diffusion includes Lumenga-Neso, Olarreaga and Schiff (2005), who examine the indirect effects of trade-related R&D spillovers. Instead of computing the foreign technology variable as a bilateral-import-share-weighted sum of foreign R&D, they construct an indirect trade related R&D spillover variable that takes into account previous rounds of imports as well. This captures the fact that technology spillovers may take place between countries, even if they do not trade with each other. For example, if country A imports only from country B, country A might still benefit from technology from countries other than B if country B has in turn imported from those other countries. Using this alternative variable they find that the effects of indirect trade-related R&D spillover are more important than direct effects. Their results add to evidence that strengthens the view that trade is crucial to international technology diffusion.

The above studies mainly consider trade to be the sole channel of technology diffusion. They are likely to have underestimated the relative magnitude of international spillover effects that come from other channels. Keller (1998) repeats the CH regressions by generating simulated and randomly selected trade partners to test the international R&D spillover effects. He shows that his results have larger positive international R&D spillovers than CH's results and explain more of the variation in productivity across countries. This implies that the role of trade as a mechanism for disseminating foreign knowledge has not been convincingly demonstrated and that technology diffusion may occur through channels other than international trade.

Since the 1980s, as a large share of global R&D has been undertaken by multinational corporations (MNCs), FDI by MNCs has been considered as a dominant channel for transferring technology internationally. Blomstrom, Lipsey and Zejan (1992) use the data of 78 developing countries from 1970 to 1990 to study the relationship between FDI and economic growth in these countries. They find that FDI by multinational enterprises is positively correlated with per capita income growth of developing countries in the long run via technological upgrading and knowledge spillovers.

Lichtenberg and Pottelsberghe (1996) extend CH's analysis by adding both inward and outward FDI flows as additional channels of technology diffusion to CH's regression. They find that the elasticities of foreign R&D capital stocks with respect to imports and outward FDI are both significant. However, inward FDI does not contribute to the technology transfer in this study. This might be due to the fact that data on bilateral FDI are not as good as data on bilateral trade. Therefore, this research uses data on FDI stocks, which are derived from balance of payments, without considering the fact that FDI does not necessarily involve net flows of capital.

Borensztein, Gregorio and Lee (1998) present an endogenous model in which FDI involves technology transfer through an increase in the number of varieties of capital goods. They also investigate FDI flows from OECD countries to developing countries over the period 1970-1989. Their results show that FDI can increase host country's economic growth only when the host country's human capital achieves a certain threshold level.

Hejazi and Safarian (1999) examine both FDI and trade as channels for technology diffusion from G7 countries to other OECD countries plus Israel. Using the data from Coe and Heplman (1995), they find that both FDI and trade play important roles in promoting technology transfer. In addition, they show that FDI dominates trade in the effect of transferring technology, and the importance of trade diminishes as FDI is introduced in their model. However, since Hejazi and Safarian capture spillovers only from G7 countries to other OECD countries plus Israel, the coefficients cannot be identified in any meaningful way for other cases.

Xu and Wang (2000) investigate international trade and foreign direct investment as channels of technology diffusion in industrialised countries using three different specifications for foreign R&D stock. These specifications include the CH measure, the LP measure and an unweighted variable to capture international R&D spillovers in embodied and disembodied forms. In addition, they introduce a human capital variable and a variable for the technology gap between the countries' technology level and the world frontier. Their results show strong empirical support for capital goods trade as a channel of international technology diffusion. This finding is robust to both measures of CH and LP. In addition, they find evidence that outward FDI is associated with foreign technology transfer back to the home country, but no evidence that inward FDI is a significant channel of technology diffusion. Xu and Wang point out that further research is required to prove a theoretical framework for measuring foreign R&D stock.

Xu and Chiang (2005) use the CHH framework with the addition of foreign patent stock as another channel of technology diffusion in a sample of 48 countries for the period 1980-2000. They decompose the sample into three groups by income level to examine the sources of productivity growth in each group. Their results show that all countries benefit from foreign technology spillovers, but there are differences in the channels they rely on. Foreign technology embodied in imported capital goods has a significant productivity effect in high and middle-income countries, but not in low-income ones. In contrast, foreign patents generate technology diffusion in middle and low-income countries, but less in high-income countries. In addition, Xu and Chiang investigate determinants of technology diffusion in these countries. They find that trade openness affects productivity by expanding the variety of capital goods and stimulating the inflow of foreign patents. Intellectual property rights protection also has an important effect on foreign technology diffusion in middle and low-income countries.

Regarding the studies on Vietnam, most studies employ qualitative methods to examine the effects of trade and FDI on technology transfer and economic growth. Nguyen and Bui (2003) compare the movements of FDI inflows to Vietnam and

China in the period 1979-2002, and point out some lessons for Vietnam. They show that FDI plays an important role in Vietnam's development in terms of economic growth, economic structure improvement, government budget revenues and employment generation. In another study, Doan (2004) shows that the economic growth of Vietnam depends largely on the foreign invested sector. In particular, FDI has contributed to many aspects of the economy by increasing capital formulation and productivity, creating jobs, promoting commodity production and exports, improving the balance of payments and strengthening the competitiveness of the economy.

By analysing the structure and characteristics of failed FDI projects in Vietnam during the period 1988-1994, Kokko and Zejan (1996) show that most of the failed FDI projects are small joint ventures and located outside the Ho Chi Minh and Hanoi regions. They argue that the main reasons for FDI failures are weak infrastructures and problems in communication and co-ordination with Vietnamese authorities and joint venture partners.

Besides qualitative analyses, the paper by Nguyen (2004) is one of the few studies, which uses quantitative method to examine the effects of FDI on economic growth. She shows that FDI has positive effects on Vietnamese provincial economic growth through formation and accumulation of capital assets. There has been no quantitative research on the impacts of trade and FDI on technology transfer in Vietnam.

Although the above studies provide evidence for the importance of trade and FDI in technology diffusion and economic improvement, these studies mainly consider technology transfer from developed countries to developing countries or between developed countries. Thus, the results from these studies may understate the role that technology transfer may play between developing countries. In addition, a developing country may absorb technologies from technologically advanced developing countries more easily than from developed countries as these technologies are likely to be less sophisticated. As a result, technology transfer in a developing country may come not only from developed countries, but also from other developing countries. In this chapter, we fill this gap in the literature by considering the importance of both international trade and FDI as channels for technology transfer from both developed and developing countries to Vietnam. In addition, we answer the question of which factors determine technology adoption in Vietnam, an issue not adequately addressed in the previous literature.

3.4 Technology Transfer and Economic Growth

3.4.1 Empirical model

Based on the theoretical model of Borensztein, Gregorio and Lee (1998) in chapter 2, the following regression model is specified to test the impacts of foreign technology diffusion on Vietnamese economic growth:

$$g_{it} = \alpha + \beta\, GL_{it} + \lambda\, H_{it} + \nu\, FRD_{it} + \chi\, DRD_{it} + \varepsilon_{it} \tag{3.1}$$

Where g is the annual growth rate of provincial GDP measured at constant 1994 prices. H is human capital stock and GL is the annual growth rate of labour force. FRD is foreign technology diffusion, and DRD is domestic R&D. The subscripts i and t denote province and time respectively, and ε_{it} is the random error term.

As foreign technology diffusion comes from international trade and foreign direct investment, FRD is decomposed into those that are made through trade and those that are made through FDI. Thus, the regression model is expanded as follows:

$$g_{it} = \alpha + \beta GL_{it} + \lambda H_{it} + \nu FRD_{it}^{FDI} + \varphi FRD_{it}^{TRADE} + \chi DRD_{it} + \varepsilon_{it} \qquad (3.2)$$

There has been some controversy as to whether or not it is necessary to use bilateral import weights for the measure of foreign technology diffusion. According to Coe and Hoffmaister (1999), regressions using a measure of foreign R&D capital based on bilateral import weights, or on a simple average, tend to be quite similar. Thus, technology transfer through trade is simply measured as the ratio of total imports of machinery and equipment to GDP. Technology transfer through FDI is measured as the ratio of implemented FDI to GDP.

In order to compare the relative importance of technology transfer from OECD countries and developing countries, total import of capital goods is decomposed into capital goods imported from OECD countries and capital goods imported from developing countries. Similarly, two measures of technology transfer from FDI are separated: one for FDI from OECD countries and another one for FDI from non-OECD countries.

$$\begin{aligned} g_{it} = {} & \alpha + \beta GL_{it} + \lambda H_{it} + \nu FRD_{it}^{Trade-OECD} + \varphi FRD_{it}^{Trade-NonOECD} \\ & + \mu FRD_{it}^{FDI-OECD} + \theta FRD_{it}^{FDI-NonOECD} + \chi DRD_{it} + \varepsilon_{it} \end{aligned} \qquad (3.3)$$

Domestic R&D inputs (*DRD*) should be the sum of R&D inputs of domestic firms, government as well as scientific and research institutes. However, since R&D inputs of both domestic firms and research institutes are unavailable, and government R&D expenditures in various levels are the major sources of Vietnam's R&D inputs for a long period, government R&D expenditures are chosen as the index of *DRD*.

Human capital implies skills that workers attained through education and training. Working experiences also increase human capital. Therefore, the measurement of this variable is neither simple nor straightforward. In this study, human capital stock is measured by both the average educational attainment and the percentage of skilled workers in the total labour force. Based on the Vietnamese context, educational attainment is specified as 5 years, 9 years and 12 years for primary school graduates, secondary school graduates and high school graduates respectively.

We also consider the fixed effects that will necessarily impact the model. Obviously, economic business cycles, the Asian financial crisis in this case, will likely impact results. Thus, a financial crisis dummy is included in all of the specifications.

Three types of econometric estimation for the cross-sectional time-series data, simple pooled OLS, fixed effects (FE) model and random effects (RE) model, are considered in this study. The advantage of pooled OLS is that it has more degrees of freedom, but this method assumes that the intercepts and slope coefficients are the same across provinces and time. The FE model incorporates differences between provinces in the sense that it allows intercepts to vary across different provinces, but assumes the intercepts stay constant over time. The RE model also allows the intercepts to change for different provinces, but the changes are random. The Breusch-Pagan LM test shows that the FE and RE model are preferred to the pooled model. In addition, the Hausman test is used to decide between the fixed effect and the random effect specifications. This test shows that the fixed effect estimate is more efficient than the random effect estimate. Therefore, FE estimation is adopted to examine the panel characteristics of the data set.

3.4.2 Empirical results and interpretation

3.4.2.1 The relative importance of trade and FDI to technology transfer

Equation (3.1) is tested for 59 provinces and for the 1996-2003 period when data for all the variables are available. The regression results are introduced in Table 3.5. While regressions (1) and (4) use trade in capital goods as a channel of technology transfer, regressions (2) and (5) use FDI as another channel. Regressions (3) and (6) use both trade and FDI as channels of technology transfer.

The results show that capital goods imports have positive impacts on Vietnamese provincial economic growth in the 1996-2003 period and the impacts are statistically significant at the 1% level in all regressions. In contrast, the coefficients on FRD-FDI are positive but not significant. This implies that foreign technology through FDI does not affect economic growth in Vietnam.

In addition, when both channels are modelled simultaneously, the coefficients on trade are still positive and significant, and the coefficients on FDI are still not significant. These results suggest that trade dominates FDI as a channel for technology transfer in Vietnam. In other words, trade is more important channel of technology transfer and has a larger impact on provincial economic growth than FDI in Vietnam. One possible reason for this is that FDI in Vietnam might contribute more to capital accumulation than to technology improvement at provincial level. Another reason may come from the fact that FDI from different countries may have different impacts on economic growth. Therefore, the pooling of FDI from different countries may cause the insignificance of FDI.

Table 3.5: The effect of foreign technology on provincial economic growth (Fixed effects panel data estimate)

Dependant variable: The growth rate of GDP

Explanatory variables	Regression numbers					
	1	2	3	4	5	6
Schooling	1.05 (0.48)**	1.68 (0.54)***	1.63 (0.55)***			
Skills				0.08 (0.05)*	0.14 (0.06)**	0.13 (0.06)**
Labour	0.11 (0.06)*	0.28 (0.07)***	0.19 (0.07)**	0.11 (0.06)*	0.27 (0.07)***	0.18 (0.07)**
Domestic R&D	-6.30 (4.91)	-7.26 (5.11)	-9.85 (6.90)	-6.58 (5.17)	-7.70 (5.36)	-10.08 (7.27)
FRD-Trade	0.58 (0.16)***		0.57 (0.17)***	0.56 (0.16)***		0.55 (0.17)***
FRD-FDI		0.05 (0.04)	0.06 (0.04)		0.05 (0.04)	0.06 (0.04)
DVFC	-2.00 (0.41)***	-1.96 (0.45)***	-1.81 (0.48)***	-1.87 (0.41)***	-1.73 (0.46)***	-1.62 (0.49)***
Constant	3.21 (2.84)	-0.64 (3.30)	-0.80 (3.45)	8.32 (0.84)***	7.49 (1.02)***	7.28 (1.16)***
Number of observations	398	367	326	398	367	326
R-squared	0.40	0.36	0.41	0.39	0.36	0.40
Hausman Test	21.04***	11.98**	11.31**	18.86***	13.90**	10.33**

Notes: *, ** and *** indicate statistically significant at the 10%, 5% and 1% respectively. Standard errors are in parentheses.

Provincial economic growth is significantly affected by human capital if human capital is either defined as educational attainment or as the percentage of skilled workers in the total labour force. According to the regression results, while a one-year increase in educational attainment will raise the rate of economic growth by more than 1%, an improvement in the percentage of skilled workers in the total labour force by 1% will contribute about 0.1% increase to economic growth. The growth rate of labour force also helps raise economic growth.

However, the relationship between domestic R&D expenditures and economic growth in Vietnam is uncertain. This is due to the fact that the role of domestic R&D activities in domestic production cannot be fully reflected in the government's R&D expenditures. In addition, the impacts of the government's R&D inputs on technology progress and production efficiencies are indirect compared with firm's micro R&D activities, as the primary goals of the government are not profit maximization when it comes to R&D activities. The result that domestic R&D expenditure is statistically insignificant provides a justification for Coe, Helpman and Hoffmaister's (1997) assumption that the productivity effect of domestic knowledge capital in less developing countries is negligible.

The Asian financial crisis impacts adversely and significantly on provincial growth, as the estimated coefficients on DVFC are all negative and statistically significant at the 1% level in all regressions. Vietnam is thus considerably vulnerable to the Asian financial crisis and this is due to the fact that Asian countries are Vietnam's main importers and investors.

3.4.2.2 Testing technology transfer from OECD countries against non-OECD countries

The relative importance of technology transfer from OECD countries and non-OECD is presented in Table 3.6. It can be seen from all regressions in Table 3.6 that capital goods imported from both OECD countries and from non-OECD countries are statistically significant determinants of provincial economic growth. In addition, technology imports from OECD countries have a higher impact on economic growth than from non-OECD countries. The F-test of the equality of the coefficients on FRD-Trade confirms this finding by showing a statistically significant difference between the impacts of technology imports from OECD and non-OECD countries.

For FDI as a channel of technology transfer, only FDI from non-OECD countries generates positive impacts on economic growth. FDI from OECD countries does not affect economic growth at the provincial level. These results are confirmed when all variables on OECD countries and non-OECD countries are used simultaneously (regressions 3 and 6). In particular, the coefficients on FRD-FDI (non-OECD) are still statistically significant, but the coefficients on FRD-FDI (OECD) are not significant. This implies that technology transfer from non-OECD investors is more appropriate for Vietnamese economic growth than technology from OECD investors. This may be due to the fact that FDI from OECD investors have tended to be showcase projects or joint ventures with state enterprises. Another reason is that there may exist complementarity between technology transfer from OECD countries and the level of human capital in Vietnam. As argued by Borensztein et al. (1998), for foreign technology to promote economic growth, host countries must achieve a certain threshold level of human capital. Therefore, an interaction between human capital and FDR-FDI (OECD) is included in regressions (4) and (8) to examine the role of human capital on technology transfer from OECD countries.

Table 3.6: The effect of technology transfer from OECD countries and non-OECD countries on provincial economic growth (Fixed effects panel data estimate)

Dependant variable: The growth rate of GDP

Explanatory variables	Regression numbers							
	1	2	3	4	5	6	7	8
Schooling	1.63 (0.55)***	1.55 (0.54)***	1.58 (0.54)***	1.50 (0.56)***				
Skills					0.15 (0.06)**	0.14 (0.06)**	0.14 (0.06)**	0.13 (0.06)**
Labour	0.21 (0.07)**	0.19 (0.07)**	0.18 (0.07)**	0.18 (0.07)**	0.20 (0.07)**	0.18 (0.07)**	0.17 (0.07)**	0.17 (0.07)**
Domestic R&D	-12.42 (6.98)	-7.84 (6.98)	-9.43 (6.99)	-9.27 (7.01)	-13.05 (8.31)	-8.68 (7.33)	-9.84 (7.34)	-10.34 (7.36)
FRD-Trade (OECD)	0.93 (0.36)**		0.66 (0.37)*	0.67 (0.37)*	0.88 (0.36)**		0.60 (0.37)*	0.63 (0.37)*
FRD-Trade (non-OECD)		0.67 (0.23)***	0.53 (0.24)**	0.53 (0.24)**		0.65 (0.23)***	0.52 (0.24)**	0.52 (0.24)**
FRD-FDI (OECD)	0.09 (0.08)		-0.28 (0.22)	-0.49 (0.44)	0.11 (0.09)		-0.27 (0.22)	-0.42 (0.27)
FRD-FDI (non-OECD)		0.21 (0.09)**	0.46 (0.23)**	0.46 (0.23)**		0.23 (0.09)**	0.47 (0.23)**	0.50 (0.23)**
Schooling* FRD-FDI (OECD)				0.03 (0.05)				
Skills* FRD-FDI (OECD)								0.01 (0.01)
DVFC	-2.01 (0.48)***	-1.69 (0.49)***	-1.54 (0.50)***	-1.54 (0.50)***	-1.78 (0.49)***	-1.47 (0.50)***	-1.32 (0.51)**	-1.32 (0.51)***
Constant	-0.63 (3.40)	-0.61 (3.38)	-1.21 (3.38)	-0.77 (3.49)	7.47 (1.13)***	6.75 (1.18)***	6.41 (1.19)***	6.45 (1.19)***
Number of observations	326	326	326	326	326	326	326	326
R-squared	0.40	0.40	0.42	0.43	0.39	0.40	0.41	0.42
Hausman Test	13.66**	19.53**	13.07**	15.96**	18.01**	15.89**	19.08**	26.43***
F test for equal coefficients on FRD-Trade			8.06**	8.07**			7.02**	7.05**
F test for equal coefficients on FRD-FDI			2.87*	2.64			2.84*	3.72*

Notes: *, ** and *** indicate statistically significant at the 10%, 5% and 1% respectively. Standard errors are in parentheses.

It can be seen in columns (4) and (8) in Table 3. 6 that the coefficients on the interaction variables between schooling and the skills of labour force, and FRD-FDI (OECD) are positive, but not significant at conventional levels. However, the positive coefficients on these interaction variables might suggest the potential complementarity of technology transfer via FDI from OECD countries and human capital in Vietnam. This is consistent with the situation in Vietnam that there is a relative shortage of human capital for the absorption of technology transfer from developed countries.

The finding that technology transfer from non-OECD investors is more suitable than technology transfer from OECD investors in Vietnam is also consistent with the idea of Basu and Weil (1998) that technologies have to be appropriate in order to give rise to the full effect on productivity. In fact, Vietnam absorbs technologies from technologically advanced developing countries more easily than from developed countries because the former technologies are likely to be less sophisticated[5].

3.5 Determinants of Technology Transfer in Vietnam

3.5.1 Empirical model

Given the importance of technology transfer through trade, this section examines the factors that determine the success of technology transfer through trade. The determinants of technology transfer are estimated with a specification of the following form:

$$FRD_{it} = \alpha + \beta X_{it} + v_t + \varepsilon_{it} \qquad (3.4)$$

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[5] See Bui (2000) for detailed explanations

where FRD_{it} is the ratio of machinery and equipment imports from foreign countries to GDP in province *i* and year *t*. X_{it} is a macroeconomic and institutional set of explanatory variables trying to explain the capability of a province to adopt foreign technologies, ν_t is the Asian financial crisis dummy, and ε_{it} is an error term identically and independently distributed across provinces and time.

