Essays in international trade, FDI and technology spillovers

Author:
Nguyen, Thanh Xuan

Publication Date:
2011

DOI:
https://doi.org/10.26190/unsworks/23494

ESSAYS IN INTERNATIONAL TRADE, FDI AND TECHNOLOGY SPILLOVERS

Doctor of Philosophy

by

THANH XUAN NGUYEN

*****

University of New South Wales

The School of Economics

February 5, 2011

Supervisors

Associate Professor Hodaka Morita

Associate Professor Arghya Ghosh

Contents

Copyright Statement

Signed ....

Date ....

Authenticity Statement

'I certify that the Library deposit digital copy is a direct equivalent of the final officially approved version of my thesis. No emendation of content has occurred and if there are any minor variations in formatting, they are the result of the conversion to digital format.'

Signed ....

Date ....

Originality Statement

'I hereby declare that this submission is my own work and to the best of my knowledge it contains no materials previously published or written by another person, or substantial proportions of material which have been accepted for the award of any other degree or diploma at UNSW or any other educational institution, except where due acknowledgment is made in the thesis. Any contribution made to the research by others, with whom I have worked at UNSW or elsewhere, is explicitly acknowledged in the thesis. I also declare that the intellectual content of this thesis is the product of my own work, except to the extent that assistance from others in the project's design and conception or in style, presentation and linguistic expression is acknowledged.'

Signed ....

Date ....

Acknowledgments

I would like to express my deepest appreciation to my supervisors, Associate Professor Hodaka Morita and Associate Professor Arghya Ghosh. Throughout my thesis-writing period, they have provided encouragement, criticism, advice, and lots of original ideas. Without their guidance and support, this dissertation would not have been possible.

I would also like to acknowledge the financial support provided to me by various institutions. It is an honor for me to have received the UIPA Scholarship from The University of New South Wales and the Supplementary Scholarship from The Australian School of Business through-out the PhD program. I am also grateful to The Tokyo Foundation for awarding me the Sasakawa Young Leaders Fellowship and the Sasakawa Research Abroad (SRA) grant to conduct my research at the Hitotsubashi University in June 2010. I would also like to thank The Hitotsubashi University for offering me the Young Visiting Researcher Fellowship with the Centre of Excellence.

While working on this thesis, I have benefited from presentation at various conferences in Australia, New Zealand, Hong Kong, Japan, and USA. These include Australasian Economic Theory Workshop 2009 and 2010; Australasian Trade Workshop 2009 and 2010; Asia Pacific Trade Seminars 2009 and 2010; Australasian Meeting of the Econometric Society 2009; Japan-UNSW Applied Microeconomics Workshop 2009; 2010 PhD Conference in Economics and Business; and Fall 2010 Midwest International Trade Meeting. I would like to thank these conference organizers for their invitation and to participants and discussants for their useful feedback. Special thanks go to Professor Andrew Daughety, Professor Taiji Furusawa, Professor James Hartigan, Professor Russell Hillberry, Professor Jota Ishikawa, Dr Yi Jin, Dr Tina Kao, Dr Oliver Lorz, Dr Laura Meriluoto, Professor Larry Qiu, Professor Martin Richardson, Professor Ray Riezman, Professor Nicolas Schmitt and Professor Frank Stadhler for detailed discussions. Travel grants from New Zealand Institute of Economic Research, Econometric Society, 2010 PhD Conference in Economics and Business, and School of Economics and Graduate Research School at The University of New South Wales are also gratefully acknowledged.

I wish to thank the many visitors to the School of Economics at University of New South Wales who have provided advice on my research. These include Professor Simon Anderson, Professor Jay Pil Choi, Professor Jota Ishikawa, Professor Rod Falvey, Professor Taiji Furusawa, Professor James Markusen, Professor Devashish Mitra, Dr Alireza Naghavi, Professor Hiroshi Ohashi, Professor Larry Qiu, Professor Kamal Saggi and Professor Larry Samuelson.

I am indebted to academic staff at the School of Economics for teaching me economics and helping me with my research (especially Professor Bill Schworm and Professor Kieron Meagher), and to administrative staff for assisting me in many different ways. Dr Sasan Bakhtiari, Dr Gautam Bose, Associate Professor Chris Carter, Professor Denzil Fiebig, Professor Kevin Fox, Associate Professor Elisabetta Magnani, Professor John Piggott, Dr Nigel Stapledon, Professor Andy Tremayne, Professor Alan Woodland, Ms Rebecca Crosby, Ms Yukimi Morita, Ms Grace Setiawan and Ms Fei Wong deserve special mention.

In my daily work I have been blessed with a friendly and cheerful group of fellow students: Amy Cheung, Phuong Hoang, Meliyanni Johar, Ha Nguyen, Thai Nguyen, Thuy Nguyen, Chung Tran, Joaquin Vespignani and many others. I would like to thank Jonathan Lim for his assistance in many aspects of life, especially in proof reading this thesis.

Lastly, and most importantly, I am heartily thankful to my family and relatives for their persistent encouragement. I owe my deepest gratitude to my beautiful wife, Oanh Trieu, and my lovely little princess, Suri Nguyen. They have supported me and loved me, without which I would have been lost. To them I dedicate this thesis.

Extended Abstracts

The dissertation develops theoretical frameworks to analyze the welfare impact of technology spillovers in the context of international trade with foreign direct investment (FDI). It consists of three closely related essays. The first essay (Chapter 2) explores technology spillovers in an international duopoly model of vertical product differentiation. The second essay (Chapter 3) analyzes cost-reducing spillovers in an international duopoly model and discusses the differences and similarities of quality-enhancing and cost-reducing spillovers. The third essay (Chapter 4) investigates technology spillovers in an export-platform FDI model.

Chapter 2: FDI and Technology Spillovers under Vertical Product Differentiation

FDI induces technology spillovers, which often enhances local firms's quality standards. That is, if a foreign firm builds its manufacturing plant in a less developed country to produce high-quality products, local firms can enhance their product quality by learning the foreign firm's advanced technology. We explore welfare consequences of quality-enhancing technology spillovers that is accompanied by a Northern firm's FDI in the South. To this end, we develop an international duopoly model of vertical product differentiation in which a Northern firm (firm N) and a Southern firm (firm S) compete in the Southern market. Firm S is located in the South, while firm N can locate itself in the North (home-production) or in the South (FDI). By undertaking FDI, firm N can reduce its production costs and avoid tariff. At the same time, however, firm N's technology spills over to firm S under FDI. We show that, when the tariff rate is higher than a threshold, firm N undertakes FDI to avoid tariff and this results in technology spillovers which increases firm S's equilibrium product quality. This increases both firm S's profitability as well as Southern consumers' surplus, since the amount of rent captured by Southern consumers increases as the Southern firm's product quality increases.

In this context we find that when firm N undertakes FDI, it strategically reduces the level of quality for its product under a range of parameterizations. As a consequence, FDI could hurt the South. This result suggests that inducing FDI (with technology spillovers), a strategy which many Southern countries followed recently, may not be efficient from welfare standpoint. We also find that the optimal spillover rate for the South is higher than the spillover rate that maximizes the global welfare in a range of parameterizations. This is consistent with the observations that Southern governments are often reluctant to strengthen Intellectual Property Rights (IPR).

Northern firms' choices of export versus FDI have been previously addressed in the trade literature. However, to the best of our knowledge, no previous papers have addressed this issue in the context of vertical product differentiation with technology spillovers. By exploring the idea that technology spillovers enhance Southern firms' product quality under the context of vertical product differentiation, we discover new welfare implications of FDI and technology spillovers as outlined above.

Chapter 3: Multinational Firms and Optimal Intellectual Property Rights

In this chapter, we augment the traditional cost-reducing technology spillovers (Chin & Grossman 1990, Zigic 1998, Naghavi 2007) by focusing on the Northern firm's choice of technology levels when it undertakes FDI in the South. Our model shows that, the Northern firm always chooses the minimum level of marginal cost for its product (the best technology), regardless of its location choice, i.e., home-production or FDI. Consequently, under linear demand, we find that FDI benefits the South since the positive externalities associated with FDI increase the Southern firm's profitability and consumer surplus which overwhelms the loss in tariff revenue.

What level of Southern IPR protection is optimal for the South and the world? Since under the FDI equilibrium, the South always benefits if the level of spillovers increases, it follows that South-optimal IPR policy is represented by the highest level of spillovers that still induces FDI by the Northern firm. At the same time, the global welfare-maximizing level of spillovers is either zero (North-optimal) or the same as South-optimal level. Therefore, the social planner, such as WTO, should either support the North or the South in the context of cost-reducing spillovers.

These findings suggest that cost-reducing and quality-enhancing technology spillovers can yield different policy implications. Thus, both Southern government and the social planner should take into account the mechanism of spillovers when choosing optimal trade and IPR policy for the South.

Chapter 4: Technology Spillovers and Export-Platform FDI

The last essay of the dissertation explores optimal IPR policy for a Southern country which hosts export-platform FDI (EPF) undertaken by a Northern firm. In our model, a Northern firm competes with a Southern firm in both the Southern market and a third country market. We demonstrate that under certain parameterizations, the South has incentive to induce EPF by choosing an IPR policy which is just loose enough. As trade becomes more liberalized between the South and the third country, our model predicts that the South could provide weaker IPR protection for the Northern firm. Our framework not only justifies the connection between EPF literature and IPR literature but also helps us to understand better the strategies of inducing foreign investment in export sectors that many developing countries adopted in recent years.

Chapter 1

Introduction

Foreign direct investment (FDI) by Northern firms in the South often induces technology spillovers which benefits their Southern competitors. This topic has recently received significant attention in the international trade literature. The focus of the literature thus far has been on the North-South conflict concerning Intellectual Property Rights (IPR) regime in the South. Under this setting, we could translate loose IPR environment as an increase in the degree of spillovers. There are two main aspects of such a conflict. One the one hand, Southern countries can choose their trade and IPR policy in such as a way as to maximize the benefits of the presence of Northern firms in the South. These policies by nature often favor domestic firms which compete with foreign firms. On the other hand, trade protection and loose IPR regime are not supported by the World Trade Organization (WTO). Especially, under the Trade Related Aspects of Intellectual Property Rights (TRIPS) agreement, the WTO aims to strengthen the level of IPR protection for foreign firms in Southern countries.

Is inducing FDI with technology spillovers always a good policy for the South? Should the WTO support the North or the South in the IPR debate? With the exception of Naghavi (2007), most previous papers have addressed these questions in the context of international trade without FDI and have yielded mixed results. For instance, Diwan and Rodrik (1991) argued that, if the global social-planner values Northern welfare and Southern welfare equally, she should choose the same level of IPR protection in both North and South. However, Deardorff (1992) argued that harmonizing IPR in the imitating country (often the South) with the level implemented in innovating country (often the North) could reduce global welfare.

This thesis addresses the above questions by focusing on technology spillovers that is accompanied by Northern firms' FDI in the South. In the first two essays (Chapter 2 and Chapter 3), we consider two different frameworks of technology spillovers, namely quality-enhancing spillovers and cost-reducing spillovers. The goal of these chapters is to provide an explanation for the above mentioned North-South IPR conflict and suggest policy recommendations along this line. From our analysis, we find that quality-enhancing and cost-reducing spillovers (both induced by FDI) can yield contrasting results, specifically in relation to optimal trade and IPR policies. Chapter 4, the last essay, studies an augmented export platform FDI model with technology spillovers. Our goal for this chapter is to understand the connection between regional trade liberalization and IPR regime in the South. This extends the work of Ekholm, Forslid and Markusen (2007) and others in the export platform FDI literature which has focused mainly on competition between symmetric Northern firms.

The thesis leads to several new policy implications, some of which can be listed as follows. First, in the presence of quality-enhancing spillovers in the South, the Northern firm strategically reduces its product quality level under FDI in a range of parameterizations. Consequently, this leads to the possibility in which FDI could harm the South, and at the same time, the optimal level of spillovers for global welfare could be strictly less than South-optimal level. Second, when spillovers are cost-reducing, these results do not necessarily hold. The driving force is that, the Northern firm chooses the minimum marginal cost level for its product regardless of its location choice between home-production and FDI with cost-reducing spillovers. Furthermore, under linear demand, we find that, FDI always improves Southern welfare and global welfare. Consequently, cost-reducing spillovers and quality-enhancing spillovers yield different policy implications. Finally, if the Northern firm chooses to follow the export-platform FDI strategy then FDI benefits the South under a range of parameterizations. This is because FDI leads to positive externalities from the Northern firm to the Southern firm which intensifies competition between them in both Southern and third market. This not only increases the Southern firm's profitability but also enhances consumers surplus. Therefore Southern welfare is also enhanced. Furthermore, when export-platform FDI is optimal for the South, if trade becomes more liberalized between the South and the export market, we find that, the South has less incentive to protect the technology of the Northern firm.

The thesis will proceed as follows. Chapter 2 investigates an international duopoly model of vertical product differentiation with technology spillovers and provides recommendations for trade and IPR policies for the South and the world. Chapter 3 revisits these issues in the context of cost-reducing technology spillovers. Chapter 4 examines technology spillovers in an export-platform FDI model, and Chapter 5 concludes.

Chapter 2

FDI and Technology Spillovers under Vertical Product Differentiation

2.1 Introduction

Foreign direct investment (FDI) induces technology spillovers, which often enhances local firms' quality standards. That is, if a foreign firm builds its manufacturing plant in a less developed country, local competitors can enhance their product quality by learning the foreign firm's performance, or by employing workers from the foreign firm.[1] Throughout this chapter, this phenomenon is referred to as quality-enhancing technology spillovers. For example, Chery Automobile, a Chinese automaker, hired a number of engineers from the Nissan-Dongfeng joint venture which was established upon Nissan's FDI in China. The resulting technology spillovers through these engineers have sig-

[1] In *World Investment Report*, UNCTAD (1997) argued that, Transnational Corporations (TNCs) are often more cost-efficient and produce higher quality products than domestic firms in developing countries. To survive, domestic firms need to learn or imitate production performance of TNCs. This leads to production efficiency gains in which domestic manufacturers have to offer less expensive products or improve quality to win consumers back from the TNCs.

nificantly improved Chery's car quality (Luo 2005). Similarly, the investment of U.S. software firms in Bangalore in 1984 has also created technological and information externalities to Indian software firms. Consequently, this has enabled the local firms to produce softwares which meet international standard (Patibandla, Kapur & Petersen 1999, Pack & Saggi 2006). In section 2.2, we present more real-world examples of quality-enhancing technology spillovers.

By anticipating the potential benefits of technology spillovers from Northern firms (including quality-enhancing spillovers), many Southern governments have actively induced FDI in industries where local firms need to learn advanced production know-how from foreign firms. In the case of Chinese automotive industry, the government imposed high tariff rates on imports of foreign cars to induce foreign automakers to undertake FDI in China.[2] Likewise, the Indian government promoted FDI in software sector by enforcing the copyright act. This has strengthened the Intellectual Property Rights (IPR) protection for both local and foreign firms upon production in India.[3] These types of policy have proved to be sucessful in terms of attracting FDI into a number of industries where local firms need to learn technologies from foreign firms.

Under what circumstances would a Northern firm undertake FDI in the South where quality-enhancing technology spillovers is an unavoidable consequence of FDI? In this context, what is the optimal quality level the Northern firm should choose for its product under FDI? Does FDI improve Southern welfare and global welfare? What are the optimal trade and IPR policies for the South and the world?

---

[2]Chinese automobile industry developed quickly in late 1990s and early 2000s following investment of foreign automakers. High levels of trade barrier, evidenced by average tariff rate for complete vehicles of around 50% in 1999 and remained 30% in 2005 even China has become a member of WTO since 2001, have induced foreign automakers to set up production in China (Gallagher 2003, Luo 2005).

[3]With the enforcement of the copyright act, in 1989-1990 domestic firms launched about 120 new software products and foreign firms about 160 (Patibandla et al. 1999).

We address these questions by studying an international duopoly model of vertical product differentiation based on the standard product-line pricing framework of Mussa and Rosen (1978) where we focus on two types of consumers. The two-type consumers approach in models of vertical product differentiation has been adopted to analyze durable good pricing (Waldman 1996, 1997), international technology transfer with quality ladders (Glass & Saggi 1998), or entry impact on product design (Davis, Murphy & Topel 2004). In our model, a Northern firm (firm N) and a Southern firm (firm S) compete in the Southern market which consists of high-valuation and low-valuation consumers. Firm S is located in the South, while firm N can locate in the North (home-production) or in the South (FDI). By undertaking FDI, firm N can reduce its production costs and avoid tariff. However, firm N's technology spills over to firm S under FDI that extends the upper bound of quality level firm S can choose for its product. We find that, when the tariff rate is higher than a threshold, firm N undertakes FDI to avoid tariff, and the resulting technology spillovers increases both firm S's profitability and Southern consumers' surplus. This is because the amount of rents captured by Southern consumers increases as firm S's product quality increases.

In this context, we find that, when firm N undertakes FDI, it may strategically reduce the level of its product quality to reduce the amount of technology that spills over to firm S. That is, the equilibrium level of firm N's product quality is lower under FDI than under home-production under a range of parameterizations. In reality, Northern firms often bring dated technologies to the South and use these technologies to produce goods with lower quality levels compared to similar products they produce at home. This is further reinforced by Gallagher (2003), who reported that Chrysler and Ford brought with them dated technologies to China and, as a result, the quality of cars manufactured and sold in China by these firms was below that of cars they manufactured and sold in Japan or the U.S. markets. Our analysis captures this type of real world phenomena.

Consequently, the above results lead to new policy implications. First, we demonstrate that, the level of spillovers which maximizes global welfare can be strictly between North-optimal level and South-optimal level. In other words, the social planner, by reconciling North-South IPR conflict in the South, can maximize global welfare. Second, we show that FDI does not necessarily improve Southern welfare. This is because when firm N reduces the level of its product quality, net social benefits associated with the consumption of firm N's products decline. These new results, as discussed in subsequent sections, are unique to quality-enhancing technology spillovers. The driving force behind these results is because the Northern firm strategically chooses a lower quality level for its product under FDI compared to home-production.

Our framework suggests that the World Trade Organization (WTO) should play certain roles in influencing the Southern IPR policy, which often offers weak protection for the technology of the foreign firms. WTO's Trade Related Aspects of Intellectual Property Rights (TRIPS) states that it "establishes minimum levels of protection that each government has to give to the intellectual property of fellow WTO members. In doing so, it strikes a balance between the long term benefits and possible short term costs to society." The present essay lends a support to this statement by exploring the level of IPR protection in the South that maximizes global welfare. In our model, this global optimal level of IPR protection tends to fall between what is demanded by the North and what is demanded (and often offered) by the South.

Technology spillovers from Northern firms to Southern firms have previously been discussed in the trade literature (Chin & Grossman 1990, among others). Most papers along this line, however, focused on technology spillovers from Northern firms to Southern firms which lower the latter's marginal costs. This is referred to as cost-reducing technology spillovers. A number of authors have also incorporated FDI in this literature to study the impact of a change in IPR policy in the South on production location (home-production and FDI) and welfare (Glass & Saggi 2002, Naghavi 2007, Helpman 1993). They demonstrated that, FDI usually improves Southern welfare.[4] However,

[4]Glass and Saggi (2002) considered an international duopoly model with a source firm

the impact of a change in Southern IPR policy on global welfare has not been explicitly addressed in this literature.[5]

To summarize, this chapter concentrates on new policy implications of quality-enhancing technology spillovers. To this end, we develop a North-South duopoly model of vertical product differentiation with technology spillovers and study the welfare impact of a change in trade and IPR policy in the South. The chapter will proceed as follows. Section 2.2 presents real-world examples of quality-enhancing technology spillovers, followed by literature review in Section 2.3. The model and its equilibrium characterizations are laid out in Section 2.4. Section 2.5 and 2.6 will study the welfare impact of trade policy and IPR policy, respectively, followed by discussions in Section 2.7. Section 2.8 offers some concluding remarks.

2.2 Quality-enhancing Technology Spillovers: Examples

Recently, UNCTAD (2000) have identified various channels under which technology spillovers from foreign to domestic firms can take place. These include

---

and a FDI-hosting country firm, and the host country in their model could be regarded as the South. Glass and Saggi pointed out that, unless production elsewhere is very costly, FDI improves host country's welfare. Naghavi (2007) introduced FDI into a North-South trade duopoly model with technology spillovers and argued that FDI always improves Southern welfare.

[5]Glass and Saggi (1998) examined a quality ladders product cycle model with high-type and low-type consumers. In their model, the North has state-of-the-art technology which is one or two level above the technology base of the South. A Northern multinational undertakes FDI in the South by assumption and she brings state-of-the-art technology to the South if the gap in quality between two regions is one level and second-best technology otherwise. If Northern firm brings the best technology to the South, a Southern firm imitates this technology to produce products targeting the low-end market. Glass and Saggi called this "high quality FDI" outcome, which arises as a result of the South's effort to improve its technology base.

(i) labor mobility between foreign firms and local firms, and (ii) proximity between foreign firms and local firms which leads to the upgrade of technological level in the host country.[6] UNCTAD has also argued that, multinational firms' entry leads to an increase in product quality, variety and innovation in host economies, but little evidence that it leads to lower prices. In this section, we consider real world cases of quality-enhancing technology spillovers that is induced by FDI.

Let us consider first the case of Bangladesh garment industry where Desh (a Bangladesh firm) and Daewoo (a Korean firm) collaborated in 1980, under which Daewoo trained 130 workers in Desh to manufacture high quality clothing products. Rhee (1990) reported that, only a few years after this collaboration, 115 workers have left the company to either work for other competing firms or run their own business.[7] As a result, not only could Desh produce high quality clothes but firms that benefited from these workers were also capable of manufacturing high quality clothing products. UNCTAD (1992) also discussed this case and argued that, these 115 workers were major agents for imparting the skills throughout the whole garment industry in Bangladesh.[8]

[6]UNCTAD has also defined FDI which leads to strong links to the domestic economy, such as that associated with advanced technology and/or spillovers effects, as "high quality" FDI. See also a discussion on international technology diffusion in Keller (2004).

[7]Rhee pointed out that, prior to 1980, the clothing industry in Bangladesh was outdated and could not export to the world market. In 1979, Desh signed an agreement with Daewoo, which was then a leading firm in the world for clothing products, under which Daewoo invested in technical training, plant start-up, and marketing activities for Desh. Desh then produced clothing products under supervision and consultancy from Daewoo. Daewoo trained 130 Desh workers in Korea in 7 months which enabled them to produce high quality products, and later sent a team to train other workers in Desh factory in 1980. Consequently, Desh successfully produced high quality clothing products and exported them under Daewoo's network, where Desh also learned marketing skills, quality upgrading from Daewoo. Desh experienced significant increase in its product quality: its value per piece increased from \$1.3 in 1980 to \$2.3 in 1986.

[8]Along this line, UNCTAD (1992) also documented technology spillovers from Yamaha-Escorts collaboration in India to other local firms through the channel of labor mobility.

Quality-enhancing technology spillovers from foreign to local firms have not only been observed in sectors that are labor intensive such as garment and textile, but also in other sectors such as information technology and manufacturing. Patibandla et al. (1999) documented that, the investment of Texas Instruments in Bangalore in 1984 and other U.S. software firms in late 1980s created significant technological and information externalities to Indian firms. As such, this gave the Indian firms access to the trend in the software market in the world and enabled them to move to the higher-end market (see also Pack & Saggi 2006).

Recently, as pointed out by various authors, Chinese car manufacturers have learned from foreign competitors on how to manufacture high quality cars and/or improve the quality of cars to be sold in the local market (Gallagher 2003, Luo 2005).[9] Employing workers with experience from foreign firms was the practice used by many Chinese automakers. For instance, Chery Automobile, during its early development time hired engineers from Nissan-Dongfeng joint venture which was set up upon Nissan's investment in China, to develop new products (Luo 2005). This is a typical example of what has often been observed in Chinese automobile industry in recent years. That is, on average, the quality of cars made by Chinese manufacturers has increased sharply as they benefited from foreign automakers' presence in China. The 2007 survey of J.D. Power in China's automobile market indicated that the average number of problems per 100 vehicles produced by local firms in China was 368, compared to 800 in 2000 (Li 2007).

Similarly, Thompson (2003) found that labor mobility as a channel for quality-enhancing technology spillovers from foreign (mainly Hong Kong) firms to local firms has also been observed in garment industry in China. His survey showed that, local firms have attempted to copy Hong Kong firms' production processes and techniques, learn their managerial practices, and particularly hire Hong Kong firms' employees. In his survey, about 13,000 workers per annum left Hong Kong firms and many of these workers later worked for local firms.

[9] China only allows foreign automakers to form joint venture with local firms but not wholly owned foreign company, as the government wants foreign firms to share technologies with local partners (Qiu 2005).

What are the strategies employed by multinationals to deal with the resulting quality-enhancing technology spillovers upon FDI? It was observed that in many cases, Northern firms intentionally brought dated technologies to the South to produce goods of lower quality when compared to similar products they produced at home factories. As such, they could decrease the amount of technology that spills over to local competitors. Gallagher (2003) showed that Chrysler and Ford brought dated technologies to China to produce cars which did not meet quality requirement of Japan, the United States or Europe and thus could only be sold in China's market. Ernst & Young (2005) also reported that, Volkswagen initially brought obsolete models along with factories and engines needed to build them from Europe to China. Similarly, Japanese firms often brought technologies at their mature period to Malaysian electronics industry (Praussello 2005). As these examples reveal, choosing low quality level for their products is an usual practice that many Northern firms use to cope with resulting quality-enhancing technology spillovers in the South.

In summary, the Northern firms' production in the South often creates positive externalities to local firms which improve local firms' product quality. This chapter considers a theoretical model that captures these phenomena, and explores policy implications of quality-enhancing technology spillovers.

2.3 Relationships to the Literature

Technology spillovers from Northern firms to Southern firms upon FDI usually improves the performance of the latter and intensifies competition between them (UNCTAD 1997). Several papers have theoretically addressed this issue in the international trade and FDI literature under cost-reducing technology spillovers frameworks (Helpman 1993, Glass & Saggi 2002, Naghavi 2007). By surveying related papers, this section highlights the importance of a new framework which helps to analyze the welfare consequences of quality-enhancing spillovers.[10]

The framework, which is closest to ours is the model of Naghavi (2007).[11] Naghavi considered a cost-reducing technology spillovers model in which a Northern firm can choose to either export or undertake FDI in a Southern country, which has a potential competitor. The game consists of five stages, starting with Southern government choosing its IPR policy, represented by the spillover rate. In second stage, the Northern firm chooses its mode of entry. If it chooses export, it will be the monopolist in the Southern market and the game proceeds to third stage where the Southern government chooses its optimal tariff rate. If the Northern firm chooses FDI instead, a Southern firm could emerge and benefits from the technology spillovers of the Northern firm. In forth stage, the Northern firm chooses the level of R&D investment. In the final stage, we have production and competition.

Given the above framework, Naghavi found that, stringent IPR regime in the South (low spillover rate) induces the Northern firm to undertake FDI. The resulting FDI improves Southern welfare whenever the Northern firm's FDI induces entry of the Southern firm (that is, when duopoly is the prevailing form of competition). Hence, the Southern government can maximize

[10] Many authors have empirically investigated technology spillovers from foreign firms to local firms upon FDI, where technology spillovers are often measured by changes in local firms' productivity. The findings along this line are mixed. For instance, Aitken and Harrison (1999) found negative impact of FDI on local firms' productivity using data from 4,000 Venezuelan firms; Djankov and Hoekman (2000) found negative spillovers in Czech Republic; while Haddad and Harrison (1993) found positive relationship between FDI and productivity in manufacturing sector in Morocco. See also Carluccio and Fally (2010) for a survey.

[11] Helpman (1993) focused on the impact of tightening Southern IPR regime on Northern and Southern welfare in a general equilibrium model where Northern firms innovate while Southern firms imitate. He showed that tightening Southern IPR protection always hurts the South. When imitation rate is low, tightening Southern IPR protection hurts the North if Northern firms are not allowed to undertake FDI, and it benefits the North if Northern firms are allowed to undertake FDI in the South. However, technology imitation is not induced by FDI in his framework, which is different from ours.

Southern welfare by choosing the highest possible spillover rate which still induces Northern firm to undertake FDI.

Glass and Saggi (2002) developed a cost-reducing technology spillovers model in which a superior-technology source firm chooses whether to produce elsewhere (such as home-production) or undertake FDI in a competing host firm's country. By undertaking FDI, the source firm can save production cost but its workers may then choose to work for the host firm and decrease the host firm's marginal cost from Θ to $\theta(< \Theta)$.[12] To prevent this technology transfer, the source firm can pay a wage premium to retain workers. Interestingly, Glass and Saggi found that, under FDI, the greater the cost reduction the host firm could achieve by hiring workers from the source firm, the greater the incentive the source firm has toward making technology transfer available. That is, when θ is under a threshold value θ_S, the equilibrium with technology transfer will occur. The intuition is that, high technology diffusion (low θ) increases the level of wage host firm is willing to offer workers from the source firm. This increases the wage premium the source firm needs to incur to retain workers, which reduces its incentive to prevent technology transfer. Glass and Saggi also found that, unless production elsewhere is very costly, FDI also improves host country's welfare.

Similar to Naghavi (2007), the model of Glass and Saggi (2002) helps to explain why in many cases Southern countries often strengthen the level of IPR protection for foreign firms to make FDI attractive. However, these authors have not considered the impact of technology spillovers on global welfare. This brings the following question: What level of IPR protection in the South would maximize global welfare? By developing a new international duopoly model with quality-enhancing technology spillovers, we show that the social planner could maximize global welfare by choosing a spillover rate that is higher than the level desired by the North and lower than the level desired by the South. The necessary condition for this result to hold is that, the Northern

[12] In their analysis, technology can be transferred at no cost to the local firm, so it can also be categorized as technology spillovers.

firm chooses a lower quality level for its product under FDI compared to the level of quality it would choose under home-production.