The explanatory variables (*X*) that we use can be classified into six categories. The classifications of these variables are as follows:

(A) Standard variables, which contain the growth rate of real GDP per capita and the ratio of domestic investment to GDP. We include these variables in order to capture both income and investment effects that inherently contribute to the different rates of technology adoption as well as endowment differences across provinces that are omitted in other variables.

(B) Human capital endowments are used not only as inputs in production but also fulfil crucial tasks in the creation and adoption of technologies. Human capital is influenced by the level of education, job training and work-experience. In this study, the human capital variables are measured by educational attainment and by the percentage of skilled workers in total labour force.

(C) Trade variable refers to the level of openness of each province. The level of openness is defined as the ratio of exports plus imports to GDP in each province.

(D) Factor endowment variables that take into account the share of agriculture and the share of industry in GDP. These variables also measure the comparative advantage of each province.

(E) Infrastructure: Since there exists no comprehensive indicator of infrastructure, an individual aspect of infrastructure is used. In this study, we use the number of telephones per 1,000 people in a province to proxy for its infrastructure.

(F) Fixed effect variables which will necessarily impact the model. Obviously, economic business cycles, the Asian financial crisis in this case, are likely to impact results. Therefore, a financial crisis dummy is included in all of the specifications.

Like Caselli and Coleman (2001), and Lee (2000), we do not think that simultaneity bias is a particularly big problem for the regression results that we present in the following. The reason is that these regressions try to explain the adoption of micro technologies by considering overall macroeconomic factors. This is an important advantage of having the level of adoption in some specific technologies as the dependent variable (instead of GDP per capita or TFP). For example, it is hard to argue that the number of machinery and equipment imports affects the type of regime, the degree of openness or the enrolment rates in the province, or even has an immediate effect on GDP. As in the previous section, we use fixed effects estimation to examine the determinants of technology transfer.

3.5.2 Empirical results and interpretation

Equation (3.4) is tested for 59 provinces and for the 1996-2003 period when data for all the variables are available. The regression results are introduced in Table 3.7. Each column represents different specifications of the model. The first and the second ones show the role of different measures of human capital in technology adoption. The results in columns 3 and 4 are the determinants of technology transfer from OECD countries and non-OECD countries by decomposing the total sample into OECD sample and non-OECD sample.

Table 3.7: The determinants of technology adoption in Vietnam (Fixed effects panel data estimate)

Dependant variable: The ratio of capital goods imports to GDP

Explanatory variables	Total sample	Total sample	OECD	Non-OECD
GDP per capita	0.05 (0.01)***	0.06 (0.01)***	0.01 (0.008)**	0.03 (0.01)***
Domestic R&D	-0.40 (1.72)	0.28 (1.72)	1.09 (0.84)*	-1.49 (1.31)
Skills	0.07 (0.02)**		0.04 (0.01)***	0.03 (0.02)*
Schooling		-0.03 (0.18)		
Investment/GDP	-0.02 (0.01)**	-0.01 (0.01)*	-0.009 (0.005)*	-0.01 (0.008)*
Openness	0.64 (0.16)***	0.65 (0.16)***	0.14 (0.07)*	0.50 (0.12)***
Inflation	0.001 (0.006)	0.001 (0.006)	-0.0003 (0.003)	0.001 (0.004)
Agricultural share in GDP	-0.04 (0.02)**	-0.03 (0.02)*	-0.02 (0.01)*	-0.02 (0.01)*
Industry share in GDP	0.002 (0.01)	0.001 (0.01)	-0.002 (0.007)	0.005 (0.01)
Infrastructure	-0.006 (0.003)	0.001 (0.003)	-0.007 (0.001)***	0.001 (0.002)
DVFC	-0.19 (0.14)	-0.19 (0.14)	-0.09 (0.06)	-0.10 (0.10)
Constant	0.82 (1.02)	1.31 (1.55)	0.60 (0.50)	-0.22 (0.78)
Observations	398	398	398	398
R-squared	0.54	0.53	0.51	0.43
Hausman Test	77.51***	61.67***	78.10***	74.24***

Notes: *, ** and *** indicate statistically significant at the 10%, 5% and 1% respectively. Standard errors are in parentheses

The results in all regressions show that openness to international trade is one of the most relevant and robust determinants of technology adoption in Vietnam. When trade openness is measured as the ratio of exports and imports to GDP, openness is the highest coefficient and significantly positive at 1% level. In particular, the results show that a 1% increase in the ratio of exports and imports to GDP would generate a 0.64% increase in technology adoption. This suggests that when provinces are open to trade, they are not only buying products from abroad, but they are also establishing information channels that are extremely useful for the transfer of technology.

Another robust finding is that the skill of labour force is an important determinant of technology adoption. In all regressions, the coefficients on skill are positive and significant. This implies that the skills of the labour force are necessary for the acquisition of technological skills and the use of new technologies through learning by doing and learning on job techniques. However, when human capital is measured as the educational attainment, the coefficients on this variable are not significant. This may be due to the fact that Vietnam has not met a certain threshold level of education to adopt effectively foreign technology. Moreover, teaching may not be updated to satisfy the requirements of development practice. These can make educational quantification of less practical value.

The growth rate of GDP per capita is also an important determinant of technology transfer. Provinces with high growth rate of GDP per capita can adopt more foreign technology. A 1 % increase in GDP per capita leads to a 0.05% rise in technology adoption in the total sample, 0.03% from non-OECD countries and 0.01% from OECD countries.

The size of the agriculture sector is a good predictor of technology adoption at the provincial level. In particular, provinces with higher shares of agriculture in GDP import less new technologies than other provinces.

R&D expenditures of a province do not affect its capability to adopt technology from non-OECD countries. However, provinces with higher levels of R&D expenditures adopt more technology from OECD countries. This may be due to the fact that technology from OECD countries is more complicated than from non-OECD ones. Therefore, the success of adopting technology from OECD countries in each province depends not only on the skills of its labour force, but also on its R&D expenditures that reflect the absorptive capacity of each province.

There appear to be different effects of the level of a province's infrastructure on technology adoption from OECD countries and non-OECD countries. Provinces with lower level of infrastructure import more technology from OECD countries than other provinces. However, technology imports from non-OECD countries are not affected by the level of infrastructure.

The Asian financial crisis does not significantly affect technology imports of each province. Similarly, inflation rate is not a significant influential factor of technology adoption in Vietnam. Surprisingly, investment in a province affects negatively its technology imports. This may imply that technology import is less in more capital-intensive activities.

Since technology imports in the past may help increase current GDP, and the current GDP and current investment may be the determinants of technology adoption in the future, identifying the determinants of technology adoption may suffer from endogeneity. Hence, it is necessary to use lagged explanatory variables to reflect the time lap so that the effects from influential factors on technology adoption can take effect. Explanatory variables lagged by one year are chosen.

Table 3.8: The determinants of technology adoption in Vietnam (one year lag) (Fixed effects panel data estimate)

Dependant variable: The ratio of capital goods imports to GDP

Explanatory variable	Total sample	Total sample	OECD	Non-OECD
Lagged GDP per capita	0.01 (0.01)	0.02 (0.01)	0.004 (0.008)	0.008 (0.01)
Lagged domestic R&D	-0.32 (1.68)	0.40 (1.68)	0.61 (0.82)	-0.94 (1.28)
Lagged skills	0.10 (0.03)***		0.04 (0.01)**	0.06 (0.02)**
Lagged schooling		-0.25 (0.20)		
Lagged investment/GDP	-0.01 (0.01)	-0.006 (0.01)	-0.002 (0.005)	-0.01 (0.007)
Lagged openness	0.37 (0.17)**	0.41 (0.17)**	0.05 (0.04)*	0.32 (0.13)**
Lagged inflation	0.004 (0.006)	0.004 (0.006)	0.001 (0.003)	0.003 (0.004)
Lagged agricultural share in GDP	-0.06 (0.02)**	-0.03 (0.02)*	-0.01 (0.01)	-0.04 (0.01)**
Lagged industry share in GDP	-0.004 (0.01)	-0.01 (0.01)	-0.005 (0.007)	0.001 (0.01)
Lagged infrastructure	-0.008 (0.005)*	0.003 (0.004)	-0.009 (0.002)***	0.001 (0.003)
DVFC	-0.28 (0.13)	-0.30 (0.13)*	-0.15 (0.06)*	-0.12 (0.10)
Constant	1.44 (1.07)	3.55 (1.65)**	0.78 (0.52)	0.65 (0.82)
Observations	348	348	348	348
R-squared	0.54	0.53	0.51	0.45
Hausman Test	39.73***	36.79***	35.61***	37.60***

Notes: *, ** and *** indicate statistically significant at the 10%, 5% and 1% respectively. Standard errors are in parentheses

In general, the regression results of the one-year lag models in Table 3.8 are rather similar to the results shown in Table 3.7. In particular, these results show that openness to international trade and skills of labour force are important explanatory factors of technology adoption in Vietnam, and they are robust to variation in specifications.

3.6 Conclusion

This chapter has examined technology transfer via trade and FDI from both OECD countries and non-OECD countries to Vietnam. Consistent with most empirical evidence in the literature, the chapter found that technology transfer through trade is more important and has a stronger effect on economic growth than through FDI in Vietnam. We extend the literature by arguing that studies that ignore technology transfer between developing countries may underestimate the total effect of technology transfer. Our empirical results confirm this expectation. In particular, technology transfer via FDI from non-OECD countries is more appropriate than that from OECD countries for Vietnam. In addition, technology transfer from OECD countries depends not only on the skills of labour force, but also on the R&D activities in each province.

This chapter has investigated the conditions under which technology transfer through international trade occurs in Vietnam. The empirical results based on data across the Vietnamese provinces provide strong evidence that openness to international trade is one of the most relevant and robust determinants of technology adoption at provincial level. Moreover, provinces have to invest in human capital to adopt new technologies. Human capital is crucial in order to transfer foreign technology and to maintain sustainable provincial economic growth. Two important roles of human capital are highlighted in this chapter. On the one hand, human capital directly improves output levels by improving the education and skill levels of workers and therefore the productivity of employees. On the other hand, human capital also indirectly promotes economic growth by enhancing the level of the country's absorptive capability and R&D efficiency.

There are some important issues that have not been considered in this chapter. First, the measures of technology transfer through trade and FDI are still too general due to the use of provincial data. There may be indirect channels of technology transfer that cannot be observed at the provincial level. Channels and measures of technology transfer via trade and FDI need to be explored at the firm level for a clearer understanding of technology transfer. Secondly, although it is found that FDI is not a major channel for technology transfer at the provincial level, we cannot make the same conclusion at firm level due to the nature of FDI tending to concentrate in certain industries and certain firms. Thus, there is clearly a need for an empirical analysis at the microeconomic level. These issues are the subjects of the following chapter.

Chapter 4
FDI, International Trade and Technology Spillovers in Vietnam: A Firm-Level Analysis

4.1 Introduction

It is widely recognized that FDI and trade play an important role in the process of international technology transfer. Technology transfer through FDI and trade can be observed at both macro and micro levels. While macro level analysis has done a decent job of outlining international trade and FDI as channels of technology transfer, not enough is known about how exactly technology diffusion takes place via these channels. A major question of interest is, once a technology has been introduced into a country, how is it subsequently diffused throughout the rest of the country? Thus, there is a clear need for better understanding of technology spillovers at the micro level. Some studies suggest that micro level study may advance the analysis of the role of trade and FDI in technology transfer. First, there may be indirect channels of technology transfer such as spillover externalities between firms that cannot be observed at the macro level, and that micro level study allows us to define measures of technology transfer more accurately. Secondly, micro level study avoids composition and aggregation biases that may present in macro level analysis.

This chapter extends our study of technology transfer through trade and FDI in Vietnam by using firm level data. The chapter advances our understanding as to when, where, and under what conditions trade and FDI generate technology spillovers to domestic firms. In particular, we extend the analysis of technology spillovers to include different channels and measures of spillovers from FDI and trade. With respect to technology spillovers from FDI, while there are numerous empirical studies on horizontal spillovers (between foreign firms and domestic firms within the same sector), there are relatively few studies on vertical spillovers (between foreign firms and their domestic suppliers). The chapter adds to the literature by distinguishing between horizontal spillovers and vertical spillovers in the Vietnamese context. More importantly, we advance the literature by shedding light on the impacts of characteristics of industries and domestic firms on the strength of horizontal and vertical spillovers. In particular, the technological gap between multinational enterprises (MNEs) and domestic firms, the local market competition, and the absorptive capacity of local firms are considered in searching for the different effects of spillovers. We also address the question of whether the characteristics of FDI and foreign firms affect the strength of technology spillovers by looking at types of foreign ownership and trade orientation of foreign firms.

With respect to technology spillovers via international trade, most studies identify imports of capital goods as a major source of technology transfer. This chapter contributes to the literature by shedding light on the argument that learning from imports not only occurs through direct imports of capital goods, but also occurs among local suppliers upstream of import-intensive sectors. This suggests that linkages through vertical supply relationships are the relevant mechanism through which import-driven knowledge transfer occurs.

The remainder of the chapter is organised as follows. Section 4.2 reviews the literature on FDI, trade and technology spillovers at the firm level. Section 4.3 provides an empirical model underlying the effects of technology spillovers through FDI and trade on productivity. Section 4.4 describes the firm level data. The empirical results and analyses are presented in section 4.5. Section 4.6 concludes the chapter.

4.2 Literature Review on Technology Spillovers through FDI and Trade at the Firm Level

4.2.1 Technology spillovers from FDI

Based on the theoretical models in chapter 2, FDI introduces two channels through which technology spillovers may boost the productivity of a firm in the host country: horizontal spillovers (intra-industry spillovers) and vertical spillovers (inter-industry spillovers).

4.2.1.1 Horizontal spillovers

Horizontal spillovers refer to knowledge spillovers within an industry due to the presence of MNEs. The entry of MNEs may provide technology externalities to local firms through a number of mechanisms. First, local firms may be able to learn simply by observing and imitating product innovations or novel forms of organization adapted to local conditions. The reason for this effect is that it may be very costly for local firms to collect information on new technology or processes in the absence of MNEs. In addition, domestic firms may have little information on the costs and benefits of innovations and new technology, and they may thus regard them to be highly risky. As they make direct contacts with MNEs' affiliates, information is diffused, uncertainty is reduced, and the possibility of adoption increases (Blomstrom and Kokko, 1996).

Secondly, a more observable mechanism of technology spillovers within the same industry is the movement of employees. In fact, technology is embodied not only in machinery, but also in workers in MNEs. This is acquired through the MNE's training of local employees. Labour turnover may disseminate technology from MNEs to other firms as workers trained or employed by MNEs move to domestic firms or start their own businesses. This spillover is especially important for sectors, which are strongly competitive, or in which human capital formation is very costly. This is also crucial for firms that lack the technological capability and managerial skills to compete in world markets. However, MNEs naturally tend to discourage highly trained workers from leaving by paying salaries above local standard. Therefore, labour turnover would be low in countries where MNEs have substantial advantages over domestic firms (Meyer, 2003).

Thirdly, technology spillovers may come from competition generated by the presence of MNEs. MNEs may increase market competition because they have advantages over domestic firms in technology. As a result, greater competitive pressure faced by domestic firms may induce them to introduce new products or new technology to defend their market share, and to adopt new management methods to increase productivity. However, MNEs may have a negative effect on domestic firms because they may attract demand away from domestic firms, thus forcing the domestic firms to reduce their output and productivity (Aitken and Harrison, 1999).

Many empirical studies have used different types of datasets to assess the incidence of horizontal spillovers to domestic firms. The empirical results from the literature on horizontal technology spillovers are mixed. While some studies find that foreign presence has a positive impact on the productivity of domestic firms, others find either no evidence or negative effect.

In terms of industry level data, a pioneering attempt to examine impacts of foreign presence on the productivity of domestic sectors is Caves (1974) on Australia and Canada. He employs data of 23 Australian manufacturing industries in 1962 and 1966 to examine technology transfer from multinational firms, finding that the productivity level of local firms, which is measured by value-added per employee, is positively related to foreign subsidiary shares of employment in the same industry. For Canada, he finds evidence that the shares of foreign subsidiaries in an industry are negatively related to the profitability of Canadian firms. This means that foreign firms may raise the level of competition and reduce the excess profits of their local rivals. A later study by Globerman (1979), using a cross sectional dataset of Canadian manufacturing in 1972, presents evidence on the positive effects of foreign presence on the labour productivity of local firms. Other studies which also find positive spillovers are Blomstrom and Persson (1983) for the Mexican manufacturing industry, Blomstrom and Sjoholm (1999) for Indonesian manufacturing sectors, Liu (2002) for 29 Chinese manufacturing industries, and Le (2005) for 29 Vietnamese industries. All these studies, using basic aggregate data, confirm that spillovers are significant across industries. However, aggregate data at the industry level have been unable to control for differences of productivity across sectors. As a result, the positive correlation between the foreign presence and the productivity of domestic firms might be partially due to the fact that foreign firms invest in more productive industries. This may lead to an endogeneity problem and an upward bias. Some studies argue that spillovers might not occur in all types of industry. Kokko (1994), using a cross section of the Mexican manufacturing industry, finds that spillovers exist when enclaves, i.e. in isolation from domestic firms, are dropped. Specifically, industries with high foreign market share and larger productivity gaps do not show a positive impact of foreign presence on local productivity.

With firm level data, the literature provides mixed evidence of technology transfer and spillovers. Haddad and Harrison (1993) employ data on Morocco to investigate the effect of foreign presence on the relative productivity of local firms.

They show that there is no evidence of spillovers, and competition seems to push local firms towards the best practice frontier in industries with low level of technology. For Venezuela, Aitken and Harrison (1999) find that there is a negative relationship between foreign ownership in an industry and the productivity of domestic plants in the same industry. They describe this negative spillover as a market stealing effect as foreign firms force domestic ones to cut production. The authors report similar findings for Indonesia, except that negative effects are smaller in Indonesia than found in Venezuela. In addition, they test the possibility that spillovers are local and find no evidence to support this idea. Using panel data of UK manufacturing industries, Girma, Greenaway and Wakelin (2001) find no significant effect of foreign presence, measured by shares of employment or output, on the labour productivity or total factor productivity of UK firms from 1991 to 1996. However, Griffith (1999), Liu et al. (2000), Haskel et al. (2002), and Harris and Robinson (2003) use the UK micro data for manufacturing firms and present a significantly positive correlation between a domestic firm's total factor productivity and the foreign affiliate share of activity in that industry. More interestingly, Haskel et al. (2002) show that positive spillovers are found to come from US and French presence, but Japanese presence produces negative spillovers.

Studies on transition economies have emerged in recent years and also show negative or insignificant spillover impacts. Konings (2001) finds that FDI may be important for transferring technology to an affiliate, but provides negative evidence of spillovers to local firms in Bulgaria and Romania from 1993 to 1997. In contrast, there is no evidence of negative spillovers in Poland. Using firm level data for the Czech Republic for the period 1992-1996, Djankov and Hoeckman (1998) also find negative effects of spillovers on domestic firms and suggest that firm characteristics, such as firm size, labour productivity and profitability, seem to attract FDI. They also find negative and significant impacts of spillovers on domestic firms and conclude that other channels of technology transfer, such as trade, positively affect the productivity of Czech firms. Recently, using both the static and dynamic growth accounting approach, Damijan et al. (2003) use large samples of firms in 10 transition economies in Eastern Europe and confirm that spillovers are rare in these countries, but there is no evidence of negative spillovers.

In making efforts to find the causes of mixed results on horizontal technology spillovers and search for factors affecting the magnitude of such spillovers, some studies look into the characteristics of the host country and local firms. The first factor influencing spillover effects to mention is the technology gap between local firms and foreign firms. Kokko (1994) shows that spillovers are smaller in Mexican industries with larger labour productivity gap between local and foreign firms. Kokko, Tasini and Zejan (1996) find a similar result in Uruguayan manufacturing sectors. If the productivity gap is small, foreign technology appears to be more useful for domestic firms as they have the skills needed to learn the foreign technology. In contrast, using the Indonesian manufacturing data, Sjohlom (1999) finds evidence of spillovers to domestic firms only in a sub-sample with a large technology gap. Gorg and Strobl (2001b), using panel data on Irish manufacturing enterprises, state that the presence of foreign investment has a positive spillover to local enterprises in high technology sectors but not in low technology ones.