Does this result arise in cost-reducing technology spillovers framework? In the next chapter, we consider an augmented cost-reducing technology spillovers model with similar structure to the base model of the present chapter. We find that in the equilibrium, Northern firm chooses the minimum marginal cost level for its product regardless of its location choice. Thus FDI always improves Southern welfare and consequently global welfare. This also leads to the outcome in which the social planner can either support the North by choosing a zero spillover rate, or the South by choosing some positive spillover rate to maximize global welfare.[13]

Recently, the issue of whether IPR should be strengthened in the South has received considerable attention in the international trade literature, but FDI was absent in such an approach. Diwan and Rodrik (1991) considered a model in which some Northern firms innovate while some Northern firms and Southern firms imitate. Diwan and Rodrik pointed out that, a global social-planner who values Northern welfare and Southern welfare equally should choose the same level of IPR protection in both the North and the South. If she values the South more than the North then IPR should be protected more in the North than in the South.[14] Lai and Qiu (2003) explored a model where firms

[13] Meanwhile, a number of authors have discussed quality competition in the context of North-South trade. For instance, Das and Donnenfeld (1989) analyzed an international duopoly model of vertical product differentiation in which two firms in different countries compete against each other by producing products with different qualities. They showed that trade policy influences the firms's choice of equilibrium quality levels (see also Falvey 1979, Das & Donnenfeld 1987, Boccard & Wauthy 2005, Toshimitsu 2005, Gonzalez & Viaene 2005). In these papers, however, neither the Northern firm's choice of modes of entry into Southern market, nor technology spillovers have been examined.

[14] Deardorff (1992) studied the impact of extending patent protection from innovating country to another country. He showed that, if the size of the innovating country is large, this spreads of patent protection benefits innovating country, harms the other country and the total impact on global welfare is negative.

in both the North and the South can innovate, and IPR protection in each region is represented by the length of product cycles. Assuming this length is higher in the North than in the South in a pre-TRIPS regime, Lai and Qiu showed that, to maximize global welfare under post-TRIPS regime, the South should adopt a stronger IPR protection compared to that in the North under pre-TRIPS regime. Since this benefits the North, the North should open its market for other competitive products as a compensation for the South.[15]

Finally, in a seminal contribution to the cost-reducing technology spillovers literature, Chin and Grossman (1990) developed a Cournot duopoly model in which a Northern firm competes with a Southern firm in an integrated world market. They assumed that both firms have access to a standard technology, however only the Northern firm can invest in R&D in order to lower its marginal cost. If the Southern IPR regime is weak, the Southern firm can imitate the Northern firm's technology. Zigic (1998) extended this framework with a continuous spillover rate that represents the strength of Southern IPR policy.[16] Under this type of set up, previous authors found that stringent Southern IPR regime always benefits the North, while it has an ambiguous impact on Southern welfare. However, these previous frameworks did not capture the case in which technology spillovers is induced by FDI, thus their focus are different from ours.

As pointed out by Helpman (1993), FDI is crucial in determining the impact of a change in the Southern IPR environment on welfare. In light of this argument, we show that, when quality-enhancing technology spillovers is

---

[15]With a closely related framework, Grossman and Lai (2004) demonstrated that, if the North's human capital endowment is higher than the South and its market is larger, it always has incentive to provide stronger IPR than that in the South.

[16]Zigic (2000) augmented this cost-reducing spillovers framework focusing on Northern market only to discuss optimal trade policy. He showed that, a positive tariff on Southern firm's product is better for Northern firm, but it has ambiguous effects on consumers. Kim and Lapan (2008) considered spillovers from a Northern firm to many firms in different Southern countries and found that, in a non-cooperative equilibrium, all Southern countries choose loose IPR regime, while collectively, they tend to protect Northern firm's technology.

an unavoidable consequences of FDI, the quality level Northern firm chooses will determine how a change in IPR environment affects welfare. Specifically, if the Northern firm chooses the level of quality for its product under FDI equal to that of what it would choose with home-production, FDI necessarily improves Southern welfare and global welfare. In this case, it follows that the social planner and Southern government would choose the same IPR policy, the loosest one which still induces FDI. However, if the equilibrium quality level the Northern firm chooses under FDI is lower than that under home-production level, FDI could hurt the South. In this latter case, it is possible that the level of spillovers that maximizes global welfare falls between zero (which is North-optimal) and some positive value (which is South-optimal). We find this result to be unique to our framework.

2.4 Technology Spillovers under Vertical Product Differentiation

In this section, we present a model of vertical product differentiation and technology spillovers under international duopoly. Wee adopt the standard framework of product-line pricing (Mussa & Rosen 1978) and focus on two-type consumer case (Davis et al. 2004, Glass & Saggi 1998, Waldman 1996, 1997). We then characterize Subgame Perfect Nash Equilibria (SPNEs) of the model.

2.4.1 The Model

We consider an international duopoly model of vertical product differentiation in which a Northern firm (firm N) and a Southern firm (firm S) compete in the Southern market. Firm S is located in the South, while firm N can locate itself in the North (home-production, denoted HP) or in the South (FDI). Let q_k (≥ 0, $k = N$, S) denote the quality of firm k's product.

On the demand side, there are two groups of consumers, denoted H (type H

consumers) and L (type L consumers), where group j consists of a continuum of nonatomic consumers of mass m_j, $j = H, L$. A representative individual in group j consumes either zero units or one unit of the products, and derives a gross benefit of $v_j q_k$ from the consumption of one unit of quality q_k product, where $v_H > v_L > 0$.

We assume that, firm N can choose any quality level for its product, q_N. Meanwhile, firm S, using less advanced technology, can only choose a quality level for its product up to a certain upper bound value. This value differs for FDI and HP. Specifically, when firm N locates itself in the North, the maximum possible quality level firm S can choose is given by $\bar{q}_S$. When firm N undertakes FDI, technology spillovers extends this upper bound quality level and the maximum quality level firm S can choose for its product is given by $\hat{q}_S(q_N) = max(\bar{q}_S + \theta(q_N - \bar{q}_S), \bar{q}_S)$, $\theta \in [0, 1)$.[17] In our model, θ captures the degree of technology spillovers from firm N to firm S, which can only happen under FDI, i.e. firm N investing in the South. Hence, when firm N undertakes FDI and chooses $q_N > \bar{q}_S$, the higher θ enables firm S to choose a higher quality level.

Each firm k can produce a product of quality q_k at a constant marginal cost of $c_k(q_k)$ with zero fixed costs. Thus, firm S incurs a marginal cost of $c_S(q_S) = c(q_S)$. Firm N's marginal cost is $c_N(q_N) = c(q_N) + w$ under HP and $c_N(q_N) = c(q_N)$ under FDI, where w captures Northern country's cost disadvantages (eg., higher labor costs).[18] We assume that $c(\cdot)$ is a twice-continuously differentiable, and is a convex cost function, i.e. $c'(\cdot) > 0$ and $c''(\cdot) > 0$. To derive closed form solutions, we assume that $c(q_k) = \frac{1}{2}q_k^2$. A specific tariff, t ($\geq 0$), is imposed on imports of firm N's product.

[17]In other words, we assume firm S has some limitation concerning quality while firm N can choose any quality level.

[18]The inclusion of w not only captures real world differences of production cost in the North and in the South but also helps us to simplify the proof concerning the existence of parameterizations for the welfare implications of our model. The qualitative nature of our results would remain mostly unchanged by setting $w = 0$.

We consider a three-stage game, described below.

[Stage 1] Firm N determines whether to locate itself in the North (HP) or in the South (FDI).

[Stage 2] Firm N chooses quality level q_N for its product. Having observed q_N, firm S chooses quality level q_S, subject to $q_S \leq \hat{q}_S(q_N)$.

[Stage 3] Firm N and firm S simultaneously set prices for their own product, and consumers make their purchase decisions.

Notice that the game described above has two stage 2 subgames, one is HP subgame in which firm N locates itself in the North, while the other is FDI subgame in which firm N locates itself in the South.

2.4.2 Equilibrium Characterization

Throughout the analysis we assume that $\bar{q}_S < v_L$ holds. This assumption enables us to reduce a number of cases to be considered and focus on deriving meaningful economic implications of technology spillovers. If $\bar{q}_S \geq v_L$, then $\bar{q}_S$ does not impose a binding constraint on firm S's choice of quality level, since firm S can choose its profit-maximizing level of quality v_L without technology spillovers as shown later in this section.

Let us now derive Subgame Perfect Nash Equilibria of the model described above. We focus on a range of parameterizations in which firm N sells its product to all type H consumers and firm S sells its product to all type L consumers in the equilibrium. Following Davis et al. (2004) and Glass and Saggi (1998), we define this type of equilibrium as a *separating equilibrium.* Note that all proofs are presented in the Appendix.

Proposition 1. There exists an unique value $\tilde{m}_H > 0$ such that the game has a separating equilibrium if and only if $m_H > \tilde{m}_H$. Furthermore, if $m_H > \tilde{m}_H$, the separating equilibrium is the unique equilibrium of the game.

To understand the logic behind Proposition 1, let us first consider the case in which the spillover rate, θ, is equal to zero. This implies that, technology does not spill over from firm N to firm S even when firm N chooses to locate itself in the South. In this case, firm N's optimal choice in Stage 1 is to locate itself in the South to reduce the production cost and avoid the tariff.

Suppose that the game has a separating equilibrium when $\theta = 0$. In equilibrium, firm N sells its product with quality q_N at a price of p_N to m_H type H consumers, while firm S sells its product with quality q_S at a price of p_S to m_L type L consumers. We find that

$$p_N = v_H q_N - (v_H - v_L) q_S, \tag{2.1}$$

$$p_S = v_L q_S, \tag{2.2}$$

where $q_N > q_S$.[19] Firm S extracts all surplus from type L consumers by charging $p_S = v_L q_S$. If a type H consumer purchases firm S's product at p_S, the consumer's net benefit is $v_H q_S - p_S = (v_H - v_L) q_S$. Then, in order for firm N to sell its product to type H consumers, it must leave the same amount of surplus, $(v_H - v_L) q_S$, to be captured by the consumers, and hence $p_N = v_H q_N - (v_H - v_L) q_S$. Then, the equilibrium profits of firms N and S, denoted respectively $\pi_N(q_N)$ and $\pi_S(q_S)$, are

$$\pi_N(q_N) = m_H[p_N - c(q_N)] = m_H[v_H q_N - (v_H - v_L) q_S - \frac{1}{2} q_N^2], \tag{2.3}$$

$$\pi_S(q_S) = m_L[p_S - c(q_S)] = m_L[v_L q_S - \frac{1}{2} q_S^2]. \tag{2.4}$$

At stage 2, firm N chooses $q_N = v_H$ which maximizes $\pi_N(q_N)$, while firm S chooses $q_S = min\{v_L, \bar{q}_S\}$ which maximizes $\pi_S(q_S)$ subject to $q_S \leq \hat{q}_S(q_N)$. Note that if $\theta = 0$ then $\hat{q}_S(q_N) = \bar{q}_S$, so that firm S chooses $q_S = \bar{q}_S$ in this case, even though $q_S = v_L$ is its profit maximizing level of quality.

Proposition 1 tells us that the number of type H consumers, m_H, must be greater than a threshold value $\tilde{m}_H$ for the game to have a separating equilibrium. This is because, if m_H is lower than the threshold, ignoring type L

[19] Market separating constraints are: $v_H q_N - p_N \geq v_H q_S - p_S \rightarrow p_N - p_S \leq v_H(q_N - q_S)$ and $v_L q_S - p_S \geq v_L q_N - p_N \rightarrow p_N - p_S \geq v_L(q_N - q_S)$. Combining these and given one constraint must hold with strict inequality, we have $v_L(q_N - q_S) < v_H(q_N - q_S) \rightarrow q_N > q_S$.

consumers is no longer firm N's optimal choice, and firm N is strictly better off by selling its product to both types of consumers.

In the case where $\theta > 0$, the positive spillover rate can negatively affect firm N's profitability. The maximum possible quality firm S can choose is $q_S = \bar{q}_S$ without technology spillovers, but firm S's profit-maximizing level of quality is $q_S = v_L > \bar{q}_S$. An increase in θ mitigates this constraint, and hence increases the equilibrium level of firm S's quality. This in turn increases the amount of surplus, $(v_H - v_L)q_S$, that firm N must offer to type H consumers to ensure they purchase firm N's product, resulting in the reduction of firm N's equilibrium profit.

Firm N continues to undertake FDI when the value of θ is relatively small, but may switch to home-production when θ becomes higher. In any case, Proposition 1 again tells us that m_H must be greater than a threshold for the game to have a separating equilibrium, because, otherwise, firm N will be strictly better off by selling its product to both types of consumers. In most of the cases in our analysis, firm N has the advantage over firm S concerning its choice of quality for production so that it can choose which segment of the market to sell its product to. The threshold value of $\tilde{m}_H$ somehow captures the required thickness of the market for our analysis, or the minimum relative size of the population of high-valuation consumers compared to the population of low-valuation consumers.[20]

Next, Proposition 2 tells us that if $m_H > \tilde{m}_H$, the unique equilibrium of the game is an FDI equilibrium if θ is relatively small, and it is an HP equilibrium otherwise.

Proposition 2. Suppose $m_H > \tilde{m}_H$. There exist a value $\theta^* \in (0, 1]$ such that the equilibrium of the game is an FDI equilibrium if $\theta \leq \theta^*$, and it is an HP equilibrium if $\theta > \theta^*$. Furthermore, there exists a value $\Psi \geq 0$ such that $\theta^*(< 1)$ is strictly increasing in t if $t + w < \Psi$, and $\theta^* = 1$ otherwise.

As mentioned above, firm N chooses to undertake FDI if $\theta = 0$. An

[20]We would like to thank Ray Riezman for pointing this out.

increase in θ reduces firm N's profitability because the higher rate of technology spillovers increases the equilibrium quality of firm S's product. Note that firm N's disadvantage of home-production is captured by $t+w$. Proposition 2 tells us that if the disadvantage of home-production is small enough, there exists a threshold $\theta^* < 1$ such that firm N switches from FDI to home-production if θ becomes greater than θ^*. In this case, an increase in tariff increases θ^* because the disadvantage of home-production is higher, so that firm N has less incentive to switch from FDI to HP. However, if the disadvantage is relatively large, firm N undertakes FDI for all $\theta \in [0,1)$ (Proposition 2 captures this case by setting $\theta^* = 1$ if $t + w \geq \Psi$ holds.)

Finally, Proposition 3 below characterizes the level of product quality that firm N chooses in equilibrium.

Proposition 3. Suppose $m_H > \tilde{m}_H$. There exists a threshold $\hat{\theta}$, $\hat{\theta} \in (0, \theta^*]$, such that, in the equilibrium of the game firm N chooses $q_N^* = (1-\theta)v_H + \theta v_L$ $(< v_H)$ if $\theta \leq \hat{\theta}$ and $q_N^* = v_H$ if $\theta > \hat{\theta}$.

When firm N's product is consumed by type H consumers, $q_N = v_H$ maximizes the net social benefit associated with the consumption of firm N's product.[21] If the spillover rate θ is high enough satisfying $\theta > \theta^*$, then firm N chooses home-production to avoid technology spillovers. In this case, firm N chooses the socially optimal quality level $q_N^* = v_H$, which maximizes its profit $m_H[v_H q_N - (v_H - v_L)\bar{q}_S - \frac{1}{2}q_N^2 - (w+t)]$. If $\theta \leq \theta^*$, firm N undertakes FDI to save production cost and avoid tariff, but FDI reduces firm N's profitability by inducing technology spillovers. Proposition 3 tells us that, in order to mitigate this problem, firm N may choose a lower level of quality to reduce the amount of technology that spills over from firm N to firm S. In other words, FDI may reduce the quality of firm N's product from the socially optimal level $q_N^* = v_H$ to a suboptimal level $q_N^* = (1-\theta)v_H + \theta v_L \leq v_H$.

Proposition 3 says that FDI induces firm N to choose a socially suboptimal

[21] The net social benefit is $m_H[v_H q_N - \frac{1}{2}q_N^2]$ in the FDI subgame and $m_H[v_H q_N - \frac{1}{2}q_N^2 - w]$ in the HP subgame.

level of quality if the spillover rate θ is relatively small. This result can be explained as follows. Consider the equilibrium of the FDI subgame. Given firm N's quality choice q_N, firm S chooses q_S to maximize $\pi_S(q_S) = m_L[v_L q_S - \frac{1}{2}q_S^2]$ subject to $q_S \leq \hat{q}_S(q_N) \equiv max(\bar{q}_S + \theta(q_N - \bar{q}_S), \bar{q}_S)$. Let $q_S^*(q_N)$ denote firm S's best response function. By anticipating firm S's response to q_N, firm N chooses q_N to maximize its profit in the subsequent equilibrium, which is

$$\pi_N(q_N) \equiv m_H[v_H q_N - (v_H - v_L)q_S^*(q_N) - \frac{1}{2}q_N^2]. \tag{2.5}$$

We find that the candidates for the profit-maximizing level of firm N's product quality are $q_N = v_H$ and $q_N = (1-\theta)v_H + \theta v_L$. If the level of q_N does not impose a binding constraint on firm S's choice of q_S then firm N chooses $q_N^* = v_H$ that maximizes $[v_H q_N - \frac{1}{2}q_N^2]$. In contrast, if the level of q_N does impose a binding constraint, firm N chooses $q_N^* = (1-\theta)v_H + \theta v_L$, which is lower than v_H, to reduce the amount of technology spillovers from firm N to firm S.

Note that, without the constraint $q_S \leq \hat{q}_S(q_N)$, firm S would choose $q_S = v_L$ to maximize its profit $m_L[v_L q_S - \frac{1}{2}q_S^2]$. If the spillover rate θ is large enough so that $v_L < \hat{q}_S((1-\theta)v_H + \theta v_L) \Leftrightarrow \theta > \frac{v_L - \bar{q}_S}{v_H - v_L}$ then the constraint is no longer binding at both candidates $q_N = (1-\theta)v_H + \theta v_L$ and $q_N = v_H$. In this case, firm N chooses $q_N^* = v_H$ in equilibrium. In contrast, if θ is small enough so that $v_L \geq \hat{q}_S(v_H) \Leftrightarrow \theta \leq \frac{v_L - \bar{q}_S}{v_H - \bar{q}_S}$, then the constraint is binding at both candidates $q_N = (1-\theta)v_H + \theta v_L$ and $q_N = v_H$. In such cases, firm N chooses $q_N^* = (1-\theta)v_H + \theta v_L$ in equilibrium. We find that there exists a unique value $\dot{\theta} \in (0,1)$ such that, in the equilibrium of the FDI subgame, firm N chooses $q_N^* = v_H$ if $\theta > \dot{\theta}$ and $q_N^* = (1-\theta)v_H + \theta v_L$ if $\theta \leq \dot{\theta}$. Finally, we define $\hat{\theta} \equiv min\{\dot{\theta}, \theta^*\}$ in order to state this result in terms of the equilibrium of the entire game, leading to Proposition 3.

Lemma 1. $\hat{\theta} < \theta^* = 1$ if $t + w \geq \Psi$, and $\hat{\theta} = \theta^* < 1$ otherwise.

Recall from Proposition 2 that, when $t + w \geq \Psi$ then $\theta^* = 1$ which implies that firm N undertakes FDI for all $\theta \in [0,1)$. Lemma 1 says that $\hat{\theta} < \theta^*$ holds in this case. This means that if $\theta \in [0, \hat{\theta}]$ then $q_N^* = (1-\theta)v_H + \theta v_L \leq v_H$ and hence, $q_S^* = \hat{q}_S(q_N^*) < v_L$ (see Proposition 3). In order to impose a binding constraint on firm S's quality choice, firm N chooses a quality level below v_H in the equilibrium of the game. If $\theta \in (\hat{\theta}, 1)$ then firm N does not attempt to impose a binding constraint on firm S's quality, which leads to $q_N^* = v_H$ and $q_S^* = v_L$.

On the other hand, if $t + w < \Psi$ then $\theta^* < 1$ by Proposition 2. Lemma 1 says that $\hat{\theta} = \theta^*$ in this case. This means that if $\theta \in [0, \theta^*]$ then firm N undertakes FDI and chooses $q_N^* = (1-\theta)v_H + \theta v_L \leq v_H$ followed by firm S's choice of $q_S^* = \hat{q}_S(q_N^*) < v_L$. However, if $\theta \in (\theta^*, 1)$ then firm N undertakes HP and $q_N^* = v_H$ and $q_S^* = \bar{q}_S$. To understand why $\hat{\theta} = \theta^*$ holds in this case, suppose $\hat{\theta} < \theta^*$. Then, for all $\theta \in (\hat{\theta}, \theta^*]$, the equilibrium of the game is an FDI equilibrium with $q_N^* = v_H$, and $q_S^* = v_L$. But since firm N prefers FDI to HP for all $\theta \in (\hat{\theta}, \theta^*]$, it also chooses FDI for all $\theta \in (\theta^*, 1)$, which leads to $\theta^* = 1$, a contradiction. Therefore, $\hat{\theta} = \theta^*$ must hold.

In summary, we have shown that the game has a separating equilibrium if and only if the population of type H consumers is large enough. The separating equilibrium is the unique equilibrium, which is an FDI equilibrium if the spillover rate θ is low enough and it is an HP equilibrium otherwise. We have also found that FDI reduces the equilibrium quality of firm N's product from the socially optimal level v_H to a suboptimal level $(1-\theta)v_H + \theta v_L$ under a range of parameterizations. This is because, by reducing its product quality, firm N can reduce the amount of technology that spills over to firm S, and this in turn increases firm N's profitability.

2.5 Welfare Implications of Trade Policy

In this section, we investigate the effects of trade policy by undertaking comparative statics concerning the tariff rate, t. We focus on the range of parameterizations in which the equilibrium of the game is a separating equilibrium for all $t \geq 0$.[22] Let $\pi_N(t)$, $\pi_S(t)$, $CS(t)$, $WS(t)$, and $WW(t)$ respectively denote firm N's profit, firm S's profit, consumer surplus, Southern welfare, and global welfare in the equilibrium of the game. Proposition 2 tells us that, the equilibrium of the game is an FDI equilibrium for all $t \geq 0$ if (i) $w \geq \Psi$, or (ii) $w < \Psi$ and $\theta \leq \theta^*|_{t=0}$. In such cases, a change in tariff does not affect $\pi_N(t)$, $\pi_S(t)$, $CS(t)$, $WS(t)$, and $WW(t)$.

Given this, in what follows we analyze the case in which $w < \Psi$, and $\theta > \theta^*|_{t=0}$. In this case, if t is relatively small, firm N chooses home-production to avoid technology spillovers. However, if t is relatively large then firm N undertakes FDI to avoid tariff. This is formalized in the following lemma.

Lemma 2. Suppose $w < \Psi$ and $\theta > \theta^*|_{t=0}$. Then, there exists a threshold $\bar{t}$, $0 \leq \bar{t} \leq \Psi - w$, such that:
(i) the equilibrium of the game is an HP equilibrium if $t < \bar{t}$, and
(ii) the equilibrium of the game is an FDI equilibrium if $t \geq \bar{t}$.

For any $t \in [0, \bar{t})$, firm N chooses home-production and $q_N = v_H$, while, since there are no technology spillovers, firm S chooses $q_S = \bar{q}_S$. Any change in t within $[0, \bar{t})$ does not affect equilibrium levels of product quality of each of these firms. Thus, $\pi_S(t)$, $CS(t)$, and $WW(t)$ are independent of t for all $t \in [0, \bar{t})$. Since an increase in t within $[0, \bar{t})$ transfers a part of firm N's profit to the Southern government, $\pi_N(t)$ is decreasing in t and $WS(t)$ is increasing in t for all $t \in [0, \bar{t})$. That is, when the products of firm N and firm S are vertically differentiated, and the equilibrium of the game is an HP equilibrium, raising the tariff rate on imports of firm N's product always raises the revenue and welfare for the South. The intuition is simple: since tariff does not change the nature of competition between firm N and firm S in this case, the Southern government can extract as much as possible (part of) profit accruing to firm N by increasing the tariff rate.

Once the tariff is high enough satisfying $t = \bar{t}$, the equilibrium of the game switches from the HP equilibrium to the FDI equilibrium. What are the

[22] The condition can be written as $m_H > \lim_{t \to (\Psi - w)} \tilde{m}_H$, see the proof of Proposition 1.

effects of the tariff increase from $t = t' < \bar{t}$ to $t = \bar{t}$? This is the key question of this section which we will explore in what follows.

Proposition 4. $\pi_S(\bar{t}) > \pi_S(t')$ and $CS(\bar{t}) > CS(t')$.

Firm N chooses home-production for all $t = t' < \bar{t}$. Since there are no technology spillovers, the highest possible quality level of firm S's product is $\bar{q}_S$, and firm S chooses $q_S = \bar{q}_S$ in equilibrium. When t is raised to $t = \bar{t}$, firm N undertakes FDI and chooses either $q_N^* = v_H$ or $(1-\theta)v_H + \theta v_L$ depending on the level of spill over, θ (see Proposition 3). In either case, technology spillovers from firm N to firm S increases firm S's highest possible quality level from $\bar{q}_S$ to $\bar{q}_S + \theta(q_N^* - \bar{q}_S)$, and firm S chooses $q_S^* = min\{v_L, \bar{q}_S + \theta(q_N^* - \bar{q}_S)\}$ $(> \bar{q}_S)$ in equilibrium. This implies that FDI induced by the tariff increase raises firm S's equilibrium profit (that is, $\pi_S(\bar{t}) > \pi_S(t')$ holds). Also, since technology spillovers increase firm S's equilibrium product quality, firm N has to leave a larger amount of rent to type H consumers to induce them to purchase firm N's product. This implies that the induced FDI increases the equilibrium consumer surplus as well (that is, $CS(\bar{t}) > CS(t')$ holds).

Next we show that the FDI induced by the tariff increase may increase or decrease Southern welfare and global welfare depending on parameter values. This policy implication of technology spillovers arises from our focus on quality-enhancing spillovers. Note that firm N is indifferent between choosing HP and FDI at $t = \bar{t}$, therefore $\pi_N(\bar{t}) = \pi_N(t')$. Hence, $WW(\bar{t}) > (=,<)\ WW(t')$ if and only if $WS(\bar{t}) > (=,<)\ WS(t')$. In other words, if FDI benefits (hurts) the South, it also increases (decreases) global welfare.

Proposition 5. There exists a value $\hat{m}_{H1}$ with the following properties:

(i) If $\theta > \hat{\theta}$, then $WS(\bar{t}) > WS(t')$ and $WW(\bar{t}) > WW(t')$, and
(ii) If $\theta \leq \hat{\theta}$, then $WS(\bar{t}) > (=,<) WS(t')$ and $WW(\bar{t}) > (=,<) WW(t')$ if $m_H < (=,>) \hat{m}_{H1}$, where $\hat{m}_{H1} > \lim_{t \to (\Psi - w)} \tilde{m}_H$ holds under a range of parameterizations.

The socially optimal levels of product quality are $q_N = v_H$ and $q_S = v_L$

when firm N's product is consumed by type H consumers while firm S's product is consumed by type L consumers. In the HP equilibrium, firm N chooses $q_N = v_H$ and firm S chooses $q_S = \bar{q}_S$, where the level of firm S's product quality $\bar{q}_S$ is less than the socially optimal level v_L because of firm S's limited technological expertise.

In the FDI equilibrium, technology spillovers increases firm S's product quality, and this increases equilibrium welfare. At the same time, technology spillovers may induce firm N to choose suboptimal level of product quality. From Proposition 3, firm N chooses $q_N^* = v_H$ even in the FDI equilibrium if $\theta > \hat{\theta}$, and FDI unambiguously improved welfare in this case. However, if $\theta \leq \hat{\theta}$, firm N chooses $q_N^* = (1-\theta)v_H + \theta v_L \leq v_H$ under FDI, which creates a trade-off. Specifically, we have that technology spillovers improve the net social benefit associated with the consumption of firm S's product at the expense of the reduction of the net social benefit associated with the consumption of firm N's product. If the population of type H consumers is relatively large, the latter negative welfare effect overshadows the former positive effect and hence FDI induced by the tariff increase reduces global welfare. If the population of type H consumers is relatively small, FDI increases global welfare by a similar argument. Proposition 5 tells us that the level of spillovers and the population of consumers will be crucial in clarifying the welfare impact of a change in trade policy.

When technology spillovers are an unavoidable consequence of a Northern firm's FDI in the South, the Northern firm may choose a lower level of product quality under FDI than under home-production. This in turn implies that the Northern firm's FDI may reduce global and Southern welfare. This is a new policy implication of technology spillovers that arises from our focus on quality-enhancing spillovers. Under a model of cost-reducing technology spillovers with otherwise similar logical structure, we show that, firm N always chooses the lowest possible cost even in the presence of technology spillovers, and consequently FDI unambiguously improves welfare (see the analysis in Chapter 3).

In reality, when Northern firms undertake FDI in South countries, Northern firms often choose products with lower quality to reduce the amount of technology that spills over to local firms. Our analysis captures this phenomena and indicates that FDI may reduce Southern welfare. Thus, high trade barrier to induce FDI with technology spillovers may not be a good choice for Southern countries (see Figure 2.1). Section 2.7 is devoted elaborates more on this new policy implication of our analysis.