The second factor of local firms affecting spillovers is absorptive capacity, such as research and development (R&D) expenditures or labour quality. Kinoshita (2000) find evidence of spillovers in the Czech Republic from 1995 to 1998, but these spillovers are limited to firms engaged in R&D. This suggests that there is a significant positive impact of absorptive capacity of Czech domestic firms in exploiting spillovers generated by foreign firms. For India, Kathuria (2000) find that spillovers from foreign presence are found in scientific industries, but only if domestic firms invest in significant R&D activities. This suggests that R&D and spillovers may be complementary. In a study of spillovers to UK manufacturing firms, Girma, Greenaway and Wakelin (2001) relate the extent of spillovers to the characteristics of firms and industries and find that the skill level of the industry is correlated with productivity spillovers. Specifically, the higher the skill level of the industry, as measured by the ratio of skilled to unskilled employment, the greater the productivity spillovers. Schoors and Van der Toll (2001) also show that horizontal spillovers in Hungary are significant and positive if the domestic firms have sufficiently invested in human capital. Sinani and Meyer (2004), in a study of Estonian firms, confirm that technology spillovers depend on local firms' investment in intangible assets, new machinery and equipment.

The third factor that may affect horizontal technology spillovers is competition in the domestic market. In a model of strategic interaction between MNCs and domestic firms, Wang and Blomstrom (1992) show that high competition forces MNCs to bring in relatively new and sophisticated technologies from their parent company in order to retain their market shares. As a result, the stronger the competition, the more the advanced technology brought into the domestic market. Using industry data from the Mexican manufacturing industry, Blomstrom, Kokko and Zejan (1992) find that local competition is positively related to imports of technology by affiliates of multinationals. Their suggestion for increasing the inflow of modern technology is to create competitive conditions in the industries where foreign firms are present. Sjoholm (1999) presents evidence supporting the idea that higher technology spillovers of FDI are found in the industries with higher domestic competition. Girma, Greenaway and Wakelin (2001) also point out the importance of competition in determining the extent of spillovers in UK manufacturing. They conclude that the greater the degree of foreign competition in the industry, the larger the spillover.

Another factor that is argued to influence technology diffusion in host economies is the export orientation of domestic firms. Domestic firms involved in exporting are argued to be more capable of learning or copying technology so that the impact of spillovers on their productivity may be larger than for non-exporting firms. However, Blomstrom and Sjoholm (1999), who study Indonesian manufacturing, show that while non-exporting domestic firms experience positive significant direct spillovers, exporting domestic ones do not have significant spillovers. Sinani and Meyer (2004) also show a similar result in Estonia. Their explanation for this finding is that export-oriented firms already face competitive pressure from the world market. Therefore, the presence of foreign enterprises in domestic markets does not influence their productivity.

In another line of interest, Gorg and Strobl (2001a) provide a formal meta-analysis of the literature on foreign firms and productivity spillovers and investigate whether some aspects of the empirical methods used may affect the results. Using the t-statistic in spillover equations as the dependent variable, they find that on average, cross-sectional studies report higher coefficients of the effect of foreign presence than panel data studies, and the definition of the foreign presence variable included in the studies seems to affect the results obtained. This finding suggests that researchers need to take care in defining spillovers in a sector and to use different measures of spillover before concluding that domestic firms may benefit from foreign firms through technology spillovers. They also point out that the results of productivity spillover studies seem to be affected by whether the data used are cross-sectional or panel data. Specifically, cross-sectional studies may overstate the spillover effects of foreign firms on domestic ones because they do not control for other time-invariant firms or sector specific effects. In contrast, panel data would allow for the control of such factors. This raises a question as to how empirical studies should use empirical methods appropriately.

To sum up, the empirical literature has shown two partial answers on the issue of horizontal technology spillovers. First, the evidence of horizontal spillovers is mixed. Secondly, the literature has suggested characteristics of local country and domestic firms, such as absorptive capacity, in assessing the existence of horizontal spillovers. However, the literature has not paid sufficient attention to the conditions and characteristics of foreign firms through which horizontal spillovers take place. Thus, in this chapter, we expand on the literature by focusing more deeply on the conditions of the local country, sectors and domestic firms, as well as the characteristics of foreign firms to answer the questions of when, where and under what circumstances FDI generates horizontal spillovers to domestic firms.

4.2.1.2 Vertical spillovers

Vertical spillovers occur through linkages between MNEs and local enterprises across industries. In particular, vertical technology spillovers may occur through both backward linkages (from buyer to supplier) and forward linkages (from supplier to buyer).

Backward linkages create technology spillovers through several mechanisms. First, MNEs may transfer technology directly to their local suppliers by training or joint product development. MNEs may give technical assistance and labour training to their local suppliers in order to increase the quality of the suppliers' products. Secondly, close linkages between MNEs and their local suppliers may induce workers in MNEs to move to local suppliers, thereby disseminating technology from MNEs. Thirdly, higher requirements for product quality and on-time delivery set by MNEs may provide incentives to local suppliers to improve their production process or technology (Smarzynska, 2004).

Forward linkages induce technology spillovers through similar channels. First, domestic firms may benefit from supplies of intermediate goods and machinery from MNEs that provide better quality products and lower costs. Secondly, as marketing outlets for MNEs, domestic firms may receive considerable support in the form of training in sales techniques and supply of sales equipment, therefore generating more technology externalities. Thirdly, FDI in infrastructure and business services directly improves the productivity of its customers if these services are introduced or improved (Meyer, 2003).

The incentive structure of foreign investors suggests that vertical spillovers are more likely to be positive than horizontal spillovers. Foreign firms have incentives to prevent spillovers within the same industry that may strengthen the performance of their local competitors. But, at the same time, they have incentives to transfer their technologies to their local suppliers.

The empirical literature on technology transfer through vertical linkages is relatively rare, as this requires data on industry-level input-output relationships. Among these studies, Kugler (2001) develops a structural estimation framework to assess whether inward foreign direct investment generates technological externalities. He shows that spillovers from FDI should be primarily inter-industry and not intra-industry. This conjecture is confirmed by testing of the multisectoral model of FDI spillover diffusion on Colombian manufacturing data. In particular, Kugler finds that the greatest impact of MNEs in Colombian manufacturing is across rather than within the subsidiaries' own industries.

Blalock and Gertler (2002), employing firm level data from Indonesia, provide evidence of positive FDI spillovers through backward linkages. Specifically, Indonesian firms in industries with growing downstream FDI experience greater productivity growth than other firms. Similarly, Schoors and Van der Tol (2001), in a study on Hungary, find that there are spillover effects between sectors. While there are positive and significant effects of forward linkages on the productivity, the effects of backward linkages are negative and significant.

Based on firm-level panel data from Lithuania, Smarzynska (2004) also finds a similar result that technology spillovers from FDI take place through contacts between foreign firms and their local suppliers in upstream sectors, while at the same time finding evidence of technology spillovers within the same industry. This provides strong evidence that backward linkage spillovers do exist in Lithuania.

Thus, the literature has provided a broad consensus and fair econometric evidence in support of vertical technology spillovers. However, the existing empirical literature has mainly focused on the basic questions of whether or not vertical spillovers exist and with little evidence on which circumstances would determine the strength of such spillovers. In fact, the second question merits most attention because the major policy debates are no longer on whether or not to allow FDI, but on how to maximize the benefits of FDI spillovers for local firms. Thus, this chapter fills this gap by considering the specific actors involved, foreign enterprises and local firms, and the relationships between them. In this chapter, we also examine the question of which conditions and characteristics facilitate vertical spillovers.

4.2.2 Technology spillovers from international trade

4.2.2.1 Exports

Exports may lead to an increase in a domestic firm's productivity. First, exporting firms may receive technical assistance from overseas buyers, which have strong incentives to transmit knowledge to the exporting firms as their suppliers. Secondly, exporting firms producing for international markets cannot survive without innovating and adopting new technology. Therefore, they must continually improve their technology and productivity (Blalock, and Gertler, 2004).

Using firm-level data, some empirical studies have investigated whether entering a foreign market through exports may serve as a mechanism through which domestic firms may learn technology. So far, there have been mixed results. The positive spillovers through exports depend on the characteristics of the market, and the initial conditions of the firms that decide to export to a foreign market.

Using a panel data of US manufacturing firms, Bernard and Jensen (1999) examine productivity growth before and after entry into export markets. They find that an increase in productivity occurs prior to exporting, and firms entering the export market are unlikely to increase their productivity substantially. They also suggest that technology improvement is the result of selection rather than exporting. In a study of Columbia, Mexico and Morocco, Clerides, Lach and Tybout (1998) find further evidence that there is little learning by exporting and the positive effect of export status on productivity is due solely to the self-selection of relatively more efficient firms into the export market. Aw, Chung and Roberts (2000) provide the same findings for Taiwan and Korea in the late 1980s and early 1990s, a time by which both Taiwan and Korea had already developed successful export-oriented industries. They also provide an explanation as to why learning by exporting may have been more important for Korea only in the early years of its export-oriented policy. More recently, Delgado, Farinas and Ruano (2002) consider the case of Spanish firms and show that learning by exporting is weak. They also conclude that a higher level of productivity for exporting firms reflects the self-selection of more productive firms in the export market.

In contrast to these studies, few studies find evidence of learning from exporting. Using a panel dataset of Indonesian manufacturing establishments, Blalock and Gertler (2004) find strong evidence that Indonesian firms show increases in productivity by 2% to 5% upon entering export markets. They suggest that productivity improvement is a result of learning from export, rather than the self-selection of better firm into export markets. Van Biesebroeck (2005) uses a panel of manufacturing firms in nine African countries and finds that exporters increase their productivity advantage after entry into the export market. In addition, this productivity advantage remains after controlling for the endogenous export decision.

An effort to explain why there have been mixed results on exports as a mechanism of technology spillover is presented by Blalock and Gertler (2004). They show that the level of economic development is the main reason for the differing results. Both Indonesia and Sub-Saharan Africa are much less developed than in countries described in other studies. Clearly, firms in countries with poor technology and low productivity can earn a greater marginal benefit from exposure to international markets.

4.2.2.2 Imports

There are two mechanisms through which a firm can improve its productivity by importing. First, importing new intermediated goods, which embody advanced technology, may trigger learning that enables domestic firms to produce similar goods at lower cost at home (Keller and Yeaple, 2003). Secondly, learning from importing provides exposure to foreign technology. In particular, learning from imports may occur among local suppliers upstream of import-intensive sectors. Therefore, domestic firms supplying sectors with higher levels of technology inputs purchased in foreign markets may have greater productivity than other domestic firms (Blalock and Veloso, 2005).

While there are many empirical studies examining the spillover effects of exports, few studies have been conducted using firm-level data to examine imports as a learning mechanism. Hasan (2002) uses panel data on Indian manufacturing firms to examine the impact of imported and domestic technologies on the productivity of domestic firms. He finds that imports of technology, both embodied and disembodied technology, make significant and direct contributions to the productivity of Indian firms, especially in industries where technological opportunities and technology investments are highly prevalent. Keller and Yeaple (2003) examine international technology spillovers to US manufacturing firms through import and FDI from 1987 to 1996. They provide evidence that both FDI and imports lead to significant productivity benefits for domestic firms. However, the effect of imports is weaker than the effect of FDI. Damijan and Knell (2005) develop an empirical model that addresses the importance of FDI and trade in technology transfer in Estonia and Slovenia. Their results show that, while Estonia uses FDI as a channel to gain direct access to international technology diffusion, exports and imports are channels to gain technology spillovers in Slovenia. Using firm-level data from Indonesia, Blalock and Veloso (2005) provide evidence that importing is an effective channel of international technology transfer. They also suggest that linkages through vertical supply relationships are the relevant mechanism through which import-driven knowledge spillover occurs.

4.3 Empirical Framework

The empirical framework used in this chapter is similar to those of earlier empirical studies (Caves, 1974; Globerman, 1979; Blomstrom and Persson, 1983; Kokko, 1994; and Sjoholm, 1999). The production function of domestic firm i in industry j at time t is assumed to be Cobb-Douglas form and is homogeneous of degree one:

$$Y_{ijt} = (K_{ijt})^{\alpha}(L_{ijt})^{1-\alpha} e^{Z^{ijt}} \tag{4.1}$$

Where Y_{ijt}, K_{ijt}, and L_{ijt} are output, capital and labour of domestic firm i in industry j at time t respectively. Z^{ijt} presents sectorial externalities, which will be explained specifically later.

Dividing both sides of equation (4.1) by L_{ijt}, we have the following function for labour productivity of domestic firm i.

$$\frac{Y_{ijt}}{L_{ijt}} = \left(\frac{K_{ijt}}{L_{ijt}}\right)^{\alpha} e^{Z^{ijt}} \tag{4.2}$$

Felipe (1999, p.6) in a survey of the literature on total factor productivity describes Z as "a measure of elements such as managerial capabilities and organizational competence, R&D, inter-sector transfer of resources, increasing return to scale, embodied technical progress, and diffusion of technology". Hence, we can express Z^{ijt} as a function of the following variables:

$$Z^{ijt} = f(Labour\,Quality_{ijt}, Scale_{ijt}, Concentration_{jt}, Technology\ Gap_{ijt}, Spillovers_{jt}, Exports_{ijt} / Sales_{ijt}, Imports_{ijt} / Costs_{ijt})$$

(4.3)

Labour productivity of domestic firm *i* can thus be expressed as follows:

$$\frac{Y_{ijt}}{L_{ijt}} = \left(\begin{array}{l} \frac{K_{ijt}}{L_{ijt}}, Labour\ Quality_{ijt}, Scale_{ijt}, Concentration_{jt}, Technology\ \ Gap_{ijt}, \\ Spillovers_{jt}, Exports_{ijt} / Sales_{ijt}, Imports_{ijt} / Costs_{ijt} \end{array} \right)$$

(4.4)

$\frac{Y_{ijt}}{L_{ijt}}$ is average labour productivity of domestic firm *i* in industry *j* and is measured as the ratio of gross output to total employees.

$\frac{K_{ijt}}{L_{ijt}}$ is domestic firm *i*'s capital intensity, which is measured as the ratio of fixed assets to total employees in firm *i*. It is argued in the literature that foreign firms are more capital intensive and larger than domestic firms. This characteristic may account for some of productivity differentials between foreign firms and domestic firms. Thus, we use this variable to control for the impact of capital intensity on productivity.

$Labour\,Quality_{ijt}$ represents the skills of workers and increases overall productivity of firm *i*. Since the data on the number of skilled workers are not available, labour costs (including wages and training costs) per employee are used as a proxy for the human capital stock of the firm. This is based on an assumption that firms with higher average per capita labour costs do, on average, employ higher skilled labour.

To account for the impact of scale on productivity, we measure the scale effect ($Scale_{ijt}$) using the ratio of sales in firm i to total industry sales.

$Concentration_{jt}$ is industry j's concentration, which is proxied by the Herfindahl index for domestic firms. The level of concentration in industry j is calculated as follows:

$$HERF_{jt} = \sum_{i=1}^{n} \left(\frac{x_{ijt}}{X_{jt}} \right)^2 \qquad i=1,2,\ldots,n. \qquad (4.5)$$

where x_{ijt} is the sales of the firm i in industry j; X_{jt} denotes the total sales of industry j. A higher value of this variable indicates a high degree of industry concentration, thus less competition.

To examine the effect of technology gap on technology spillovers, we define the technology gap for each domestic firm as the percentage difference between its labour productivity and that of the average foreign firms in the same industry.

$$Technology\ Gap_{ijt} = (AverageLP_{jt} - LP_{ijt}) / LP_{ijt} \qquad (4.6)$$

where $AverageLP_{jt}$ is the mean of the labour productivity of foreign firms in industry j at time t. LP_{ijt} is the labour productivity of domestic firm i in industry j at time t. A negative value of the variable indicates that a given domestic firm is more productive than the average foreign firm in the industry. A larger positive value suggests that a larger technology gap exists between the domestic firm and the average foreign firm in the same industry.

Technology spillovers from FDI ($Spillovers_{jt}$) in this chapter are considered under two categories. On the one hand, technology spillovers from FDI may occur between domestic firms and foreign firms within the same industry. This spillover is called a horizontal spillover (intra-industry spillovers). On the other hand, technology may be transferred from foreign firms to domestic firms that are vertically integrated with them. This spillover is defined as a vertical spillover (inter-industry spillovers). In particular, vertical technology spillovers may occur through backward linkages (from foreign firms to their domestic suppliers) or forward linkages (from foreign firms to their domestic buyers). Because most foreign firms in Vietnam are export-oriented and generally do not supply Vietnamese customers, we only focus on technology spillovers through backward linkages.

$Horizontal_{jt}$ is a sector specific variable that captures the extent of foreign presence in industry j at time t and is defined as the part of foreign firms in the total employment of the industry.

$$Horizontal_{jt} = \frac{\sum_{k=1}^{m} FL_{kjt}}{\sum_{k,i=1}^{m,n} (FL_{kjt} + DL_{ijt})} \tag{4.7}$$

where $Horizontal_{jt}$ is horizontal spillovers in industry j in year t, FL_{kjt} *(k=1,...,m)* is employment of foreign firms k in industry j and year t, and DL_{ijt} *(i=1,...,n)* is employment of domestic firms i in industry j and year t. This measure reflects mainly the competitive pressures that encourage domestic firms to introduce new products to defend their market share and adopt new management methods to increase productivity. Imitation, reverse engineering, personal contact and industrial espionage may also be captured by this measure.

$Backward_{jt}$ is a sector specific variable that represents the extent of foreign presence in industry j that is being supplied by other sectors. It captures the extent of potential contacts between domestic suppliers and foreign affiliates in industry j and is defined as follows:

$$Backward_{jt} = \sum_{r=1}^{p} \alpha_{jrt} * Horizontal_{rt} \qquad (r=1,...,p) \qquad (4.8)$$

where α_{jrt} ($0 \leq \alpha_{jrt} \leq 1$) is the proportion of industry r's output that is supplied to industry j taken from the input-output table (IO table) at the two-digit level of Vietnamese Standard Industrial Classification (VSIC). As the formula indicates, inputs supplied within the industry are not included, since this effect is already captured by the *Horizontal* variable. The values of α_{jrt} from 2000 to 2004 are based on the 2000 IO table. Besides data limitation, this approach may be justified on the grounds that industrial structures do not change rapidly over time. In any case, while the coefficients taken from the IO table remain fixed for some years, horizontal values do change over time so the measures of backward linkages are time-varying sector-specific variables (Smarzynska, 2004).

We measure backward spillovers from FDI by industry, rather than by firm, for two reasons. First, estimation with industry measures of backward spillovers avoids the endogeneity of a particular firm's decision to sell its products to foreign firms. Secondly, the data do not reveal which specific domestic firms supply foreign firms.

$Exports_{ijt} / Sales_{ijt}$ captures the international spillovers through exports and is defined as the exports' share of sales for firm i.

$Imports_{ijt} / Costs_{ijt}$ captures the international spillovers through imports and is defined as the imports' share of total costs for firm *i*.

We use OLS with the correction for heteroskedasticity and restrict our attention to domestic firms. Considering only domestic firms allows us to avoid a potential bias stemming from the endogeneity problem that occurs if foreign investors tend to acquire stakes in the large and most successful domestic firms.

Another econometric issue that needs to be addressed is the potential endogeneity of foreign presence and industry characteristics. As argued in the literature, foreign firms may choose to locate in a given region because there is better infrastructure, such as better telecommunications or better organizational structure, which is also improving the efficiency of domestic firms. In addition, there is a possibility that foreign investors are attracted to industries with higher labour productivity; therefore the observed correlation between foreign presence and domestic productivity may overestimate the positive impact of the foreign sector. As a result, an OLS estimation may lead to inconsistent results. We are able to control for this endogeneity by adding fixed effects for industry, region and time. Specifically, the industry, region, and time dummies will control for unobserved variables that may be driving changes in, for example, the attractiveness of a given industry or region. We also use lagged values of relevant variables as instruments to account for endogeneity.

4.4 Data Description

The data used in this chapter come from the annual enterprise survey conducted by the General Statistics Office of Vietnam (GSO). The data provide information on formal economic entities in Vietnam from 2000 to 2004. The number of firms per year varies from a low of 10,945 firms in 2000 to a high of 23,121 firms in 2004. The number of firms is reduced by deleting those with missing values, zero sales, zero output, zero employment, and observations failing to satisfy other basic error checks. Finally, the data set is an unbalanced panel of 7,140 domestic firms and 1,461 foreign firms.

The data set contains information on the property structure of the enterprise, sales, output, labour, total costs (wages and training costs), capital stock, investment, location, ownership, research and development (R&D) activity, international trade, and other specialized questions. This enables a test of technology spillovers from FDI in the 2000-2004 period. Unfortunately, data on exports and imports are only available in 2000. Therefore, it is impossible to test the effects of technology spillovers from trade and FDI simultaneously, and we examine technology spillovers through international trade only in 2000.

The sectoral classification of enterprises is at the two-digit level of Vietnamese Standard Industrial Classification (VSIC), which includes 29 sectors from three industrial groups of mining and quarrying, manufacturing, and electricity, gas and water supply. There are 4 sectors in mining and quarrying, 23 sectors in manufacturing, and 2 sectors in electricity, gas and water supply (Appendix C.1).

The domestic sector is defined to include state owned enterprises (SOEs), non-state collective establishments, and domestic private firms and households. The foreign sector includes all establishments with foreign investors. There are two types of foreign firms, namely joint ventures and 100% foreign-invested firms. We distinguish between joint ventures and 100% foreign-invested firms in order to examine the impact of foreign ownership on domestic sectors' performance through technology spillovers.

A common problem with data over time is that for any given year data are expressed in current prices. This makes it important to avoid biases that might arise due to inflation. With 1994 as the base year, all variables are deflated to 1994 prices using the appropriate producer price index deflators.

4.5 Empirical Results and Analyses

4.5.1 Horizontal and vertical spillovers of FDI and labour productivity

In this section, we focus on the effects of technology spillovers from FDI on labour productivity of domestic firms. Table 4.1 reports the estimation results obtained by estimating the model (4.4) with the OLS method for technology spillovers from FDI.

The results in all regressions in Table 4.1 show that the effect of technology transfer is positive and significant at the 1% level when spillover is measured as backward linkages between foreign firms and domestic ones. This implies that greater amounts of backward linkages with foreign firms increase the labour productivity of domestic firms in Vietnam. The positive effects of backward linkages on the productivity of domestic firms may come from the transfer of technology and know-how between foreign buyers and their suppliers. These spillover estimates suggest that an increase of backward linkages by 1% point would increase the labour productivity of domestic sectors by 1.09%. These results aslo suggest that backward linkages are an efficient mechanism to diffuse technology from foreign firms to domestic ones. There are some reasons to explain why backward linkage is an important channel of technology diffusion in Vietnam. First, foreign firms are more likely to share their know-how and their technology with Vietnamese firms because the intermediate goods supplied are specific to their production processes. Secondly, domestic firms may benefit from technology spillovers through the training and turnover of workers provided by foreign firms, and through visits to domestic firms by technical staff of foreign firms.

Table 4.1: The impact of horizontal and vertical spillovers on labour productivity of domestic firms

Dependent variable: Labour productivity of domestic firms

Explanatory variables	1	2	3
Horizontal	-1.19 (0.58)**		-1.02 (0.58)*
Backward	1.09 (0.29)***		1.10 (0.29)***
Horizontal - Region			-0.39 (0.14)***
Lagged Horizontal		-1.64 (1.01)*	
Lagged Backward		1.01 (0.33)***	
Capital intensity	0.50 (0.009)***	0.64 (0.01)***	0.50 (0.009)***
Labour quality	7.49 (0.26)***	8.19 (0.29)***	7.49 (0.26)***
Scale	3.18 (0.32)***	3.52 (0.42)***	3.15 (0.32)***
Concentration	-0.61 (0.08)***	-0.88 (0.14)***	-0.60 (0.08)***
Technology gap	-0.87 (0.05)***	-0.90 (0.07)***	-0.87 (0.05)***
Time dummies	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes
Number of firms	7140	7140	7140
Number of observations	34536	34536	34536
R-squared	0.22	0.25	0.22

Notes: *, ** and *** indicate statistically significant at the 10%, 5% and 1% respectively. Standard errors are in parentheses.

The coefficient on Horizontal reflects the effect of foreign presence on domestic firms within the same sector. This coefficient is negative and significant, which is consistent with the existing literature that finds evidence of negative intra-industry effect in developing countries. This may be explained by the fact that the presence of foreign firms reduces the productivity of Vietnamese firms through competition effects. In fact, foreign firms have some advantages of technology, which allow them to attract demand away from domestic firms. Thus, this forces domestic firms to increase their average cost and to reduce their productivity. Another explanation is that the negative competition effects may outweigh the positive effects of demonstration and imitation generated by the presence of foreign firms.

Since technology spillovers from foreign firms to domestic ones may take time to manifest, we re-estimate the model with lagged spillover variables. The results in column 2 of Table 4.1 confirm those with contemporaneous spillover variables that there are positive technology spillovers from backward linkages, but negative effects from the presence of foreign firms in the same industry..

Among the other control variables, labour productivity is positively related to capital intensity. The results suggest that a 1% increase in the ratio of capital to labour will lead to a 0.5% increase in labour productivity in domestic sectors. The coefficient of labour quality is positive and significant at the 1% level in all cases and similar in magnitude, suggesting that a larger share of skilled workers increases the labour productivity of domestic firms.

The effect of domestic competition is captured by the Herfindahl index (concentration variable) for domestic firms. This coefficient is negative and significant. A reduction of an industry concentration (an increase in the level of competition) by 10% increases the productivity of domestic firms in that industry by 6.1%. This suggests that competition from a domestic firm may be important for the productivity of another domestic firm. Competition from a domestic firm appears to induce other domestic firms to use their resources better in order to maintain their market share, which in turn enhances their productivity.

The production scale of a domestic firm has a positive and significant effect on its productivity. This implies that a firm that is smaller than the most efficient firm in the same industry can take advantage of scale economies.

The technology gap between domestic firms and foreign firms affects the productivity of domestic firms, as the coefficient of the technology gap is negative and significant. This implies that a domestic firm lagging behind foreign technology seems to have lower productivity.

4.5.2 The effect of geographical proximity on technology spillovers

The Horizontal variable is measured on the industry level and does not account for geographical proximity between firms. Geographical proximity may affect the extent of technology diffusion. Demonstration of new products and production techniques are more likely to be observed and copied by neighbouring firms. Aitken and Harrison (1999), and Sjoholm (1999) show that technological diffusion is easier, faster and more probable between firms located near each other. In fact, geographical proximity may reduce transportation costs and facilitate the establishment of backward linkages. In addition, domestic firms may benefit from the infrastructure installed by foreign affiliates located in the same region.

In order to capture the effect of geographical proximity on technology spillovers, we introduce a regional spillover variable. This is measured in the same way as Horizontal but control for the regional location of firms. Specifically, regional spillover in an industry in a region is measured as the share of employment employed by foreign firms in that industry and that region. According to the classification of General Statistics Office of Vietnam, the country is divided into 7 regions, namely North Mountain and Midland; Red River Delta; North Cental Coast; South Central Coast; Central Highland; South East; and Mekong River Delta. Since data on the linkages between foreign firms and local suppliers are not available, it is impossible to test the effect of geographical proximity on backward spillovers.

The results in column 3 of Table 4.1 also show that there is competition effect generated by foreign firms in the same industry within the same region, as the coefficient on horizontal-region is negative. However, the absolute value of the coefficient on horizontal-region is smaller than that of the coefficient on horizontal-industry. This implies that the effect of competition at the regional level is smaller than at the industrial level.

4.5.3 Importance of absorptive capacity of domestic firms

The absorptive capacity of domestic firms may play an important role in generating technology spillovers. To account for the absorptive capacity of domestic firms in determining the existence and extent of spillovers in all industries, we consider two variables on the interaction of labour quality and technology gap with the spillover variables.

Table 4.2 illustrates the effect of the absorptive capacity and the technology gap on the intensity of technology transfer between foreign firms and domestic ones. As seen in Table 4.2, labour quality appears to be important in domestic firms, as domestic firms with larger labour quality grow faster in terms of labour productivity. In addition, the interactions of labour quality with the spillover variables are positive and significant at the 1% level when spillovers are horizontal and backward. This means that labour quality plays an important role in capturing external spillovers. The technology spillovers from FDI are bigger in firms with higher levels of labour quality.

Table 4.2: The importance of absorptive capacity of domestic firms on technology spillovers

Dependent variable: Labour productivity of domestic firms

Explanatory variables	1	2
Horizontal	-2.08 (0.01)***	-0.92 (0.58)
Backward	0.35 (3.04)	1.02 (0.29)***
Capital intensity	0.51 (0.009)***	0.50 (0.009)***
Labour Quality	2.67 (0.41)***	7.40 (0.26)***
Scale	3.54 (0.32)***	3.36 (0.32)***
Concentration	- 0.66 (0.08)***	- 0.63 (0.08)***
Technology Gap	-0.88 (0.05)***	-0.26 (0.08)***
Labour Quality*Horizontal	0.07 (0.01)***	
Labour Quality*Backward	0.59 (0.04)***	
Technology gap* Horizontal		-0.05 (0.005)***
Technology gap* Backward		0.006 (0.01)
Time dummies	Yes	Yes
Industry dummies	Yes	Yes
Region dummies	Yes	Yes
Number of firms	7140	7140
Number of observations	34536	34536
R-squared	0.23	0.23

Notes: *, ** and *** indicate statistically significant at the 10%, 5% and 1% respectively. Standard errors are in parentheses.

The results also show that the technology gap is related to the existence of technology transfer through horizontal linkage, as the coefficient on the interaction between technology gap and horizontal variable is negative and significant. This suggests that domestic firms with a narrow technology gap may have a certain level of technological capacity to compete with foreign firms, reducing the negative effects of competition generated by foreign firms.

Technology gap does not affect the extent of backward spillovers. This may be due to the fact that foreign firms may provide technical assistance to local suppliers to help them raise the quality of intermediate products.

4.5.4 The effect of ownership structure of domestic firms on technology spillovers

As suggested in the literature, FDI may foster economic growth by increasing competition in the host country. This forces domestic firms to restructure in order to be efficient. The outcome of economic renovation in Vietnam has resulted in a wide variety of ownership structures. In this study, the data set is divided into three main groups of domestic firm ownership: state-owned firms, private firms and collective firms. This section addresses the issue as to whether ownership structure is vital to the ability of domestic firms to benefit from spillovers of technology transfer. The results of the impact of ownership structure on technology spillovers are presented in Table 4.3.

Table 4.3: The impact of ownership structure on technology spillovers from foreign firms to domestic firms

Dependent variable: Labour productivity of domestic firms

Explanatory variables	State firms		Private firms		Collective firms	
	1	2	3	4	5	6
Horizontal	-0.07	0.18	-1.72	-3.06	0.15	-0.23
	(1.01)	(0.11)	(0.76)**	(0.84)***	(0.50)	(0.55)
Backward	1.39	-0.47	1.11	-0.08	0.20	0.17
	(0.53)***	(0.55)	(0.39)***	(0.40)	(0.10)*	(0.24)
Capital intensity	0.25	0.25	0.82	0.81	0.52	0.51
	(0.01)***	(0.01)***	(0.01)***	(0.01)***	(0.03)***	(0.03)***
Labour Quality	8.49	6.29	7.58	9.42	3.38	1.35
	(0.37)***	(0.53)***	(0.37)***	(0.67)**	(0.39)***	(0.79)***
Scale	5.07	5.03	7.52	8.47	5.39	5.14
	(0.41)***	(0.41)***	(0.81)***	(0.82)***	(0.47)***	(0.46)***
Concentration	-1.36	-1.31	- 1.13	-1.27	-2.87	-2.59
	(0.15)***	(0.15)***	(0.14)***	(0.14)***	(0.48)***	(0.48)***
Technology Gap	-1.69	-1.24	-1.36	-1.63	-1.80	-0.39
	(0.16)***	(0.28)***	(0.09)***	(0.19)***	(0.02)***	(0.28)*
Labour Quality* Horizontal		-0.11		0.12		0.05
		(0.03)***		(0.02)***		(0.02)**
Labour Quality* Backward		0.80		0.66		0.05
		(0.07)***		(0.07)***		(0.06)
Technology gap* Horizontal		-0.03		-0.03		-0.01
		(0.01)**		(0.01)***		(0.003)***
Technology gap* Backward		0.01		0.13		-0.03
		(0.03)		(0.01)***		(0.007)***
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of firms	1397	1397	4971	4971	772	772
Number of observations	6900	6900	23837	23837	3769	3769
R-squared	0.40	0.42	0.22	0.23	0.29	0.31

Notes: *, ** and *** indicate statistically significant at the 10%, 5% and 1% respectively. Standard errors are in parentheses.

The results from columns 1, 3 and 5 in Table 4.3 show that the presence of foreign firms does not affect the productivity of state firms and collective firms. In other words, these firms are not significantly affected by the competition generated by the entry of foreign firms. However, private firms are negatively influenced by the presence of foreign firms. This may be due to the fact that private firms are small in terms of skilled labour, technology and capital. Therefore, they are less able to absorb technology and cope with competition from foreign presence than state firms and collective firms. In contrast, state firms have more skilled workers and technological ability to compete with foreign firms in the same industry.

The results from all the regressions also show that all types of domestic firms benefit from backward linkages from foreign firms, as the coefficients on Backward are all positive and significant. Combined with the results from previous sections, the study shows a positive and significant coefficient on the measure of backward linkages both in the full sample and the sub-sample of domestic firms.

4.5.5 The effect of the size of domestic firms on technology spillovers

The size of domestic firms can be linked to their capacity for obtaining the benefits associated with the presence of foreign firms. Small firms measured in terms of employment or production may not have a sufficient production scale to imitate or adopt technologies introduced by foreign firms. We examine the impact of firm size on the existence of technology spillovers by considering two types of firm size: large firms, and small and medium firms. A large firm is defined as one with more than 100 employees; a small and medium firm is one with less than 100 employees.

Table 4.4: The impact of firm size on technology spillovers

Dependent variable: Labour productivity of domestic firms

Explanatory variables	Large firms		Small and medium firms	
	1	2	3	4
Horizontal	-0.64	0.07	-1.97	-3.57
	(0.65)	(0.73)	(0.91)**	(0.98)***
Backward	1.52	0.95	0.91	-0.39
	(0.43)***	(0.45)**	(0.37)***	(0.38)
Capital intensity	0.35	0.38	0.58	0.57
	(0.01)***	(0.01)***	(0.01)***	(0.01)***
Labour Quality	6.70	5.86	7.70	-0.19
	(0.34)***	(0.51)***	(0.36)***	(0.63)
Scale	5.17	5.39	20.03	19.98
	(0.39)***	(0.39)***	(1.33)***	(1.33)***
Concentration	-1.38	-1.39	- 2.88	-2.89
	(0.14)***	(0.14)***	(0.20)***	(0.20)***
Technology Gap	-0.35	-0.07	-1.42	-1.13
	(0.06)***	(0.07)	(0.09)***	(0.18)***
Labour Quality* Horizontal		-0.03		0.14
		(0.02)		(0.02)***
Labour Quality* Backward		0.26		0.80
		(0.06)***		(0.06)***
Technology gap* Horizontal		-0.04		-0.02
		(0.006)***		(0.009)***
Technology gap* Backward		0.03		0.02
		(0.01)**		(0.02)
Time dummies	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes	Yes
Number of firms	2192	2192	4948	4971
Number of observations	10817	10817	23719	23837
R-squared	0.37	0.42	0.20	0.23

Notes: *, ** and *** indicate statistically significant at the 10%, 5% and 1% respectively. Standard errors are in parentheses.

The results from columns 1 and 3 in Table 4.4 show that the impact of foreign firms' presence in an industry on the productivity of domestic firms is negative for both types of firms, but only significant for small and medium firms. This result confirms the idea that small and medium firms have less capacity to compete with foreign firms, therefore suffering more significant losses.

Both large firms and small-medium firms benefit from technology spillovers due to backward linkages from foreign firms. These effects are stronger for large firms and are related to the size of the technology gap. Large firms with a small technology gap benefit more from backward linkages while small and medium firms benefit less from backward linkages and the size of the technology gap is not statistically significant. In both two types of domestic firms, spillovers from backward spillovers are stronger in firms with higher levels of labour quality.

4.5.6 The effect of types of industry on technology spillovers

The pooling of all domestic firms in the sample to estimate the spillover effects may hide important variations in technology spillovers for different types of industry. Separating all domestic firms into different industry groups allows examination of details how spillovers in each group occur. The sample is divided into three groups. Group 1 includes industries of low technology; group 2 consists of medium technology industries; and group 3 is for industries of high technology. These groups are listed in Appendix C.3. The division of all firms into these three groups is based on the Classification of the General Statistics Office of Vietnam.

Table 4.5: The impact of types of industry on technology spillovers

Dependent variable: Labour productivity of domestic firms

Explanatory variable	1	2	3
Horizontal - domestic firms in low technology industries (HL)	-1.40 (0.69)**	-1.56 (0.76)**	-1.12 (0.69)*
Horizontal - domestic firms in medium technology industries (HM)	3.00 (2.58)	-1.73 (2.86)	0.58 (0.26)*
Horizontal - domestic firms in high technology industries (HH)	-0.53 (1.36)	-2.70 (1.51)*	-0.94 (1.37)
Backward - domestic firms in low technology industries (BL)	-0.32 (0.52)	0.45 (0.53)	-0.33 (0.52)
Backward - domestic firms in medium technology industries (BM)	1.38 (0.43)***	2.88 (0.52)***	1.11 (0.43)***
Backward - domestic firms in high technology industries (BH)	2.02 (0.57)***	2.56 (0.62)***	2.02 (0.57)***
Capital intensity	0.51 (0.01)***	0.51 (0.01)***	0.51 (0.01)***
Labour quality	7.79 (0.28)***	4.90 (0.55)***	7.64 (0.28)***
Scale	4.94 (0.40)***	5.50 (0.40)***	5.37 (0.40)***
Concentration	-0.76 (0.09)***	-0.84 (0.09)***	-0.81 (0.09)***
Technology gap	-1.33 (0.07)***	-1.38 (0.07)***	-1.09 (0.18)***
Labour quality*HL		0.03 (0.02)	
Labour quality*HM		1.57 (0.12)***	
Labour quality*HH		0.16 (0.04)***	
Labour quality*BL		-0.32 (0.08)***	
Labour quality*BM		-1.17 (0.21)***	
Labour quality*BH		-0.37 (0.16)**	
Technology gap* HL			-0.05 (0.008)***
Technology gap* HM			-0.23 (0.02)***
Technology gap* HH			-0.001 (0.01)
Technology gap* BL			0.11 (0.01)***
Technology gap*BM			0.25 (0.03)***
Technology gap*BH			0.04 (0.04)
Time dummies	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes
Number of firms	7140	7140	7140
Number of observations	32279	32279	32279
R-squared	0.22	0.24	0.23

Notes: *, ** and *** indicate statistically significant at the 10%, 5% and 1% respectively. Standard errors are in parentheses.

Table 4.5 provides the impact of types of industry on technology spillovers from foreign firms to domestic firms. As can be seen from column 1, while the presence of foreign firms generates a negative effect on the productivity of domestic firms in industries of low technology, domestic firms in industries of medium and high technology are not influenced by the competition from foreign firms. This finding is consistent with the hypothesis that the competition effects imposed by foreign firms differ across industries. Domestic firms operating in low technology sectors, like textiles and clothing, seem to be damaged by the competition effect since the success of these kinds of firms depends on market and input costs. Conversely, domestic firms in industries whose products are highly technological have stronger abilities to compete with foreign firms.

The results from Table 4.5 also show that there is a positive and significant effect of backward linkages on the productivity of domestic firms operating in the industries of medium and high technology. However, domestic firms in low technology sectors do not benefit from backward spillovers from foreign firms.

4.5.7 The effect of trade orientation of domestic firms on technology spillovers

As trade-oriented domestic firms produce for foreign markets, they may have more opportunities to learn about advanced technology. To examine whether the trade orientation of domestic firms is important for technology spillovers, two categories of the Horizontal and Backward variables are created: one for domestic firms involving in international trade, and one for domestic firms targeting only domestic market.