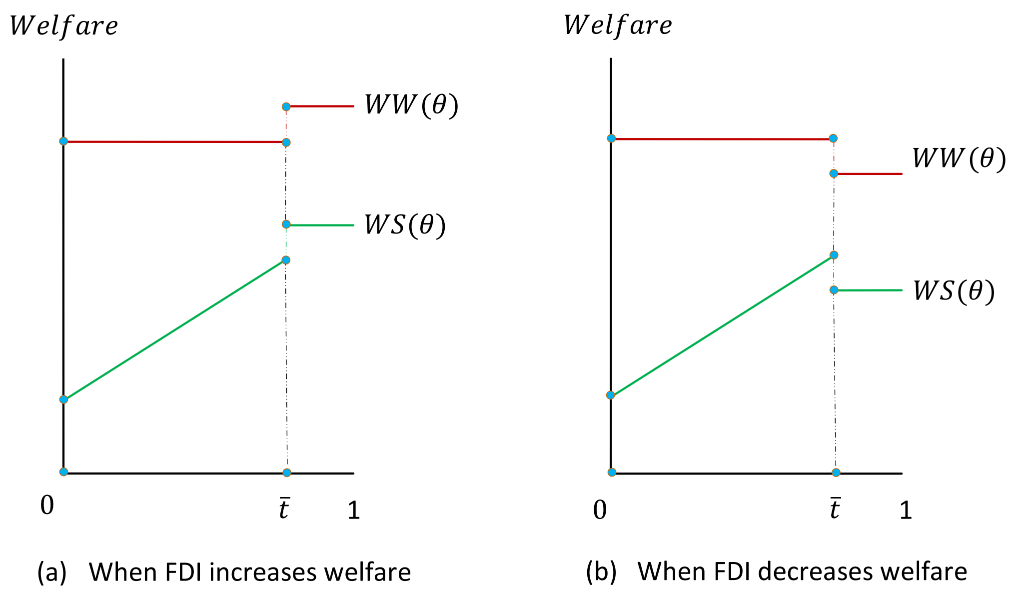

Figure 2.1: The impact of trade policy.

2.6 Welfare Implications of IPR Policy

This section explores the economic implications of IPR policy in the South. In our set up, Southern IPR policy is represented by a change in the spillover rate. For example, if the spillover rate becomes higher, the Southern firm can benefit more from the presence of the Northern firm in the South, which is equivalent to as if the Southern IPR policy becomes more lax. In contrast, a stringent IPR policy can be represented by a decrease of the spillover rate. Even though the spillover rate can not characterize the full IPR environment in the South, it has been widely accepted that it represents the government policy concerning the strength of the IPR environment (for example, see the work of Zigic 1998, 2000 and Naghavi 2007).

To focus the analysis, this section considers only the cases under which the equilibrium of the game is a separating equilibrium for all $\theta \in [0, 1)$.[23] To undertaking comparative statics concerning technology spillovers, θ, we let $\pi_N(\theta)$, $\pi_S(\theta)$, $CS(\theta)$, $WS(\theta)$, and $WW(\theta)$ respectively denote profit of Northern firm and Southern firm, consumer surplus, Southern welfare, and global welfare in the equilibrium of the game, respectively. Following Lemma 1, there will be two cases to be examined: (i) $t + w \geq \Psi$ where firm N undertakes FDI for all θ, and (ii) $t + w < \Psi$ where firm N chooses FDI if $\theta \leq \theta^*$ and it chooses HP otherwise. In either of these cases, we find that there exists an unique value of θ that maximizes $WW(\theta)$ for all $\theta \in [0, \hat{\theta}]$, as formalized below.

Lemma 3. There exists a value $\tilde{\theta} \in [0, \hat{\theta}]$ such that $WW(\theta)$ is increasing in θ for all $\theta \in [0, \tilde{\theta}]$ and decreasing in θ for all $\theta \in [\tilde{\theta}, \hat{\theta}]$, where $\tilde{\theta} < \hat{\theta}$ holds if and only if $m_H > m_H^*$ where $m_H^* > \lim_{\theta \to \theta^*} \tilde{m}_H$ holds under a range of parameterizations.

When $\theta \leq \hat{\theta}$, firm N imposes a binding constraint on firm S's quality choice following Proposition 3. We find that, an increase in θ where $\theta \in [0, \hat{\theta}]$ decreases firm N's equilibrium quality level, q_N^*, and increases firm S's equilibrium quality level, q_S^*. How would this affect global welfare? Since q_N^* deviates from v_H, net social benefit associated with the consumption of firm N's product declines, while net social benefit associated with the consumption of firm S's product increases since its quality level gets closer to v_L (as discussed in previous section, $q_N = v_H$ and $q_S = v_L$ maximize global welfare). The net effect, or the impact on global welfare of an increase in θ, is thus ambiguous. We find that, global welfare is increasing in θ for all $\theta \in [0, \tilde{\theta}]$, and decreasing in θ for all $\theta \in [\tilde{\theta}, \hat{\theta}]$, where $0 \leq \tilde{\theta} \leq \hat{\theta}$ holds. This leads to Lemma 3.

[23]The condition can be written as $m_H > \lim_{\theta \to \theta^*} \tilde{m}_H$, see the proof of Proposition 1.

We can now examine impact of Southern IPR policy. First, let us consider the case of $t + w \geq \Psi$.

Proposition 6. Suppose $t + w \geq \Psi$ so that $\hat{\theta} < \theta^* = 1$. Then,
(i) $\pi_N(\theta)$ is decreasing in θ for all $\theta \in [0, \hat{\theta}]$, $\pi_N(\theta) = \pi_N(\hat{\theta})$ for all $\theta \in (\hat{\theta}, 1)$,
(ii) $\pi_S(\theta)$, $CS(\theta)$, and $WS(\theta)$ are increasing in θ for all $\theta \in [0, \hat{\theta}]$; $\pi_S(\theta) > \pi_S(\hat{\theta})$, $CS(\theta) > CS(\hat{\theta})$, and $WS(\theta) > WS(\hat{\theta})$ for all $\theta \in (\hat{\theta}, 1)$, and
(iii) $WW(\theta)|_{\theta \in (\hat{\theta}, 1)} > WW(\tilde{\theta})$ holds,
where $\pi_S(\theta)$, $CS(\theta)$, $WS(\theta)$, and $WW(\theta)$ are all constant for all $\theta \in (\hat{\theta}, 1)$.

When $\theta \leq \hat{\theta}$, an increase in θ decreases firm N's equilibrium quality level, $q_N^* = (1 - \theta)v_H + \theta v_L$. There are two effects on firm S's equilibrium quality level, $q_S^* = \bar{q}_S + \theta(q_N^* - \bar{q}_S)$: a (positive) direct impact of an increase in θ, and a (negative) indirect impact arising from the closing gap in quality between firms N and S. We find that the former positive impact overwhelms the negative impact for all $\theta \leq \hat{\theta}$, so that an increase in θ increases firm S's equilibrium quality level. Consequently, this leads to a reduction in firm N's profitability and an increase in firm S's profit. Furthermore, recall that consumer surplus, captured by $(v_H - v_L)q_S^*$, is increasing in q_S^*, it follows that $\theta = \hat{\theta}(> 0)$ maximizes Southern welfare for all $\theta \in [0, \hat{\theta}]$, with $\theta = 0$ maximizing firm N's profit.

Once θ exceeds $\hat{\theta}$, it becomes too costly for firm N to impose a binding constraint on firm S's quality choice. Therefore, firm N chooses $q_N^* = v_H$ while firm S chooses $q_S^* = v_L$ for all $\theta \in (\hat{\theta}, 1)$. Since both firms choose their socially optimal quality level for all $\theta \in (\hat{\theta}, 1)$, global welfare, and consequently Southern welfare, is maximized. Proposition 6 states that, with a large home-production disadvantage the separating SPNE of the game is an FDI equilibrium for all θ. The optimal IPR policy for the South is represented by any value $\theta \in (\hat{\theta}, 1)$, while $\theta = 0$, a stringent IPR regime, is desirable for the North (Northern welfare is firm N's profit in our model). Let θ^S and θ^W respectively denote optimal spillover rate for the South and the world, these results are summarized in following Corollary.

Corollary 1. Suppose $t + w \geq \Psi$, then $\theta^S \in (\hat{\theta}, 1)$ and $\theta^W \in (\hat{\theta}, 1)$ hold.

In the case where $t + w \geq \Psi$ and the equilibrium of the game is an FDI equilibrium for all θ, Lemma 3 and Proposition 6 together imply that a high enough value of spillovers, $\theta \in (\hat{\theta}, 1)$, will maximize both Southern welfare and global welfare. This is because with a high enough θ, both firm N and firm S choose socially optimal levels of quality for their products in equilibrium.

We now turn to the case where $t + w < \Psi$, so that $\hat{\theta} = \theta^* < 1$. From Proposition 3, firm N chooses suboptimal quality level for its product when it undertakes FDI. Proposition 7 says that Southern welfare is increasing in θ under FDI.

Proposition 7. Suppose $t + w < \Psi$ so that $\hat{\theta} = \theta^* < 1$. Then,
(i) $\pi_N(\theta)$ is decreasing in θ for all $\theta \in [0, \theta^*]$, and $\pi_N(\theta) = \pi_N(\theta^*)$ for all $\theta \in (\theta^*, 1)$, and
(ii) $\pi_S(\theta)$, $CS(\theta)$, and $WS(\theta)$ are increasing in θ for all $\theta \in [0, \theta^*]$, and $\pi_S(\theta^*) > \pi_S(\theta)|_{\theta \in (\theta^*, 1)}$ and $CS(\theta^*) > CS(\theta)|_{\theta \in (\theta^*, 1)}$ hold, where $\pi_S(\theta)$ and $CS(\theta)$ are constant for all $\theta \in (\theta^*, 1)$.

When $\hat{\theta} = \theta^*$, for all $\theta \in [0, \theta^*]$, firm N undertakes FDI and, by Proposition 3, it chooses $q_N^* = (1 - \theta)v_H + \theta v_L$ for its product in this case. Hence, an increase in $\theta \in [0, \theta^*]$ decreases firm N's equilibrium quality by increasing firm S's equilibrium quality. Consequently, this raises firm S's equilibrium profit and consumer surplus, but decreases firm N's profitability. Now, consider a further increase in spillover rate from $\theta = \theta^*$ to $\theta' > \theta^*$. Following this, the equilibrium of the game switches from FDI to HP, and firm N increases its equilibrium quality from $q_N^* = (1 - \theta)v_H + \theta v_L$ to $q_N^* = v_H$, while firm S decreases its equilibrium quality from $\hat{q}_S(q_N = (1 - \theta)v_H + \theta v_L)$ to $\bar{q}_S$. As such, this switching of equilibrium hurts both firm S and consumers.

Above results suggest that, in the case where $t + w < \Psi$, for all $\theta \in [0, \theta^*]$, $\theta = \theta^*$ maximizes Southern welfare while $\theta = \tilde{\theta}(\leq \theta^*)$ maximizes global welfare. Would these levels of spillovers maximize Southern welfare and global welfare, respectively, for all $\theta \in [0, 1)$? The following proposition provides an answer to this question.

Proposition 8. Suppose $t + w < \Psi$ so that $\hat{\theta} = \theta^* < 1$. There exists a value $\hat{m}_{H2}$ with following properties:
(i) $WS(\theta)|_{\theta \in (\theta^*, 1)} > (=, <) WS(\theta^*)$ if $m_H > (=, <) \hat{m}_{H2}$, and
(ii) $WW(\theta)|_{\theta \in (\theta^*, 1)} < WW(\tilde{\theta})$ holds,
where $\hat{m}_{H2} > \lim_{\theta \to \theta^*} \tilde{m}_H$ holds under a range of parameterizations, and $WS(\theta$ and $WW(\theta)$ are constant for all $\theta \in (\theta^*, 1)$.

Proposition 8 tells us that, the switching of the equilibrium from FDI (when $\theta \leq \theta^*$) to HP (when $\theta > \theta^*$) can increase Southern welfare under a range of parameterizations. Under these cases, inducing FDI hurts the South. However, despite the fact that FDI could hurt the South, it always improves global welfare provided that the spillover rate is set at $\theta = \tilde{\theta}$.

To understand the logic behind Proposition 8, let us consider an increase in spillover rate from θ^* to $\theta'(> \theta^*)$ which switches the equilibrium from FDI to HP. Then, firm N increases its equilibrium quality level from $q_N^* = (1-\theta)v_H + \theta v_L \leq v_H$ to $q_N^* = v_H$, and firm S decreases its equilibrium quality level from $q_S^* = \hat{q}_S(q_N = (1-\theta)v_H + \theta v_L)$ to $\bar{q}_S$. As firm S's quality deviates from its socially optimal level, v_L, the net social benefit associated with the consumption of firm S's product declines. At the same time, since firm N's quality converges to its socially optimal level, v_H, the net social benefit associated with the consumption of firm N's product increases provided that the cost disadvantage, w, is not too high.[24] We find that the latter positive impact overwhelms the former negative impact when the population of type H consumers is relatively large, thus HP increases global welfare. In such cases, HP unambiguously raises the level of Southern welfare since firm N is indifferent at θ^* and at $\theta' > \theta^*$. That is, not inducing FDI could be optimal for the South.

[24]When the equilibrium switches from FDI to HP, the change in net social benefit of consuming firm N's product is $m_H[\frac{[\theta^*(v_H - v_L)]^2}{2} - w]$.

Finally, the reason why $\theta = \tilde{\theta}$ maximizes $WW(\theta)$ for all θ can be explained as follows. Consider the case the spillover rate is zero, so that firm N undertakes FDI. Then, it chooses $q_N^* = (1-\theta)v_H + \theta v_L = v_H$, while firm S chooses $q_S^* = \bar{q}_S$. Thus, the level of global welfare when $\theta = 0$ is measured by $WW(0) = m_H[\frac{v_H{}^2}{2}] + m_L[v_L\bar{q}_S - \frac{\bar{q}_S^2}{2}]$. Recall that, $q_N^* = v_H$ and $q_S^* = \bar{q}_S$ are also the product quality firms N and S would choose under HP equilibrium (i.e. when $\theta \in (\theta^*, 1)$). In the presence of w, the Northern country's cost disadvantage, it can easily be established that, the level of global welfare under HP equilibrium can be measured by $WW(\theta) = WW(0) - m_H w$. That is, global welfare for any $\theta \in (\theta^*, 1)$ is lower than $WW(0)$. Then, by Lemma 3, $WW(\tilde{\theta}) > WW(0) > WW(\theta)$ for all $\theta \in (\theta^*, 1)$, so that $WW(\theta)$ is maximized at $\theta = \tilde{\theta}$. Note that, when $w = 0$, our analysis is still valid since then, $WW(\theta) = WW(0) < WW(\tilde{\theta})$ for all $\theta \in (\theta^*, 1)$.

We are now ready to relate the global optimal level of spillovers (θ^W) with South-optimal level of spillovers (θ^S) when the disadvantage of home-production is relatively low ($t + w < \Psi$). Our analysis suggests that there are certain parameterizations where $\theta^W < \theta^S$ can hold in this case. First, when FDI improves Southern welfare, we find that $\theta = \theta^*$ is optimal for the South and $\tilde{\theta}$, which maximizes global welfare, could be strictly less than $\hat{\theta}(= \theta^*)$ by Lemma 3. Second, if FDI decreases Southern welfare then $\theta^S \in (\theta^*, 1)$. In this case, $\theta^W = \tilde{\theta}(< \theta^S)$.

In any case, the necessary condition for $\theta^W < \theta^S$ is that firm N reduces the quality level for its product when it undertakes FDI. To see this more intuitively, suppose that firm N does not reduce the level of product quality when it undertakes FDI (that is $q_N = v_H$ for all θ). Then under FDI, $\theta = \theta^*$ maximizes both Southern welfare and global welfare. This is because a change in $\theta \in [0, \theta^*)$ affects the net social benefits of consuming firm S's product in this case (which in turn depends merely on firm S's product quality) but does not affect the benefits associated with consuming firm N's product. Hence, $\theta^W < \theta^S$ cannot hold when firm N does not decrease its product quality under FDI. We summarize these findings in Corollary 2.

Corollary 2. Suppose $t + w < \Psi$ so that $\hat{\theta} = \theta^* < 1$, then
(i) $\theta^S \in (\theta^*, 1)$ if $m_H > \hat{m}_{H2}$ and $\theta^S = \theta^*$ otherwise, and
(ii) $\theta^W = \tilde{\theta}$ holds.

In summary, this section provides an analysis concerning the impact of IPR policy, which is represented by a change in spillover rate, θ. We find that, when $t + w \geq \Psi$ so that the equilibrium is FDI for all θ, then $\theta \in (\hat{\theta}, 1)$ is optimal for the South and the world. In the case when $t + w < \Psi$, firm N chooses suboptimal quality level for its product under FDI. We find that the spillover rate that maximizes global welfare could be strictly less than South-optimal level (an illustration is provided in Figure 2.2). As will be shown in the subsequent sections, these findings are unique to our framework of quality-enhancing spillovers.

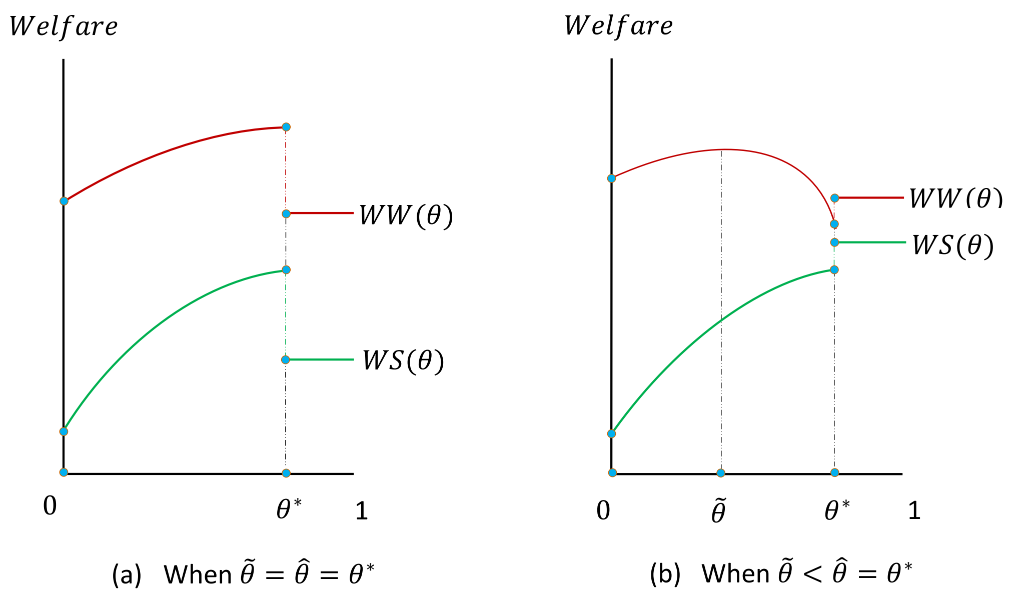

Figure 2.2: The impact of IPR policy.

2.7 Discussion

Under the presence of quality-enhancing technology spillovers in the South, Northern firm could strategically reduce its product quality level when it undertakes FDI in the South. This result leads to a number of new policy implications of our analysis.

Firstly, we demonstrate that FDI induced by stringent IPR policy can benefit or hurt the South. In the traditional cost-reducing technology spillovers literature, previous authors argued that FDI always improves Southern welfare (see more in Section 2.3). We show that, in the case of quality-enhancing technology spillovers, if Northern firm strategically reduces its product quality level under FDI then FDI could reduce the level of Southern welfare. Hence, our framework suggests that the policy to induce Northern firms to undertake FDI to improve quality for local firms may not be efficient, especially if welfare is the primary concern (such policies include high trade barrier and/or strengthening IPR protection for foreign firms as we mentioned in previous sections).

Secondly, our framework helps us to identify optimal IPR policy not only for the South but also for the world. We show that, the global optimal level of IPR protection in the South tends to be more stringent than South-optimal level but more lax than North-optimal level. This not only provides an explanation for the North-South conflict concerning Southern IPR regime, but also suggests a framework to identify optimal IPR regime for the world.

It should be kept in mind, however, that we do share several similar findings with cost-reducing technology spillovers literature. In particular, in our model it is also possible that FDI improves Southern welfare. For instance, when the trade cost is high and IPR environment in the South is weak, the Northern firm still undertakes FDI but it does not reduce the quality level for its product which consequently implies that FDI is beneficial for the South. In such cases, FDI should be encouraged such as through trade protection or stringent IPR regime.

In the real world, IPR is governed by the WTO under TRIPS, which establishes minimum levels of IPR protection that each government has to give to other WTO members. The implementation of this agreement aims to strengthen IPR environment in Southern countries. However, in its original form, TRIPS says that the objective of IPR protection is to "contribute to promotion of technological innovation and to the transfer and dissemination of technology... in a manner conducive to social and economic welfare." Our model supports the WTO in this regards. Our central recommendation is that, by playing the role of a global social-planner, the WTO could choose an IPR policy for the South which is not too lax or too stringent to maximize the social benefits of Northern firm's FDI in the South.

Since the establishment of TRIPS in 1995, there has been tremendous improvement in trade liberalization in the world, especially with recent memberships from Southern countries. It is thus important to understand how a change in IPR environment in Southern countries could affect North/South/global welfare. Our framework of quality-enhancing technology spillovers captures this idea and suggests that some positive spillovers from Northern firms to Southern firms is good for the society. However, there seems to be difference concerning the optimal level of IPR protection for the South, the North, and the world.

2.8 Conclusion

Technology spillovers induced by FDI usually improve performance of the local firms at the cost of the foreign firms. For instance, Australian Chamber of Commerce and Industry estimated that IPR infringements in China cost foreign firms a total of US$50 billion annually. This has become an important issue in the international trade literature. Various papers have analyzed technology spillovers from Northern firms to Southern firms that reduce the latter's marginal cost (Chin and Grossman 1990, among others). Incorporating FDI in such cost-reducing technology spillovers framework, previous authors found that, Northern FDI usually benefits the South (Naghavi 2007).

Our work departs from this literature by exploring an international duopoly model of vertical product differentiation with technology spillovers. We show that, the conventional argument that FDI accompanied by technology spillovers benefits the South does not necessarily hold in the presence of quality-enhancing technology spillovers. The driving force behind this result is that, the Northern firm could strategically reduce the level of quality it chooses when it invests via FDI. This strategic reduction of product quality reduces the net social benefits associated with the consumption of Northern firm's product, which is harmful for the South. In this context, we also find that the social planner would choose an IPR policy for the South which is strictly between North-optimal and South-optimal policy. These findings support the role played by WTO in reconciling North-South conflict concerning the level of IPR protection in the South.

Similar implications for trade policy are also embodied in our analysis. Particularly, since FDI could hurt the South, implementing a high trade barrier to attract FDI with technology spillovers might not be a good choice for Southern countries. This suggests that Southern governments should carefully assess the impact of spillovers, especially those are associated with product quality.

In summary, this chapter contributes to international trade and FDI literature in a number of ways. First, we construct an international duopoly model of vertical product differentiation with technology spillovers to study the location choice of a Northern firm between home-production and FDI. We then analyze the equilibrium quality levels that Northern firm and Southern firm would choose for their product. By exploring these strategic choices of product quality, we discover novel policy implications of quality-enhancing technology spillovers, which are also consistent with reality.

Appendix

Proof of Proposition 1.

Let us denote by p_k^i and q_k^i respectively price and quality levels chosen by firm $k(=N,S)$ in subgame $i(=HP,FDI)$. Also, let ${q_k^i}^*$ be quality level chosen by firm k in the separating equilibrium of subgame i. The proof goes as follows. First, we assume that the separating SPNE of the game exists to find the quality level each firm chooses in the separating SPNE. We then focus on HP subgame only (that is, without considering FDI subgame) to characterize necessary conditions for such separating SPNE within HP subgame (Claim 1 and 2). We then repeat this step but focus on FDI subgame only (Claim 3 and 4). Finally, sufficient conditions for separating SPNE of the entire game are examined in Claim 5 and 6 where we consider off-equilibrium credible threat (that is when firm N deviates by selling to consumers in the other subgame).

Let us now find the values of ${q_k^i}^*$. First, consider the HP subgame. Assume that there exists a separating equilibrium in this subgame, then pricing constraints are given by:

$$v_H q_N^{HP} - p_N^{HP} \geq 0 \tag{A.1}$$

$$v_L q_S^{HP} - p_S^{HP} \geq 0 \tag{A.2}$$

$$v_H q_N^{HP} - p_N^{HP} \geq v_H q_S^{HP} - p_S^{HP} \tag{A.3}$$

$$v_L q_S^{HP} - p_S^{HP} \geq v_L q_N^{HP} - p_N^{HP} \tag{A.4}$$

From (A.2) and (A.3), it follows that $v_H q_N^{HP} - p_N^{HP} \geq v_H q_S^{HP} - p_S^{HP} \geq 0$. So that (A.1) holds and can be excluded. Next, if (A.2) does not hold with equality, we can increase both p_S^{HP} and p_N^{HP} by some small amount without affecting any other constraints, a contradiction, so that (A.2) should hold with equality. Then, if (A.3) does not hold with equality, we can increase p_N^{HP} by a small amount without affecting any other constraints, a contradiction. So (A.3) holds with equality. Lastly, plug p_N^{HP} from (A.3) to (A.4), we see that (A.4) always holds and can be excluded. So that we end up with only two constraints being held with equality, (A.2) and (A.3). Thus, $p_S^{HP} = v_L q_S^{HP}$, and $p_N^{HP} = v_L q_S^{HP} + v_H(q_N^{HP} - q_S^{HP})$.

Note that $q_N^{HP} > q_S^{HP}$ holds because from (A.3) and (A.4), we have $v_H(q_S^{HP} - q_N^{HP}) \leq p_S^{HP} - p_N^{HP} \leq v_L(q_S^{HP} - q_N^{HP}) \rightarrow v_H(q_S^{HP} - q_N^{HP}) \leq v_L(q_S^{HP} - q_N^{HP}) \rightarrow q_N^{HP} \geq q_S^{HP}$ and the equality can not hold (when both firms choose same quality level then they engage in Bertrand pricing game and each makes a zero profit). Therefore, $q_N^{HP} > q_S^{HP}$.

The problem facing firm S becomes:

$$\max_{q_S^{HP}} m_L[v_L q_S^{HP} - \frac{{q_S^{HP}}^2}{2}], \tag{A.5}$$

$$\text{subject to: } q_S^{HP} \leq \bar{q_S}.$$

Firm N takes firm S's quality level as given to solve his problem:

$$\max_{q_N^{HP}} m_H[v_L q_S^{HP} + v_H(q_N^{HP} - q_S^{HP}) - \frac{{q_N^{HP}}^2}{2} - t - w]. \tag{A.6}$$

The solutions are given by: $q_S^{HP^*} = \bar{q_S}$ and $q_N^{HP^*} = v_H$. The profits accrued to firm N and firm S in the separating equilibrium of HP subgame are respectively given by $\pi_N^{HP^*} = m_H[v_L\bar{q}_S + \frac{v_H^2}{2} - v_H\bar{q}_S - t - w]$, and $\pi_S^{HP^*} = m_L[v_L\bar{q}_S - \frac{\bar{q}_S^2}{2}]$.

Now, let us explore the FDI subgame. Assume that, there exists a separating equilibrium in this subgame, then the price constraint will be similar to that under the separating equilibrium of HP subgame. Since firm S sells to type L consumers, it has the response function $q_S^{FDI} = v_L$ if $\hat{q_S}(q_N^{FDI}) = \bar{q_S} + \theta(q_N^{FDI} - \bar{q_S}) \geq v_L$, and $q_S^{FDI} = \bar{q_S} + \theta(q_N^{FDI} - \bar{q_S})$ otherwise. Anticipating this, firm N solves its problem:

$$\max_{q_N^{FDI}} m_H[v_L q_S^{FDI} + v_H[q_N^{FDI} - q_S^{FDI}] - \frac{{q_N^{FDI}}^2}{2}] \tag{A.7}$$

There are two relevant options for firm N. The first option is to make the constraint $\hat{q_S}(q_N^{FDI}) = \bar{q_S} + \theta(q_N^{FDI} - \bar{q_S})$ bind by choosing $q_N^{FDI^*} = q'_N = (1-\theta)v_H + \theta v_L$ so that firm S chooses $q_S^{FDI^*} = \hat{q_S}(q'_N)$. The second option is to choose $q_N^{FDI^*} = v_H$, allowing firm S to choose $q_S^{FDI^*} = v_L$. Note that the possibility in which firm N chooses $q_N^{FDI^*} = v_H$ and firm S chooses $q_S^{FDI^*} = \hat{q}_S(v_H) < v_L$ does not arise because it is then more profitable for firm N to choose $q_N^{FDI^*} = q'_N$. Similarly, the possibility in which firm N chooses $q_N^{FDI*} = q'_N$ and firm S chooses $q_S^{FDI*} = v_L$ does not arise because it is then more profitable for firm N to choose $q_N^{FDI*} = v_H$.

$q_N^{FDI*} = v_H$ gives firm N's profit $\pi_N^{FDI*} = m_H[\frac{v_H^2}{2} + v_L^2 - v_H v_L]$ and firm S obtains profit $\pi_S^{FDI*} = m_L[\frac{v_L^2}{2}]$, whereas $q_N^{FDI*} = (1-\theta)v_H + \theta v_L$ gives firm N profit $\pi_S^{FDI*} = m_H[-(1-\theta)(v_H - v_L)\bar{q_S} + \frac{((1-\theta)v_H+\theta v_L)^2}{2}]$ and firm S obtains profit $\pi_S^{FDI*} = m_L[v_L(1-\theta)\bar{q_S} + \theta[(1-\theta)v_H + \theta v_L] - \frac{((1-\theta)\bar{q_S}+\theta[(1-\theta)v_H+\theta v_L])^2}{2}]$. Simple comparison suggests that if $\theta > \hat{\theta} = \frac{v_H - \bar{q_S} - \sqrt{(v_H-\bar{q_S})^2 - 2(v_H-v_L)(v_L-\bar{q_S})}}{v_H - v_L}$ then firm N chooses $q_N^{FDI*} = v_H$, and it chooses $q_N^{FDI*} = q'_N = (1-\theta)v_H + \theta v_L$ otherwise.

We can now focus on HP subgame to find the necessary conditions for separating SPNE within this subgame as formalized in Claim 1 and 2.