Table 4.6: The effect of the trade orientation of domestic firms on technology spillovers

Dependent variable: Labour productivity of domestic firms

Explanatory variables	1	2	3
Horizontal - domestic firms with trade orientation (HTO)	-1.05 (1.59)	-0.91 (0.67)	-0.86 (0.59)
Horizontal - domestic firms with domestic orientation (HDO)	-1.58 (0.61)***	-3.27 (0.67)***	-1.18 (0.61)**
Backward - domestic firms with trade orientation (BTO)	1.02 (0.29)***	0.48 (0.30)	0.94 (0.29)***
Backward - domestic firms with domestic orientation (BDO)	1.29 (0.30)***	-0.50 (0.31)	1.21 (0.30)***
Capital intensity	0.50 (0.009)***	0.51 (0.009)***	0.50 (0.009)***
Labour quality	7.38 (0.26)***	2.67 (0.41)***	7.28 (0.26)***
Scale	2.96 (0.33)***	3.31 (0.33)***	3.08 (0.33)***
Concentration	-0.56 (0.08)***	-0.61 (0.08)***	-0.57 (0.08)***
Technology gap	-0.87 (0.05)***	-0.89 (0.05)***	-0.23 (0.08)***
Labour quality*HTO		-0.02 (0.02)	
Labour quality*HDO		0.15 (0.02)***	
Labour quality*BTO		1.13 (0.07)***	
Labour quality*BDO		0.14 (0.06)**	
Technology gap* HTO			-0.03 (0.007)***
Technology gap* HDO			-0.06 (0.007)***
Technology gap* BTO			0.01 (0.01)
Technology gap*BDO			-0.003 (0.01)
Time dummies	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes
Number of firms	7140	7140	7140
Number of observations	34536	34536	34536
R-squared	0.22	0.23	0.23

Notes: *, ** and *** indicate statistically significant at the 10%, 5% and 1% respectively. Standard errors are in parentheses.

Table 4.6 reports the impact of trade orientation of domestic firms on technology spillovers. It can be seen from column 1 that domestic-oriented firms experience negative effect from the presence of foreign firms, as the coefficient on the Horizontal variable (HDO) is negative and significant. In contrast, domestic firms with international trade orientation are not affected by the competition generated by the presence of foreign firms because the coefficient on HTO is not significantly different from zero. This result supports the arguments of Blomstrom and Sjoholm (1999) that international trade-oriented domestic firms already face significant competitive pressure in the foreign market, and that foreign firms operating in the domestic market are not expected to create relevant additional pressures.

The result also shows that both domestic-oriented firms and international trade-oriented firms benefit from backward linkages. The established backward linkages with foreign firms have a greater effect on the productivity of international trade-oriented firms than those established with domestic-oriented firms. This may be due to the fact that international trade-oriented firms may have higher quality products than domestic-oriented ones. Therefore, international trade-oriented firms can more adequately serve quality requirements of foreign firms.

4.5.8 The effect of R&D activity of domestic firms on technology spillovers

The R&D activity of domestic firms plays an important role in generating knowledge spillovers. It affects not only the amount of technology transferred, but also increases the absorptive capacity of domestic firms. It is likely that domestic firms with R&D activity may get greater opportunities for technology spillovers than domestic firms without R&D activity. To examine the effect of R&D activity on technology spillovers, two categories of the horizontal and backward variables are created for the two types of domestic firms: one variable for domestic firms with R&D activities, and one for those without R&D performance.

Table 4.7 presents the impact of R&D activity on technology spillovers to domestic firms. The results show that there are negative effects of competition from foreign firms on domestic firms without R&D performance in the same industry. In contrast, R&D performing firms are not affected by this competition. These results support the argument that domestic firms with R&D activities tend to have greater ability to compete with foreign firms, compared with domestic firms without R&D.

Both domestic firms with and without R&D activities gain benefit for technology spillovers from backward linkages with foreign firms. In addition, the magnitude of backward spillovers for R&D performing firms is larger than for non-R&D performing firms. This result is consistent with the hypothesis that absorptive capacity depends not only on human capital, but also on R&D activities. In particular, R&D activities augment a domestic firm's ability to benefit from spillovers of technology transfer.

Table 4.7: The impact of R&D activity of domestic firms on technology spillovers

Dependent variable: Labour productivity of domestic firms

Explanatory variables	1	2	3
Horizontal - domestic firms with R&D activities (HRD)	-0.57 (0.62)	-0.81 (0.73)	-0.59 (0.63)
Horizontal - domestic firms without R&D activities (HNRD)	-1.41 (0.58)**	-2.82 (0.64***	-1.02 (0.58)***
Backward - domestic firms with R&D activities (HRD)	1.17 (0.29)***	0.61 (3.06)	1.06 (0.0.29)***
Backward - domestic firms without R&D activities (HNRD)	0.90 (0.30)***	0.11 (0.32)	0.92 (0.30)***
Capital intensity	0.50 (0.009)***	0.50 (0.09)***	0.50 (0.09)***
Labour quality	7.51 (0.26)***	2.48 (0.41)***	7.40 (0.26)***
Scale	3.21 (0.33)***	3.91 (0.33)***	3.33 (0.33)***
Concentration	-0.61 (0.08)***	-0.73 (0.08)***	-0.63 (0.08)***
Technology gap	-0.87 (0.05)***	-0.87 (0.05)***	-0.26 (0.08)***
Labour quality*HRD		0.02 (0.03)	
Labour quality*HNRD		0.11 (0.02)***	
Labour quality*BRD		0.69 (0.05)***	
Labour quality*BNRD		0.38 (0.08)***	
Technology gap* HRD			-0.03 (0.008)***
Technology gap* HNRD			-0.06 (0.006)***
Technology gap* BRD			-0.02 (0.01)**
Technology gap* BNRD			-0.10 (0.03)***
Time dummies	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes
Number of firms	7140	7140	7140
Number of observations	34536	34536	34536
R-squared	0.22	0.23	0.23

Notes: *, ** and *** indicate statistically significant at the 10%, 5% and 1% respectively. Standard errors are in parentheses.

4.5.9 The effect of ownership structure of foreign firms on technology spillovers

The ownership structure of foreign firms may affect the degree of both horizontal and backward spillovers. With respect to horizontal spillovers, foreign firms with the most sophisticated technologies may fear technology leakage, especially in countries with limited rules of law (Smarzynska and Wei, 2000). They will therefore shy away from shared ownership and instead choose to invest only in fully owned subsidiaries. In addition, foreign investors are more likely to transfer technology within wholly owned networks of multinational's subsidiaries, than to joint ventures or licenses (Ramachandran, 1993). As a result, wholly owned foreign firms may generate potentially stronger positive spillovers than partially owned foreign firms.

With respect to backward spillovers, it has been argued that affiliates established through joint ventures are more likely to source their inputs locally than those taking the form of full foreign ownership. This is due to the fact that, while wholly owned foreign firms need to set up linkages with local suppliers, partially owned foreign firms (or joint ventures) can take advantage of pre-existing supplier relationships with local partners. Therefore, there may be larger vertical spillovers associated with partially owned foreign firms than with wholly owned foreign firms. Moreover, wholly owned foreign firms may have higher requirements on their local suppliers than partially owned foreign firms, as they may use more sophisticated technologies. As a result, only a limited number of domestic firms can meet these requirements and gain benefit from vertical spillovers generated by wholly owned foreign firms.

To examine the effects of ownership structure of foreign firms on technology spillovers to domestic firms, two measures of horizontal spillovers are calculated for two types of foreign firm. The measure for fully owned foreign firms is defined as follows:

$$Horizontal(Fully\ foreign-owned\ firms\ (FFOF))_{jt} = \frac{\sum_{k=1}^{n} FO_{kjt} * FL_{kjt}}{\sum_{k,j=1}^{n,m} (FL_{kjt} + DL_{ijt})} \quad (4.9)$$

Similarly, two measures of backward spillovers are calculated for two types of foreign firms. The measure for fully owned foreign firms is as follows:

$$Backward(FFOF)_{jt} = \sum_{r=1}^{p} \alpha_{jrt} * Horizontal(FFOF)_{rt} \quad (4.10)$$

Where FL_{kjt}, DL_{ijt} and α_{jrt} are as in section 4.3. FO_{kjt} is a dummy for fully foreign-owned firms. It is equal to one for foreign firms with 100% foreign invested, otherwise zero. The measures of horizontal and backward spillovers for partially foreign-owned firms are calculated analogously.

As can be seen from column 1 in Table 4.8, while domestic firms are not affected by the presence of partially foreign-owned firms, fully foreign-owned firms exert a negative impact on the productivity of domestic firms in the same sector. This may be due to the fact that fully foreign-owned firms have more advanced technology, allowing them to impose a higher level of competition on domestic markets, thus forcing domestic firms to reduce their productivity.

The results also show that both fully foreign-owned firms and partially foreign-owned firms generate positive spillovers to domestic firms through backward linkages. Moreover, domestic firms benefit more from backward spillovers from partially foreign-owned firms than from fully foreign-owned firms. This finding is consistent with the fact that partially foreign-owned firms are more likely to source their inputs locally, thus creating greater scope for technology spillovers to domestic firms operating in upstream sectors. The F-test of the equality of the coefficients on Backward confirms the results by showing a statistically significant difference between the impacts of the two types of foreign ownership.

Table 4.8: The impact of ownership structure of foreign firms on technology spillovers

Dependent variable: Labour productivity of domestic firms

Explanatory variables	1	2	3
Horizontal - Fully foreign ownership (HFO)	-1.37 (0.69)**	-0.58 (0.09)***	-2.08 (0.71)***
Horizontal - Partially foreign ownership (HPO)	-0.72 (1.28)	-0.76 (0.14)***	-0.26 (1.28)
Backward - Fully foreign ownership (BFO)	0.92 (0.32)***	-0.77 (0.48)	0.82 (0.32)***
Backward - Partially foreign ownership (BPO)	1.54 (0.47)***	1.93 (0.34)***	1.58 (0.47)***
Capital intensity	0.50 (0.009)***	0.50 (0.09)***	0.50 (0.09)***
Labour quality	7.50 (0.26)***	3.76 (0.44)***	7.35 (0.26)***
Scale	3.18 (0.32)***	3.77 (0.32)***	3.33 (0.32)***
Concentration	-0.61 (0.08)***	-0.70 (0.08)***	-0.63 (0.08)***
Technology gap	-0.87 (0.05)***	-0.88 (0.05)***	-0.26 (0.08)***
Labour quality*HFO		-0.59 (0.06)***	
Labour quality*HPO		0.54 (0.06)***	
Labour quality*BFO		-0.81 (0.09)***	
Labour quality*BPO		1.63 (0.07)***	
Technology gap* HFO			0.10 (0.02)***
Technology gap* HPO			-0.16 (0.01)***
Technology gap* BFO			0.05 (0.02)***
Technology gap* BPO			-0.11 (0.02)***
Time dummies	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes
Number of firms	7140	7140	7140
Number of observations	34536	34536	34536
R-squared	0.22	0.24	0.23
F test for equal coefficients on Horizontal (HFO = HPO)	3.18**	45.01***	2.38*
F test for equal coefficients on Backward (BFO = BPO)	4.59**	28.35***	4.41**

Notes: *, ** and *** indicate statistically significant at the 10%, 5% and 1% respectively. Standard errors are in parentheses.

4.5.10 The effect of export orientation of foreign firms on technology spillovers

The export intensity of foreign firms may affect the extent of technology spillovers from both horizontal and backward linkages. Regarding horizontal spillovers, since export-oriented foreign firms serve essentially foreign markets, they may exert less competitive pressure on domestic firms than host market-oriented foreign firms. Therefore, horizontal spillovers may be mitigated by the decreased competition generated by export-oriented foreign firms.

Regarding backward spillovers, the export orientation of foreign firms is likely to be more relevant to backward spillovers than horizontal spillovers since it contributes to the degree of contact that foreign firms have with domestic ones. As mentioned by Altenburg (2000) and UNCTAD (2000), foreign firms that serve local markets are more likely to have vertical linkages with domestic suppliers than foreign firms who export, since they need to adapt their products to local market conditions and tend to be more integrated into the local economy. Export-oriented foreign firms may have higher quality requirements on inputs supplied by domestic firms, as they are generally part of global sourcing and distribution networks managed by the parent company. These requirements can be difficult for the domestic supplier to meet. As a result, export-oriented foreign firms are less favourable for technology transfer to domestic firms than domestic market-oriented foreign firms.

To examine whether the export orientation of foreign firms is important for technology spillovers, two measures of Horizontal and Backward spillovers are calculated: one for foreign firms involving international markets, and one for foreign firms targeting only domestic market. Specifically, two variables of Horizontal and Backward spillovers for export-oriented foreign firms are defined as follows:

$$Horizontal(Export\!-\!oriented\,firms\,(EOF))_{jt} = \frac{\sum_{k=1}^{n} TO_{kjt} * FL_{kjt}}{\sum_{k,j=1}^{n,m} (FL_{kjt} + DL_{ijt})} \quad (4.11)$$

$$Backward\,(EOF)_{jt} = \sum_{r=1}^{p} \alpha_{jrt} * Horizontal\,(EOF)_{rt} \quad (4.12)$$

Where FL_{kjt}, DL_{ijt} and α_{jrt} are as in section 4.3. TO_{kjt} is a dummy for export-oriented foreign firms. $TO_{kjt} = 1$ if foreign firm k involves in international trade and zero otherwise. The measures of horizontal and backward spillovers for foreign firms with domestic market orientation are defined analogously.

The results in column 1 in Table 4.9 indicate that domestic-oriented foreign firms exert a negative impact on the productivity of domestic firms in the same industry. However, domestic firms are not affected by the presence of export-oriented foreign firms in the same industry. These results are in line with the conclusion of Gimar et al. (2004) that export intensity is relevant for the detection of horizontal spillovers, since the larger the export intensity, the less the perceived competition from foreign firms.

The results also show that domestic firms benefit from backward linkages with both export-oriented foreign firms and domestic-oriented foreign firms. Furthermore, domestic firms seem to benefit more from the latter than the former. These results support the hypothesis that domestic firms have more contact with domestic-oriented foreign firms than with export-oriented foreign firms. Therefore, the higher level of backward spillovers from domestic-oriented foreign firm might well be determined by the strong linkages, which these firms establish with local suppliers. The F-test of the equality of the coefficients on Backward confirms the finding that there is a statistically significant difference in the magnitude of the backward spillovers associated with the two types of foreign firms.

Table 4.9: The impact of export activity of foreign firms on technology spillovers

Dependent variable: Labour productivity of domestic firms

Explanatory variables	1	2	3
Horizontal - Export-oriented foreign firms (HEO)	-0.89 (1.28)	-0.42 (0.99)	-0.27 (1.28)
Horizontal - Domestic-oriented foreign firms (HDO)	-1.33 (0.69)**	-0.61 (0.14)***	-2.24 (0.71)***
Backward - Export-oriented foreign firms (BEO)	0.92 (0.30)***	-0.78 (0.46)	0.82 (0.30)***
Backward - Domestic-oriented foreign firms (BDO)	1.79 (0.45)***	2.13 (0.33)***	1.83 (0.45)***
Capital intensity	0.50 (0.009)***	0.50 (0.09)***	0.50 (0.09)***
Labour quality	7.49 (0.26)***	2.93 (0.45)***	7.36 (0.26)***
Scale	3.18 (0.32)***	3.82 (0.32)***	3.34 (0.32)***
Concentration	-0.61 (0.08)***	-0.71 (0.08)***	-0.63 (0.08)***
Technology gap	-0.87 (0.05)***	-0.88 (0.05)***	-0.13 (0.08)***
Labour quality*HEO		-0.46 (0.06)***	
Labour quality*HDO		0.39 (0.05)***	
Labour quality*BEO		-1.14 (0.11)***	
Labour quality*BDO		2.06 (0.09)***	
Technology gap* HEO			-0.17 (0.01)***
Technology gap* HDO			0.12 (0.02)***
Technology gap* BEO			-0.07 (0.03)**
Technology gap* BDO			0.05 (0.03)*
Time dummies	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes
Number of firms	7140	7140	7140
Number of observations	34536	34536	34536
R-squared	0.22	0.24	0.23
F test for equal coefficients on Horizontal (HEO = HDO)	3.08**	27.51***	3.62**
F test for equal coefficients on Backward (BEO = BDO)	4.57**	41.79***	5.94**

Notes: *, ** and *** indicate statistically significant at the 10%, 5% and 1% respectively. Standard errors are in parentheses.

4.5.11 International Trade and Technology Spillovers

Besides backward spillovers from FDI, there may be some alternative sources of technology transfer to domestic firms. This subsection examines the impact of international trade as an alternative source of international technology diffusion for domestic firms.

Technology spillovers through international trade to a domestic firm are measured by the share of its imports (imports of capital equipment and intermediate goods) in its total costs, and by the share of its exports in its total sales. The former measure reflects the role of imports as a channel of technology transfer, which is suggested by Coe and Helpman (1995). The latter measure considers exporting as a mechanism of technology spillovers. It also indicates the capability of the domestic firm to meet high quality standards in international markets.

Since data on exports and imports are only available for 2000, this subsection only tests technology spillovers from international trade for domestic firms in that year. An OLS regression with White covariance estimation is employed to correct for within sector heteroskedasticity.

The results in column 1 from Table 4.10 show that there is a positive and significant relationship between imports and the productivity of domestic firms. This implies that importing is another important source of technology spillovers for domestic firms. However, there is no evidence that exporting generates technology spillovers to domestic firms. The results in column 2 reveal that labour quality affects technology spillovers from exports and imports in different ways. The effect of technology spillovers from exports is bigger in firms with higher levels of labour quality. In contrast, firms with higher levels of labour quality gains less technology spillovers from imports.

Table 4.10: The impact of technology spillovers through trade on labour productivity of domestic firms

Dependent variable: Labour productivity of domestic firms

Explanatory variables	1	2
Exports/Sales	0.04	-0.23
	(0.21)	(0.80)
Imports/Total costs	0.87	1.77
	(1.15)*	(0.24)*
Capital intensity	0.33	0.32
	(0.05)*	(0.05)*
Labour quality	7.59	8.22
	(1.43)*	(1.46)*
Scale	1.15	0.94
	(0.91)	(0.90)
Concentration	-0.13	0.10
	(0.19)	(0.19)
Labour quality* Exports/ Sales		0.43
		(0.14)*
Labour quality* Imports/ Total costs		-0.04
		(0.01)*
Industry dummies	Yes	Yes
Regional dummies	Yes	Yes
Number of observations	1619	1619
R squared	0.18	0.19

Notes: *, and ** indicate statistically significant at the 1%, and 5% respectively. Standard errors are in parentheses.

As suggested by Blalock and Veloso (2005), learning from imports is associated with exposure to foreign technology. Learning from imports may occur among local suppliers upstream of import-intensive sectors. Specifically, local firms supplying industries and regions with higher levels of inputs imported from foreign markets may show greater productivity than other local firms. In other words, linkages through vertical supply relationships may be the effective channel through which import-driven technology transfer occurs. To test this hypothesis, we evaluate the impact of downstream imports on domestic firm's productivity. First, own-sector imports variable is estimated to measure how much does a sector rely on imported materials.

$$Own-Sector\ Imports_j = \frac{\sum_{i=1}^{n}{}_{i\in j}\ Imports_{ij}}{\sum_{i=1}^{n}{}_{i\in j}\ MC_{ij}} \qquad (i=1,\ldots,n) \qquad (4.13)$$

where MC_{ij} is the total costs of materials purchased by firm i in industry j, and $Imports_{ij}$ is the value of capital and intermediate goods that firm i in industry j purchases from foreign suppliers. This measure varies by industry and region. Therefore, it avoids the endogeneity of a particular firm's decision to buy from foreign suppliers.

Secondly, the estimates of own-sector imports are then used to estimate downstream imports, which proxy for supply chain technology transfer.

$$Downstream\ Imports_j = \sum_{k=1}^{m} \alpha_{jk} * Own-Sector\ Imports_k \quad (k=1,\ldots,m) \quad (4.14)$$

where α_{jk} $(0 \leq \alpha_{jk} \leq 1)$ is the proportion of sector j's output that is consumed by sector k. The values of α_{jk} are based on the 2000 IO table.

Table 4.11 provides evidence that domestic firms benefit from downstream imports. In particular, the productivity of domestic firms increase approximately by 1.87% as the proportion of downstream imports rises by 1%. Own-sector imports also affect positively the productivity of domestic firms.

Column 2 tests the role of labour quality on technology spillovers from downstream imports. The interaction between labour quality and downstream imports is positive, but not significant. This implies that technology spillovers through downstream imports to a domestic firm are not affected by its labour quality.

Table 4.11: The impact of technology spillovers through downstream imports on labour productivity of domestic firms

Dependent variable: Labour productivity of domestic firms

Explanatory variables	1	2
Downstream imports	1.87	1.86
	(0.32)*	(0.32)*
Own-sector imports	0.88	0.88
	(0.11)*	(0.11)*
Capital intensity	0.31	0.31
	(0.05)*	(0.05)*
Labour quality	8.16	6.75
	(1.42)*	(4.11)**
Scale	0.74	0.79
	(0.90)	(0.91)
Concentration	-0.08	-0.08
	(0.19)	(0.19)
Labour quality* Downstream imports		0.08
		(0.23)
Industry dummies	Yes	Yes
Regional dummies	Yes	Yes
Number of observations	1619	1619
R squared	0.20	0.20

Notes: *, and ** indicate statistically significant at the 1%, and 5% respectively. Standard errors are in parentheses.

4.6 Conclusion

This chapter examines technology spillovers from FDI and international trade to domestic firms in Vietnam. Using firm level data for the period 2000-2004, the chapter investigates technology spillovers taking place through horizontal linkages (interaction between foreign firms and domestic ones in the same sector), backward linkages (contact between foreign firms and their domestic suppliers), exports and imports.

The most robust finding of this chapter is that backward linkage is an important mechanism of technology transfer from foreign firms to domestic firms. Vietnamese firms in industries with growing backward linkages experience greater productivity, ceteris paribus, than other firms. Backward spillover is affected by the quality of labour; technology spillovers through backward linkages to domestic sectors are bigger in firms with higher levels of labour quality.

The effect of the horizontal presence of foreign firms on the productivity of domestic firms is negative. This implies that the competition effect induced by the entry of foreign firms is stronger than the potential technology transfer between foreign firms and their domestic competitors. The results show that the existence of this competition effect depends on the types of domestic firms and on the characteristics of each industry. While state firms, collective firms, trade oriented firms, R&D performing firms and the firms in the industries of medium and high technology are not affected by the competition generated by foreign firms, the presence of foreign firms negatively affects the productivity of private firms, domestic oriented firms, non R&D performing firms, and firms in low technology industries. In addition, the productivity of domestic firms is found to be negatively associated with the presence of fully owned foreign firms and domestic market-oriented foreign firms. This confirms the hypothesis that spillovers vary with the specific features of both domestic firms and foreign firms.

Another finding of this chapter is that importing is also an important channel for technology diffusion. Domestic firms may benefit from foreign technology not only through direct imports of machinery and equipment, but also via vertical linkages with other firms in import-intensive sectors. These findings contribute to the argument that international trade provides an alternative source for technology spillovers at the firm level.

Chapter 5

Foreign Direct Investment and Wage Spillovers in Vietnam

5.1 Introduction

Foreign direct investment (FDI) is often considered as an engine of economic growth and development. Host country effects of FDI through multinational enterprises (MNEs) are well documented in the literature (Lipsey, 2002; Gorg and Greenaway, 2004). One of the main impacts of FDI on the domestic economy, which has been considered in the previous chapters, is productivity spillovers. In contrast to productivity spillovers, comparatively little effort has been spent on identifying other indirect benefits from FDI, such as wage spillovers from foreign firms. Wage spillovers from FDI are the focus of this chapter. FDI may have direct and indirect effects on the average wages of domestic firms. The direct effects operate through MNEs paying higher wage levels than those paid by domestic firms operating in the same sector, hence raising average wages. The indirect effects arise through the positive effect that the entry or the presence of MNEs may have on wages in domestic sectors. That is, the wage levels in domestic firms are higher in sectors where there is a higher presence of MNEs.

Existing empirical studies in the literature have found inconclusive evidence regarding wage spillovers from FDI. The literature has so far only considered intra-industry (horizontal) wage spillovers or those occurring in a delimited geographical area (Aitken et al. 1996; Lipsey and Sjoholm, 2001). Part of the contributions we make in this chapter is to build on the productivity spillovers literature and to allow for inter-industry (vertical) wage spillovers due to buyer-supplier linkages between foreign and domestic firms. In doing so, we clarify the understanding of the relative strength of channels through which wage spillovers occur. Like the previous chapter, we address the issue as to how the characteristics of industry, domestic firms and foreign firms influence the strength of wage spillovers.

The rest of the chapter is organised as follows. Section 5.2 reviews the literature and points out a number of shortcomings. The empirical model and data are discussed in sections 5.3 and 5.4 respectively. Section 5.5 provides empirical results. Finally, section 5.6 presents conclusions.

5.2 Literature Review

The general approach in the empirical literature to the examination of wage spillovers from foreign firms to domestic ones has been to examine whether the presence of foreign firms affects the wage levels of domestics firms. Such effects are called wage spillovers from foreign firms to domestic firms. Like empirical work on productivity spillovers, existing studies identify wage spillovers as the impact of foreign presence, measured as the share of employment in foreign firms in a given sector, on the wage rates in domestic firms. Compared to the literature on productivity spillovers, there have been relatively few papers analysing wage spillovers, due in part to the higher data requirements.

In one of the early studies in this literature, Aitken, Harrison and Lipsey (1996) examine the impact of FDI on wages in domestic firms in Mexico, Venezuela, and the US using 4-digit industry level data. Impacts of shares of employment in foreign firms in an industry and a region on wages in domestic firms are measured. In the US, they find that wages in domestic firms appear to be higher where there is a high presence of foreign firms. This implies that there is evidence in favour of wage spillovers in the US. However, they find no evidence of wage spillovers for Mexico and Venezuela since FDI is associated with higher wages only for foreign firms in these countries. To some extent, this result may reflect a reallocation of the labour force to foreign firms with higher salaries.

Using the existence of two years of data in the United States, Feliciano and Lipsey (1999) examine the effects of foreign ownership in a state by industry cell on wages in domestically owned establishments. They find that there are no significant impacts of foreign ownership on wages in manufacturing industries. However, outside of manufacturing industries, there are large and statistically significant effects on domestic firm wages, although the significance becomes marginal when education levels of state by industry are included. This study differs from most other studies because it only examines geographical effects, rather than the effects within the industry of the foreign investment.

Lipsey and Sjoholm (2001) test for wage spillovers in the Indonesian manufacturing industry using a cross section of plants in 1996. They use measures of foreign presence at various levels of industry and geography to calculate spillovers from foreign enterprises to wages in domestic enterprises. In every measure, there is a significantly positive relationship between foreign presence and the levels of wages in domestic enterprises. This suggests that wage spillovers take place as a result of increases in the demand for labour. They also find that the effect of FDI on wages is generally higher for white-collar workers than for blue-collar workers.

In another analysis of the effects of FDI on wages in Indonesian manufacturing, Lipsey and Sjoholm (2003) use plant level data for the period 1975-1999. They investigate the impact of FDI on wages of domestic enterprises that are taken over by foreign enterprises during the same period. Once again, they find that after foreign takeovers, both white-collar and blue-collar wages increase significantly.

Girma, Greenaway and Wakelin (2001) use a panel of firm level data to examine wage spillovers from foreign to domestic firms in the UK manufacturing industry for the period 1991-1996. They show that when spillovers are assumed to be identical across industries and firms, there is no significant evidence of wage spillovers. However, when the effects are permitted to vary across industries, wage spillovers are found. In addition, they find that the gap in productivity may affect the extent of wage spillovers. The larger the productivity gap, the smaller the wage spillover. In this study, the degree of import penetration also influences wage spillovers. The higher the degree of import penetration, the larger the wage spillover.

In a study of Ireland, Barry, Gorg and Strobl (2005) investigate the effect of foreign presence on wages in domestic exporting and non-exporting firms using firm level data. They find that, on average, there are negative spillovers from foreign presence on wages paid by domestic exporting firms, but no effect on wages in domestic non- exporting firms in the same sector.

Using data on the electronics industry in the UK for the period 1980-1992, Driffield and Girma (2003) examine the extent to which foreign firms generate wage spillovers in domestic firms using a simultaneous dynamic panel data model. They find that in general there are wage spillovers from foreign firms to domestic firms in regions where FDI takes place. They also find that the effect of wage spillovers on skilled workers results from an increase in foreign wages paid at both intra-industry and inter-industry level. In contrast, wage spillovers to unskilled workers are confined to the regions where workers are less mobile and with high levels of unemployment.

The existing literature is subject to a number of shortcomings, which may explain the failure to detect significant wage spillover effects on domestic firms. First, most studies have only attempted to examine horizontal wage spillovers, by relating the level of wages of domestic firm in an industry to the presence of foreign firms in the same industry. Foreign firms often pay higher wages than domestic firms, even after controlling for size and other firm and sectoral characteristics (Girma et al, 2001; Lipsey and Sjoholm, 2001). Therefore, if foreign and domestic firms compete in the same labour market, domestic firms have to pay higher wages to attract workers. Thus, horizontal wage spillovers occur through the shift in labour demand or increased competition in labour markets. This largely neglects the possibility of vertical wage spillovers to domestic firms from linkages with foreign firms in different industries. Vertical wage spillovers may occur through vertical productivity spillovers. If there are positive productivity spillovers from foreign firms to domestic firms through vertical linkages, then domestic firms will become more productive, and be able to pay higher wages.

Secondly, in many studies the coefficient indicating wage spillovers is constrained to be the same for all firms. In particular, all domestic firms are assumed to benefit equally from FDI, so that findings on wage spillovers are a result of ignoring differences in the characteristics of firms and industries. When firm heterogeneity is taken into account, wage spillovers may be associated not only with identifiable differences across industries, but also with differences between firms within industries.

Thirdly, it is usually assumed that FDI is homogeneous and therefore that the wage spillover effect is the same for all types of FDI. However, as Moran (2001) shows in a number of case studies, foreign investment is quite heterogeneous with respect to its relationship with domestic firms, which can be assumed to have implications for any spillovers. Wage spillovers can arise when workers receive training or accumulate experience by working for foreign firms and then move to domestic firms. Using a matched firm and worker level dataset for Ghanaian manufacturing firms, Gorg, Strobl and Walsh (2002) find that those who work for and receive training in foreign firms experience more rapid wage growth than workers being trained only in domestic firms. This is consistent with their theoretical model, which shows that training provided by foreign firms is more productive than that of domestic firms, and hence that workers trained in foreign firms have steeper wage profiles.

In this chapter, we take all of these issues into account using firm level data for Vietnamese industries from 2000 to 2004. First, we investigate the importance of both horizontal and vertical wage spillovers. In particular, we distinguish spillover effects due to the presence of foreign firms in the same industry from effects due to vertical linkages between foreign and domestic firms. Secondly, we examine the effects of wage spillovers under different characteristics of firms and industries. Thirdly, we consider the role of training on wage spillovers by distinguishing spillovers from foreign firms with and without training activity in the host country.

5.3 Empirical Model

In examining wage spillovers from foreign firms to domestic firms in Vietnamese industry, we estimate an equation of the following form:

$$\ln W_{ijt} = \beta_1 HS_{jt} + \beta_2 VS_{jt} + \beta_3 X_{ijt} + S_j + D_t + L_i + \varepsilon_{ijt} \tag{5.1}$$

where *i*, *j*, and *t* represent firms, sectors, and years respectively. W_{ijt} is average wage of firm *i* in sector *j* in year *t*. S_j is two-digit dummy for fixed industry effects. D_t represents time dummies that account for aggregate shocks. L_i is regional dummies that control for fixed region effects. ε_{ijt} denotes a random noise term. X_{ijt} is a vector of firm *i*'s characteristics that may influence the level of wages.

Horizontal wage spillover (HS_{jt}) is measured as the share of employment accounted by all foreign firms in the sector *j* in which the firm operates.

$$HS_{jt} = \frac{\sum_{k=1}^{m} FL_{kjt}}{\sum_{k,i=1}^{m,n} (FL_{kjt} + DL_{ijt})} \tag{5.2}$$

where FL_{kjt} *(k=1,...,m)* is employment of foreign firms *k* in industry *j* and year *t*, and DL_{ijt} *(i=1,...,n)* is employment of domestic firms *i* in industry *j* and year *t*. This spillover indicates the degree of foreign penetration in each sector's labour market. It also reflects the competitive pressures from foreign firms that encourage domestic firms to increase wages to attract workers.

Vertical wage spillover (VS_{jt}) is derived from the extent of contacts between domestic firms and foreign firms in different industries. These contacts may lead to productivity gains to domestic firms and they will pay higher wages.

$$VS_{jt} = \sum_{r=1}^{p} \alpha_{jrt} * HS_{rt} \tag{5.3}$$

where α_{jrt} $(0 \le \alpha_{jrt} \le 1)$ is the proportion of sector *r*'s output (*r=1,...,p*) that is supplied to sector *j* taken from the input-output table (IO table) at the two-digit level of the Vietnamese Standard Industrial Classification (VSIC). The values of α_{jrt} from 2000 to 2004 are based on the 2000 IO table. Besides data limitation, this approach may be justified on the grounds that industrial structures do not change rapidly over time. Although the coefficients taken from the IO table remain fixed for some years, horizontal values do change over time so the measures of vertical linkages are time-varying sector-specific variables (Smarzynska, 2004).

As pointed out above, a contribution of this chapter is that we consider the role of training on wage spillovers. Hence, two measures of Horizontal and Vertical wage spillovers described above are calculated considering the training activities of foreign firms with domestic firms to obtain four measures, namely HS-Training, HS-No-training, VS-Training, and VS-No-training. The measures with the Training suffix are computed with consideration of the employment of foreign firms, which undertake domestic training, whereas the measures with the No-training suffix take the employment of foreign firms that do not train local labour. The training activity of foreign firms is likely to be relevant to wage spillovers since it contributes to the degree of contact that foreign firms have with domestic markets. Foreign firms with domestic training presumably have more integration into local markets than foreign firms without domestic training. Moreover, the training activity may encourage labour movement between foreign and domestic firms, hence enhancing wage spillovers.

Regarding firm's characteristics, it is argued in the literature that foreign firms are more capital intensive and larger than domestic firms. These characteristics may account for some of the wage differentials between foreign and domestic firms. Thus, we use the capital intensity variable, measured by the ratio of fixed assets to total employment, in order to control for the impact of capital intensity on wage differentials.

Skills that workers attained through education and training may affect the level of wages. We use workers' educational attainment as a proxy to control for the impact of skills on wages. As data on educational attainment are not available on each firm, the educational attainment of workers in the province where the firm is located is used to represent the firm's skill level.

To account for the impact of scale on wage differentials, we measure the scale effect using the ratio of sales in each firm to total industry sales. Another factor that may influence the average wages paid by firms is the level of competition in each industry. To control for this factor, we use the Herfindahl index, which is proxied for the level of competition. The Herfindahl index in industry *j* in year *t* is calculated as follows:

$$HERF_{jt} = \sum_{i=1}^{n} \left(\frac{x_{ijt}}{X_{jt}} \right)^2 \qquad i=1,2,\ldots,n. \qquad (5.4)$$

where x_{ijt} is the sales of the firm *i* in industry *j*; X_{jt} denotes the total sales of industry *j*. A higher value of this variable indicates a high degree of industry concentration, and thus less competition.

To examine the effects of technology gap on wage spillovers, we define the technology gap for each firm as the percentage difference between its labour productivity and that of the average of foreign firms in the same industry.

$$Technology\ Gap_{ijt} = (AverageLP_{jt} - LP_{ijt}) / LP_{ijt} \qquad (5.5)$$

where $AverageLP_{jt}$ is the mean of the labour productivity of foreign firms in industry *j* in year *t*. LP_{ijt} is the labour productivity of domestic firm *i* in industry *j* in year t. A negative value of the variable indicates that firm i is more productive than the average foreign firm in the industry and a positive value indicate that firm i is less productive than the average foreign firm in the industry. A larger positive value shows that a larger technology gap exists between the domestic firm and the average foreign firm in the same industry.

All regressions in this chapter are estimated by using OLS with the correction for heteroskedasticity. An econometric issue that needs to be addressed is the potential endogeneity of foreign presence and domestic firms' wages. As argued in the literature, foreign firms may choose to locate in a region or an industry with lower wage level. Therefore the observed correlation between foreign presence and domestic firms' wages may overestimate the positive impact of the foreign sector. As a result, OLS estimation may lead to inconsistent results. We are able to control for this endogeneity by adding fixed effects for industry, region and time. Specifically, the industry, region and time dummies will control for unobserved variables that may be driving changes in, for example, the attractiveness of a given industry or region.

5.4 Data Description

The data used in this study come from the annual enterprise survey conducted by the General Statistics Office of Vietnam (GSO). The data provide information on formal economic entities in Vietnam from 2000 to 2004, and this enables a test of wage spillovers from FDI in the 2000-2004 period. The number of firms per year varies from a low of 10,945 firms in 2000 to a high of 23,121 firms in 2004. The number of firms is reduced by deleting those with missing values, zero wages, zero sales, zero output, zero employment, and observations failing to satisfy other basic error checks. Finally, the data set is an unbalanced panel of 7,140 domestic firms and 1,461 foreign firms.

The data set contains information on the property structure of the enterprise, wages, sales, output, capital stock, employment, investment, location, research and development (R&D) activity and international trade. The sectoral classification of enterprises is at the two-digit level of Vietnamese Standard Industrial Classification (VSIC), which includes 29 sectors from three industrial groups of mining and quarrying, manufacturing, and electricity, gas and water supply. There are 4 sectors in mining and quarrying, 23 sectors in manufacturing, and 2 sectors in electricity, gas and water supply (Appendix C.1).

The Appendix table provides some descriptive statistics by sector. Among industries at the two-digit VSIC level, electrical machinery and appliances, radios, television and telecommunication devices, and medical equipment and optical instruments are relatively large in terms of foreign share of employment (Appendix D.1). The foreign shares of employment are small in mining, cigarettes and tobacco, and collection, purification and distribution of water.

The high wage industries in Vietnamese industry are chemicals and chemical products, computer and office equipment, and television and telecommunication devices. The low wage industries are food and beverages, and textile. Wages in foreign firms are relatively high in all industries except cigarettes and tobacco. The average wage in foreign firms is about 70 per cent higher than in domestic firms within two-digit industries (Appendix D.1).

The domestic sector is defined to include state owned enterprises (SOEs), non-state collective establishments, and domestic private firms and households. The foreign sector includes all establishments with foreign investors (joint ventures and

100% foreign-invested firms). In this chapter there is no distinction between joint ventures and 100% foreign-invested firms because one of the purposes is to examine the impact of foreign firms on domestic firms' wages.

A common problem with data over time is that for a given year data are expressed in current prices. This makes its important to avoid biases that might arise due to inflation. With 1994 as the base year, all variables are deflated to 1994 prices using the appropriate producer price index deflators.

5.5 Empirical Results and Analyses

5.5.1 Horizontal and vertical effects of FDI on wages of domestic firms

This section tests the effect of FDI through both horizontal and vertical linkages on wages of domestic firms. Table 5.1 reports the estimation results obtained by estimating equation (5.1).

The results in column 1 in Table 5.1 show that there are wage spillovers from foreign firms to domestic firms, as the coefficients on horizontal and vertical linkages are positive and significant. On the one hand, a larger presence of foreign firms is positively associated with higher average wages of domestic firms, after controlling for fixed effects of industry, region and time. This may imply that the presence of foreign firms causes an overall shift in labour demand leading to upward pressure on wages faced by both foreign firms and domestic firms. On the other hand, the vertical linkages between foreign firms and domestic ones are associated with increased average wages in domestic sectors. This may due to the fact that wages in domestic firms are accompanied by higher productivity, as a result of technological or productivity spillovers from foreign firms via the vertical linkages.