Claim 1. Consider HP subgame. Assume that firm N chooses $q_N^{HP*} = v_H$, then firm S only sells to type L consumers in this subgame if and only if $m_H < \bar{m}_{H1}$, where $\bar{m}_{H1} \equiv m_L \frac{\bar{q_S}(v_L - v_H) + \frac{v_H^2}{2} - t - w}{\frac{-(v_H-\bar{q_S})^2}{2} + t + w}$ if $\frac{(v_H-\bar{q_S})^2}{2} + v_L\bar{q}_S - \frac{\bar{q}_S^2}{2} > t + w > \frac{(v_H-\bar{q_S})^2}{2}$, $\bar{m}_{H1} \equiv 0$ if $t + w \geq \frac{(v_H-\bar{q_S})^2}{2} + v_L\bar{q}_S - \frac{\bar{q}_S^2}{2}$, and $\bar{m}_{H1} \equiv +\infty$ otherwise.

Proof. Consider off-equilibrium credible threat in which firm S deviates from separating SPNE of HP subgame to sell to type H consumers under HP. Then its $[quality, price]$ menu, $[q_S^{HP}, p_S^{HP}]$, satisfies:

$$v_H q_S^{HP} - p_S^{HP} \geq v_H^2 - p_N^{HP} \tag{A.8}$$

That is, firm S will choose $p_S^{HP} = v_H q_S^{HP} - v_H^2 + p_N^{HP}$. Then, since $v_H q_S^{HP} - v_H^2 + p_N^{HP} < v_L q_S^{HP} - v_L v_H + p_N^{HP} \rightarrow v_L q_S^{HP} - p_S^{HP} > v_L v_H - p_N^{HP}$, type S consumers still purchase from firm S, so that it sells to all consumers and firm N sells nothing. Since firm N never chooses a price below its average cost, $\frac{v_H^2}{2} + t + w$, for firm S to sell to all consumers then $p_N^{HP} = \frac{v_H^2}{2} + t + w$ must hold. Firm S then chooses $p_S^{HP} = v_H q_S^{HP} - \frac{v_H^2}{2} + t + w$, obtaining profit $\pi_S^{HP'} = (m_H + m_L)(t + w - \frac{(v_H - q_S^{HP})^2}{2})$ which can be maximized at $q_S^{HP} = \bar{q_S}$ and thus $\pi_S^{HP'} = (m_H + m_L)(t + w - \frac{(v_H-\bar{q}_S)^2}{2})$. If $t + w \leq \frac{(v_H-\bar{q_S})^2}{2}$ this profit is non-positive so that firm S will not deviate. If $t + w > \frac{(v_H-\bar{q_S})^2}{2}$, for firm S to be better off under separating equilibrium, we need $\pi_S^{HP'} < \pi_S^{HP*}$, or $(m_H + m_L)(t + w - \frac{(v_H-\bar{q_S})^2}{2}) < m_L(v_L\bar{q_S} - \frac{\bar{q_S}^2}{2}) \rightarrow m_H < m_L \frac{v_L\bar{q_S} - \frac{\bar{q_S}^2}{2} + \frac{(v_H-\bar{q_S})^2}{2} - t - w}{t + w - \frac{(v_H-\bar{q_S})^2}{2}} \equiv \bar{m_{H1}}$, which also requires $t + w < \frac{(v_H-\bar{q_S})^2}{2} + v_L\bar{q}_S - \frac{\bar{q}_S^2}{2}$. Q.E.D.

Claim 2. Consider HP subgame. In this subgame, firm N only sells to type H consumers if and only if $m_H > \tilde{m}_{H1}$, where $\tilde{m}_{H1} = m_L \frac{\frac{(v_L-\bar{q_S})^2}{2}-t-w}{\frac{v_H^2}{2}-\bar{q_S}(v_H-v_L)-\frac{(v_L-\bar{q_S})^2}{2}}$ if $t+w < \frac{(v_L-\bar{q_S})^2}{2}$, and $\tilde{m}_{H1} = 0$ otherwise.

Proof. Assume firm N deviates from separating equilibrium of HP subgame, choosing $q_N^{HP} \neq v_H$ to sell to type L consumers under HP. Then, $v_L q_N^{HP} - p_N^{HP} \geq v_L q_S^{HP} - p_S^{HP}$ holds, so that $p_N^{HP} = v_L q_N^{HP} - v_L q_S^{HP} + p_S^{HP}$ and since $v_L q_N^{HP} - v_L q_S^{HP} + p_S^{HP} < v_H q_N^{HP} - v_H q_S^{HP} + p_S^{HP} \rightarrow v_H q_N^{HP} - p_N^{HP} > v_H q_S^{HP} - p_S^{HP}$, type H consumers still purchase firm N's product. It then sells to all consumers and firm S sells nothing. Firm S's reservation price is $\frac{q_S^{HP2}}{2}$, so that deviation implies firm N chooses a $[quality, price]$ menu, $[q_N^{HP}, p_N^{HP}]$, satisfying:

$$v_L q_N^{HP} - p_N^{HP} \geq max(v_L q_S^{HP} - \frac{q_S^{HP2}}{2}) \tag{A.9}$$

Firm S's profit, $v_L q_S^{HP} - \frac{q_S^{HP2}}{2}$, is concave in q_S^{HP} and since $v_L > \bar{q}_S$, firm S's profit is maximized at $q_S^{HP} = \bar{q}_S$. This in turn implies that for firm N to sell to all consumers then $p_N^{HP} = v_L q_N^{HP} - v_L \bar{q_S} + \frac{\bar{q_S}^2}{2}$ must hold. The profit of firm N under such a deviation will be $\pi_N^{HP'} = (m_H+m_L)(v_L q_N^{HP} - v_L \bar{q_S} + \frac{\bar{q_S}^2}{2} - \frac{q_N^{HP2}}{2})$, which could be maximized at $q_N^{HP} = v_L$, and firm N obtains profit $\pi_N^{HP'} = (m_H+m_L)(\frac{(v_L-\bar{q_S})^2}{2} - t - w)$. If $t+w \geq \frac{(v_L-\bar{q_S})^2}{2}$, this profit is non-positive and firm N will not deviate. If $t+w < \frac{(v_L-\bar{q_S})^2}{2}$, for firm N to be better off under separating equilibrium, we need $\pi_N^{HP'} < \pi_N^{HP*}$, or $(m_H+m_L)(\frac{(v_L-\bar{q_S})^2}{2} - t - w) < m_H[\frac{v_H^2}{2} - \bar{q_S}(v_H-v_L) - t - w] \rightarrow m_H > m_L \frac{\frac{(v_L-\bar{q_S})^2}{2}-t-w}{\frac{v_H^2}{2}-\bar{q_S}(v_H-v_L)-\frac{(v_L-\bar{q_S})^2}{2}} \equiv \tilde{m}_{H1}$. Note that $\frac{v_H^2}{2} - \bar{q_S}(v_H-v_L) - \frac{(v_L-\bar{q_S})^2}{2} = \frac{(v_H-\bar{q}_S)^2}{2} - \frac{(v_L-\bar{q}_S)^2}{2} + v_L\bar{q}_S + \frac{\bar{q}_S^2}{2} > 0$.

Q.E.D.

Claim 3. Consider FDI subgame. Assume that firm N chooses q_N^{FDI*} ($=v_H$ or q'_N), then in this subgame firm S always sells to type L consumers only.

Proof. Assume that firm S deviates from this separating equilibrium by selling to type H consumers in separating equilibrium of FDI subgame. It then chooses a $[quality, price]$ menu, $[q_S^{FDI}, p_S^{FDI}]$, satisfying equation (A.10) below:

$$v_H q_S^{FDI} - p_S^{FDI} \geq v_H q_N^{FDI*} - p_N^{FDI} \tag{A.10}$$

That is, firm S will choose $p_S^{FDI} = v_H q_S^{FDI} - v_H q_N^{FDI*} + p_N^{FDI}$. However, since $v_H q_S^{FDI} - v_H q_N^{FDI*} + p_N^{FDI} < v_L q_S^{FDI} - v_L q_N^{FDI*} + p_N^{FDI} \rightarrow v_L q_S^{FDI} - p_S^{FDI} >$

$v_L q_N^{FDI*} - p_N^{FDI}$, firm S then sells to all consumers and firm N sells nothing. Note that firm N never charges price below $\frac{q_N^{FDI*2}}{2}$, its unit cost, thus, for firm S to sell to all consumers then $p_S^{FDI} = v_H q_S^{FDI} - v_H q_N^{FDI*} + \frac{q_N^{FDI*2}}{2}$ must hold, and firm S's profit is $\pi_S' = (m_H + m_L)(-\frac{(q_N^* - q_S^{FDI})(2v_H - q_N^{FDI*} - q_S^{FDI})}{2}) < 0$. Therefore, firm S will not deviate.

Q.E.D.

Claim 4. Consider FDI subgame. In this subgame, firm N only sells to type H consumers if and only if $m_H > \tilde{m}_{H2}$, where $\tilde{m}_{H2} = m_L \frac{\frac{(1-\theta)(v_L - \bar{q_S})^2}{2(1+\theta)}}{\frac{v_H^2}{2} - v_H v_L + v_L^2 - \frac{(1-\theta)(v_L - \bar{q_S})^2}{2(1+\theta)}}$ if $\theta \geq \hat{\theta}$, and $\tilde{m}_{H2} = m_L \frac{\frac{(1-\theta)(v_L - \bar{q_S})^2}{2(1+\theta)}}{-(1-\theta)(v_H - v_L)\bar{q_S} + \frac{((1-\theta)v_H + \theta v_L)^2}{2} - \frac{(1-\theta)(v_L - \bar{q_S})^2}{2(1+\theta)}}$ otherwise, and $\hat{\theta} = \frac{v_H - \bar{q}_S - \sqrt{(v_H - \bar{q}_S)^2 - 2(v_H - v_L)(v_L - \bar{q}_S)}}{v_H - v_L}$.

Proof. Assume firm N deviates from the separating equilibrium of FDI subgame by selling to type L consumers under FDI. Then, firm N chooses a $[quality, price]$ menu, $[q_N^{FDI}, p_N^{FDI}]$, satisfying:

$$v_L q_N^{FDI} - p_N^{FDI} \geq max(v_L q_S^{FDI} - \frac{q_S^{FDI^2}}{2}) \qquad \text{(A.11)}$$

That is, firm N will choose $p_N^{FDI} = v_L q_N^{FDI} - max(v_L q_S^{FDI} - \frac{q_S^{FDI^2}}{2})$. Since $v_L q_S^{FDI} - \frac{q_S^{FDI^2}}{2}$ is concave in q_S^{FDI}, its maxima is obtained at $q_S^{FDI} = min(\hat{q}_S(q_N^{FDI}), v_L)$. Can firm S choose $q_S^{FDI} = v_L$ if firm N deviates from the separating equilibrium of FDI subgame? If this happens then $p_N^{FDI} = v_L q_N^{FDI} - \frac{v_L^2}{2}$, so that profit of firm N from deviation will then be $\pi_N = (m_H + m_L)(v_L q_N^{FDI} - \frac{v_L^2}{2} - \frac{q_N^{FDI^2}}{2}) \leq 0$, contradiction. Therefore, if firm N deviates then $q_S^{FDI} = \hat{q}_S(q_N^{FDI})$ must hold. In such a deviation, firm N chooses $p_N^{FDI} = v_L q_N^{FDI} - v_L \hat{q_S}(q_N^{FDI}) + \frac{\hat{q}_S^2(q_N^{FDI})}{2}$. Then, $v_H q_N^{FDI} - p_N^{FDI} > v_H q_S^{FDI} - \frac{q_S^{FDI^2}}{2}$, so that firm N sells to all consumers and firm S sells nothing.

The profit of the firm N from deviation will be $\pi_N^{FDI'} = (m_H + m_L)(v_L q_N^{FDI} - v_L \hat{q_S}(q_N^{FDI}) + \frac{\hat{q_S}^2(q_N^{FDI})}{2} - \frac{q_N^{FDI^2}}{2})$, which is maximized at $q_N^{FDI} = \frac{v_L + \theta \bar{q_S}}{1+\theta}$. Thus, $\pi_N^{FDI'} = (m_H + m_L)\frac{(1-\theta)(v_L - \bar{q_S})^2}{2(1+\theta)}$. Then, $\hat{q}_S(q_N^{FDI}) = \frac{\bar{q}_S + \theta v_L}{1+\theta} < v_L$.

- If $\theta > \hat{\theta}$, for firm N to be better off under separating equilibrium, we need $\pi_N^{FDI'} < \pi_N^{FDI*}|_{\theta > \hat{\theta}}$, or $(m_H + m_L)\frac{(1-\theta)(v_L - \bar{q_S})^2}{2(1+\theta)} < m_H[\frac{v_H^2}{2} - v_H v_L + v_L^2] \rightarrow m_H > m_L \frac{\frac{(1-\theta)(v_L - \bar{q_S})^2}{2(1+\theta)}}{\frac{v_H^2}{2} - v_H v_L + v_L^2 - \frac{(1-\theta)(v_L - \bar{q_S})^2}{2(1+\theta)}} = \tilde{m}_{H2}$. Note that $\frac{v_H^2}{2} - v_H v_L + v_L^2 -$

$\frac{(1-\theta)(v_L-\bar{q_S})^2}{2(1+\theta)} > \frac{v_H^2}{2} - v_H v_L + v_L^2 - \frac{(v_L-\bar{q_S})^2}{2} > 0 \leftrightarrow \frac{(v_H-v_L)^2}{2} + \frac{v_L^2}{2} - \frac{(v_L-\bar{q}_S)^2}{2} > 0$ which always holds.

- If $\theta \leq \hat{\theta}$, $\pi_N^{FDI'} < \pi_N^{FDI*}|_{\theta\leq\hat{\theta}} \leftrightarrow (m_H + m_L)\frac{(1-\theta)(v_L-\bar{q_S})^2}{2(1+\theta)} < m_H[-(1-\theta)(v_H - v_L)\bar{q_S} + \frac{((1-\theta)v_H+\theta v_L)^2}{2}] \rightarrow m_H > \frac{m_L\frac{(1-\theta)(v_L-\bar{q_S})^2}{2(1+\theta)}}{-(1-\theta)(v_H-v_L)\bar{q_S}+\frac{((1-\theta)v_H+\theta v_L)^2}{2}-\frac{(1-\theta)(v_L-\bar{q_S})^2}{2(1+\theta)}} = \tilde{m}_{H2}$. Note that the denominator of $\tilde{m}_{H2}$ is positive because following its deviation from separating SPNE, firm N reduces its quality from $q_N = (1-\theta)v - H + \theta v_L$ to $q_N = \frac{\bar{q}_S+\theta v_L}{1+\theta}$ so that per-consumer profit declines for two reasons: (i) it reduces its quality from separating equilibrium level, and (ii) once reaching $q_N = \frac{\bar{q}_S+\theta v_L}{1+\theta}$, it even has to reduce its price further to preempt firm S from selling. The denominator of $\tilde{m}_{H2}$ simply captures this per-consumer profit reduction.

Q.E.D.

Claim 5. Assume $\theta > \hat{\theta}$. Then,
(i) the separating SPNE is an FDI equilibrium if $t \geq \bar{t_1} \equiv \Psi - w$ and $m_H > max(\tilde{m}_{H2}, \tilde{m}_{H3})$, where $\Psi = (v_H - v_L)(v_L - \bar{q_S})$, $\tilde{m}_{H3} = m_L\frac{\frac{(v_L-\bar{q_S})^2}{2}-t-w}{v_L^2-v_Hv_L-\frac{\bar{q}_S^2}{2}+v_H\bar{q}_S+t+w}$ if $t + w < \frac{(v_L-\bar{q}_S)^2}{2}$ and $\tilde{m}_{H3} = 0$ otherwise, and
(ii) the separating SPNE of the game is an HP equilibrium if $t < \bar{t_1}$ and $m_H > max(\tilde{m}_{H1}, \tilde{m}_{H4})$, where $\tilde{m}_{H4} = m_L\frac{\frac{(1-\theta)(v_L-\bar{q_S})^2}{2(1+\theta)}}{v_L\bar{q}_S+\frac{v_H^2}{2}-v_H\bar{q}_S-t-w-\frac{(1-\theta)(v_L-\bar{q_S})^2}{2(1+\theta)}}$.

Proof. Let us compare firm N's profit in the separating SPNE of HP and FDI subgames when $\theta > \hat{\theta}$. It follows that FDI is better for firm N if $\pi_N^{FDI*}|_{\theta>\hat{\theta}} \geq \pi_N^{HP*} \rightarrow m_H[v_L^2 + \frac{v_H^2}{2} - v_H v_L] \geq m_H[v_L\bar{q_S} + \frac{v_H^2}{2} - v_H\bar{q_S} - w - t] \rightarrow t + w \geq (v_H - v_L)(v_L - \bar{q_S}) = \Psi$ which always holds if $w \geq \Psi$, or if $w < \Psi$ and $t \geq \bar{t_1} = \Psi - w$ (by defining $\bar{t_1} = 0$ if $w \geq \Psi$ leads to Claim 5). In other cases, HP makes firm N better off.

- For the separating SPNE of the game to be an FDI equilibrium, beside condition $t + w \geq \Psi$, we need firm N's profit if it deviates to sell to all consumers in HP subgame is lower than its profit in such an SPNE, $\pi_N^{HP'} < \pi_N^{FDI*}|_{\theta>\hat{\theta}} \rightarrow (m_H + m_L)(\frac{(v_L-\bar{q_S})^2}{2} - t - w) < m_H[v_L^2 + \frac{v_H^2}{2} - v_H v_L]$, which is always true if $t + w \geq \frac{(v_L-\bar{q}_S)^2}{2}$. If $t + w < \frac{(v_L-\bar{q}_S)^2}{2}$, we need $m_H > m_L\frac{\frac{(v_L-\bar{q}_S)^2}{2}-t-w}{v_L^2-v_Hv_L-\frac{\bar{q}_S^2}{2}+v_H\bar{q}_S+t+w} \equiv \tilde{m}_{H3}$. Note that $v_L^2 - v_H v_L - \frac{\bar{q}_S^2}{2} + v_H\bar{q}_S + t + w >$

$v_L^2 - v_H v_L - \frac{\bar{q}_S^2}{2} + v_H\bar{q}_S + (v_H - v_L)(v_L - \bar{q}_S) = v_L\bar{q}_S - \frac{\bar{q}_S^2}{2} > 0$. Claim 4 then provides sufficient condition.

- For the separating SPNE of the game is an HP equilibrium, beside condition $t + w < \Psi$, we need firm N's profit if it deviates to sell to all consumers in FDI subgame is lower than its profit in such an equilibrium, $\pi_N^{FDI'} < \pi_N^{HP*} \rightarrow (m_H + m_L)\frac{(1-\theta)(v_L-\bar{q}_S)^2}{2(1+\theta)} < m_H[v_L\bar{q}_S + \frac{v_H^2}{2} - v_H\bar{q}_S - t - w] \rightarrow m_H > m_L\frac{\frac{(1-\theta)(v_L-\bar{q}_S)^2}{2(1+\theta)}}{v_L\bar{q}_S+\frac{v_H^2}{2}-v_H\bar{q}_S-t-w-\frac{(1-\theta)(v_L-\bar{q}_S)^2}{2(1+\theta)}} \equiv \tilde{m}_{H4}$. Note that the denominator of $\tilde{m}_{H4}$ is positive since firm Ns' per-consumer profit in SPNE of HP subgame is higher than that in SPNE of FDI subgame which is higher than per-consumer profit it gets by deviation (see similar logic in the proof of Claim 4). The sufficient condition is then given by Claim 2. Note that, $\frac{(v_H-\bar{q}_S)^2}{2} > (v_H - v_L)(v_L - \bar{q}_S)$, so condition $m_H < \bar{m}_{H1} = +\infty$ in Claim 1 is always satisfied.

Q.E.D.

Claim 6. Assume $\theta \leq \hat{\theta}$. Then,
(i) the separating SPNE of the game is an FDI equilibrium if $t \geq \bar{t}_2$ and $m_H > max(\tilde{m}_{H2}, \tilde{m}_{H5})$, where $\tilde{m}_{H5} = m_L\frac{\frac{(v_L-\bar{q}_S)^2}{2}-t-w}{-(v_H-v_L)\bar{q}_S(1-\theta)+\frac{((1-\theta)v_H+\theta v_L)^2}{2}-\frac{(v_L-\bar{q}_S)^2}{2}+t+w}$ if $t+w < \frac{(v_L-\bar{q}_S)^2}{2}$ and $\tilde{m}_{H5} = 0$ otherwise, and $\bar{t}_2 \equiv \theta(v_H-v_L)[v_H-\bar{q}_S-\theta\frac{v_H-v_L}{2}]-w$, and
(ii) the separating SPNE of the game is an HP equilibrium if $t < \bar{t}_2$ and $m_H > max(\tilde{m}_{H1}, \tilde{m}_{H4})$.

Proof. Let us compare profit of firm N under separating SPNE of FDI and HP subgames when $\theta \leq \hat{\theta}$. It follows that FDI is better for firm N if $\pi_N^{FDI*}|_{\theta\leq\hat{\theta}} \geq \pi_N^{HP*} \leftrightarrow m_H[-(v_H-v_L)\bar{q}_S(1-\theta)+\frac{((1-\theta)v_H+\theta v_L)^2}{2}] \geq m_H[v_L\bar{q}_S+\frac{v_H^2}{2}-v_H\bar{q}_S-w-t]$, or similarly, $t \geq \bar{t}_2 = \theta(v_H-v_L)[v_H-\bar{q}_S-\theta\frac{v_H-v_L}{2}]-w$. This condition always holds if $\bar{t}_2 \leq 0$, which is true when $w \geq \frac{(v_H-\bar{q}_S)^2}{2}$ (case a), or both $w < \frac{(v_H-\bar{q}_S)^2}{2}$ and $\theta \leq \frac{v_H-\bar{q}_S-\sqrt{(v_H-\bar{q}_S)^2-2w}}{v_H-v_L}$ hold (case b). If $w < \frac{(v_H-\bar{q}_S)^2}{2}$ and $\theta > \frac{v_H-\bar{q}_S-\sqrt{(v_H-\bar{q}_S)^2-2w}}{v_H-v_L}$, then FDI is better for firm N if $t \geq \bar{t}_2$ (case c) (by defining $\bar{t}_2 = 0$ in case a and b leads to Claim 6). Note that, by defining $\theta^* = \frac{v_H-\bar{q}_S-\sqrt{(v_H-\bar{q}_S)^2-2(t+w)}}{v_H-v_L}$, $\theta^* \in [0, 1)$, then case (b) and (c) can be summarized as if $\theta \leq \theta^*$ then firm N chooses FDI, and it chooses HP otherwise. This also captures case (a) by setting $\theta^* = 1$ if

$w > \frac{(v_H - \bar{q}_S)^2}{2}$.[25]

- For the separating SPNE of the game to be an FDI equilibrium, beside condition $t \leq \bar{t}_2$, we need firm N's profit by deviating from this SPNE to sell to all consumers under HP will be lower, $\pi_N^{HP'} < \pi_N^{FDI*}|_{\theta \leq \hat{\theta}} \rightarrow (m_H + m_L)(\frac{(v_L - \bar{q}_S)^2}{2} - t - w) < m_H[(v_H - v_L)\bar{q_S}(1-\theta) + \frac{((1-\theta)v_H + \theta v_L)^2}{2}]$, which is always true if $t + w \geq \frac{(v_L - \bar{q}_S)^2}{2}$. If $t + w < \frac{(v_L - \bar{q}_S)^2}{2}$, we need $m_H > m_L \frac{\frac{(v_L - \bar{q}_S)^2}{2} - t - w}{-(v_H - v_L)\bar{q_S}(1-\theta) + \frac{((1-\theta)v_H + \theta v_L)^2}{2} - \frac{(v_L - \bar{q}_S)^2}{2} + t + w} \equiv \tilde{m}_{H5}$. Note that the denominator of $\tilde{m}_{H5}$ is positive thanks to per-consumer profit firm N obtains under SPNE of FDI subgame is higher than that in HP subgame and higher than per-consumer profit it gets from deviation (see more on this logic in proof of Claim 4 and 5). Claims 4 then provides sufficient condition.

- For the separating SPNE of the game to be an HP equilibrium, beside condition $t > \bar{t}_2$, we need firm N's profit by deviating from this SPNE to sell to all consumers under FDI is lower than the profit it reaps in such an SPNE, $\pi_N^{FDI'} < \pi_N^{HP*} \rightarrow (m_H + m_L)\frac{(1-\theta)(v_L - \bar{q_S})^2}{2(1+\theta)} < m_H[v_L\bar{q}_S + \frac{v_H^2}{2} - v_H\bar{q}_S - t - w] \rightarrow m_H > \tilde{m}_{H4}$ (where the denominator of $\tilde{m}_{H4}$ is positive as in the proof of Claim 5). The sufficient condition is then given by Claim 2. Note that, the condition of $m_H < \bar{m}_{H1}$ in Claim 1 is always satisfied in this case, since (i) if $t + w < \frac{(v_H - \bar{q}_S)^2}{2}$ then $\bar{m}_{H1} = +\infty$, and (ii) if $t + w \geq \frac{(v_H - \bar{q}_S)^2}{2} > \Psi$ then $\theta^* > \hat{\theta}$ and by defining $\theta^* = 1$, the separating SPNE is then an FDI equilibrium.

Q.E.D.

With the help of Claims 1-6, the proof of Proposition 1 is constructed as we define:

$$\tilde{m}_H = \begin{cases} max(\tilde{m}_{H2}, \tilde{m}_{H3}) & \text{if } \theta > \hat{\theta} \text{ and } t \geq \bar{t}_1 \\ max(\tilde{m}_{H1}, \tilde{m}_{H4}) & \text{if } \theta > \hat{\theta} \text{ and } t < \bar{t}_1 \\ max(\tilde{m}_{H2}, \tilde{m}_{H5}) & \text{if } \theta \leq \hat{\theta} \text{ and } t \geq \bar{t}_2 \\ max(\tilde{m}_{H1}, \tilde{m}_{H4}) & \text{if } \theta \leq \hat{\theta} \text{ and } t < \bar{t}_2 \end{cases}$$

Finally, since $\tilde{m}_{H1}$, $\tilde{m}_{H3}$, and $\tilde{m}_{H5}$ are weakly decreasing in t, $\tilde{m}_{H2}$ is independent of t while $\tilde{m}_{H4}$ is weakly increasing in $t \in [0, \Psi - w]$, if $m_H > \lim_{t \to (\Psi - w)} \tilde{m}_H$ then

[25] Without loss of generality, we assume that firm N chooses HP if $t < \bar{t}_2$ or if $\theta > \theta^*$, and it chooses FDI if $t \geq \bar{t}_2$ or if $\theta \leq \theta^*$.

the game has a separating equilibrium for all $t \geq 0$. Similarly, since $\tilde{m}_{H2}$ and $\tilde{m}_{H4}$ are weakly decreasing in θ, $\tilde{m}_{H1}$ and $\tilde{m}_{H3}$ are independent of θ while $\tilde{m}_{H5}$ is weakly increasing in $\theta \in [0, \theta^*]$, if $m_H > \lim_{\theta \to \theta^*} \tilde{m}_H$ then the game has a separating equilibrium for all $\theta \in [0, 1)$.

Q.E.D.

Proof of Proposition 2.

Consider the case of $t + w \geq \Psi$. For all θ in $(0, \hat{\theta})$, from the proof of Claim 6 above, $\theta^* = \frac{v_H - \bar{q}_S - \sqrt{(v_H - \bar{q}_S)^2 - 2(t+w)}}{v_H - v_L} \geq \hat{\theta} = \frac{v_H - \bar{q}_S - \sqrt{(v_H - \bar{q}_S)^2 - 2(v_H - v_L)(v_L - \bar{q}_S)}}{v_H - v_L}$ so that the separating SPNE of the game is an FDI equilibrium for all $\theta \in (0, \hat{\theta}]$. Furthermore, for all $\theta \in (\hat{\theta}, 1)$, following the proof of Claim 5 above, the separating SPNE of the game is an FDI equilibrium. Hence, we can re-define $\theta^* = 1$ to formalize the proof of Proposition 2.

Consider the case of $t + w < \Psi$. In this case, since $\Psi \leq \frac{(v_H - \bar{q}_S)^2}{2}$, it follows that $\theta^* < \hat{\theta}$ as proof of Claim 6 stated. Then, $\theta^* = \frac{v_H - \bar{q}_S - \sqrt{(v_H - \bar{q}_S)^2 - 2(t+w)}}{v_H - v_L}$ is increasing in t.

Q.E.D.

Proof of Proposition 3.

The proof comes directly from proof of Proposition 1. Q.E.D.

Proof of Lemma 1.

The proof comes directly from proof of Proposition 1 and Proposition 2. Q.E.D.

Proof of Lemma 2.

Let us define

$$\bar{t} = \begin{cases} \bar{t}_1 & \text{if } \theta > \hat{\theta} \\ \bar{t}_2 & \text{if } \theta \leq \hat{\theta} \end{cases}$$

then it follows that for all $t \geq \bar{t}$, the separating SPNE of the game is an FDI equilibrium and it is an HP equilibrium otherwise, based on the proof of Claim 5 and 6.

Q.E.D.

Proof of Proposition 4.

When tariff rate increases from $t' < \bar{t}$ to $t = \bar{t}$, the separating SPNE of the game switches from HP to FDI equilibrium by Lemma 2. Then, firm S's equilibrium quality under FDI is always higher than under HP, because $q_S^{FDI*} = v_L > \bar{q}_S$ (in case $\theta > \hat{\theta}$), and $q_S^{FDI*} = \hat{q}_S(q'_N) > \bar{q}_S$ (in case $\theta \leq \hat{\theta}$). Therefore:

- $\pi_S(\bar{t}) > \pi_S(t')$, since $\pi_S = m_L[v_L q_S - \frac{q_S^2}{2}]$ is concave in q_S, maximized at $q_S = v_L$.
- $CS(\bar{t}) > CS(t')$ since $CS = m_H(v_H - v_L)q_S$ is increasing in q_S.