Table 5.1: Horizontal and vertical effects of FDI on wages of domestic firms

Dependent variable: Logarithm of wages per employee in a domestic firm

Explanatory variables	1	2	3
Horizontal	0.002		0.002
	(0.0008)*		(0.0008)*
Horizontal - province		0.002	
		(0.0001)**	
Vertical	0.008	0.009	0.007
	(0.004)**	(0.004)**	(0.004)**
Capital intensity	0.16	0.16	0.16
	(0.002)*	(0.02)*	(0.002)*
Skills	0.05	0.05	0.05
	(0.003)*	(0.003)*	(0.003)*
Scale	0.15	0.15	0.15
	(0.004)*	(0.004)*	(0.004)*
Concentration	-0.002	-0.003	-0.002
	(0.0001)*	(0.0001)*	(0.0001)*
Technology gap	-0.002	-0.002	-0.002
	(0.0008)*	(0.0008)*	(0.0001)*
Horizontal* Technology gap			-0.0003
			(0.00001)*
Vertical*Technology gap			-0.0007
			(0.00001)*
Industry dummies	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
Number of firms	7140	7140	7140
Number of observations	34508	34508	34508
R-squared	0.36	0.35	0.36

Notes: *, ** and *** indicate statistically significant at the 1%, 5%, and 10% respectively. Standard errors are in parentheses.

As Lipsey and Sjoholm (2001) argue, the potential impact of FDI on domestic wages may be conditional on geographic proximity. In addition, the Vietnamese labour market shows some degree of regional segmentation. In fact, labour may be mobile among industries within a province, but not across provinces. In order to capture the effect of geographical proximity on wage spillovers, we calculate an alternative measure of *HS - HS province,* which is the share of foreign firms' employment in the same industry and the same province. The result from column 2 in Table 5.1 shows that foreign firms positively affect wages in domestic firms in the same industry within the same province, as the coefficient on *HS-province* is positive and significant. This implies that wage spillovers occur at both industry level and provincial level.

Among other explanatory variables, average wage levels are positively associated with educational level of workers, capital intensity and production scale. The effect of competition on wages is captured by the concentration variable, and its coefficient is negative and significant. This implies that a reduction of an industry concentration (an increase in the level of competition) by 10% increases the average wages of domestic firms in that industry by 0.02%. This also suggests that competition from a domestic firm may be important for the wage level of another domestic firm. Competition from a domestic firm may induce other domestic firms to pay higher wages in order to attract good workers.

To test the hypothesis that technology gap affects the extent to which domestic firms can benefit from wage spillovers, we consider the interactions between technology gap and wage spillover coefficients. It can be seen from column 3 that the coefficients on these interactions are negative and significant. This suggests that the larger the technology gap between domestic and foreign firms, the smaller the wage spillovers.

5.5.2 The effects of ownership structure and types of industry on wage spillovers

As suggested by Fosfuri et al. (2001), the impact of FDI on domestic firms' wages may be larger when the local firm can compete in markets for products that are unrelated or complementary to those produced by foreign firms. Therefore, product market as well as industry and firm characteristics are relevant in considering the impact of FDI on local wages. In this section we focus on differences in ownership structure, training, technology level and scale economies.

Table 5.2 presents the results of the impact of ownership structure on wage spillovers. It can be seen from all regressions that all types of firms experience from horizontal wage spillovers as the coefficients on horizontal variable are all positive and significant. Combined with the results from table 5.1, the study shows positive and significant wage spillovers both in the full sample and the sub-sample of domestic firms.

Table 5.2: The effect of ownership structure of domestic firms on wage spillovers

Dependent variable: Logarithm of wages per employee in a domestic firm

Explanatory variables	State firms	Private firms	Collective firms
Horizontal	0.002 (0.001)**	0.001 (0.001)***	0.003 (0.002)***
Vertical	0.008 (0.008)	0.01 (0.005)**	0.01 (0.01)
Capital intensity	0.12 (0.006)*	0.12 (0.003)*	0.13 (0.007)*
Skills	0.07 (0.005)*	0.05 (0.004)*	0.03 (0.009)*
Scale	0.14 (0.006)*	0.13 (0.01)*	2.99 (0.23)*
Concentration	-0.004 (0.0002)*	-0.002 (0.0001)*	-2.22 (0.24)*
Technology gap	-0.005 (0.0002)*	-0.003 (0.0001)*	-0.001 (0.0001)*
Industry dummies	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
Number of firms	1397	4971	772
Number of observations	6930	23811	3767
R-squared	0.53	0.27	0.32

Notes: *, ** and *** indicate statistically significant at the 1%, 5%, and 10% respectively. Standard errors are in parentheses.

The results from Table 5.2 also show that only private firms benefit from vertical wage spillovers. Wages in both state firms and collective firms are not significantly influenced by vertical linkages with foreign firms. This may be due to the fact that state firms and collective firms are heavily protected by different means. As a result, private firms have a stronger linkage with foreign firms than state and collective firms.

Table 5.3 reports the effects of the training activity of domestic firms on wage spillovers. It can be seen that foreign firms generate horizontal wage spillovers to both domestic firms with and without training activity. However, only domestic firms having training activity benefit from vertical wage spillovers.

Table 5.3: The effect of training activity of domestic firms on wage spillovers

Dependent variable: Logarithm of wages per employee in a domestic firm

Explanatory variables	Domestic firms with training	Domestic firms without training
Horizontal	0.002 (0.001)**	0.002 (0.001)**
Vertical	0.01 (0.005)**	0.004 (0.007)
Capital intensity	0.14 (0.003)*	0.16 (0.005)*
Skills	0.04 (0.004)*	0.08 (0.006)*
Scale	0.13 (0.008)*	0.17 (0.007)*
Concentration	-0.002 (0.0001)*	-0.004 (0.0002)*
Technology gap	-0.002 (0.0001)*	-0.004 (0.0002)*
Industry dummies	Yes	Yes
Region dummies	Yes	Yes
Year dummies	Yes	Yes
Number of firms	5351	1789
Number of obs	25744	8764
R-squared	0.33	0.44

Notes: *, ** and *** indicate statistically significant at the 1%, 5%, and 10% respectively. Standard errors are in parentheses.

The pooling of all firms in the sample so as to estimate wage spillover effects may hide important variations in spillover effects for different types of industry. Separating all domestic firms into different industry groups allows the examination of details as to how wage spillovers in each group occur. The sample is divided into three groups: group 1 includes industries of low technology; group 2 consists of medium technology industries; and group 3 is for high technology industries. The division of all firms into three groups is based on the Classification of the General Statistics Office of Vietnam.

Table 5.4: The impact of type of industry on wage spillovers to domestic firms

Dependent variable: Logarithm of wages per employee in a domestic firm

Explanatory variables	Low technology	Medium technology	High technology
Horizontal	0.002	0.006	- 0.002
	(0.001)*	(0.004)***	(0.002)
Vertical	0.03	0.001	0.006
	(0.007)*	(0.007)	(0.009)
Capital intensity	0.13	0.15	0.11
	(0.003)*	(0.005)*	(0.01)*
Skills	0.05	0.06	0.11
	0.004)*	(0.006)*	(0.01)*
Scale	0.15	0.41	0.47
	(0.006)*	(0.02)*	(0.03)*
Concentration	-0.002	-0.02	-0.05
	(0.0001)*	(0.001)*	(0.006)*
Technology gap	-0.004	-0.003	-0.002
	(0.0001)*	(0.0001)*	(0.0002)*
Industry dummies	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
Number of firms	4148	1915	557
Number of obs	20218	9277	2756
R-squared	0.33	0.36	0.37

Notes: *, ** and *** indicate statistically significant at the 1%, 5%, and 10% respectively. Standard errors are in parentheses.

Table 5.4 expresses the impact of types of industry on wage spillovers to domestic firms. As can be seen, while there are horizontal wage spillovers with firms in the industries of low and medium technology, firms in the industries of high technology do not experience horizontal wage spillovers. Foreign firms only generate vertical wage spillovers to domestic firms in low technology industries. This finding implies that wage spillover effects differ across industries where FDI occurs. FDI in low technology sectors like textiles and clothing, food and beverages etc, seems to create more wage spillovers since the success of these kinds of FDI depend on market and labour costs.

Table 5.5: Wage spillovers in different sizes of domestic firms

Dependent variable: Logarithm of wages per employee in a domestic firm

Explanatory variables	Small and medium firms	Large firms
Horizontal	0.001	0.003
	(0.0009)***	(0.001)*
Vertical	0.01	0.004
	(0.005)*	(0.007)
Capital intensity	0.14	0.16
	(0.003)*	(0.004)*
Skills	0.05	0.06
	(0.004)*	(0.005)*
Scale	0.13	0.14
	(0.01)*	(0.006)*
Concentration	-0.002	-0.003
	(0.0002)*	(0.0002)*
Technology gap	-0.003	-0.001
	(0.0001)*	(0.0001)*
Industry dummies	Yes	Yes
Region dummies	Yes	Yes
Year dummies	Yes	Yes
Number of firms	4948	2192
Number of obs	23695	10813
R-squared	0.30	0.46

Notes: *, ** and *** indicate statistically significant at the 1%, 5%, and 10% respectively. Standard errors are in parentheses.

Table 5.5 shows the results of wage spillovers in different size of firms. All domestic firms are divided into two types of firm size: large firms, and small and medium firms. A large firm is defined as one with more than 100 employees, and a small and medium firm is one with less than 100 employees. The results indicate that the presence of foreign firm increases the wage levels of large firms as well as small and medium firms. However, only small and medium firms gain wage spillovers from vertical linkages with foreign firms.

5.5.3 The role of domestic training activity of foreign firms in wage spillovers

As pointed out in section 2, foreign firms with domestic training activities have more contacts with domestic firms than those without training. Therefore, domestic training may be relevant to the process of wage spillovers. Training may promote labour mobility and the extent of FDI spillovers on wages. The results in Table 5.6 deals with the domestic training activity of foreign firms.

The results in columns 3 and 4 in Table 5.6 show that both domestic firms with or without training experience horizontal wage spillovers only from foreign firms, which provide local training activity. This implies that the presence of foreign firms with domestic training has a stronger pressure on labour market than that of foreign firms without training activities. This may be due to the fact that training enables domestic firms to get labour movement from foreign firms, hence enhancing horizontal wage spillovers.

The results in column 2 indicate that foreign firms with domestic training activity appear to generate positive and significant wage spillovers to those domestic firms with training in vertical linkages. This reflects the fact that domestic firms with training commitments have more contacts with foreign firms than domestic firms without such commitments. As a result, it is more likely that there is labour mobility between foreign firms and domestic firms with training across industries, hence leading to vertical wage spillovers between these firms.

Table 5.6: The effect of domestic training activity of foreign firms on wage spillovers

Dependent variable: Logarithm of wages per employee in a domestic firm

Explanatory variables	All domestic firms	Domestic firms with training	Domestic firms without training
Horizontal - Training	0.002 (0.001)*	0.002 (0.001)**	0.003 (0.001)**
Horizontal - No training	0.001 (0.001)	0.001 (0.002)	0.001 (0.003)
Vertical – Training	0.01 (0.004)*	0.01 (0.005)*	0.008 (0.008)
Vertical - No training	-0.003 (0.006)	-0.001 (0.008)	0.001 (0.01)
Capital intensity	0.16 (0.002)*	0.14 (0.003)*	0.16 (0.005)*
Skills	0.05 (0.003)*	0.05 (0.004)*	0.05 (0.004)*
Scale	0.15 (0.04)*	0.13 (0.008)*	0.17 (0.007)*
Concentration	-0.002 (0.0001)*	-0.002 (0.0001)*	-0.004 (0.0002)*
Technology gap	-0.002 (0.0008)*	-0.002 (0.0001)*	-0.004 (0.0002)
Industry dummies	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
Number of firms	7140	5351	1789
Number of observations	34508	25744	8764
R-squared	0.36	0.33	0.44
F test for equal coefficients on Horizontal	2.46**	0.26	0.43
F test for equal coefficients on Vertical	3.27**	3.20**	0.37

Notes: *, ** and *** indicate statistically significant at the 1%, 5%, and 10% respectively. Standard errors are in parentheses.

5.5.4 Robustness checks

This section examines the robustness of the above results by running the regressions for each year with undeflated values. This alternative specification avoids any added errors that may be due to faulty price indices. This also allows us to see if there are any changes in wage spillovers over time.

The results in Table 5.7 show that there are horizontal wage spillovers from foreign firms to domestic ones in every year, although the magnitude and the degree of significance of these spillovers are different over time. As shown, wage spillovers from the vertical linkages between foreign firms and domestic firms are limited in some years, as the coefficients on vertical wage spillovers are positive but not statistically significant in all years. This is consistent with the results found in previous sections that vertical wage spillovers only take place in some specific industries and in some types of domestic firms.

Table 5.7: Horizontal and vertical effect of FDI on wages from 2000 to 2004

Dependent variable: Logarithm of wages per employee in a domestic firm

Explanatory variables	2000	2001	2002	2003	2004
Horizontal	0.02	0.02	0.005	0.02	0.002
	(0.006)*	(0.01)***	(0.003)**	(0.002)*	(0.001)**
Vertical	0.08	0.07	0.02	0.09	0.005
	(0.01)*	(0.04)***	(0.02)	(0.06)***	(0.009)
Capital intensity	0.08	0.07	0.06	0.05	0.05
	(0.003)*	(0.002)*	(0.002)*	(0.002)*	(0.002)*
Skills	0.02	0.03	0.02	0.02	0.02
	(0.003)*	(0.003)*	(0.003)*	(0.003)*	(0.003)*
Scale	0.06	0.06	0.09	0.10	0.11
	(0.004)*	(0.004)*	(0.005)*	(0.005)*	(0.006)*
Concentration	-0.001	-0.001	-0.003	-0.003	-0.003
	(0.0001)*	(0.0001)*	(0.0002)*	(0.0002)*	(0.0002)*
Technology gap	-0.0008	-0.001	-0.001	-0.002	-0.003
	(0.0001)*	(0.0006)*	(0.0008)*	(0.0001)*	(0.0001)*
Industry dummies	Yes	Yes	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes	Yes	Yes
Number of obs	6149	7016	7093	7109	7140
R-squared	0.32	0.35	0.36	0.38	0.36

Notes: *, ** and *** indicate statistically significant at the 1%, 5%, and 10% respectively. Standard errors are in parentheses.

5.6 Conclusion

This chapter has considered wage spillovers from foreign firms to domestic firms using the firm level data of Vietnam from 2000 to 2004. Unlike previous empirical studies, this chapter investigates not only horizontal (intra-industry) wage spillovers, but also vertical wage externalities (inter-industry). The empirical results provide strong evidence that there are wage spillovers from foreign firms to domestic firms in Vietnam industry. In particular, we find positive and significant horizontal wage spillovers, that is to say, that wage levels in domestic firms are higher in sectors where there is a higher presence of foreign firms. In addition, there are significant vertical wage spillovers in some types of domestic firms. This implies that domestic firms that have backward linkages to foreign firms can gain vertical productivity spillovers, and be able to pay higher wages.

Wage spillovers vary across sectors and firms. While private firms, firms with training activity, and firms in industries of low and medium technology experience wage spillovers from foreign firms, wage spillovers are limited among other types of domestic firms. This suggests that the characteristics of domestic firms and sectors are relevant in analysing the impact of FDI on domestic wages.

The other major findings in the chapter may be considered to be only partially conclusive, but are important nevertheless. We find that the training activity of domestic firms and foreign firms alike is relevant to wage spillovers. More specifically, only domestic firms with training gain wage spillovers from foreign firms. In addition, only foreign firms involved in training with domestic ones appear to generate positive and significant wage spillovers to domestic firms via horizontal and vertical linkages.

Chapter 6

Conclusion

What is the impact of international trade and FDI on economic development? The answer to this question is crucial for policymakers and firms in developed and developing countries, given the rapid pace of global integration in recent years. Economic theory makes reasonably clear prescriptions regarding the roles of trade and FDI in technology transfer and economic development, but empirical studies provide mixed evidence for these prescriptions. If the roles of trade and FDI are to be reliably addressed, we need an understanding of how trade and FDI contribute to technology transfer, economic growth and income improvement in a developing country. Moreover, it is important to identify under what conditions the country concerned can influence the degree of these effects of trade and FDI. This thesis has attempted to examine these issues in the Vietnamese context at both the macro and the micro levels.

The first major implication of this study is given in chapter 3, which examines the impacts of technology transfer through trade and FDI on economic growth at the provincial level. In this chapter, we argued that Vietnam may absorb technologies from technologically advanced developing countries more easily than from developed countries, as these technologies are likely to be less sophisticated. This suggests that we need to examine foreign technology transfer not only from developed countries, but also from other developing countries. The chapter attempted to fill this gap in the literature, finding that both technology imports from OECD countries and non-OECD countries affect positively the growth rate of

Vietnamese provinces. This implies that international trade, particularly imports of capital goods, plays an important role in the transfer of technology to Vietnam. However, the importance of FDI as a channel for technology transfer in Vietnam is limited in that only FDI from non-OECD countries has a positive impact on economic growth. Given these findings, we have examined the question as to what are the determinants of technology transfer from trade. The chapter found that the skills of the labour force and openness to trade are the most robust determinants of technology adoption at the provincial level. In addition, provinces with higher levels of R&D expenditure adopt more technology from OECD countries than do other provinces. Although we have tried to demonstrate the importance of trade and FDI in technology and economic growth, we are aware that the measures of technology transfer at the provincial level are still general, and do not take into account the firm level behaviour of technology transfer. Thus it is necessary to assess channels and determinant factors in technology transfer at micro level, and to integrate the findings into macro analysis. This is the subject of chapter 4.

Using firm-level data, chapter 4 explored and compared in detail the differing impacts of different channels of technology spillovers via FDI and trade at the firm level. The first part of the chapter considered mechanisms of technology transfer via FDI. The chapter distinguished two mechanisms of technology spillovers introduced by FDI: a horizontal one, between foreign firms and domestic firms within the same sector, and a vertical one, between foreign firms and their domestic suppliers. It presented strong evidence that domestic firms gain from technology spillovers through vertical linkages with foreign firms. The absorptive capabilities of domestic firms facilitate this type of technology spillover. In contrast to the vertical linkages, the effect of the horizontal presence of foreign firms on the productivity of domestic firms is found to be negative. This suggests that potential technology transfer between foreign firms and their local competitors is more than offset by the competition induced by the entry of foreign firms. The existence of this competition effect depends on the characteristics of domestic firms. In particular, domestic firms with higher absorptive capacity (higher relative human capital and R&D expenditure, and smaller technology gap with foreign firms) experience no competition effect, while those with low absorptive capacity witness negative horizontal spillovers. In the second part of the chapter, an attempt has been made to explore the mechanisms of technology spillovers via international trade. While there is no evidence of technology learning from exporting, importing is found to be a driver of technology transfer to domestic firms. Moreover, the empirical results have provided evidence that firms in industries supplying increasingly import-intensive sectors have higher productivity than other firms. This adds another mechanism of technology spillovers into the view that international trade plays an important role in technology transfer.

The role of FDI in the labour market and its impacts on wage levels of Vietnamese domestic firms are the subject of chapter 5. Similarly to chapter 4, it was found that there are two channels through which FDI can affect wage levels of domestic firms. The first one is horizontal wage spillover, measured by the effect of the presence of foreign firms on the wages of domestic firms in the same sector. Here the literature is extended by the introduction of vertical wage spillover as a second channel. As argued in the chapter, vertical wage spillover occurs through productivity spillovers from foreign firms to their domestic suppliers. Despite different labour market conditions and firms' characteristics, the empirical findings provide strong support for the hypothesis that there are horizontal wage spillovers from foreign firms to domestic firms in Vietnam. Wage spillovers from the vertical linkages between foreign firms and domestic suppliers depend on the firms' specific characteristics. A further important finding of this chapter is that training activities facilitate wage spillovers.

The main contribution of this thesis to the literature is that it provides a case study on the role of trade and FDI in technology transfer and economic development in a less developed country. In particular, the study provides a comprehensive analysis of the topic in the context of Vietnam, in which we address all the channels through which trade and FDI affect economic growth, productivity and wages in the country. The study also advances the literature by shedding light on the impacts of a country's characteristics and types of trade and FDI on the strength of technology transfer and wage spillovers. To the best of our knowledge, this thesis is the first to take account of all of the issues concerning trade, FDI, technology transfer and wage spillovers in the context of Vietnam in a consistent way.