Q.E.D.

Proof of Proposition 5.

Global welfare level in the separating equilibrium of FDI subgame is given by $WW(\bar{t}) = m_H\big(q_N^{FDI} v_H - \frac{q_N^{FDI^2}}{2}\big) + m_L\big(q_S^{FDI} v_L - \frac{q_S^{FDI^2}}{2}\big)$ and under HP, $WW(t') = m_H\big(q_N^{HP} v_H - \frac{q_N^{HP^2}}{2} - w\big) + m_L\big(q_S^{HP} v_L - \frac{q_S^{HP^2}}{2}\big)$. From first-order conditions, it follows that, $q_N^i = v_H$ and $q_S^i = v_L$ maximize global welfare in subgame i.

- If $\theta > \hat{\theta}$ then under FDI firm N chooses $q_N^{FDI*} = v_H$ while firm S chooses $q_S^{FDI*} = v_L$, the socially optimal quality levels. Under HP, firm S chooses $\bar{q}_S < v_L$. Therefore, $WW(\bar{t}) > WW(t')$.
- If $\theta \leq \hat{\theta}$ then $WW(\bar{t}) > WW(t') \leftrightarrow m_H\big(q_N^{FDI} v_H - \frac{q_N^{FDI^2}}{2} - q_N^{HP} v_H + \frac{q_N^{HP^2}}{2} + w\big) > m_L\big(q_S^{HP} v_L - \frac{q_S^{HP^2}}{2} - q_S^{FDI} v_L + \frac{q_S^{FDI^2}}{2}\big) \leftrightarrow m_H\big(\frac{\theta^2(v_H - v_L)^2}{2} - w\big) < m_L \theta(q'_N - \bar{q}_S)(v_L - \frac{\hat{q}_S(q'_N) + \bar{q}_S}{2})$, which is always true if $\frac{\theta^2(v_H - v_L)^2}{2} \leq w$. If $\frac{\theta^2(v_H - v_L)^2}{2} > w$, $WW(\bar{t}) > WW(t') \leftrightarrow m_H < m_L \frac{\theta(q'_N - \bar{q}_S)(v_L - \frac{\hat{q}_S(q'_N) + \bar{q}_S}{2})}{\frac{\theta^2(v_H - v_L)^2}{2} - w} \equiv \hat{m}_{H1}$. The proof is completed by setting $\hat{m}_{H1} = 0$ if $\frac{\theta^2(v_H - v_L)^2}{2} \leq w$. Furthermore, we can always finds parameterizations under which $\hat{m}_{H1} > \lim_{t \to (\Psi - w)} \tilde{m}_H$, i.e. by making $\big(\frac{\theta^2(v_H - v_L)^2}{2} - w\big)$ small enough.

Q.E.D.

Proof of Lemma 3.

When $\theta \leq \hat{\theta}$ then $WW(\theta) = m_H\big(q_N^{FDI} v_H - \frac{q_N^{FDI^2}}{2}\big) + m_L\big(q_S^{FDI} v_S - \frac{q_S^{FDI^2}}{2}\big)$, so that $\frac{\partial WW(\theta)}{\partial \theta} = -m_H \theta (v_H - v_L)^2 + m_L(v_L - \hat{q}_S(q'_N)) \frac{\partial \hat{q}_S(q'_N)}{\partial \theta}$, which is positive when $\theta = 0$. Furthermore, $\frac{\partial^2 WW(\theta)}{\partial \theta^2} = -m_H(v_H - v_L)^2 - m_L\big((\frac{\partial \hat{q}_S(q'_N)}{\partial \theta})^2 + (v_L - \hat{q}_S(q'_N)(v_H - v_L)\big) < 0$, hence $WW(\theta)$ is concave in θ for all $\theta \in [0, \hat{\theta}]$ and can be maximized at some $\tilde{\theta} \leq \hat{\theta}$, where $\theta = \tilde{\theta}$ makes $\frac{\partial WW(\theta)}{\partial \theta} = 0$. Note that when m_H is relatively high then $\tilde{\theta} \approx 0 < \hat{\theta}$. Formally, when $WW(\theta = 0) > WW(\theta = \hat{\theta})$ then $\tilde{\theta} < \hat{\theta}$ holds, which happens

when $m_H(\frac{v_H^2}{2}) + m_L(v_L\bar{q}_S - \frac{\bar{q}_S^2}{2}) > m_H(v_H q'_N - \frac{{q'_N}^2}{2}) + m_L(v_L q_S(q'_N) - \frac{q_S(q'_N)^2}{2}) \leftrightarrow$ $m_H > m_L \frac{(v_L[\bar{q}_S + \hat{\theta}((1-\hat{\theta})v_H + \hat{\theta}v_L - q_S)] - \frac{[\bar{q}_S + \hat{\theta}((1-\hat{\theta})v_H + \hat{\theta}v_L - q_S)]^2}{2}) - (v_L\bar{q}_S - \frac{\bar{q}_S^2}{2})}{\hat{\theta}^2 \frac{(v_H - v_L)^2}{2}} \equiv m_H^*$, where $\hat{\theta}$ is given in the proof of Proposition 2. Finally, we can always restrict parameters such that the denominator of m_H^* becomes small so that $m_H^* > \lim_{\theta \to \theta^*} \tilde{m}_H$.
Q.E.D.

Proof of Proposition 6.

If $\theta > \hat{\theta}$ then under separating equilibrium of FDI subgame, firm N chooses $q_N^{FDI*} = v_H$ while firm S chooses $q_S^{FDI*} = v_L$, so that $\pi_N(\theta)$, $\pi_S(\theta)$, $CS(\theta)$, $WS(\theta)$ are all independent of θ.

If $\theta \leq \hat{\theta}$ then in the separating equilibrium of FDI subgame (see also proof of Claim 3), it follows that $sign[\frac{\partial \pi_S(\theta)}{\partial \theta}] = sign[\frac{\partial CS(\theta)}{\partial \theta}] = sign[\frac{\partial WS(\theta)}{\partial \theta}] = sign[\frac{\partial q_S^{FDI}}{\partial \theta}] = v_H - \bar{q}_S - 2\theta(v_H - v_L) > 0$ since $\hat{\theta} < \frac{v_H - \bar{q}_S}{2(v_H - v_L)} \leftrightarrow 3(v_H - \bar{q}_S)^2 > 8(v_H - v_L)(v_L - \bar{q}_S)$ always holds; whereas $sign[\frac{\partial \pi_N^{FDI}}{\partial \theta}] = sign[\frac{\partial q_N^{FDI}}{\partial \theta}] = v_L - v_H < 0$.

If θ increases from $\theta = \hat{\theta}$ to $\theta' > \hat{\theta}$ then global welfare is maximized (see proof of Proposition 5). Therefore, $WS(\theta') > WS(\hat{\theta})$ since firm N's profit remains constant. Furthermore, since firm S chooses higher quality level following this increase in spillover rate, $CS(\theta') > CS(\hat{\theta})$ and $\pi_S(\theta') > \pi_S(\hat{\theta})$ hold.
Q.E.D.

Proof of Proposition 7.

If $\theta > \theta^*$ then the separating SPNE of the game is an HP equilibrium in which firm N chooses $q_N^{HP*} = v_H$ while firm S chooses $q_S^{HP*} = \bar{q}_S$, so that $\pi_N(\theta)$, $\pi_S(\theta)$, $CS(\theta)$, $WS(\theta)$ are all independent of θ.

If $\theta \leq \theta^*$ then the separating SPNE of the game is an FDI equilibrium, and firm N chooses $q_N^{FDI*} = q'_N$ while firm S chooses $q_S^{FDI*} = \hat{q}_S(q'_N)$. Hence, $sign[\frac{\partial \pi_S^{FDI}(\theta)}{\partial \theta}] = sign[\frac{\partial CS(\theta)}{\partial \theta}] = sign[\frac{\partial WS(\theta)}{\partial \theta}] = sign[\frac{\partial q_S^{FDI}}{\partial \theta}] = v_H - \bar{q}_S - 2\theta(v_H - v_L) > 0$ as $\theta^* = \hat{\theta} < \frac{v_H - \bar{q}_S}{2(v_H - v_L)}$ (see more in proof of Proposition 6), whereas $sign[\frac{\partial \pi_N^{FDI}(\theta)}{\partial \theta}] = sign[\frac{\partial q_N^{FDI}}{\partial \theta}] = v_L - v_H < 0$

If θ increases from $\theta = \theta^*$ to $\theta' \geq \theta^*$, by Proposition 3 and Lemma 1, firm S chooses lower quality level thus $CS(\theta') < CS(\theta^*)$ and $\pi_S(\theta') < \pi_S(\theta^*)$ hold.
Q.E.D.

Proof of Proposition 8.

An increase in θ from θ^* to $\theta' > \theta^*$ switches the equilibrium of the game from

FDI to HP, so that global welfare changes from $WW(\theta^*) = m_H(q''_N v_H - \frac{{q''_N}^2}{2}) + m_L(\hat{q}_S(q''_N)v_L - \frac{\hat{q}_S(q''_N)^2}{2})$ to $WW(\theta') = m_H(\frac{v_H^2}{2} - w) + m_L(v_L\bar{q}_S - \frac{\bar{q}_S^2}{2})$, where $q''_N = (1-\theta^*)v_H + \theta^* v_L$. Therefore, $WW(\theta') > WW(\theta^*) \leftrightarrow m_H(\frac{v_H^2}{2} - w) + m_L(v_L\bar{q}_S - \frac{\bar{q}_S^2}{2}) > m_H(q''_N v_H - \frac{{q''_N}^2}{2}) + m_L(\hat{q}_S(q''_N)v_L - \frac{\hat{q}_S(q''_N)^2}{2})$. This requires $w < \frac{{\theta^*}^2(v_H - v_L)^2}{2}$ and $m_H > m_L \frac{\theta^*(q''_N - \bar{q}_S)(v_L - \frac{(2-\theta^*)\bar{q}_S + \theta^* q''_N}{2})}{\frac{{\theta^*}^2(v_H - v_L)^2}{2} - w} \equiv \hat{m}_{H2}$.

Finally, recall that $\theta = \tilde{\theta}$ maximizes global welfare for all $\theta \in [0, \theta^*]$ by Lemma 3. Then, since either at $\theta = 0$ (FDI) or at $\theta = \theta' > \hat{\theta}$ (HP), firm N chooses $q_N = v_H$ while firm S chooses $q_S = \bar{q}_S$, it follows that $WW(\theta = 0) = m_H \frac{v_H^2}{2} + m_L(v_L\bar{q}_S - \frac{\bar{q}_S^2}{2}) > m_H(\frac{v_H^2}{2} - w) + m_L(v_L\bar{q}_S - \frac{\bar{q}_S^2}{2}) = WW(\theta = \theta')$. This implies that $\theta = \tilde{\theta}$ maximizes global welfare for all $\theta \in [0, 1)$. Finally, we can always restrict parameters such that the denominator of $\hat{m}_{H2}$ becomes small so that $\hat{m}_{H2} > \lim_{\theta \to \theta^*} \tilde{m}_H$.

Q.E.D.

2.9 References

Aitken, B.J. & Harrison, A.E. 1999, "Do Domestic Firms Benefit from Direct Foreign Investment? Evidence from Venezuela." *The American Economic Review,* Vol. 89(3).

Australian Chamber of Commerce and Industry. 2006, *China FTA - Need for Progress on Intellectual Property Rights.*

Boccard, N. & Wauthy, X. 2005, "Enforcing Domestic Quality Dominance through Quotas." *Review of International Economics,* Vol. 13(2).

Carluccio, J. & Fally, T. 2010, "Multinationals, Technological Incompatibilities, and Spillovers." *CEPR Discussion Papers 7869.*

Chin, J.C. & Grossman, G.M. 1990, *Intellectual Property Rights and North-South Trade,* In: Jones, R.W., Krueger, A.O. (eds), The Political Economy of International Trade: Essays in Honor of Robert E. Baldwin. Blackwell, Cambridge, MA.

Das, S.P. & Donnenfeld, S. 1987, "Trade Policy and its Impact on Quality of Imports: a Welfare Analysis." *Journal of International Economics,* Vol. 23.

Das, S.P. & Donnenfeld, S. 1989, "Oligopolistic Competition and International Trade: Quantity and Quality Restrictions." *Journal of International Economics,* Vol. 27.

Davis, S.J., Murphy, K.M. & Topel, R.H. 2004, "Entry, Pricing and Product Design in an Initially Monopolized Market." *Journal of Political Economy,* Vol. 112(1).

Deardorff, A. 1992, "Effects of Global Patent Protection." *Economica,* Vol. 59(233).

Diwan, I. & Rodrik, D. 1991, "Patents, Appropriate Technology, and North-South Trade." *Journal of International Economics,* Vol. 30.

Djankov, S. & Hoekman, B. 2000, "Foreign Investment and Productivity

Growth in Czech Enterprises." *World Bank Economic Review,* Vol. 14(1).

Ernst & Young. 2005, "China's Automotive Sector - At the Crossroads." *EYG No. CT0003.*

Falvey, R. 1979, "The Composition of Trade Within Import Restricted Trade Categories." *Journal of Political Economy,* Vol. 87.

Freenstra, R.C. 2004, *Advanced International Trade: Theory and Evidence,* Princeton University Press.

Gallagher, K.S. 2003, "Foreign Technology in China's Automobile Industry: Implications for Energy, Economic Development, and Environment." *China Environment Series,* Issue 6.

Glass, A.J. & Saggi, K. 1998, "International Technology Transfer and The Technology Gap." *Journal of Development Economics,* Vol. 55.

Glass, A.J. & Saggi, K. 2002, "Multinational Firms and Technology Transfer." *Scandinavian Journal of Economics,* Vol. 104(4).

Gonzalez, J. & Viaene, J.M. 2005, "Trade Policy and Quality Leadership in Transition Economies." *European Economic Review,* Vol. 49.

Grossman, G.M. & Lai, E. 2004, "International Protection of Intellectual Property." *American Economic Review,* Vol. 94(5).

Haddad, M. & Harrison, A. 1993, "Are there positive spillovers from direct foreign investment?: Evidence from panel data for Morocco." *Journal of Development Economics,* Vol. 42.

Helpman, E. 1993, "Imitation, and Intellectual Property Rights." *Econometrica,* Vol. 61(6).

Keller, W. 2004, "International Technology Diffusion." *Journal of Economic Literature,* Vol. 42(3).

Kim, J.E. & Lapan, H.E. 2008, "Heterogeneity of Southern Countries and Southern Intellectual Property Rights Policy." *Canadian Journal of Economics,* Vol. 41(3).

Lai, E. & Qiu, L.D. 2003, "The North's Intellectual Property Rights Standard for the South?" *Journal of International Economics,* Vol. 59.

Li, L. 2007, "The Quality Drag on China's Car Industry", *Bloomberg Business Week*, 29 June, viewed 29 June 2008, `<http://www.businessweek.com/globalbiz/content/jun2007/gb20070629_028900.htm>`.

Luo, J. 2005, "The Growth of Independent Chinese Automotive Companies." *International Motor Vehicle Program,* MIT.

Mussa, M. & Rosen, S. 1978, "Monopoly and Product Quality" *Journal of Economic Theory,* Vol. 18.

Naghavi, A. 2007, "Strategic Intellectual Property Rights Policy and North-South Technology Transfer." *Review of World Economics,* Vol. 143(1).

Pack, H. & Saggi, K. 2006, "Is There a Case for Industrial Policy? A Critical Survey." *The World Bank Reserve Observer,* Vol. 21(2).

Patibandla, M., Kapur, D. & Petersen, B. 1999, "A Byproduct of Import Substitution and Competitiveness out of International Orientation: A Brief Story of India's Software Industry and Policy Implications." *Working paper.*

Praussello, F. 2005, "Country Case Studies on Unequal Technology Transfer." *Working paper.*

Qiu, L.D. 2005, "China's Automotive Industry." *Working paper.*

Rhee, Y.W. 1990, "The Catalyst Model of Development: Lessons from Bangladesh's Success with Garment Exports." *World Development,* Vol. 18(2).

Saggi, K. 2002, "Trade, Foreign Direct Investment, and International Technology Transfer: A Survey." *The World Bank Research Observer,* Vol. 17(2).

Thompson, E.R. 2003, "Technology Transfer to China by Hong Kong's Cross-border Garment Firms." *Developing Economies,* Vol. 41(1).

Toshimitsu, T. 2005, “Tariffs, Quality Choice, and Cost Functions: a Foreign Monopoly Case.” *Review of International Economics,* Vol. 13(2).

UNCTAD. 1992, *World Investment Report.* United Nations Publication, New York.

UNCTAD. 1997, *World Investment Report.* United Nations Publication, New York.

UNCTAD. 2000, *World Investment Report.* United Nations Publication, New York.

Waldman, M. 1996, “Durable Goods Pricing when Quality Matters.” *Journal of Business,* Vol. 69.

Waldman, M. 1997, “Eliminating the Market for Secondhand Goods: An Alternative Explanation for Leasing.” *Journal of Law and Economics,* Vol. 40(1).

World Trade Organization. 2009, *Understanding the WTO: The Agreements. Intellectual Property: Protection and Enforcement,* viewed 10 April 2009, <http://www.wto.org/english/thewto_e/whatis_e/tif_e/agrm7_e.htm>

Zigic, K. 1998, “Intellectual Property Rights Violations and Spillovers in North-South Trade.” *European Economic Review,* Vol. 42.

Zigic, K. 2000, “Strategic Trade Policy, Intellectual Property Rights Protection, and North-South Trade.” *Journal of Development Economics,* Vol. 61.

Chapter 3

Multinational Firms and Optimal Intellectual Property Rights

3.1 Introduction

In the previous chapter, we showed that, in the presence of quality-enhancing technology spillovers in the South, foreign direct investment (FDI) by a Northern firm can hurt the South.[1] The driving force behind this result is that the Northern firm could strategically decrease its product quality level when it undertakes FDI. In such cases, the net social benefits associated with the consumption of Northern firm's product declines, which can result in a total welfare loss for the South. Moreover, we demonstrated that the global optimal level of spillovers tends to be less than the South-optimal level, but higher than the North-optimal level. These findings provide an explanation for the North-South conflict concerning optimal Intellectual Property Rights (IPR) regime in the South, and also support the role played by the World Trade Organization (WTO). In particular, the model suggests that WTO should stand in between

[1] Quality-enhancing technology spillovers is defined as technology spillovers from a Northern firm to a Southern competitor that enhances the latter's product quality.

North and South to reconcile the IPR conflict, rather than supporting the North, as has been argued in the literature.

This chapter reexamines the above issues in an international Cournot duopoly model with cost-reducing spillovers. In our model, FDI by the Northern firm does not create a quality-enhancing effect but a cost-reduction effect. That is, it leads to a reduction in the marginal cost of production for the Southern firm, who has less advanced technology. The central research questions of this chapter are: (i) In the presence of cost-reducing technology spillovers in the South, does FDI by the Northern firm improve Southern welfare and global welfare? (ii) What are the optimal level of spillovers for the North, the South, and the world in this context? By addressing these questions, we attempt to elucidate the differences and similarities between quality-enhancing and cost-reducing spillovers to provide a comprehensive set of policy recommendations on IPR issue.

In our set up, a Northern firm with advanced technology competes with a Southern firm in the Southern market. The firms compete by producing a homogeneous product. All else equal, the advanced technology allows the Northern firm to produce the product at a lower marginal cost. By undertaking FDI, the Northern firm can avoid trade costs. However, the Northern firm's superior technology spills over to the Southern firm upon FDI which decreases the latter's marginal cost. We find that, the Northern firm chooses the lowest marginal cost level for its product regardless of its location choice. When linear demand is adopted, it follows that FDI always benefits the South through the positive externalities from the Northern firm to the Southern firm and consumers. These outweigh the loss in tariff revenue for the South. As a consequence, the optimal IPR policy for the South is represented by the highest level of spillovers that still induces FDI. This level of spillovers is also globally optimal under a range of parameterizations. It is also possible that the global optimal level of spillovers is zero, which is also North-optimal.

The result in which the Northern firm chooses its lowest marginal cost under FDI can be interpreted as if it chooses the best technology for production when it invests in the South. That is, the Northern firm possesses a technology for producing the good in the North. When it undertakes FDI, it can choose to set up a plant with a technology that has a higher marginal cost than the one used in the North if it so desires. In such a case, the Northern firm chooses an inferior technology with FDI. If this happens, it is equivalent to the case of the previous chapter in which the Northern firm produces products with lower quality under FDI. However, as demonstrated in our analysis, in the presence of cost-reducing technology spillovers, the Northern firm still chooses its best technology for production in the South.[2]

The logic behind our results goes as follows. Consider the case the Northern firm undertakes FDI and it chooses the lowest possible marginal cost level. Then, if the Northern firm increases its marginal cost, there will be two negative effects: (i) it directly hurts Northern firm's profitability because of the higher cost incurred per unit of output; and (ii) it decreases the relative cost advantage (that is the difference marginal cost between firm S and firm N) and intensifies competition. Thus, the Northern firm does not have incentive to raise its marginal cost from the lowest level. At the same time, with the presence of the Northern firm in the South, an increase in the level of spillovers not only benefits the Southern firm but also increases total quantity supplied - which in turn benefits consumers. Consequently, when the spillover rate is such that Northern firm is indifferent between home-production and FDI then Southern welfare is maximized within FDI equilibrium. When the demand curve in the South is linear, we find that, the increase in consumer surplus of the South as a consequence of FDI is more than enough to offset the loss in tariff revenue. Hence, this leads to an unique optimal IPR policy for the South, which is represented by the highest possible level of spillovers which still induces the Northern firm to invest in the South.[3]

By successfully inducing the Northern firm to undertake FDI (by making

[2]We would like to thank Don Wright for suggesting this interesting discussion.

[3]We treat the case of general demand in the Appendix where we demonstrate that some of the results still hold with general demand.

the Northern firm at least equally profitable under FDI compared to home-production), the South is better off. It then follows that FDI also improves global welfare. However, when the Northern firm undertakes FDI, an increase in the level of spillovers makes Northern firm worse off. That is, more stringent IPR regime in the South is always preferred by the Northern firm while more lax IPR regime is preferred by the Southern firm and Southern consumers. Consequently we find that, more spillovers do not necessarily increase global welfare when Northern firm undertakes FDI. Specifically, we demonstrate that there are only two candidates for the level of spillovers which maximizes global welfare: (i) zero (North-optimal) or (ii) South-optimal level. The intuition of this result is as follows. Starting with a zero spillovers so that the Northern firm undertakes FDI in the South and its cost advantage is largest, consider an increase in spillover rate. This decreases the cost advantage of the Northern firm and intensifies competition. Under linear demand and suppose the spillover rate is relatively low, we find that, the reduction in Northern firm's profitability following an increase in spillover rate is higher than the increase in total surplus for the South (consisting of Southern firm's profit and consumer surplus), thus implying that global welfare is decreasing in spillover rates. If spillovers are high enough, a further increase in spillovers results in the total welfare gain becoming higher than total welfare loss. Thus global welfare is increasing in spillover rates when spillover rate is high. That is the planner, whose objective is to maximize world welfare, would either support the North or the South in choosing its optimal level of IPR protection in the South, rather than standing in between these two polars, as is the case in Chapter 2.

Our results suggest that strengthening IPR environment to induce FDI is always a good policy choice for the Southern government in this context. Furthermore, FDI could also raise the level of global welfare. However, in contrast to the findings presented in Chapter 2, the optimal spillover rate for the world can be either zero or South-optimal level only. Hence, with linear demand, the effects of cost-reducing spillovers seem to be different to that of quality-enhancing spillovers. The intuition is that, under the cost-reducing spillovers, the Northern firm chooses the minimum marginal cost level even with FDI, whereas under quality-enhancing spillovers, the Northern firm could strategically reduce its quality level when it undertakes FDI which reduces efficiency for society.

The set up of this chapter is closely related to the paper by Naghavi (2007), who developed a North-South duopoly model with R&D spillovers and argued that FDI-induced spillovers benefit the South (see also Glass & Saggi 2002).[4] In his model, Northern firm undertakes R&D to reduce marginal cost. The Southern firm does not undertake R&D but benefits from technology spillovers from the FDI of the Northern firm. That is, it can imitate part of the R&D cost-reduction technology of the Northern firm. However, in practice, when the Northern firms undertake FDI in the South, they often choose the appropriate technology to adopt at factories in the host country, rather than undertaking R&D to develop new technology. For instance, Belderbos (2006) reported that Japanese firms rely on their home R&D activities when undertaking investment in developing countries. Specifically, the share of patents originating from Asia for Japanese firms has been almost negligible, i.e. at 0.1%.[5]. By analyzing technology spillovers in the North-South trade context with no R&D activities, we attempt to discuss new policy perspectives of IPR in developing countries.

Our work is also related to broadly defined international IPR literature. Diwan and Rodrik (1991) showed that harmonizing IPR protection in North and South could be optimal for the world. However, Deardorff (1992) argued that, extending North IPR protection regime to the South could benefit/hurt world welfare. Lai and Qiu (2003) demonstrated that, when Northern firms innovate and Southern firms imitate, then to maximize global welfare, the South needs to adopt stronger IPR protection than what was implemented in the

[4]Chin and Grossman (1990), Zigic (1998, 2000) focused on R&D investment as a source of spillovers in similar models but without FDI.

[5]The similar situation applies for U.S firms with the share of patents originating from Asia of 0.6% while this number for European firms is 0.7%.

North. In these papers, FDI was absent so that the nature of strengthening IPR policy in the South in theirs and ours are different, as detailed in the subsequent analysis (see also Helpman 1993 and Grossman & Lai 2004, and the survey papers by Saggi 2002 and Keller 2004).[6]

The remainder of the chapter will proceed as follows. Section 3.2 outlines the model, followed by its equilibrium characterization in Section 3.3. Welfare consequences of FDI are presented Section 3.4. Section 3.5 discusses the results and concludes.

3.2 The Model

Consider an international Cournot duopoly model in which a Northern firm (firm N) and a Southern firm (firm S) compete in the Southern market by producing a homogeneous good. Firm N can choose its supply strategy between export (equivalently, HP) and FDI, while firm S only produces at home. Let c_k^{hp} and c_k^f denote firm $k(= N, S)$'s constant marginal cost under HP and FDI, respectively. We assume that, under HP, firm N can freely choose any non-negative value for c_N^{hp}, while firm S can choose any positive value for c_S^{hp} subject to a lower bound $c_0 (> 0)$, that is $c_S^{hp} \geq c_0$. In other words, firm S has a less advanced technology compared to that of firm N so that it has to incur a higher marginal cost *ceteris paribus.* A specific tariff, t, is imposed on import of firm N's product.

Suppose firm N undertakes FDI. We assume that the lower bound of marginal cost for firm S becomes lower. This is given by $c_S^f(c_N^f) = min(c_0 - \theta(c_0 - c_N^f), c_0)$. That is, if firm N chooses $c_N^f < c_0$ then technology spillovers enables firm S to choose $c_S^f < c_0$. Here, $\theta \in [0, 1)$ denotes spillover rate, which represents the level of IPR protection in the Southern country. As θ increases, IPR protection in the Southern country becomes weaker which in

[6] On the other hand, there has been a number of papers empirically investigated the impact of FDI on productivities of firms in the host countries. See more in Chapter 2 and in the paper by Carluccio & Fally (2010).

turn benefits firm S.

The representative consumer maximizes her utility, $U = A(q_N + q_S) - \frac{q_N^2+2q_Nq_S+q_S^2}{2}$, where q_k, $k \in (N, S)$, denotes firm k's quantity level. The solution for the consumer yields the the following inverse demand equation under HP: $p^{hp} = A - q_N^{hp} - q_S^{hp}$, where p^{hp} is market price, q_k^{hp} is quantity level firm k chooses for its products, and A is a positive parameter. Similarly, under FDI, the inverse demand equation is given by $p^f = A - q_N^f - q_S^f$, where p^f is market price and q_k^f is quantity level firm k chooses.

We consider a two stage game, described below:

[**Stage 1**] Firm N chooses its location between HP and FDI.

[**Stage 2**] Firms N and S set their quantity levels and consumers make purchasing decision.

3.3 Equilibrium Characterization

Throughout the analysis, we focus on parameterizations so that in the equilibrium of the game, each firm sells a strictly positive amount of its product. This helps us to reduce a number of cases to be considered and makes the comparison between quality-enhancing spillovers and cost-reducing spillovers more transparent. More formally, this condition is given by $A > 2c_0$.[7]

Notice that the game described above has two stage 2 subgames: HP subgame and FDI subgame. Let us first consider the HP subgame. At stage 2, firm N chooses its quantity level q_N^{hp} to maximize its profit

$$\max_{q_N^{hp}} (A - q_N^{hp} - q_S^{hp} - c_N^{hp} - t)q_N^{hp}, \tag{3.1}$$

[7] This condition is derived by examining firm S's equilibrium quantity level which comes in subsequent analysis. Note that with home-production, we need the condition to be $A > max(2c_0, 2t)$ - however if $t > \frac{\theta c_0}{2}$ then firm N undertakes FDI so that condition $A > 2c_0$ is suffix. With this condition, there is no strategic predation, which helps simplify the analysis.

At the same time, firm S chooses its quantity level q_S^{hp} to maximize its profit

$$\max_{q_S^{hp}} \ (A - q_N^{hp} - q_S^{hp} - c_S^{hp})q_S^{hp}. \tag{3.2}$$

Routine calculation gives $q_N^{hp*} = \frac{A-2c_N^{hp}-2t+c_S^{hp}}{3}$, and $q_S^{hp*} = \frac{A-2c_S^{hp}+c_N^{hp}+t}{3}$, which result in the following equilibrium profits for firms N and S: $\pi_N^{hp*} = \big(\frac{A-2c_N^{hp}-2t+c_S^{hp}}{3}\big)^2$ and $\pi_S^{hp*} = \big(\frac{A-2c_S^{hp}+c_N^{hp}+t}{3}\big)^2$. These results suggest that each firm's equilibrium quantity and profit is decreasing in its marginal cost. This implies that, firm N optimally chooses $c_N^{hp} = 0$ and firm S optimally chooses $c_S^{hp} = c_0$. The equilibrium profit for firms N and S can be written as $\pi_N^{hp*} = \big(\frac{A-2t+c_0}{3}\big)^2$ and $\pi_S^{hp*} = \big(\frac{A-2c_0+t}{3}\big)^2$, respectively.

Now, we consider the FDI subgame. Recall that, when firm N undertakes FDI in the South, there are technology spillovers. Therefore, if firm N chooses its marginal cost level below c_0 then firm S can also choose its marginal cost level below c_0 (which follows from technology spillovers equation). In what follows, we shall consider this case. At stage 2, firm N chooses quantity q_N^f to maximize its profit

$$\operatorname*{Max}_{q_N^f} \ (A - q_N^f - q_S^f - c_N^f)q_N^f, \tag{3.3}$$

and firm S chooses quantity q_S^f to maximize its profit

$$\operatorname*{Max}_{q_S^f} \ (A - q_N^f - q_S^f - c_S^f(c_N^f))q_S^f. \tag{3.4}$$

The solutions are given by $q_N^{f*} = \frac{A-2c_N^f+c_S^f(c_N^f)}{3}$ and $q_S^{f*} = \frac{A-2c_S^f(c_N^f)+c_N^f}{3}$. Routine calculation gives the equilibrium profits for firms N and S: $\pi_N^{f*} = \big(\frac{A-2c_N^f+c_S^f(c_N^f)}{3}\big)^2$ and $\pi_S^{f*} = \big(\frac{A-2c_S^f(c_N^f)+c_N^f}{3}\big)^2$. Replacing $c_S^f = c_0 - \theta(c_0 - c_N^f)$, we obtain $\pi_N^{f*} = \big(\frac{A+(\theta-2)c_N^f+(1-\theta)c_0}{3}\big)^2$. Since $\theta < 1$, firm N's profit is decreasing in c_N^f, hence in stage 2, firm N chooses $c_N^f = 0$. Thus we obtain the following equilibrium profit for firms N and S: $\pi_N^{f*} = \big(\frac{A+(1-\theta)c_0}{3}\big)^2$ and $\pi_S^{f*} = \big(\frac{A-2(1-\theta)c_0}{3}\big)^2$.

An alternative option for firm N under FDI is to choose $c_N^f \geq c_0$. This prevents firm S from benefiting from the spillovers from firm N. In this case, firm N chooses $c_N^f = c_0$, and the technology spillovers constraint does not bind. It follows that since firm N and firm S play the same role under FDI, they both choose the same quantity level of $q = \frac{A-c_0}{3}$ in the subsequent stage of the game, following from this they each earn profit $\pi = (\frac{A-c_0}{3})^2$. Since $\theta < 1$, we have that $\pi_N^f > \pi$, thus for firm N, it is more profitable to stick to the equilibrium in which it chooses zero marginal cost. In other words, under FDI, firm N chooses $c_N^f = 0$. These results are summarized in Proposition 1 below. Note that all proofs are presented in the Appendix.

Proposition 1: In the equilibrium of the game, firm N chooses the lowest marginal cost level (equal to zero) regardless of its location choice.

Under the HP equilibrium, firm N does not have any incentive to choose a positive marginal cost since any increase in marginal cost for firm N reduces its profitability and increases profits for its competitor (firm S). Under FDI, with the presence of technology spillovers, the analysis becomes richer. Proposition 1 says that, when firm N undertakes FDI in the South, it still brings the technology with lowest marginal cost to the South.

The logic behind this result goes as follows. Under FDI, firm N chooses zero marginal cost if the level of spillovers is zero. Now, consider an increase in firm N's marginal cost by a small amount δ. One one hand, this reduces firm N's profitability, holding other things constant. On the other hand, this increases firm S's marginal cost by $\theta\delta$ which reduces the cost difference between firm N and firm S, thus intensifying competition between them. This implies that increasing marginal cost by δ always reduces firm N's profitability. This finding contrasts to the the previous chapter where we showed in a quality-enhancing spillovers model, the Northern firm can strategically decrease its product quality level upon FDI.

We next examine firm N's location choice (stage 1). We start with the case in which the level of spillovers is fixed. The following proposition says that when tariffs are relatively high, firm N undertakes FDI, and firm N chooses HP when tariffs are relatively low.

Proposition 2: There exists a threshold value of tariff, $\bar{t}$, such that the equilibrium of the game is an FDI equilibrium if $t \geq \bar{t}$ and it is an HP equilibrium otherwise.

Firm N chooses HP when tariff rate is zero to avoid the negative impact of technology spillovers in the South. An increase in tariff makes HP less attractive. If tariff is equal to some threshold value, firm N will be indifferent between HP and FDI and then firm N will choose FDI if tariff exceeds this threshold. This explains the logic behind proposition 2. It is worth pointing out that Proposition 2 is consistent with the literature. For instance, it is consistent with the result of Naghavi (2007) under the duopoly case. In the previous chapter (Section 2.5), we also show that with quality-enhancing spillovers, Northern firm undertakes FDI when trade cost is high.

Under the same logic, consider the case when tariffs are fixed. It follows that firm N undertakes FDI if spillover rate is low enough, and it chooses HP if the spillover rate is high. These results are formalized in what follows.

Proposition 3: There exists a threshold value of spillovers, θ^*, such that the equilibrium of the game is an FDI equilibrium if $\theta \leq \theta^*$ and it is an HP equilibrium otherwise.

Under the presence of cost-reducing technology spillovers in the South, the Northern firm chooses its minimum marginal cost level regardless of its location choice. This result differs from the findings of the previous chapter where we find that the Northern firm could strategically reduce its product quality under FDI. How does this difference affect the policy implications of cost-reducing spillovers? We address this question in the subsequent analysis.

3.4 Welfare Consequences of FDI

This section explores welfare implications of FDI induced by either trade protection (higher tariff rates on import of firm N's product) or strengthening IPR regime (reduction in spillover rate). We start by investigating a change in trade policy. Let $\pi_N(t)$, $\pi_S(t)$, $WS(t)$ and $WW(t)$ respectively denote firm N's profit, firm S's profit, Southern welfare and global welfare. All these expressions are functions of tariff, t. Recall from previous section that when tariff increases from $t = t' < \bar{t}$ to $t = \bar{t}$ the equilibrium of the game switches from HP to FDI. Proposition 4 below says that this switching of equilibrium improves Southern welfare and global welfare.

Proposition 4: For all $t' < \bar{t}$:
(i) $\pi_S(\bar{t}) > \pi_S(t')$ and $\pi_N(\bar{t}) < \pi_N(t')$, and
(ii) $WS(\bar{t}) > WS(t')$ and $WW(\bar{t}) > WW(t')$,
where $\pi_S(t)$, $\pi_N(t)$, $WS(t)$ and $WW(t)$ are all independent in t for all $t > \bar{t}$.

Proposition 4 tells us that optimal trade policy for the South is represented by a high enough tariff rate that guarantees an FDI equilibrium. That is, if the level of spillovers is fixed, the Southern government should choose $t \geq \bar{t}$. Since trade costs are high, it induces firm N to shift its production from home to the South, and thus creates positive externalities to firm S.

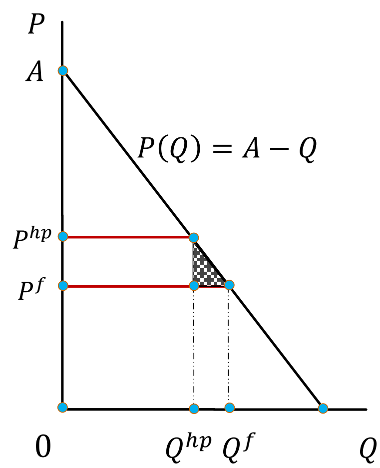

Figure 3.1: The impact of FDI.

To make the analysis more transparent, recall that the value of $\bar{t}$ is given by $\bar{t} = \frac{\theta c_0}{2}$ (see Proof of Proposition 2). With linear demand and the given technology spillovers equation, we can show that when the equilibrium switches from HP to FDI (at $t = \bar{t}$) then the equilibrium price decreases from P^{hp} to P^f while total output increases from Q^{hp} to Q^f. Note that the magnitude of the price decrease is equal to $\bar{t}$ (see more in the proof of Proposition 4). Hence, FDI not only makes firm S better off, it also improves consumer's surplus for the South. Routine calculation suggests that the amount by which consumer surplus increases is more than the loss in tariff revenue for the South (by the amount equal to the shaded area in Figure 3.1). In other words, FDI improves Southern welfare at $t = \bar{t} = \frac{\theta c_0}{2}$.

Once the tariffs are equal to or exceed $\bar{t}$, an increase in the level of tariff (or higher trade barrier) does not affect each firm's choice of output level since Northern firm undertakes FDI in the South. It follows that since when $t = \bar{t}$, firm N's profitability is the same under HP subgame and under FDI subgame, whenever FDI benefits the South it also raises the level of global welfare (which is the sum of Southern welfare and firm N's profit). Consequently, the model suggests that FDI yields a better outcome for the society as a whole.

Let us now analyze the impact of strengthening IPR in the South by assuming tariffs are fixed. We denote $\pi_N(\theta)$, $\pi_S(\theta)$, $WS(\theta)$ and $WW(\theta)$ as firm N's profit, firm S's profit, Southern welfare and global welfare, respectively. All of these expressions are functions of spillover rate, θ. From Proposition 3, we know that firm N undertakes FDI for all $\theta \leq \theta^*$ and chooses HP for all $\theta > \theta^*$. Consider the case where Southern IPR policy becomes more stringent such that the level of spillovers decreases from $\theta = \theta' > \theta^*$ to $\theta = \theta^*$. This results in a switching from HP to FDI.

Proposition 5: For all $\theta' > \theta^*$:

(i) $\pi_S(\theta^*) > \pi_S(\theta')$ and $\pi_N(\theta^*) = \pi_N(\theta')$, and

(ii) $WS(\theta^*) > WS(\theta')$ and $WW(\theta^*) > WW(\theta')$,

where $\pi_S(\theta)$, $\pi_N(\theta)$, $WS(\theta)$ and $WW(\theta)$ are all independent in θ for all $\theta \in (\theta^*, 1)$.

Inducing FDI by strengthening IPR regime makes the South better off thanks to the impact of technology spillovers. Proposition 5 says that the Southern government should choose an IPR protection level which is strict enough to attract the Northern firm's FDI. However, within the FDI subgame equilibrium, a change in IPR policy will affect each firm's choice of output level, and thus welfare. What level of spillovers would maximize Southern welfare and global welfare? To address this question, in what follows, we examine $WW(\theta)$ in the FDI subgame.

Lemma 1: There exists a value $\tilde{\theta} \leq \theta^*$ such that $WW(\theta)$ is strictly decreasing in θ for all $\theta \in [0, \tilde{\theta}]$ and it is strictly increasing in θ for all $\theta \in [\tilde{\theta}, \theta^*]$, where $\tilde{\theta} < \theta^*$ holds under a range of parameterizations.

When the level of spillovers is zero, firm N undertakes FDI in the South to avoid tariff. If the level of spillovers becomes higher, firm S starts to benefit from the presence of firm N in the South. Furthermore, consumers also benefit because the total quantity supplied increases. We find that the negative effect dominates when θ is relatively small, and the positive effect dominates when θ is relatively high. Thus we find that $WW(\theta)$ is convex in θ under the FDI equilibrium. This differs to the global welfare function in Chapter 2, which is inverted-U shape in spillover rates under the quality-enhancing spillovers model.

With the help of Lemma 1, we are now ready to compare the optimal level of spillovers for the South and the world.

Proposition 6: In the equilibrium of the game:
(i) $WS(\theta)$ is maximized at $\theta = \theta^*$, and
(ii) There exists a threshold value $\tilde{t}$ such that $WW(\theta)$ is maximized at $\theta = 0$ if $t < \tilde{t}$ and it is maximized at $\theta = \theta^*$ if $t \geq \tilde{t}$.

Proposition 6 tells us that the optimal IPR policy for the South is unique, and it is represented by the highest possible level of spillovers that still induces Northern firm's FDI. It also states that FDI can also improve the level of global welfare and that the optimal level of spillover rate for global welfare is zero (North-optimal) or South-optimal level (θ^*).

The intuition behind these results can be explained as follows. Let us fix the tariff rate and start with a zero spillovers so that firm N chooses FDI. An increase in spillover rate creates positive externalities for firm S which intensifies competition. This effect not only benefits firm S but also consumers. As a consequence, provided that the equilibrium of the game is an FDI equilibrium, the South chooses the highest possible spillover rate, $\theta^*(t)$. Now, let us consider an increase in tariff. Recall that at $\theta = \theta^*(t)$, firm N is indifferent between FDI and HP. Hence, if tariff increases, firm N's profit under HP decreases which in turn makes FDI become more attractive. Thus, the South can increase the level of spillovers, suggesting $\theta^*(t)$ is increasing in t.

The remaining task is to compare Southern welfare at $\theta = \theta^*$ and at $\theta = \theta' > \theta^*$. Analogous to Proposition 4 (for instance by replacing $\bar{t} = \frac{\theta^* c}{2}$ we can show that the reduction in equilibrium price as a result of switching from HP equilibrium to FDI equilibrium at $\theta = \theta^*$ is equal to $\bar{t} = \frac{\theta^* c}{2}$), we have that FDI is better for the South at $\theta = \theta^*(t)$. Using Lemma 1 and the fact that global welfare is the sum of Southern welfare and Northern firm's profit, it follows that if FDI makes the South better off at $\theta = \theta^*(t)$, it also increases the level of global welfare.

Proposition 6 states that, there does not exist an outcome in which optimal spillover rate for the world is positive but strictly less than South-optimal as was the case with quality-enhancing spillovers (see Chapter 2). The reason behind this difference is because with cost-reducing spillovers, the Northern firm chooses the minimum marginal cost level under FDI as outlined above.

It is worth pointing out that the Southern government should choose the loosest IPR policy which still induces FDI is consistent with Naghavi (2007) under the duopoly case. However, technology spillovers is a consequence of FDI in our model, while in Naghavi's model it is the consequence of FDI and R&D investment.

In summary, this section provides an analysis of welfare implications of

FDI that is induced by either trade protection or IPR protection. We find a set of new results which has not been captured in the literature, especially the recommendations concerning IPR policy. In the next section, we discuss the similarities and differences between cost-reducing and quality-enhancing spillovers. Such comparisons will help us understand the strategic choice of trade and IPR policy in South (or developing) countries.

3.5 Discussion and Conclusion

Despite the presence of cost-reducing technology spillovers in the South, if trade cost is relatively high and/or the level of spillovers is relatively low, the Northern firm prefers FDI to home-production. Upon FDI, it chooses the lowest marginal cost level for its product which consequently benefits the Southern firm and Southern consumers. We find that with linear demand, the Southern government chooses the optimal IPR policy which is represented by the highest possible spillover rate that guarantees an FDI equilibrium. Furthermore, FDI increases Southern welfare. The implications of FDI on global welfare are richer. Specifically, the spillover rate which would maximize global welfare can be the same as South-optimal level, or zero, which is North-optimal level.

In any case, our results suggest that with suitably designed IPR policy, FDI can increase both global welfare and Southern welfare. These findings support trade protection in Southern countries which encourage FDI that is accompanied by technology spillovers. In this regard, cost-reducing spillovers and quality-enhancing spillovers (presented in previous chapter) could yield different, even contrasting, welfare implications. In what follows, we elaborate on these similarities and differences between these two models.

First, it follows that cost-reducing and quality-enhancing spillovers could yield different outcome concerning the level of technology that Northern firms bring to the South with FDI production. Particularly, the result that the Northern firm brings dated technology to the South (to produce product with lower quality level) in the case of quality-enhancing spillovers does not carry over under cost-reducing spillovers. This is because with cost-reducing spillovers, the Northern firm's profitability becomes lower if it chooses a dated technology (with a positive marginal cost) under FDI. Depending on the level of technology provision under FDI, the consequences on Southern welfare of the two spillovers models can also be different. Hence, our analysis (previous chapter and this chapter) suggests that the Southern governments should account for the different ways in which technology spills over from foreign firms to domestic firms to design trade/IPR policy. For instance, cost-reducing spillovers lead to the outcome in which FDI is better for the South, while quality-enhancing spillovers could yield the opposite result.

Second, consider a planner whose objective is to maximize global welfare. It follows that the planner chooses different IPR policies when the focus changes from quality-enhancing spillovers to cost-reducing spillovers. For instance, the planner could choose a spillover rate which falls in between zero (or North-optimal) and South-optimal level under quality-enhancing spillovers, which does not happen under cost-reducing spillovers (at least with linear demand). With cost-reducing spillovers and linear demand, the optimal spillover rate for the world can be zero or the South-optimal level. In other words, rather than standing in between North and South in solving the IPR conflict in the South, the planner should support either the North or the South. This is a consequence of the fact that global welfare is a (weakly) convex function of the spillover rate.

In the real world, as discussed in previous chapter, the World Trade Organization (WTO) governs the implementation of IPR in its member countries. The focus thus far of this organization has been on Southern IPR regime where the level of protection tends to be the conflict between the North and the South. That is, Northern firms want more protection in the South which protects better their technology, while Southern governments are often reluctant to strengthen IPR protection. This chapter provides a new framework for WTO to justify the cases under which it should support the North and the cases under which it should support the South in designing (or influencing) Southern IPR regime. Recall that, when quality-enhancing spillovers matter, WTO could stand in between North and South. Therefore, WTO should also consider the mechanism of spillovers carefully when planning its IPR policy.

It is worth pointing out that despite some key differences, it is still possible that cost-reducing and quality-enhancing spillovers lead to same recommendations. This applies in the case where FDI improves Southern welfare under quality-enhancing spillovers so that the Southern government also chooses an unique IPR policy - the loosest one that still induces FDI. In such cases, the level of spillovers which maximizes global welfare could be the same as South-optimal level under certain circumstances. Similar trade policy recommendation are also embodied in our analysis in this case. Thus, it is possible to obtain the same policy recommendations concerning IPR policy under both cost-reducing and quality-enhancing spillovers.

Finally, our simple model of cost-reducing spillovers has many common features with previous papers. For instance, our results reinforce Naghavi (2007)'s result in the duopoly case. In Naghavi's paper, technology spills over from Northern firm to Southern firm as a consequence of Northern firm's investment in cost-reducing R&D. In practice, it is often observed that Northern firm does not undertake much R&D with their FDI in the South (see more in Section 3.1). By analyzing North-South duopoly model with spillovers with no R&D activities, this chapter helps to sharpen our understanding of this issue.

Even though most of the results presented in this chapter are specific to functional form of the demand curve, it is possible to show that Propositions 1-3 hold with general demand (downward sloping demand). That is, for any demand function satisfying certain conditions (see more in the Appendix), firm N chooses its minimum marginal cost level in the equilibrium of the game and firm S follows by choosing its lowest possible marginal cost level. This does not matter whether firm N serves Southern market with home-production or FDI. Furthermore, since firm N's profit is weakly decreasing in t (when spillover rate is fixed), and firm N's profit is weakly decreasing in θ (holding tariff rate fixed), it follows that either trade protection or IPR protection would induce FDI. It would be interesting if we could generalize welfare implications of trade/IPR policy with general demand, which will be done in our future research.

In summary, this chapter contributes to the international trade and IPR literature by examining an international Cournot duopoly model with cost-reducing technology spillovers with a focus of linear demand. Consistent to the literature, we show that the Northern firm undertakes FDI in the South when the Southern level of spillovers is low enough and/or the tariff rate is high enough. Under FDI, the Northern firm chooses the minimum marginal cost for its product despite the fact that this creates positive externalities to the Southern firm. We demonstrate that FDI benefits the South and the world as a whole. This contrasts some of the results we presented in the previous chapter where FDI could reduce both Southern and world welfare. Finally, we find that the planner, such as WTO, should either support the North or the South in reconciling the North-South IPR conflict.

Appendix

The Case of General Demand

Let us consider the case when the firms face the inverse demand given by $P(Q)$ where $Q(>0)$ denotes the aggregate output by firms N and S. We assume that $P'(Q) < 0$ for all Q, and that $2P'(Q) + QP''(Q) < 0$. These are standard assumptions for the uniqueness of Cournot equilibrium (see for example Freenstra 2004, pp.224 for the case of constant marginal cost). All other parameters remain the same as the model presented in Section 3.2.

Consider HP subgame. At stage 2, firm N chooses its quantity level q_N to maximize its profit:

$$\max_{q_N} \ (P(Q) - c_N^{hp} - t)q_N, \tag{A.1}$$

at the same time, firm S chooses its quantity level q_S^{hp} to maximize its profit:

$$\max_{q_S} \ (P(Q) - c_S^{hp})q_S. \tag{A.2}$$

First order conditions are given by $P'(Q)q_N + P(Q) = c_N^{hp} + t$ and $P'(Q)q_S + P(Q) = c_S^{hp}$. Totally differentiate these equations with respect to c_N^{hp} we have that

$$\frac{dq_N}{dc_N^{hp}}[P''(Q)q_N + 2P'(Q)] + \frac{dq_S}{dc_N^{hp}}[P''(Q)q_N + P'(Q)] = 1 \tag{A.3}$$

$$\frac{dq_N}{dc_N^{hp}}[P''(Q)q_S + P'(Q)] + \frac{dq_S}{dc_N^{hp}}[P''(Q)q_S + 2P'(Q)] = 0 \tag{A.4}$$

which yields $\frac{dq_N}{dc_N^{hp}} = \frac{P''(Q)q_S + 2P'(Q)}{[P''(Q)q_N + 2P'(Q)][P''(Q)q_S + 2P'(Q)] - [P''(Q)q_N + P'(Q)][P''(Q)q_S + P'(Q)]} = \frac{P''(Q)q_S + 2P'(Q)}{M}$ and $\frac{dq_S}{dc_N^{hp}} = \frac{-[P''(Q)q_S + P'(Q)]}{M}$, and consequently marginal change in equilibrium level of profit of firm N following a change in c_N^{hp} is given by $\frac{d\pi_N^*}{dc_N^{hp}} = \frac{-P'(Q)[2(P''(Q)q_S + P'(Q)) + P''(Q)q_N + 2P'(Q)]}{M}$.

Assumption 1. (i) $P''(Q)q_N + P'(Q) < 0$ and (ii) $P''(Q)q_S + P'(Q) < 0$.

The assumption states that "perceived" marginal revenue for each firm is steeper than the demand curve, which is consistent with Freenstra (2004, pp. 227). With this assumption, it then follows immediately that $\frac{dq_N}{dc_N^{hp}} < 0$, $\frac{dq_S}{dc_N^{hp}} > 0$, $\frac{\pi_N^*}{dc_N^{hp}} < 0$. Hence, firm N chooses the minimum marginal cost level (which equals zero) under HP. By the same token, firm S also chooses its minimum marginal cost level (which equals c_0).

We next investigate FDI subgame. It follows that most of the analysis above for HP subgame still apply. For instance, no mater what level of marginal cost firm N chooses, firm S chooses its lowest possible marginal cost level. Then, in subsequent analysis, firm N has two options: preventing firm S from choosing a marginal cost less than c_0, in which case firm N chooses $c_N^f = c_0$ and firm S chooses $c_S^f = c_0$ as well; or allowing firm S to choose a marginal cost less than c_0, in which case $\frac{\partial c_S^f}{\partial c_N^f} = \theta$ and routine calculations lead to $\frac{dq_N}{dc_N^f} = \frac{P''(Q)q_S + 2P'(Q) - \theta[P''(Q)q_S + P'(Q)]}{M}$ and $\frac{dq_S}{dc_N^f} = \frac{\theta[P''(Q)q_N + 2P'] - [P''(Q)q_S + P'(Q)]}{M}$. Firm N's equilibrium profit is changing in c_N^f at $\frac{d\pi_N^*}{dc_N^f} = \frac{-P'(Q)[2(P''(Q)q_S + P'(Q)) + P''(Q)q_N + 2P'(Q)] - \theta[P''(Q)q_N + 2P'][2P''(Q)q_N + P'(Q)]}{M}$.

Assumption 2. (i) $2P''(Q)q_N + P'(Q) < 0$.

Choosing a higher marginal cost level results in lower profitability for firm N whenever assumption 2 holds. Without such assumption, we will need to restrict parameterizations a bit further (also note that most demand functions satisfy this condition, including the popular linear demand). Comparing to the case firm N chooses its marginal cost level equal to c_0, it follows that the option of choosing a zero marginal cost level is more profitable for firm N. This is because by choosing $c_N^f = 0$ rather than choosing $c_N^f = c_0$, firm N's marginal cost reduces by an amount equal to c_0 while firm S's marginal cost reduces by θc_0, which in turn makes firm N relatively better off. Again, it follows that firm N chooses its minimum marginal cost level under FDI despite the impact of technology spillovers. This suggests that Proposition 1 still holds with general demand.

Finally, we can demonstrate that Proposition 2-3 also hold with general demand. Proposition 2 holds since t and c_N^{hp} play the same role under HP subgame, we have that $\frac{d\pi_N^*}{dt} = \frac{-P'(Q)[2(P''(Q)q_S + P'(Q)) + P''(Q)q_N + 2P'(Q)]}{M} < 0$. That is, firm N's profit is decreasing in tariff rates under HP. For a given level of θ profit of firm N under FDI is a constant, so that as long as tariff is under a certain value, firm N chooses HP and it chooses FDI if tariff becomes equal to or exceeding this value.

To show that Proposition 3 and holds with general demand, from first order conditions for problems (A.1) and (A.2), totally differentiate with respect to θ yields:

$$\frac{dq_N}{d\theta}[P''(Q)q_N + 2P'(Q)] + \frac{dq_S}{d\theta}[P''(Q)q_N + P'(Q)] = 0 \qquad (A.5)$$

$$\frac{dq_N}{d\theta}[P''(Q)q_S + P'(Q)] + \frac{dq_S}{d\theta}[P''(Q)q_S + 2P'(Q)] = -c \qquad (A.6)$$

which leads to $\frac{dq_N}{d\theta} = \frac{c[P''(Q)q_N+2P'(Q)]}{M}$ and $\frac{dq_S}{d\theta} = \frac{-c[P''(Q)q_N+2P'(Q)]}{M}$. With these results, $\frac{d\pi^*_N}{d\theta} = \frac{-q_N cP'(Q)[P''(Q)q_N+2P'(Q)]}{M} < 0$.

Corollary 1. When assumptions 1 and 2 hold then Proposition 1-3 hold with general demand.

Note that, with general demand, we have that $WW(\theta) = \int_0^Q P(x)\,\mathrm{d}x - (1-\theta)cq_S$. Therefore, $\frac{dWW^*}{d\theta} = \frac{q_S - P(Q)P'(Q)+(1-\theta)c[P''(Q)q_N+2P']}{M}$ which has ambiguous sign. However, $\frac{dWW^*}{d\theta}[\theta = 1] > 0$ so that if $\frac{dWW^*}{d\theta} = 0$ has unique solution then $WW(\theta)$ is weakly convex in θ. Linear demand is a good example, which satisfies this condition and the assumptions as have been identified as above.

Proof of Proposition 1.

Since firm $\frac{\partial \pi_N^{hp*}}{\partial c_N^{hp}} < 0$ and $\frac{\partial \pi_N^{f*}}{\partial c_N^{f}} < 0$, we have that $c_N^{hp} = c_N^f = 0$.
Q.E.D.

Proof of Proposition 2.

Compare firm N's equilibrium levels of profit between HP and FDI it follows that $\pi_N^{f*} > \pi_N^{hp*} \leftrightarrow t > \frac{\theta c_0}{2} = \bar{t}$.
Q.E.D.

Proof of Proposition 3.

Compare firm N's profit between HP and FDI it follows that $\pi_N^{f*} > \pi_N^{hp*} \leftrightarrow \theta < \frac{2t}{c_0} = \theta^*$.
Q.E.D.

Proof of Proposition 4.

In the equilibrium of HP subgame, Southern welfare is $WS(t)^{hp} = \pi_S(t)^{hp} + CS(t)^{hp} + G(t)^{hp}$ where $CS(t)^{hp}$ and $G(t)^{hp}$ respectively denote consumer surplus and government revenue. We have that $CS(t)^{hp} = \frac{1}{2}\big(q_N^{hp} + q_S^{hp}\big)^2 = \frac{1}{2}\big(\frac{2A-t-c_0}{3}\big)^2$, while $G(t)^{hp} = tq_N^{hp} = t\big(\frac{A-2t+c_0}{3}\big)$. Thus, $WS(t)^{hp} = \big(\frac{A-2c_0+t}{3}\big)^2 + \frac{1}{2}\big(\frac{2A-t-c_0}{3}\big)^2 + t\big(\frac{A-2t+c_0}{3}\big)$. It is straightforward to show that $\frac{\partial WS(t)^{hp}}{\partial t} = \frac{1}{3}(A-3t) > 0$ for all $t \leq \bar{t} = \frac{1}{2}\theta c_0$ (From footnote 7, it follows that $A > 1.5\theta c_0$ for all $\theta \in [0,1)$.), thus WS^{hp} is increasing in t for all $t \leq \bar{t}$, and it is maximized at $t = \bar{t}$.