This study has some policy implications for both policymakers and firms. First, increasing the linkages between foreign firms and domestic ones is highly relevant to the encouragement of technology spillovers from FDI. Secondly, regarding policies that can encourage the adoption of technology from trade and FDI, upgrading human capital, which includes the increase of spending on education and training, and the enhancement of co-operation between local training centres and foreign firms, are the most important. Since the non-government sector under provides the infrastructure that improves the ability of domestic firms to absorb new technologies, assistance from the government is necessary. This can be done by the introduction of government-funded programmes for exchanges of expertise between research institutes, universities and enterprises, or via research and development on new products and technologies from which the participants share the sponsorship and the benefits. Last but not least, creating efficient administrative and management environments for both the domestic sector and the foreign sector is essential. As the law and regulations relating to the foreign investment sector in Vietnam have been completed and improved, the remaining issues to be considered are how to enforce them efficiently, how to design sub-law regulations correctly, and how to maintain them in the future.

Although this thesis contributes to the understanding of the role of trade and FDI in technology transfer and wage improvement in the Vietnamese context, it still leaves several limitations requiring further study. First, although it has been established in the empirical findings that imported technology is a major channel of technology transfer, the study did not take into account the quality of imported technology. In fact, imported technology has to be appropriate in order to achieve the full effect of technology transfer on productivity. Thus, it would be interesting to investigate whether the quantity of technology or the quality of technology has a larger effect on economic growth and productivity. Secondly, the study relied only on input-output tables at the industry level to measure vertical spillovers from foreign firms to domestic firms, rather than on direct firm specific data. Therefore, it would be useful to confirm the findings of this study by using data that allow for identification of individual domestic firms as suppliers to foreign firms. It is to be hoped that improved data availability will allow further research to examine these limitations in the future.

Appendix A: Appendix to Chapter 2

A.1 Derivation of Equation (2.23)

In the lab equipment model the value of total production in manufacturing and research depends only on the aggregate stocks of inputs, not on their allocation between the two sectors:

$$Y+\frac{\dot{A}}{B}=H^{\alpha}L^{\beta}\int_{0}^{A}x(i)^{1-\alpha-\beta}\,di. \qquad \text{(A.1)}$$

Taking its supply of H and L as given, each representative firm in the manufacturing sector chooses a level of *x(i)* to maximize profits. Consequently, the first order condition for the problem of maximizing $Y+\dot{A}/B$ minus total input cost $\int p(i)x(i)di$ with respect to the use of input i yields the economy wide inverse demand curve for good i. The rental rate p that results when x units of the capital good are supplied is:

$$p=(1-\alpha-\beta)H^{\alpha}L^{\beta}x^{-(\alpha+\beta)} \qquad \text{(A.2)}$$

Input producers choose x to maximize the present value of monopoly rent minus x times the unit cost of each price of capital, $P_A=\max(px/r-x)$. Using equation (A.1), the first order condition that determines the number of machines $\bar{x}$ that the holder of the patent on goods i rents to manufacturing firms is

$$(1-\alpha-\beta)^2 H^{\alpha}L^{\beta}\bar{x}^{-(\alpha+\beta)}r^{-1}-1=0 \qquad \text{(A.3)}$$

which implies that $p/r=(1-\alpha-\beta)^{-1}$. The discounted value of profit collected by the holder of the patent can then be simplified to

$$P_A=\left(\frac{p\bar{x}}{r}\right)-\bar{x}=\frac{\alpha+\beta}{1-\alpha-\beta}\bar{x} \qquad \text{(A.4)}$$

Since $P_A=1/B$, this implies that $\bar{x}=(1-\alpha-\beta)/B(\alpha+\beta)$. Substituting this expression into equation (A.2) yields equation (23) in the text:

$$r = B^{\alpha+\beta}(\alpha+\beta)^{\alpha+\beta}(1-\alpha-\beta)^{2-\alpha-\beta}H^{\alpha}L^{\beta} \qquad \text{(A.5)}$$

A.2 Derivation of Equation (2.22)

The demand for the capital goods in this model has exactly the same form as in the lab model, with the qualification that since all of the demand comes from the manufacturing sector, H must be replaced by H_Y. If we use equation (A.1) with this replacement to substitute for p in the experience for P_A, we have

$$P_A = (\alpha+\beta)\frac{p\bar{x}}{r} = \frac{\alpha+\beta}{r}(1-\alpha-\beta)H_Y^{\alpha}L^{\beta}\bar{x}^{1-\alpha+\beta}. \qquad (A.6)$$

Equating the wages of human capital in manufacturing and research yields $P_A\ \delta A = \alpha H_Y^{\alpha-1}L^{\beta}A\bar{x}^{1-\alpha-\beta}$ (A.7). Combining these expressions and solving for H_Y gives $H_Y = (1/\delta)\ \alpha(\alpha+\beta)^{-1}(1-\alpha-\beta)^{-1}$, $r = (\Lambda/\delta)r$. Hence,

$$g = \delta H_A = \delta H - \delta H_Y = \delta H - \Lambda r. \qquad (A.7)$$

A.3 Derivation of Equation (2.31)

The price of each variety of differentiated products is as follows:

$$p^i = \frac{w^i}{\alpha} \qquad (A.8)$$

where w^i is the wage rate in country *i*, and also the marginal and average cost of a unit of output manufactured there. In an equilibrium with ongoing R&D, the value of the representative firm must be equal to

$$v^i = \frac{w^i a}{n^i} \qquad (A.9)$$

where n^i is the measure of products previously developed in country *i* and also the local stock of knowledge capital. Arbitrage equates the total return on equity claims to the interest rate ρ, or

$$\frac{1-\alpha}{n^i v^i} + \frac{\dot{v}^i}{v^i} = \rho \qquad (A.10)$$

Equilibrium in the labour market requires that

$$\frac{a}{n^i}n^i + \frac{1}{p^i} = L^i \qquad \text{(A.11)}$$

which is equality between the sum of the demand for labour by R&D and manufacturing enterprises and the exogenous factor supply.

In a steady state the aggregate value of the stock market and its inverse $V^i \equiv 1/n^i v^i$ turn out to be constant. The value of a representative firm declines at the rate of new product development; that is $\dot{v}^i / v^i - \dot{n}^i / n^i \equiv -g^i$ (A.12). The no-arbitrage condition that applies in the steady state can be written as equation (2.31) in the text.

A.4 Transforming the Integral in Equation (2.48)

$$\int_t^{\infty} e^{-r(s-t)}\, ds = -\frac{1}{r}\int_t^{\infty} -r.e^{-r(s-t)}\, ds = -\frac{1}{r}\int_t^{\infty} d\, e^{-r(s-t)} = -\frac{1}{r}[e^{-r(\infty-t)} - e^{-r(t-t)}] = \frac{1}{r} \qquad \text{(A.13)}$$

Appendix B: Appendix to Chapter 3

B.1 List of Variables of Provincial Economic Growth

Name of variables	Specification of variables	Source of data
Dependent variable		
g_{it}	Growth of gross domestic product (GDP) of province i in year t. GDP is measured in 1994 local constant prices.	General Statistics Office of Vietnam (GSO)
Independent variables		
GL_{it}	The growth rate of labour force in province i in year t	Ministry of Labour, Invalids and Social Affairs of Vietnam (MoLISA)
$Schooling_{it}$	The educational attainment in province i in year t	MoLISA
$Skills_{it}$	The percentage of skilled workers in the total labour force of province i in year t	MoLISA
DRD_{it}	The ratio of R&D expenditures to GDP in province i in year t.	Ministry of Science, Technology and Environment of Vietnam (MoSTE)
$FRD-Trade_{it}$	The ratio of machinery and equipment imports in province i in year t to its GDP in the corresponding year.	GSO
$FRD-Trade-OECD_{it}$	The ratio of machinery and equipment imports from OECD countries in province i in year t to its GDP in the corresponding year.	GSO
$FRD-Trade-nonOECD_{it}$	The ratio of machinery and equipment imports from OECD countries in province i in year t to its GDP in the corresponding year.	GSO
$FRD-FDI_{it}$	The ratio of implemented FDI to GDP in province i in year t.	GSO
$FRD-FDI-OECD_{it}$	The ratio of implemented FDI from OECD countries to GDP in province i in year t.	GSO
$FRD-FDI-nonOECD_{it}$	The ratio of implemented FDI from non OECD countries to GDP in province i in year t.	GSO
$DVFC$	Dummy variable for the Asian financial crisis. One for the year 1997 to 1999 and zero for the other.	

B.2 List of Variables of Determinants of Technology Transfer

Name of variables	Specification of variables	Source of data
Dependent variable		
FRD_{it}	The ratio of machinery and equipment imports in province i in year t to its GDP in the corresponding year.	GSO
Independent variables		
GDP_{it}	The growth rate of real GDP per capita in province i in year t.	GSO
$Investment / GDP_{it}$	The ratio of investment to GDP in province i in year t.	GSO
$Openness_{it}$	The ratio of imports and exports to GDP in province i in year t.	GSO
$Agricultural\ share_{it}$	The share of agricultural sector in GDP in province i in year t.	GSO
$Industry\ share_{it}$	The share of industrial sector in GDP in province i in year t.	GSO
$Schooling_{it}$	The educational attainment in province i in year t.	MoLISA
$Skills_{it}$	The percentage of skilled workers in the total labour force of province i in year t.	MoLISA
$Inflation_{it}$	The rate of inflation in province i in year t.	GSO
DRD_{it}	The ratio of R&D expenditures to GDP in province i in year t.	MoSTE
$Infratructure_{it}$	The number of telephone machines per 1000 people in province i in year t.	MoSTE
$DVFC$	Dummy variable for the Asian financial crisis. One for the year 1997 to 1999 and zero for the others.	

Appendix C: Appendix to Chapter 4

C.1 Data Appendix

Industrial Sector and Location

The sectoral classification of enterprises is at the two-digit level of Vietnamese Standard Industrial Classification (VSIC), which includes 29 sectors from three industrial groups of mining and quarrying; manufacturing; and electricity, gas and water supply. There are 4 sectors in mining and quarrying, 23 sectors in manufacturing, and 2 sectors in electricity, gas and water supply. Details are as follows.

Group 1: Mining and quarrying
C10: Mining of coal and lignite; extraction of peat
C11: Extraction of crude petroleum and natural gas
C12: Mining of metal ores
C13: Other mining and quarrying

Group 2: Manufacturing
D15: Food and beverages
D16: Cigarettes and tobacco
D17: Textile products
D18: Wearing apparel, dressing and dying of fur
D19: Leather and products of leather; leather substitutes; footwear.
D20: Wood and wood products, excluding furniture
D21: Paper and paper products
D22: Printing, publishing, and reproduction of recorded media
D23: Coke and refined petroleum products and nuclear fuel
D24: Chemicals and chemical products
D25: Ruber and plastic products
D26: Other non-metallic mineral products
D27: Iron, steel and non-ferrous metal basic industries
D28: Fabricated metal products, except machinery and equipment
D29: Machinery and equipment
D30: Computer and office equipment
D31: Electrical machinery apparatus, appliances and supplies
D32: Radios, television and telecommunication devices
D33: Medical equipment, optical instruments

D34: Motor vehicles and trailers
D35: Other transport equipment
D36: Furniture and other products not classified elsewhere
D37: Recycles products

Group 3: Electricity, gas and water supply
E40: Electricity, gas, steam and hot water supply
E41: Collection, purification and distribution of water

The province and region codes divide the country into 64 provinces and 7 regions respectively. According to the classification of General Statistics Office of Vietnam, the country is divided into 7 regions, namely North Mountain and Midland; Red River Delta; North cental Coast; South Central Coast; Central Highland; South East; and Mekong River Delta.

Ownership

As in other transition economies, the outcome of economic renovation in Vietnam has resulted in full or partial transfer of ownership rights to different types of ownership structures. We classify the resulting variety of ownership structures into four main groups, namely, state-owned, non-state collective owned, private owned, and foreign owned. Foreign sector includes all firms with foreign investors (joint ventures and 100% foreign-invested firms). We distinguish between joint ventures and 100% foreign-invested firms in order to examine the impact of foreign ownership on domestic sectors' performance through technology transfer.

Capital

The current values of fixed assets are reported in all years. The replacement value of fixed assets is used as the measure of capital stock for all firms.

Labour and Wages

The numbers of workers are reported in all years. The numbers of R&D workers are also available for firms, which perform R&D activity. In most years, wage payments are detailed in four categories: normal wages, overtime, gifts and bonuses, and other payments. We used the total of all payment as our measure of wages.

Output and Sales

The nominal output and sales are available every year.

C.2 Data Cleaning Appendix

Variable Deflators

In any given year, the data are expressed in current prices so that controlling for inflation is important. Taking 1994 as the base year, all variables are deflated using the appropriate PPP deflators. Nominal output and sales are fixed values at 1994 price. Fixed assets are deflated using the 1994 asset deflator.

Correction for Outliers and Missing Values in Industrial Surveys

We have cleaned key variables to minimize noise due to non-reporting, misreporting, and other mistakes. A two-stage cleaning process was used for labour, wages, output, capital, and sales. First, the earliest and latest years in which a firm reported were identified, and interpolation was used to fill-in up gaps of up to two missing years within the reporting window. If more than two continuous years of data were missing, the firm was dropped from the sample. Second, firms with unreasonably large jumps or drops in key variables not accompanied by corresponding movement in other variables (for example, large increase in labour not accompanied by any increase in output) were dropped.

Concordance of Input-Output Table Code and VSIC Codes

The IO table was published in 2000 with three variants: domestic transactions at producer prices, domestic transactions at basic prices, and domestic transactions at purchaser prices. This study considers domestic transactions at purchaser prices.

The 2000 IO table classified industrial production into 119 categories. Sectors in the IO table were regrouped so as to match the industry classification of the two-digit level industries (VSIC).

C.3 List of the Industry in Terms of Technology

Group 1: Low technology

D15: Food and beverages

D16: Cigarettes and tobacco

D17: Textile products

D18: Wearing apparel, dressing and dying of fur

D19: Leather and products of leather; leather substitutes; footwear.

D20: Wood and wood products, excluding furniture

D21: Paper and paper products

D22: Printing, publishing, and reproduction of recorded media

D23: Coke and refined petroleum products and nuclear fuel

D36: Furniture and other products not classified elsewhere

D37: Recycles products

Group 2: Medium technology

D24: Chemicals and chemical products

D25: Ruber and plastic products

D26: Other non-metallic mineral products

D27: Iron, steel and non-ferrous metal basic industries

D28: Fabricated metal products, except machinery and equipment

Group 3: High technology

D29: Machinery and equipment

D30: Computer and office equipment

D31: Electrical machinery apparatus, appliances and supplies

D32: Radios, television and telecommunication devices

D33: Medical equipment, optical instruments

D34: Motor vehicles and trailers

D35: Other transport equipment

C.4. Descriptive statistics for foreign and domestic firms by industry in 2004

Code	Sector	Domestic firms	Firms with foreign capital	All firms	Share of firms with foreign capital in the sector	Horizontal	Backward
C10	Mining of coal and lignite; extraction of peat	35	1	36	2.85	0.73	0.15
C11	Extraction of crude petroleum and natural gas	0	2	2	-	100	10.05
C12	Mining of metal ores	22	1	23	4.54	2.55	1.10
C13	Other mining and quarrying	320	7	327	2.18	0.69	0.08
D15	Food and beverages	1930	175	2105	9.06	14.58	2.02
D16	Cigarettes and tobacco	17	1	18	5.88	2.65	0.02
D17	Textile products	267	85	352	31.83	24.18	14.98
D18	Wearing apparel, dressing and dying of fur	378	178	556	47.08	54.96	5.56
D19	Leather and products of leather; leather substitutes; footwear	165	90	255	54.54	53.87	7.14
D20	Wood and wood products, excluding furniture	479	53	532	11.06	14.35	13.02
D21	Paper and paper products	334	33	367	9.88	15.11	5.65
D22	Printing, publishing, and reproduction of recorded media	254	13	267	5.11	4.16	0.28
D23	Coke and refined petroleum products and nuclear fuel	3	2	5	66.66	36.57	6.28
D24	Chemicals and chemical products	266	111	377	41.72	20.82	13.02

D25	Ruber and plastic products	341	109	450	31.96	27.79	14.23
D26	Other non-metallic mineral products	741	67	808	9.04	9.39	6.98
D27	Iron, steel and non-ferrous metal basic industries	97	20	117	20.61	12.05	13.98
D28	Fabricated metal products, except machinery and equipment	470	118	588	25.11	24.79	12.98
D29	Machinery and equipment	181	37	218	20.44	20.80	10.39
D30	Computer and office equipment	0	2	2	-	100	25.68
D31	Electrical machinery apparatus, appliances and supplies	95	56	151	58.94	61.14	17.98
D32	Radios, television and telecommunication devices	37	38	75	102.7	63.49	20.99
D33	Medical equipment, optical instruments	19	19	38	100	59.45	13.89
D34	Motor vehicles and trailers	80	40	120	50	49.23	7.13
D35	Other transport equipment	165	53	218	32.12	37.60	3.98
D36	Furniture and other products not classified elsewhere	350	144	494	41.14	45.34	1.99
D37	Recycles products	7	0	7	0	0	0
E40	Electricity, gas, steam and hot water supply	4	5	9	125	10.15	1.98
E41	Collection, purification and distribution of water	83	1	84	1.2	0.37	0.54
	Total	7140	1461	8601	20.46	-	-

Appendix D: Appendix to Chapter 5

D.1. Descriptive statistics for foreign and domestic firms by industry in 2004

Code	Sector	Domestic firms	Firms with foreign capital	All firms	Horizontal	Vertical	The ratio of wages in foreign firms to wages in domestic firms
C10	Mining of coal and lignite; extraction of peat	35	1	36	0.73	0.15	1.39
C11	Extraction of crude petroleum and natural gas	0	2	2	100	10.05	1.70
C12	Mining of metal ores	22	1	23	2.55	1.10	1.33
C13	Other mining and quarrying	320	7	327	0.69	0.08	1.84
D15	Food and beverages	1930	175	2105	14.58	2.02	1.94
D16	Cigarettes and tobacco	17	1	18	2.65	0.02	0.99
D17	Textile products	267	85	352	24.18	14.98	1.55
D18	Wearing apparel, dressing and dying of fur	378	178	556	54.96	5.56	1.01
D19	Leather and products of leather; leather substitutes; footwear	165	90	255	53.87	7.14	1.45
D20	Wood and wood products, excluding furniture	479	53	532	14.35	13.02	1.80
D21	Paper and paper products	334	33	367	15.11	5.65	1.53
D22	Printing, publishing, and reproduction of recorded media	254	13	267	4.16	0.28	1.37
D23	Coke and refined petroleum products and nuclear fuel	3	2	5	36.57	6.28	6.98

D24	Chemicals and chemical products	266	111	377	20.82	13.02	2.27
D25	Ruber and plastic products	341	109	450	27.79	14.23	1.17
D26	Other non-metallic mineral products	741	67	808	9.39	6.98	1.76
D27	Iron, steel and non-ferrous metal basic industries	97	20	117	12.05	13.98	1.73
D28	Fabricated metal products, except machinery and equipment	470	118	588	24.79	12.98	1.50
D29	Machinery and equipment	181	37	218	20.80	10.39	1.61
D30	Computer and office equipment	0	2	2	100	25.68	1.33
D31	Electrical machinery apparatus, appliances and supplies	95	56	151	61.14	17.98	0.92
D32	Radios, television and telecommunication devices	37	38	75	63.49	20.99	1.49
D33	Medical equipment, optical instruments	19	19	38	59.45	13.89	1.46
D34	Motor vehicles and trailers	80	40	120	49.23	7.13	1.30
D35	Other transport equipment	165	53	218	37.60	3.98	1.55
D36	Furniture and other products not classified elsewhere	350	144	494	45.34	1.99	1.12
D37	Recycles products	7	0	7	0	0	-
E40	Electricity, gas, steam and hot water supply	4	5	9	10.15	1.98	1.59
E41	Collection, purification and distribution of water	83	1	84	0.37	0.54	2.74
	Total	7140	1461	8601	-	-	1.70

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