In the equilibrium of FDI subgame, Southern welfare is $WS(t)^f = \pi_S(t)^f + CS(t)^f = \pi_S(t)^f + \frac{1}{2}\big(q_N^f + q_S^f\big)^2 = \big(\frac{A-2(1-\theta)c_0}{3}\big)^2 + \frac{1}{2}\big(\frac{2A-(1-\theta)c_0}{3}\big)^2$, which is increasing in θ. At

$t = \bar{t} = \frac{1}{2}\theta c_0$, it follows that $WS^{hp}|_{t=\frac{1}{2}\theta c_0} = \left(\frac{A-2c_0+\frac{1}{2}\theta c_0}{3}\right)^2 + \frac{1}{2}\left(\frac{2A-\frac{1}{2}\theta c_0-c_0}{3}\right)^2 + \frac{1}{2}\theta c_0\left(\frac{A-2(\frac{1}{2}\theta c_0)+c_0}{3}\right)$. Then $WS(\bar{t})^{hp} < WS(\bar{t})^f \leftrightarrow A - 2c_0 + 5\theta c_0 > 0 \leftrightarrow A - 2c_0 + 2.5\bar{t} > 0$, which always holds (see footnote 7). Furthermore, since firm N is indifferent between HP and FDI at $t = \bar{t}$, $WW(\bar{t})^f > WW(\bar{t})^{hp}$. It can also be verified that $\pi_S(\bar{t}) > \pi_S(t') \leftrightarrow -2(1-\theta)c_0 > -2c_0 + t \leftrightarrow 3\theta c_0 > 0$, which is true.

Alternatively, equilibrium price level between HP and FDI at $t = \bar{t} = \frac{\theta c_0}{2}$ are given by $P^f = \frac{2A+c_0+t}{3}$ and $P^{hp} = \frac{2A+(1-\theta)c_0}{3}$ so that $P^f - P^{hp} = \frac{t+\theta c_0}{3} \equiv \frac{\theta c_0}{2} = \bar{t}$ at $t = \bar{t}$. Hence, switching of equilibrium from HP to FDI improves consumer surplus more than the loss in government revenue.

Q.E.D.

Proof of Proposition 5.

The proof is similar to the Proof of Proposition 4 if we replace $\bar{t}$ by $\frac{\theta c_0}{2}$.

Q.E.D.

Proof of Lemma 1:

Under FDI, we have that $WW(\theta) = WS(\theta) + \pi_N^f$. From above calculation, we find that $\frac{\partial WW(\theta)}{\partial \theta} = \frac{1}{9}c_0\big(4A - 11c_0 + 11\theta c_0\big)$, and $\frac{\partial^2 WW(\theta)}{\partial \theta^2} = \frac{11}{9}c_0^2 > 0$. Hence, $\frac{\partial WW(\theta)}{\partial \theta} > 0 \leftrightarrow \theta > 1 - \frac{4A}{11c_0} = \tilde{\theta}$. Furthermore, $\tilde{\theta} < \theta^* \leftrightarrow 4A > 11c_0 - 22t$.

Q.E.D.

Proof of Proposition 6.

First, by Proposition 5, at $\theta = \theta^*$, Southern welfare and global welfare are higher under FDI than under HP. Second, consider FDI equilibrium: $\partial WS(\theta)/\partial\theta = 2\frac{2c_0}{3}[\frac{A-2(1-\theta)c_0}{3}] + \frac{c_0}{3}[\frac{2A-(1-\theta)c_0}{3}] > 0$ so that $WS(\theta)$ is strictly increasing in θ under FDI. By Lemma 1, if $t < \frac{11c_0-4A}{22} = \dot{t}$ then $\tilde{\theta} > \theta^*$ so that $\frac{\partial WW(\theta)}{\partial\theta} < 0$ for all $\theta \in [0, \theta^*]$ and $WW(\theta)$ is maximized at $\theta = 0$. If $t \geq \dot{t}$ then $\tilde{\theta} \leq \theta^*$, $WW(\theta)$ is convex in θ and there are two candidates which maximize $WW(\theta)$ under FDI: $\theta = 0$ or $\theta = \theta^*$. Here, $WW(\theta = 0) = [\frac{A-2c_0}{3}]^2 + \frac{1}{2}[\frac{2A-c_0}{3}]^2 + [\frac{A+c_0}{3}]^2$, while at $\theta = \theta^* = \frac{2t}{c_0}$, $WW(\theta^*) = [\frac{A-2c_0+4t}{3}]^2 + \frac{1}{2}[\frac{2A-c_0+2t}{3}]^2 + [\frac{A+c_0-2t}{3}]^2$. It then follows that $WW(\theta = 0) > WW(\theta = \theta^*) \leftrightarrow 4A < 11c_0 - 11t \leftrightarrow t < c_0 - \frac{4A}{11} = \hat{t}$. Note that $\hat{t} > \dot{t}$ holds. Finally, by defining $\tilde{t} = max(0, \hat{t})$ leads to Proposition 6.

Q.E.D.

3.6 References

Australian Chamber of Commerce and Industry. 2006, *China FTA - Need for Progress on Intellectual Property Rights.*

Belderbos, R. 2006, *R&D Activities in East Asia by Japanese, European, and US Multinationals,* JCER Discussion Paper No. 100.

Carluccio, J. & Fally, T. 2010, "Multinationals, Technological Incompatibilities, and Spillovers." *CEPR Discussion Papers 7869.*

Chin, J.C. & Grossman, G.M. 1990, *Intellectual Property Rights and North-South Trade,* In: Jones, R.W., Krueger, A.O. (eds), The Political Economy of International Trade: Essays in Honor of Robert E. Baldwin. Blackwell, Cambridge, MA.

Deardorff, A. 1992, "Effects of Global Patent Protection." *Economica,* Vol. 59(233).

Diwan, I. & Rodrik, D. 1991, "Patents, Appropriate Technology, and North-South Trade." *Journal of International Economics,* Vol. 30.

Freenstra, R.C. 2004, *Advanced International Trade: Theory and Evidence,* Princeton University Press.

Glass, A.J. & Saggi, K. 2002, "Multinational Firms and Technology Transfer." *Scandinavian Journal of Economics,* Vol. 104(4).

Grossman, G.M. & Lai, E. 2004, "International Protection of Intellectual Property." *American Economic Review,* Vol. 94(5).

Helpman, E. 1993, "Imitation, and Intellectual Property Rights." *Econometrica,* Vol. 61(6).

Keller, W. 2004, "International Technology Diffusion." *Journal of Economic Literature,* Vol. 42(3).

Kim, J.E. & Lapan, H.E. 2008, "Heterogeneity of Southern Countries and Southern Intellectual Property Rights Policy." *Canadian Journal of Economics,* Vol. 41(3).

Lai, E. & Qiu, L.D. 2003, “The North’s Intellectual Property Rights Standard for the South?” *Journal of International Economics,* Vol. 59.

Naghavi, A. 2007, “Strategic Intellectual Property Rights Policy and North-South Technology Transfer.” *Review of World Economics,* Vol. 143(1).

Saggi, K. 2002, “Trade, Foreign Direct Investment, and International Technology Transfer: A Survey.” *The World Bank Research Observer,* Vol. 17(2).

World Trade Organization. 2009, *Understanding the WTO: The Agreements. Intellectual Property: Protection and Enforcement,* viewed 10 April 2010, <http://www.wto.org/english/thewto_e/whatis_e/tif_e/agrm7_e.htm>

Zigic, K. 1998, “Intellectual Property Rights Violations and Spillovers in North-South Trade.” *European Economic Review,* Vol. 42.

Zigic, K. 2000, “Strategic Trade Policy, Intellectual Property Rights Protection, and North-South Trade.” *Journal of Development Economics,* Vol. 61.

Chapter 4

Technology Spillovers and Export-Platform FDI

4.1 Introduction

As reported by UNCTAD (2005), recently, foreign direct investment (FDI) in developing countries has been driven by export activities. That is, many multinational companies (MNCs), headquartered in Northern countries, have shifted their production from home to the South and use Southern production as a platform to export their products to other countries. This situation is often referred to as Export-Platform FDI (EPF herein after) in the international trade literature (Ekholm, Forslid & Markusen 2007). In this literature, the main driving force of EPF is the locational cost-advantage of the country that hosts EPF. These include (i) production-cost advantage, in particular low labor cost, and (ii) transaction-cost advantage, which may be the result of some bilateral (or regional) trade agreements between the country that hosts EPF and the export markets of the MNC. In this respect, FDI in automobile industry in Argentina and Brazil was mainly for export to Mexico thanks to the bilateral agreement between MERCOSUR Countries and Mexico (UNCTAD 2005). Similarly, Japanese manufacturing firms view ASEAN member countries as ideal place to invest in order to export to other ASEAN countries

(JETRO 2008).[1]

FDI often brings about several benefits for the host countries. For instance, it generates tax revenue for the government from the value-added, creates jobs and, finally it helps to modernize the production process of host countries due to technology transfer (UNCTAD 2002). In recent years, more emphasis has been placed on the role of technology spillovers. Many Southern countries have become active in seeking FDI into industries which have export potentials. However, this often requires local firms to learn advanced technologies from foreign firms. This gap in technology is due to the fact that advanced technology is often the result of extensive R&D investment that only firms in developed country could afford.[2] Very often Southern countries have weak Intellectual Property Rights (IPR) regime which enables local firms to learn from foreign firms and eventually compete with foreign firms in their export markets. In other words, local firms can benefit from technology spillovers from foreign firms under EPF, which explains the movement of Southern countries toward encouraging EPF.

In Chinese automobile industry, the government has imposed high trade barrier in order to induce foreign automakers to shift their factories to China, where they manufacture cars for sale in China as well as exporting to neighboring countries. The inclusion of foreign companies in Chinese automobile industries, as targeted by Chinese government in its 1994 "China Automotive Industry Policy", should aim to create technology transfer to local auto-makers, and expand exports (Long 2005). After nearly two decades, this policy has been successfully implemented, with Chinese automakers beginning to export cars

[1] JETRO's survey conducted in 2007 detailed that Japanese-affiliated manufacturing firms undertaking FDI in ASEAN countries have exported between 21.4% and 45.3% of their output to ASEAN region (excluding sales in the country they invest). Xuan and Xing (2008) tested the gravity model for Vietnam and found strong correlation between FDI and export.

[2] Keller (2004) demonstrated that, most of world's creation of new technology are concentrated on a few rich countries.

to the world market. It was observed that, Chinese car manufacturers learned advanced techniques from foreign firms, mainly through labor mobility (Luo 2005, Gallagher 2003). The benefit through learning is often referred to as technology spillovers. This was supported by the Chinese government through its FDI policy in which it asked foreign automakers to share their technology with local partners, and at the same time provided weak IPR protection for the industry.[3] Whilst Japan and U.S. manufacturers, such as Honda and General Motors, exported cars from China to other countries, since early 2000s, many local Chinese automakers have also started to export Chinese-made cars.[4]

This phenomenon has also been witnessed in many different industries in several countries. In India, the software industry could not have been so well developed without investments of U.S. multinationals. As documented by Bhatnagar (2006), and Pack and Saggi (2006), U.S. multinationals mainly used India as an export platform. Many local Indian firms have acquired the necessary knowledge to produce export-quality softwares by recruiting experienced engineers from U.S. software firms (both from the U.S. Silicon Valley or engineers come with U.S. multinationals to Bangalore). Consequently, as U.S. multinationals increased their export volume to over 60 countries from Indian affiliates, local firms also caught up quickly - currently, local firms account for 75% of software exports from India (Millar 2000, Bhatnagar 2006).

As suggested by above examples, in the presence of technology spillovers, different Southern countries adopt different IPR regimes to induce EPF by Northern firms. What is the optimal IPR policy the Southern government should choose to maximize the benefits of EPF? In other words, does the South benefit from protecting IPR? How does IPR protection in the South

---

[3]China only allows foreign automakers to set up joint ventures with domestic firms as the mode of entry, rather than operating wholly foreign owned company. Foreign firms are asked to share their technology with Chinese partners (Long 2005, Luo 2005).

[4]For instance, Chery exported around 50,000 cars in 2006 and 119,800 cars in 2007. Source: <www.businessweek.com/globalbiz/content/dec2008/gb20081212_144409.htm>.

affect Northern firms? How does preferential trade liberalization between the South and the export market of the Northern firms affect Southern optimal IPR policy? What is the impact of a larger Southern market on its incentive toward IPR protection?

This chapter attempts to address the above questions by exploring a North-South duopoly model with technology spillovers. In our set-up, a Northern firm (firm N) and a Southern firm (firm S) compete in the Southern market and a third-country market in a Cournot fashion. Firm N can either locate itself at home (HP) or undertake EPF in the South. However, firm S is only located in the South. If firm N locates itself in the South (EPF), it can avoid the trade costs whilst serving the Southern market. At the same time, EPF helps firm N to exploit the difference in trade costs as it exports to third market from the South.[5] However, the drawback of EPF for firm N is that its technology spills over to firm S and intensifies competition between them in both markets.

We find that, under certain parameterizations, EPF undertaken by firm N improves Southern welfare. At the same time, since a loose IPR environment benefits both firm S and Southern consumers, the South has incentive to choose the highest possible level of spillover rate that still induces EPF. If trade between the South and third market becomes more liberalized, the South demurs its incentive to strengthen its IPR protection. Finally, our model predicts that, when EPF is optimal for the South and the degree of trade liberalization between the South and the third market is great enough, following Southern market becoming larger, the South offers stronger IPR protection for the foreign firm.

The intuition of our result goes as follows. In Chapter 3, where the third market was absent, we have shown that inducing Northern firm's FDI improves Southern welfare if the market demand is linear. Now let us introduce

[5] In subsequent analysis, we will assume that trade cost between the South and third country is lower compared to that between the North and the third country. In particular, we focus our analysis here forth to the consideration of a bilateral trade agreement between the South and third country.

the third market. The presence of the third market makes Northern firm's choice between export and undertaking FDI in the South (which is EPF) become more strategic since the degree of competition in both of these markets can be higher or lower with technology spillovers. However, if the degree of trade liberalization is high enough, it follows that shifting production from home to the South enables the Northern firm to make more profit from third market. In such cases, the optimal IPR protection level of the South (which induces FDI) can be looser. Furthermore, the more trade is liberalized between the South and the third market, the higher the incentive the Northern firm to move toward EPF, which in turn induces the South to provide weaker IPR protection. By the same token, since firm N gains from the third market with EPF, it looses from Southern market (assuming the South chooses its optimal IPR policy). Therefore, if the South market becomes larger, the South needs to compensate Northern firm with a stronger IPR protection.

There has been a growing number of studies that addressed EPF in the international trade literature. However, most previous papers have focused on the strategic choice of symmetric Northern firms between export, FDI, and EPF based on the differences in production costs and tariffs between countries (Ekholm et al. 2007, Motta & Norman 1996). In these papers, there are no technology spillovers. In contrast, EPF has not yet been examined in technology spillovers literature. This literature has concentrated on how a Northern firm, which has superior technology compared to its Southern competitor, reacts to IPR regimes in the South (Chin & Grossman 1990, Zigic 1998). Loose IPR regime benefits the Southern firm who can imitate Northern competitor's technology. Naghavi (2007) augmented this cost-reducing technology spillovers framework to investigate the Northern firm's choices between export and FDI.[6] He found that if duopoly is prevailing form of market structure, FDI improves Southern welfare. To the best of our knowledge, no previous papers have analyzed the economic impact of IPR policy in an EPF model with technology spillovers.

[6]See also Glass and Saggi (2002).

The rest of the chapter will proceed as follows. Section 4.2 reviews the related literature, followed by a description of the model in Section 4.3. Section 4.4 characterizes SPNEs of the model. Section 4.5 and 4.6 explore optimal IPR policy for the South and the impact of trade liberalization. Section 4.7 discusses the results and offers some concluding remarks.

4.2 The Related Literature

The traditional argument that trade and FDI are substitutes based on the proximity-concentration trade-off, often referred to as tariff-jumping motive of FDI, does not coincide with the huge influx of FDI in many European countries in 1990s (Neary 2002, 2009). That is, even though the standard trade theory predicts that, the trade cost reduction between trading partners discourages FDI, in reality, FDI has actually been increased in these countries following trade liberalization. To explain this paradox, Neary argued that, intra-bloc trade liberalization has induced foreign firms to establish plants in one country as an export platform to serve the bloc as a whole. There are two sources of gain for the foreign firms from EPF: (i) tariff-jumping gain as the host country market is served from local plant, and (ii) trade-liberalization gain if the export market forms trade liberalization with the country that hosts EPF. This argument is supported by real world evidences, especially FDI into the European Union from U.S. and Japanese companies during the 90s (see also Head & Mayer 2004).

Motta and Norman (1996) considered an oligopoly model with three firms, one in country U, one in G, and one in J. All these countries are of equal size and the firms are similar in all respects. Motta and Norman focused on market U and market G only. They showed that, a regional trade agreement between U and G will induce the outside firm (from J) to undertake EPF in either U or G. If the degree of trade liberalization is great enough, the gain from consumer surplus (due to the price reduction) under EPF outweighs the loss in domestic firms' profit which results from increased competition. This implies that, EPF

improves total welfare for U and G. They also demonstrated that U and G could further gain by liberalizing trade between these two countries to induce EPF rather than to coordinate for a tougher common external trade policy. This result captures the gains accrued to member countries in EU, NAFTA, and ASEAN following regional trade liberalization.

Recently, Ekholm et al. (2007) developed a duopoly model with two symmetric Northern firms from countries West (W) and East (E) which serve consumers in their home country and the rival's country. There is a third country, country S, which serves as a production platform, where the production cost is lower than both W and E. They found that, when trade costs between any two countries are the same and production costs in S are low enough, both firms from W and E will pursuit a global export platform strategy in which they manufacture all products in S and export to W and E. If S and W form a free trade agreement and production cost saving in S are modest, they found that both firms will have a plant in S to serve consumers in country W, and both will have a plant in E to serve consumers in E. That is, the outside firm undertakes EPF. The authors argued that this framework explains the tendency of U.S. multinationals to adopt EPF, especially U.S. affiliates in North America and Europe.

How is FDI, in particular EPF, related to technology spillovers? Saggi (2002) argued that, firms undertaking FDI often have superior technology compared to competitors in host countries. Furthermore, FDI often leads to international technology transfer from foreign to domestic firms. How well a developing country can take advantage of technology transfer from FDI depends on several factors. Specifically, it includes the protection it offers for intellectual property rights. Along this line, there has been a large literature which examined the relationship between trade and FDI where technology spills over from foreign to local firms. In a seminal contribution, Chin and Grossman (1990) developed a Cournot duopoly model in which a Northern firm competes with a Southern firm in an integrated world market where only Northern firm can invest in cost-reducing R&D activities. However, Northern firm's technology can be imitated by a Southern competitor if Southern IPR regime is loose. Zigic (1998) extended this framework and introduced continuous spillovers, which represents the level of IPR protection in the South. These authors found that, if duopoly is the prevailing form of market structure, loose IPR regime tends to improve Southern welfare.

Naghavi (2007) augmented the above cost-reducing technology spillovers framework by focusing on Southern market and examining Northern firm's choice of modes of entry into Southern market between export and FDI. Naghavi found that FDI improves Southern welfare when duopoly is the prevailing form of competition. Glass and Saggi (2002) considered an international duopoly model where technology spillovers can be prevented by a wage premium.[7] They showed that, even when competition takes place in a different country, FDI improves the host country's welfare due to the benefits accrued to either the host firm or the workers. In Chapter 3, we introduced a simple model of cost-reducing spillovers and confirm that these results are robust in the set up where there is no R&D activities.

To the best of our knowledge, no previous papers have incorporated technology spillovers into an EPF framework. By elaborating on this aspect, we discover new policy implications of IPR policy. Most importantly, we find that if trade becomes more liberalized between the South and third country, the South has less incentive to strengthen its IPR protection. The model also predicts that if the South market becomes larger, the South provides stronger IPR protection for the foreign firm.

4.3 The Model

We consider an international duopoly model with two firms, a Northern firm (firm N) which has headquarter in the North, and a Southern firm (firm S)

[7] In Glass and Saggi (2002), technology transfer through labor mobility. When the source firm undertakes FDI, its workers can switch to work for a local competing firm. To prevent this labor mobility, the source firm can pay a wage premium to retain workers.

which has headquarter in the South. They compete by producing a homogeneous good. Firm N can locate itself in the North (home-production, denoted HP) or in the South (FDI), while firm S can only locate itself in the South. Furthermore, firm N has superior technology compared to firm S, which leads to firm N's marginal cost being lower than that of firm S. To simplify the analysis, we assume that without technology spillovers, firm N's marginal cost is zero, while firm S's marginal cost is equal to $c(> 0)$. Fixed costs are assumed to be sunk.

Technology spillovers in our model work in the following manner. If firm N locates itself in the North (HP), there is no spillover. If firm N locates itself in the South (FDI), its technology spills over to the firm S. This lowers the marginal cost of firm S by an amount equal to θc, where $\theta(\in [0, 1])$ is a parameter representing the spillover rate, which often captures the degree of IPR enforcement in the South (see more on this in previous chapters). That is, if firm N undertakes FDI, firm S's marginal cost is $c' = (1 - \theta)c$. At its extreme values, $\theta = 0$ represents the case firm N's technology is fully protected in the South so that firm S's marginal cost remains at c even if firm N undertakes FDI in the South; $\theta = 1$ represents the case firm S can fully copy firm N's technology under FDI so that its marginal cost is zero upon firm N's presence in the South.

Consumers are located in the South (market S) and a third-country (market T). Trade costs between any two countries are represented by specific tariff rates. Let t_1, t_2, and t, respectively, be the tariff rates between Northern country and Southern country, Northern country and third country, and Southern country and third country (see Figure 4.1).[8] The representative market-S consumer's utility function is given by $U_S = A(q_{NS} + q_{SS}) - b\frac{q_{NS}^2+2q_{NS}q_{SS}+q_{SS}^2}{2}$, and the representative market-T consumer's utility function is given by $U_T =$

[8]We ignore the Northern market to simplify the analysis. There are several possible explanations for this exclusion, for instance, consumer characteristics, language barrier, cultural barrier, etc. As an example, Japanese consumers often buy electronic products from Japanese firms, and they rarely buy electronic products with a foreign brand-name.

$B(q_{NT}+q_{ST}) - \frac{q_{NT}^2+2q_{NT}q_{ST}+q_{ST}^2}{2}$. Here, q_{ij}, $i \in \{N, S\}$ and $j \in \{S, T\}$, denotes firm i's quantity level in market j, and $b(>0)$ represents the size of market S - a higher b corresponds to a smaller market. The representative consumer in market j maximizes $U_j - p_j(q_{Nj} + q_{Sj})$, which yields the following inverse demands for markets S and T:

$$p_S = A - b(q_{NS} + q_{SS}), \tag{4.1}$$

$$p_T = B - q_{NT} - q_{ST}. \tag{4.2}$$

We consider a two-stage game, described below.

[**Stage 1**] Firm N chooses its location between HP and EPF.

[**Stage 2**] Firms N and S compete in quantity.

Notice that the game described above has two stage 2 subgames, one is HP subgame where firm N locates itself at home, while the other is EPF subgame where it locates itself in the South.

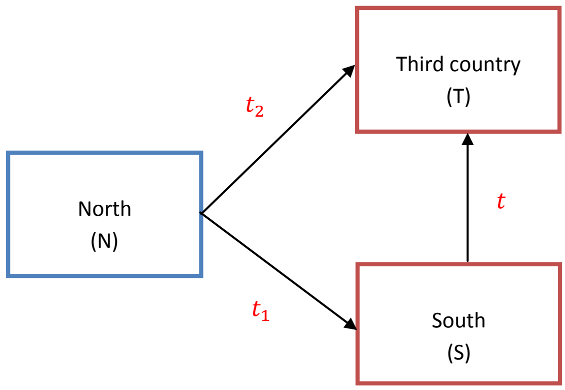

Figure 4.1: Trade between countries.

The model described above has three distinctive features compared to the traditional EPF studies (Ekholm et al. 2007, Motta & Norman 1996). First, we focus on competition between a Northern firm and a Southern firm, rather than between two symmetric Northern firms. Second, we introduce asymmetry between firms in terms of technology, that is, firm N has superior technology compared to firm S. This shows up as a gap in the firms' marginal costs of production. Finally, we incorporate technology spillovers into the model in a similar fashion to the model presented in Chapter 3. In the subsequent section, we will characterize the Subgame Perfect Nash Equilibria (SPNEs) of the game and elaborate on its basic properties.

4.4 Analysis

Let us now derive Subgame Perfect Nash Equilibria (SPNEs) of the model as described in previous section. Throughout the analysis, we focus on the case where trade is more liberalized between the South and the third country when compared to the North and the third country. This captures the case such as regional trade liberalization within European nations, or ASEAN so that foreign firms can follow export-platform FDI strategy to serve the whole region from one member country. More precisely, we assume that $t \leq t_2$ holds. We further restrict parameters such that firms N and S always sell a strictly positive amount of their products in both markets in the equilibrium of the game. This happens when the value of A and B are high enough.[9]

4.4.1 Cournot Competition

This sub section focuses on the equilibrium of the game. Let the superscript denote the subgame and let π_i^{hp} and π_i^{epf} be equilibrium profit of firm $i(=N,S)$ in the HP subgame and EPF subgame. Our analysis starts by examining the last stage of the game where firms N and S compete in quantities. Let us first consider the equilibrium of HP subgame. From Chapter 3, it follows that with duopolistic competition, each firm chooses its lowest possible marginal cost level in the equilibrium of the game. At stage 2, firm N chooses q_{NS}^{hp} and q_{NT}^{hp} and firm S chooses q_{SS}^{hp} and q_{ST}^{hp}. Routine calculations give $q_{NS}^{hp} = \frac{A-2t_1+c}{3b}$, $q_{NT}^{hp} = \frac{B-2t_2+c+t}{3}$, $q_{SS}^{hp} = \frac{A-2c+t_1}{3b}$, and $q_{ST}^{hp} = \frac{B-2(c+t)+t_2}{3}$.

[9] By examining firms N and S's profit functions in each subgame, these assumptions are given by $A > 2c$, $B > max\big(2(c+t), 2t_2\big)$. These assumptions help us to reduce a number of cases to be considered and, at the same time, simplifies the comparison of our findings with the literature.

We now turn to the EPF subgame, i.e. where firm N undertakes export-platform FDI in the South. Since firm N's marginal cost is zero while that of firm S is $(1-\theta)c$, routine calculations yield $q_{NS}^{hp} = \frac{A+(1-\theta)c}{3b}$, $q_{NT}^{hp} = \frac{B+(1-\theta)c-t}{3}$, $q_{SS}^{hp} = \frac{A-2(1-\theta)c}{3b}$, and $q_{ST}^{hp} = \frac{B-2(1-\theta)c-t}{3}$.

Firm N makes its location decision based on the level of profit it obtains from the equilibrium of HP subgame and EPF subgame. Since under the EPF subgame, firm N's profit is decreasing in spillover rates, but it is independent of the spillover rates under HP, it follows that firm N prefers EPF when the level of spillovers is not too high. This is formalized in the following proposition. Note that all proofs are presented in the Appendix.

Proposition 1. There exists a value $\theta^*(\geq 0)$ such that the equilibrium of the game is an EPF equilibrium if $\theta \leq \theta^*$ and it is an HP equilibrium otherwise, where $\theta^* \in [0, 1)$ holds under a range of parameterizations.

To understand the logic behind proposition 1, assume $\theta = 0$ and $t = 0$. Then, firm N undertakes EPF since it can avoid trade costs, and the equilibrium of the game is an EPF equilibrium in which both firms sell a strictly positive amount of products in both markets. Let us increase the value of θ. Higher spillovers reduce marginal cost for firm S. Consequently, this increases firm S's equilibrium quantity in both markets and decreases firm N's equilibrium quantity in both markets (see Chapter 3 for similar analysis of the impact of increasing in θ on each firm's equilibrium quantity and profit when demand is linear). In other words, increasing the value of spillovers decreases firm N's profitability by increasing firm S's profitability. Since firm N's profit under HP does not depend on θ, it follows that firm N has incentive to undertake EPF only when the spillover rate is not too high.

Under the presence of cost-reducing technology spillovers in the South, firm N has to compare the benefits of trade-cost saving and the negative effects of technology spillovers when it chooses the location between HP and EPF. We have shown that, to induce EPF, the South should pursue a strong enough IPR protection regime. What level of IPR protection is optimal? We address this question in the subsequent section.

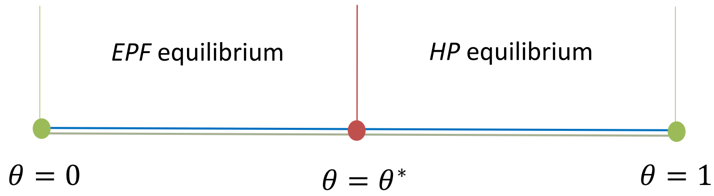

Figure 4.2: Technology spillovers and Northern firm's location choice.

4.5 The Impact of IPR Policy

We now explore the optimal IPR policy for the South, represented by the level of spillovers, θ, that maximizes Southern welfare. To fulfill this objective, we will compare the maximum level of Southern welfare under EPF equilibrium (when $\theta \in [0, \theta^*]$) and under HP equilibrium (when $\theta > \theta^*$). Even though under EPF equilibrium, Southern welfare becomes higher if the level of spillovers increases (see Lemma 1 below), which is similar to the results of Chapter 3 (where FDI replaces EPF), when there is a switching of equilibrium between HP and EPF (at $\theta = \theta^*$), there is no single answer whether EPF or HP is better for the South, because of the presence of the third market.

To simplify the analysis, we will adopt several results from Chapter 3 by assuming the following conditions: (i) $t_2 > t_1$, and (ii) $t \leq t_2 - t_1$. These conditions guarantee that if the level of spillovers in the South is set as in the model of Chapter 3 (without the third market), then the presence of the third market gives Northern firm more incentives to undertake FDI in the South. That is, if $\theta = \frac{2t_1}{c}$, Northern firm's profitability captured from market T is higher under EPF than under HP so that it continues to locate in the South (as will be shown later). These conditions help us to focus our analysis on addressing export-platform FDI into many developing countries such as China and ASEAN members by firms from Japan and the U.S. These Northern MNCs viewed export-platform FDI as a channel to exploit low trade cost from the country where the platform is located to their export markets (see Section 4.1). See section 4.7 for a discussion on the case of $t > t_2 - t_1$.

Lemma 1. Under the EPF equilibrium, Southern welfare is strictly increasing in θ.

When $\theta \leq \theta^*$, the equilibrium of the game is an EPF equilibrium. In this equilibrium, an increase in the spillover rate (i.e. when $\theta \in [0, \theta^*)$) reduces firm S's marginal cost. Consequently, this increases firm S's output in equilibrium of the EPF subgame. This effect not only benefits firm S but also Southern consumers since the increase in total output drives down equilibrium price.[10] Hence, the net effect a slight increase in $\theta \in [0, \theta^*)$ on Southern welfare (which is the sum of firm S's profit and consumer surplus) is positive.

Lemma 1 says that, under EPF equilibrium, the South should choose the highest possible value of spillovers (that is, it chooses $\theta = \theta^*$). Recall from previous section that when θ exceeds θ^*, the equilibrium of the game switches from EPF to HP. Does an increase in θ from $\theta = \theta^*$ to $\theta' > \theta^*$ improve Southern welfare? Since the Southern welfare consists of Southern consumer surplus, tariff revenue, firm S's profit from the Southern market and the third market, the answer is not clear cut. In what follows, we demonstrate the existence of parameterizations such that the Southern government chooses $\theta = \theta^*$ to maximize Southern welfare in the equilibrium. We do so by examining the case in which the inclusion of the third market makes EPF more attractive for both firm N and firm S compared to the case without the third market (Chapter 3).

Proposition 2. There exists a value $\hat{t}$, $0 \leq \hat{t} \leq max(t_2 - 4t_1, 0)$, such that when $\hat{t} \leq t \leq t_2 - t_1$ holds, the optimal IPR policy for the South is represented by the highest level of spillovers that still induces EPF by the Northern firm. That is, $\theta = \theta^*$.

Proposition 2 tell us that, for all $t \in [\hat{t}, t_2 - t_1]$, inducing EPF (by choosing $\theta = \theta^*$) always benefits the South. The intuition behind this result can be explained as follows. Let us compare the profit for firm N in market T under HP equilibrium and under EPF equilibrium. It follows that, firm N's profit

[10] In market S, total supply is given by $Q = q_{NS} + q_{SS} = \frac{2A - c'}{3b}$, which is decreasing in c'.

from the third market is higher under EPF equilibrium if $q_{NT}^{epf} > q_{NT}^{hp} \leftrightarrow \theta < \frac{2(t_2-t)}{c}$. Similar logic suggests that firm S's profit from market T is higher under EPF equilibrium if $\theta > \frac{t_2-t}{2c}$. Recall from Chapter 3 that, without the third market, the Southern government chooses $\theta = \frac{2t_1}{c}$ to induce FDI by firm N. Hence, if $\frac{t_2-t}{2c} < \frac{2t_1}{c} < \frac{2(t_2-t)}{c} \leftrightarrow t_2 - 4t_1 < t < t_2 - t_1$ then in the presence of the third market, the Southern government can continue to choose $\theta = \frac{2t_1}{c}$ to induce FDI, which actually makes both firms N and S better off. In this case, the Southern government chooses $\theta = \theta^* > \frac{2t_1}{c}$ to take away the additional profit of firm N (note that if $t_2 \leq 4t_1$ then inducing EPF with $\theta = \theta^*$ always benefits firm S).

When $t_2 > 4t_1$, we find that for all $t \in [\hat{t}, t_2 - 4t_1)$, where $\theta^*(\hat{t}) = \frac{t_2-\hat{t}}{2c}$ (see more in the Appendix), inducing EPF with $\theta = \theta^*$ benefits the South and the Southern government chooses $\theta = \theta^*$ in equilibrium.

Market Size

We next explore the impact of an increase in Southern market size on optimal IPR policy of the South. We focus on the case EPF is optimal for the South so that in the equilibrium of the game, the Southern government chooses $\theta = \theta^*$. We then undertake comparative statics concerning the parameter b (on $\theta^*(b)$). Recall that, with the linear demand equations as laid out in Section 4.3, a lower value of b implies a larger market S. Proposition 3 tells us that, if the size of market S increases, the Southern government offers a stronger IPR protection for the Northern firm provided that the degree of trade liberalization between the South and third market is great enough.

Proposition 3. Assume that $t \leq t_2 - t_1$. When EPF is optimal for the South, optimal IPR policy for the South becomes more stringent if the Southern market becomes larger. Formally, $\theta^*(b)$ is strictly increasing in b.

When EPF benefits the South, in the equilibrium of the entire game, the Southern government chooses $\theta = \theta^*$. Recall that the Southern government chooses the level of spillovers such that $\theta = \theta^* > \frac{2t_1}{c}$ to take away part of the Northern firm's additional profit from market T. The more profit firm N can make in market T, the higher value of θ^* the Southern government can choose. In other words, if the third market becomes more attractive, the optimal level of spillovers for the South will increase.

Now let us fix θ at θ^* and consider a decrease in b, which implies market S becomes larger. Since market S becomes more attractive for firm N, market T becomes (relatively) less attractive. Hence, to induce firm N to remain in the South when b decreases, the Southern government must compensate for firm N by reducing the level of spillovers. The more b decreases, the more the reduction in spillover rate is needed to guarantee an EPF equilibrium. In the extreme case when market S is very large compared to market T (or b is very small), the value of θ^* converges to $\frac{2t_1}{c}$.[11] In other words, if we measure $\theta^* = \theta^*(b)$ then this function is increasing in b. This explains Proposition 3.

The implications of a change in market size on optimal Southern IPR policy in the presence of export-platform FDI is relatively new in the literature. Our model suggests that after successfully inducing the Northern firm to undertake EPF, the Southern government should take into account the importance of its home market. This is because beside the third market, the home (Southern) market also drives the Northern firm's profitability which in turn influences its location choice.

In summary, in this section, we find that under certain parameterizations, inducing EPF by the Northern firm could benefit the South. Consequently, in such cases, the equilibrium of the game is an EPF equilibrium in which the Southern government chooses the loosest IPR policy which induces EPF. We demonstrate that when the degree of trade liberalization between the South and the third market is great enough, an increase in the size of the Southern market requires the South to offer stronger IPR protection for the Northern firm. In the next section, we continue to examine the impact of regional trade

[11] An alternative argument could be that, with $t \leq t_2 - t_1$, by undertaking EPF, firm N gains relatively from market T, loses relatively from market S. Then, following a decrease in b, the incremental increase in firm N's profit under HP is higher compared to EPF, making EPF less attractive.

liberalization between the South and third market on optimal IPR policy of the South.

4.6 The Impact of Trade Liberalization

This section studies the welfare impact of a decrease in t, which represents trade liberalization between the South and third country (regional trade liberalization). In the traditional export platform literature, previous authors have argued that this regional trade liberalization induces EPF by the outside (Northern) firm (see more in Section 4.2). In our set up, the presence of technology spillovers in the South makes the location choice of Northern firm become more strategic, since the spillovers reduces Southern firm's cost, which in turn intensifies competition between Northern firm and Southern firm in both South and third markets. This is a result which previous authors have not examined. In what follows, we continue with the analysis of the previous section to focus on parameterization such that inducing EPF benefits the South and assume that the Southern government chooses $\theta = \theta^*$ throughout the analysis. We then let $\theta^* = \theta^*(t)$ to explore the impact of a change in t on optimal IPR policy for the South.

Consider the EPF equilibrium and assume that the level of spillover rate is fixed at $\theta^*(t)$. Let us decrease the level of trade cost between the South and the third country from t to $t'(< t)$. Then, both firm N and firm S's per-unit cost for exporting to market T become lower, which lead to both of the firms obtaining higher levels of profit from market T. What is the impact on Southern welfare attributed to this reduction in South-third country trade cost? Note that such reduction in t only affects the choice of quantity levels in market T, and it does not affect the competition in market S. It then follows that the reduction in t directly improves Southern welfare by increasing firm S's profitability. At the same time, as mentioned earlier, when t decreases, firm N has more incentive to undertake EPF. Then, the Southern government can increase the spillover rate until $\theta = \theta^*(t')$ holds. That is, as t declines, $\theta^*(t)$ increases. This is the indirect (positive) effect of regional trade liberalization (between South and third country) on Southern welfare. Note that this result holds whenever EPF is optimal for the South and does not require the condition of $t \leq t_2 - t_1$.

We can now summarize the above results in Proposition 4.

Proposition 4. When EPF is optimal for the South, optimal IPR policy for the South becomes more lax when trade is more liberalized between the South and third country. That is, $\theta^*(t)$ is strictly decreasing in t.

As discussed earlier, by choosing $\theta = \theta^*(t)$, Southern welfare is maximized in the equilibrium of the game. Proposition 4 says that, regional trade liberalization between the South and third country induces the South to relax its IPR protection. This result suggests that the recent progress in regional trade liberalization could be a possible reason for the North-South IPR conflict in international trade context. Many Southern countries have place significant efforts in negotiating regional trade liberalization to boost export for both local firms and foreign firms upon production in the South. However, many MNCs have claimed that, their advanced know-how has been imitated easily by Southern competitors.[12]

4.7 Discussion and Conclusion

Why do Southern countries promote EPF? In this chapter, we have demonstrated that, in many cases, induced by the Northern firm's EPF, technology spillovers benefit Southern firm and Southern consumers and could improve Southern welfare at the aggregate level. In such cases, the Southern government chooses the loosest IPR policy which still induces EPF. Since the

[12]For instance, in China's automobile industry, many foreign automakers have sued local competitors for copyright issue. Among those, in 2005, General Motors filed suit in Shanghai court alleging that local firm Chery Automobile stole its trade secrets from Spark car in the production of competing QQ mini cars; in 2003, Toyota sued Chinese car maker Geely for copying the Japanese company's logo and slapping it on Geely models. Source: www.businessweek.com/magazine/content/05_06/b3919010_mz001.htm

inclusion of the third market makes the location choice of the Northern firm between home-production and EPF in the South become more strategic compared to the case without the third market (Chapter 3), it follows that a trade liberalization between the South and the third market plays an important role. We find that, when the degree of trade liberalization between the South and the third market is great enough and EPF is optimal for the South, the greater the degree of such trade liberalization, the looser IPR policy the Southern government can adopt. In contrast, under certain conditions, if the Southern market becomes larger, the South offers a stronger IPR protection for the Northern firm to induce EPF.

Our analysis addresses the situation in which several countries such as China and ASEAN members have recently attracted huge amount of foreign investments in export sectors. Trade liberalization between China and many Asian partners, or free trade agreement among the ASEAN members (AFTA) has made those countries an attractive destination for foreign companies to shift their production to, and use this as a platform to export their products. With relatively loose IPR regime being adopted in the South, the presence of foreign firms often generates positive externalities to local competitors that eventually increases the degree of competition in both Southern market and export markets of the foreign firms. Our analysis suggests that trade liberalization reduces these countries' incentive to strengthen their IPR environment.

In relationship to the export-platform FDI literature (see Section 4.2), we show that the main finding of this literature carries over in our framework. Specifically, the greater the degree of trade liberalization between the South and the third country, the more incentive the outsider (Northern) firm has for the EPF strategy. In this regard, our results also extend the argument of Neary (2009), who pointed out that the traditional tariff-jumping motive of FDI is not enough to explain the trend of EPF by many MNCs in the recent years. We have introduced a Cournot model with technology spillover to demonstrate the importance of Intellectual Property Rights in explaining export-platform FDI, which has not been examined in previous analysis.

Our model predicts that, regional trade liberalization (precisely, between the South and the export market of the MNCs) could potentially be the reason for why Southern countries are often reluctant to strengthen the IPR environment. As regional trade liberalization progresses, production in the South to serve both the Southern market and other export markets becomes more attractive for MNCs compared to home-production. However, the trade-off of Southern production for the MNCs is that technology spillovers benefit their local competitors and thus not all the benefits from the export market can be captured by the MNCs as they have to share that market with the Southern firms. This explains the incentive of the Southern government to make technology spillovers happen in such a way that local firms benefit from the presence of MNCs in the South.

Our model also addresses the impact of Southern market becoming larger on optimal IPR policy for the South in the context where the degree of trade liberalization between the South and third market is great enough and EPF benefits the South. It says that as Southern market becomes larger, the Southern government offers a stronger IPR environment to induce Northern firms to undertake EPF provided that trade costs between the South and third market are low enough. That is, not only the trade costs between the South and the third market but also the size of Southern market that plays an important role in determining the optimal level of IPR of the South.

Note that we have assumed that $t \leq t_2 - t_1$ in our analysis. It is possible to extend the analysis to the case in which $t > t_2 - t_1$. In such cases, if we start with Chapter 3 (without third market) and assume the Southern government chooses $\theta = \frac{2t_1}{c}$, then the Northern firm would choose home-production over EPF in the South. This is because Northern firm incurs additional loss from market T. Hence, to induce EPF, the South needs to offer even stronger IPR, that is $\theta < \frac{2t_1}{c}$. Then, depending on the relative size of Southern market and third country market, EPF could benefit or hurt the South.

Finally, the case in which $t < \hat{t}$ (section 4.5) has not been examined in our analysis. In this case, the Southern government can still induce EPF by the Northern firm by choosing $\theta = \theta^*$. However, compared to HP, EPF can benefit or hurt the South at the aggregate level. For instance, when $t < \hat{t}(< t_2 - t_1)$, inducing EPF with $\theta = \theta^*$ does not hurt firm N from market T but it hurts firm S from market T, which could result in a loss for Southern welfare if market T is large and market S is small (that is, if the third market is more important). In other words, in these cases, depending on the relative size of market S and T, the Southern government can induce or prevent EPF.

Beside relaxing the assumptions to accommodate these cases, several other future research extensions can be drawn from our framework. One possible direction is that, we can allow the Southern firm to choose whether or not to export to third market (for example if it chooses not to export then Northern firm is a monopolist in the third market) to make the analysis richer. We have also used linear demand function to simplify the model. Whether these results generalize to other demand functions will be examined in future research.

Appendix

Proof of Proposition 1.

Under HP equilibrium, at stage 2, firm N chooses the levels of quantity q_{NS}^{hp} and q_{NT}^{hp} while at the same time firm S chooses q_{SS}^{hp} and q_{ST}^{hp} which solve the firms' problem

$$\max_{q_{NS}^{hp},q_{NT}^{hp}} \pi_N^{hp} = [A - b(q_{NS}^{hp} + q_{SS}^{hp}) - t_1]q_{NS}^{hp} + [B - q_{NT}^{hp} - q_{ST}^{hp} - t_2]q_{NT}^{hp} \qquad \text{(A.1)}$$

$$\max_{q_{SS}^{hp},q_{ST}^{hp}} \pi_S^{hp} = [A - b(q_{SS}^{hp} + q_{NS}^{hp}) - c]q_{SS}^{hp} + [B - q_{ST}^{hp} - q_{NT}^{hp} - c - t]q_{ST}^{hp} \qquad \text{(A.2)}$$

The solutions to problems (7) and (8) are $q_{NS}^{hp} = \frac{A-2t_1+c}{3b}$, $q_{NT}^{hp} = \frac{B-2t_2+c+t}{3}$, $q_{SS}^{hp} = \frac{A-2c+t_1}{3b}$, and $q_{ST}^{hp} = \frac{B-2c-2t+t_2}{3}$ giving firms N and S, respectively, profits

$$\pi_N^{hp} = (\frac{A - 2t_1 + c}{3b})^2 + (\frac{B - 2t_2 + c + t}{3})^2, \qquad \text{(A.3)}$$

$$\pi_S^{hp} = (\frac{A - 2c + t_1}{3b})^2 + (\frac{B - 2c - 2t + t_2}{3})^2. \qquad \text{(A.4)}$$

Under EPF equilibrium, the problems facing firms N and S are respectively

$$\max_{q_{NS}^{epf},q_{NT}^{epf}} \pi_N^{epf} = [A - b(q_{NS}^{epf} + q_{SS}^{epf})]q_{NS}^{epf} + [B - q_{NT}^{epf} - q_{ST}^{epf} - t]q_{NT}^{epf} \qquad \text{(A.5)}$$

$$\max_{q_{SS}^{epf},q_{ST}^{epf}} \pi_S^{epf} = [A - b(q_{SS}^{epf} + q_{NS}^{epf}) - c']q_{SS}^{epf} + [B - q_{ST}^{epf} - q_{NT}^{epf} - c' - t]q_{ST}^{epf} \qquad \text{(A.6)}$$

and solutions are given by $q_{NS}^{epf} = \frac{A+c'}{3b}$, $q_{NT}^{epf} = \frac{B+c'-t}{2}$, $q_{SS}^{epf} = \frac{A-2c'}{3b}$, and $q_{ST}^{epf} = \frac{B-2c'-t}{3}$. Since $\pi_S^{epf} = (\frac{A-2c'}{3b})^2 + (\frac{B-2c'-t}{3})^2$ is decreasing in c', firm S optimally chooses $c' = (1 - \theta)c$. This implies $q_{NS}^{epf} = \frac{A+(1-\theta)c}{3b}$, $q_{NT}^{epf} = \frac{B+(1-\theta)c-t}{3}$, $q_{SS}^{epf} = \frac{A-2(1-\theta)c}{3b}$, and $q_{ST}^{epf} = \frac{B-2(1-\theta)c-t}{3}$. Equilibrium profits are

$$\pi_N^{epf} = (\frac{A + (1 - \theta)c}{3b})^2 + (\frac{B + (1 - \theta)c - t}{3})^2, \qquad \text{(A.7)}$$

$$\pi_S^{epf} = (\frac{A - 2(1 - \theta)c}{3b})^2 + (\frac{B - 2(1 - \theta)c - t}{3})^2. \qquad \text{(A.8)}$$

Let us compare firm N's profit under HP and EPF. It follows that firm N chooses to undertake EPF if it obtains higher profit under EPF. This happens when $\pi_N^{hp} \leq \pi_N^{epf} \leftrightarrow (\frac{A-2t_1+c}{3b})^2 + (\frac{B-2t_2+c+t}{3})^2 \leq (\frac{A+(1-\theta)c}{3b})^2 + (\frac{B+(1-\theta)c-t}{3})^2 \leftrightarrow \theta \leq 1 - \frac{\sqrt{(1+b^2)[(A+c-2t_1)^2+b^2(B-2t_2+c+t)^2]-(b^2A^2+b^4(B-t)^2-2A(B-t)b)}-A+b(B-t)}{(1+b^2)c} = \theta^*$.

Q.E.D.

Proof of Lemma 1.

Southern consumer surplus under EPF: $CS^{epf} = \frac{1}{2}(q_{NS}^{epf} + q_{SS}^{epf})^2$. Thus, Southern welfare, $WS^{epf} = (\frac{A-2(1-\theta)c}{3b})^2 + (\frac{B-t-2(1-\theta)c}{3})^2 + \frac{1}{2}(\frac{2A-(1-\theta)c}{3b})^2$, is increasing in θ.

Q.E.D.

Proof of Proposition 2.

It follows that firm N obtains higher profit from market T under EPF if $[\frac{B-2t_2+t+c}{3}]^2 < [\frac{B+(1-\theta)c-t}{3}]^2 \leftrightarrow \theta < \frac{2(t_2-t)}{c}$. Similarly, firm S obtains higher profit from market T if $[\frac{B-2(t+c)+t_2}{3}]^2 < [\frac{B-2(1-\theta)c-t}{3}]^2 \leftrightarrow \theta > \frac{t_2-t}{2c} = \theta_1$.

Assume now that $\theta = \frac{2t_1}{c}$. Then, if $t_2 - 4t_1 < t < t_2 - t_1$ holds, both firms N and S can capture higher profit from market T under EPF. Absence of market T, Chapter 3 suggest that the Northern firm chooses FDI. Now, Southern government can slightly increase θ from $\theta = \frac{2t_1}{c}$ to $\theta = \theta^*$. Finally, both $\theta_1(t)$ and $\theta^*(t)$ are decreasing in t (see the proof of Proposition 4), and for all $t \in [t_2 - 4t_1, t_2 - t_1]$, $\theta^*(t) > \theta_1(t)$. Hence, if $\theta^*(t=0) < \theta_1(t=0)$ then there exists a value $\hat{t} < t_2 - 4t_1$ such that $\theta_1(\hat{t}) = \theta^*(\hat{t})$. Let $\hat{t} = 0$ if $\theta^*(t=0) \geq \theta_1(t=0)$ leads to Proposition 2.

Q.E.D.

Proof of Proposition 3.

From equation to obtain θ^*, $(\frac{A-2t_1+c}{3b})^2 + (\frac{B-2t_2+c+t}{3})^2 = (\frac{A+(1-\theta^*)c}{3b})^2 + (\frac{B+(1-\theta^*)c-t}{3})^2$, let $\theta^* = \theta^*(b)$ and totally differentiate. Then, we have $-2(\frac{A-2t_1+c}{b})(\frac{A-2t_1+c}{b^2}) = 2(\frac{A+[1-\theta^*(b)]c}{b})(\frac{cb\frac{d_{\theta^*}}{d_b} - A - [1-\theta^*(b)]c}{b^2}) - 2(B + [1-\theta^*(b)]c - t)c\frac{d_{\theta^*}}{d_b} \leftrightarrow \frac{-2}{b^3}\{(A - 2t_1 + c)^2 - (A + [1-\theta^*(b)]c)^2\} = -2c\{(B + ([1-\theta^*(b)]c - t) + \frac{A+[1-\theta^*(b)]c}{b^2})\}\frac{d_{\theta^*}}{d_b}$. This equation can be rewritten as $-(\theta^*(b)c - 2t_1)\{(A - 2t_1 + c) + (A + [1-\theta^*(b)]c)\} = -cb\{b^2(B + ([1-\theta^*(b)]c - t) + (A + [1-\theta^*(b)]c)\}\frac{d_{\theta^*}}{d_b}$. Since the left hand side is negative due to the fact that $\theta^*(b) > \frac{2t_1}{c}$, it follows that $\frac{d_{\theta^*}}{d_b} > 0$.

Q.E.D.

Proof of Proposition 4.

From the equation to obtain θ^*, $(\frac{A-2t_1+c}{3b})^2 + (\frac{B-2t_2+c+t}{3})^2 = (\frac{A+(1-\theta^*)c}{3b})^2 + (\frac{B+(1-\theta^*)c-t}{3})^2$ we can make $\theta^* = \theta^*(t)$ and totally differentiate. Then, we have $2(B - 2t_2 + c + t) = 2\frac{(A+[1-\theta^*(t)]c)(-c)\frac{d_{\theta^*}}{d_t}}{b^2} + 2(B + [1-\theta^*(t)]c - t)(-c\frac{d_{\theta^*}}{d_t} - 1) \leftrightarrow b^2\{(B - 2t_2 + c + t) + (B + [1-\theta^*(t)]c - t)\} = -c\{(A + [1-\theta^*(t)]c) + b^2(B + [1-\theta^*(t)]c - t)\}\frac{d_{\theta^*}}{d_t}$. Since the left hand side is positive, it follows that $\frac{d_{\theta^*}}{d_t} < 0$.

Q.E.D.

4.8 References

Bhatnagar, S. 2006, *India's Software Industry,* Technology, Adaptation, and Exports: How Some Developing Countries Got It Right, Vandana Chandra (Ed.), World Bank.

Chin, J.C. & Grossman, G.M. 1990, "Intellectual Property Rights and North-South Trade." in *The Political Economy of International Trade: Essays in Honor of Robert E. Baldwin.* Jones, R.W., Krueger, A.O. (eds), Blackwell, Cambridge, MA.

Ekholm, K., Forslid, R. & Markusen, J.R. 2007, "Export-Platform Foreign Direct Investment." *Journal of European Economic Association,* 5(4).

Gallagher, K.S. 2003, "Foreign Technology in China's Automobile Industry: Implications for Energy, Economic Development, and Environment." *China Environment Series,* Issue 6.

Glass, A.J. & Saggi, K. 2002, "Multinational Firms and Technology Transfer." *Scandinavian Journal of Economics,* Vol. 104(4).

Head, K. & Mayer, T. 2004, "Market Potential and the Location of Japanese Investment in the European Union." *Review of Economics and Statistics,* Vol. 86(4).

JETRO. 2008, *2007 Survey of Japanese-Affiliated Firms in ASEAN and India.*

Keller, W. 2004, "International Technology Diffusion." *Journal of Economic Literature,* Vol. 42(3).

Long G. 2005, "China's Policies on FDI: Review and Evaluation." in *Does Foreign Direct Investment Promote Development?,* T. Moran, E. Graham, and M. Blomstrom, eds.

Luo, J. 2005, "The Growth of Independent Chinese Automotive Companies." *International Motor Vehicle Program,* MIT.

Millar, J. 2000, "India's Export Software Sector - Its Place in The Emerging Digital Global Economy." *delivered at the "Where in the world?" conference,* Budapest 24/25 October.

Motta, M. & Norman, G. 1996, "Does Economic Integration Cause Foreign Direct Investment?" *International Economic Review,* Vol. 37(4).

Naghavi, A. 2007, "Strategic Intellectual Property Rights Policy and North-South Technology Transfer." *Review of World Economics,* Vol. 143(1).

Neary, J.P. 2002, "Foreign Direct Investment and the Single Market." *The Manchester School,* Vol. 70(3).

Neary, J.P. 2009, "Trade Costs and Foreign Direct Investment." *International Review of Economics and Finance,* Vol. 18.

Pack, H. & Saggi, K. 2006, "Is There a Case for Industrial Policy? A Critical Survey." *The World Bank Research Observer,* Vol. 21(2).

Saggi, K. 2002, "Trade, Foreign Direct Investment, and International Technology Transfer: A Survey." *The World Bank Research Observer,* Vol. 17(2).

UNCTAD. 2002, *World Investment Report.* United Nations Publication, New York.

UNCTAD. 2005, *World Investment Report.* United Nations Publication, New York.

Xuan, N.T. & Xing, Y. 2008, "Foreign Direct Investment and Export: The Experiences of Vietnam." *Economics of Transition,* Vol. 16(2).

Zigic, K. 1998, "Intellectual Property Rights Violations and Spillovers in North-South Trade." *European Economic Review,* Vol. 42.

Zigic, K. 2000, "Strategic Trade Policy, Intellectual Property Rights Protection, and North-South Trade." *Journal of Development Economics,* Vol. 61.

Chapter 5

Conclusion

This thesis dissertation develops new theoretical frameworks to examine the welfare impact of technology spillovers, that are accompanied by a Northern firm's FDI in the South. Recently, there have been more cases related to technology spillovers in North-South trade and FDI context. At the same time, the literature on this, especially when FDI is concerned, has only been at its early stage of development.

Throughout the thesis, we focus on duopolistic competition between a Northern firm who possesses a superior technology compared to its Southern competitor. Upon Northern firm's FDI in the South, technology spillovers benefit the Southern firm and intensify competition between them. We then study the welfare consequences of FDI and the optimal IPR policy in the South. With three different models, including quality-enhancing spillovers, cost-reducing spillovers, and export platform FDI models, the thesis yields a number of new results.

In the first essay (Chapter 2), we explore a quality-enhancing technology spillovers model which incorporates the work of Mussa and Rosen (1978). We show that there are certain parameterizations in which Northern firm strategically reduces its quality level upon production in the South. This is because technology spillovers extend the upper bound quality level that the Southern firm can choose for its product, which makes the quality choice of the Northern firm become more strategic. When Northern firm finds it profitable to reduce its product quality with FDI, it follows that FDI reduces the benefits of consuming Northern firm's product. This could result in a total welfare loss for the South and the world. In such cases, our model suggests that inducing FDI (by trade protection or IPR enforcement) is not a good policy for the South. We also compare the optimal level of spillovers for the South and the world. It turns out that in the presence of quality-enhancing technology spillovers, global welfare-maximizing level of spillovers tends to be less than that which maximizes Southern welfare (but higher than which maximizes Northern welfare). In other words, the social planner would stand in between North and South in the IPR debate.

In the second essay (Chapter 3), we augment the traditional cost-reducing technology spillovers literature (Chin & Grossman 1990, Zigic 1998, Naghavi 2007) to compare quality-enhancing and cost-reducing spillovers. We show that, the Northern firm chooses the minimum marginal cost level even under FDI if cost-reducing spillovers is concerned. This contrasts the former case where the Northern firm might reduce the product quality level. Consequently, the difference regarding the choice of technology under FDI between quality-enhancing and cost-reducing spillovers leads to different, even contrasting, policy implications. Specifically, inducing FDI with strong enough IPR protection is always a good policy choice for the South under cost-reducing spillovers and linear demand is employed, whereas FDI could hurt the South under quality-enhancing spillovers.

The last essay (Chapter 4) extends the second essay by incorporating an export platform FDI model (Ekholm, Forslid & Markusen 2007). We investigate the impact of trade liberalization between the South and the export market of the Northern firm, as well as the change in market size, on optimal IPR policy for the South. Since export platform FDI could benefit the South, it turns out that, trade liberalization with the third market potentially reduce the South's incentive to protect the technology of the Northern firm. Meanwhile, under certain conditions, if the Southern market becomes larger, the South could offer stronger IPR protection to induce export-platform FDI.

Other policy recommendations along this line have been examined.

It is worth pointing out that several extensions could be developed using our framework. For instance, we have used specific demand functions in all of the three essays to simplify the analysis (with discussion on general demand wherever possible). Therefore, one could argue that our results are functional form specific, which induce generalizing the models will be an interesting research. In Chapter 3 and 4, we also focus on duopolistic competition. By allowing a richer set of supply strategies for the Southern firm (i.e., if Southern firm decides not to enter the market then Northern firm becomes a monopolist) in addition to simultaneous quantity competition could yield some policy implications, which will be done in our future research.