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Technology diffusion and global welfare effects: Imitative R&D vs. South-bound FDI

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ABSTRACT

A country in question is positioned in the middle of a global technology race. To shorten its technology gap with the forerunner (North), this middle country must invest in imitative R&D. To exploit cheap labor in the technological laggard (South), it also must invest in South-bound FDI. A dynamic general-equilibrium model of three countries (North, Middle, South) is set up to numerically analyze how the Middle's refraining South-bound FDI affects international technology diffusion, international wage gaps, and international welfare. The Middle always finds a need to socially optimize investing balance between imitative R&D and South-bound FDI, while the South is instead in favor of as much South-bound FDI as possible. Interestingly, the North may, or may not, align with the Middle's tightening South-bound FDI, depending on how fast the Northern product innovation can proceed over time. Both transitional dynamics and the steady-state equilibrium are computed.

1. Introduction

The world's technological frontier is determined by a few advanced countries' innovative outputs. For instance, of the 157,772 utility patents (i.e., patents for invention) issued by the United States Patent and Trademark Office (USPTO) in 2008, the U.S., Japan, and Germany together received more than three quarters.[1] China and India, the world's two most populated countries, merely received 0.78% and 0.40%, respectively. Of course, patents granted from a single country may be subject to the "home advantage" effect so that data from USPTO may somewhat disproportionately inflate the U.S. innovative strength.[2] Yet, the world's *triadic patent families* filed at USPTO, the European Patent Office (EPO) and the Japanese Patent Office (JPO) still portray a very skewed distribution of innovative outputs: the U.S. held 30.7% of world triadic patent families, followed by Japan (28.2%), Germany (11.9%), France (4.8%), U.K. (3.2%), respectively.[3] As such, the world's technological innovations are highly concentrated in just a few high-income countries while almost all countries are just followers in the international technology race. To most countries, therefore, the challenge in economic develop-

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[1] Specifically, the U.S. received 49% of the total utility patents in 2008, followed by Japan (21.3%), Germany (5.7%), South Korea (4.8%), Taiwan (4.0%), France (2%), and U.K. (1.97%).

[2] That is, all else equal, domestic applicants tend to file more patents with their home-country patent office than foreign applicants do (Criscuolo, 2006).

[3] From the Conference Board of Canada, these figures are country shares of world triadic patent families in 2007. Data of 2003 indicates that China held only 0.34% and India 0.16% of world triadic patent families. Dernis and Khan (2004) illustrate the process of defining patent families and the methodology used to build triadic patent families.

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ment is to narrow their technology gaps especially with those forerunners at the technological frontier.

Indeed, the international technology gap question and its welfare implications have been an active line of research in the North–South trade literature. As a pioneering study, Krugman (1979) developed a simple North–South trade model, showing that the South can narrow its income gap with the innovating North by narrowing the North–South technology gap.[4] Yet, the question of how governments can use policy instruments to influence the technology gap had been unresolved. In less than a decade, many studies began to extend Krugman (1979) to examine either North–South trade or North–South intellectual property rights (IPR) protection.[5] Notably, Helpman (1993) extended Krugman's North–South model by endogenizing a time-sequential innovation process that occurs in the North to shift the technological frontier by introducing newer product varieties over time. His work shows that the developing South can gain while the developed North can lose in welfare terms, if the former enforces laxer IPR so as to imitate Northern technologies at a faster rate.

That is, Helpman (1993) highlights a sheer North–South conflict of interest in that the South pursues economic development by impinging on Northern intellectual property rights. Grinols and Lin (1997, 2006), however, contend that there does exist room for North–South IPR cooperation. They demonstrate that if the Northern innovation process is *bi-directional*, then strengthening Southern IPR enforcement can induce Northern innovation in the direction of inventing goods that better meet the needs of Southern consumers.[6] These interesting results weaken the robustness of Helpman's analysis, while unfolding another policy dimension that the South must consider in an effort to narrow the North–South technology gap through imitation and laxer IPR enforcement. More recent studies advanced our understanding of the technology gap issue by focusing either on other international technology-transfer channels such as foreign direct investment (FDI) and licensing (see Glass and Saggi, 1998, 2002; Lai, 1998; Yang and Maskus, 2001; Tanaka et al., 2007) or on labor market flexibility (see Fosfuri et al., 2001; Arnold, 2002).[7]

The purpose of the present paper is to examine the global welfare effects of international technology diffusion when a *middle* economy seeks to optimize the allocation of domestic resources between acquiring advanced technologies from innovative countries (called "North") operating at the world's technological frontier, on the one hand, and transferring older technologies to backward countries (called "South") for cost-saving manufacturing locations, on the other hand. This economy in question is positioned in the middle of a global technology race in the sense that it falls behind the North with a technology gap while leading the South with another technology gap. The middle economy therefore features a technology position symbolizing the world's newly developed economies such as Singapore, South Korea, Taiwan, or even many high-income countries that are not at the world's technological frontier. By incorporating such a middle economy into a North–South model of the Krugman–Helpman type, we let it play catch-up to the North via imitative R&D and at the same time transfer older technologies to the South via FDI (called "South-bound FDI"), given that the world's technological frontier (or the measure of available product varieties) keeps expanding at an exogenous innovation rate.

Traditionally, North–South models assume a two-country world in which a country must be either a forerunner or a follower outright in the global technology race. In contrast, the paper formulates a global economy composed of the North, Middle, and South.[8] The development-relevant issue of international technology gaps thus becomes more complicated but more real world-consistent. It warrants a painstaking examination. This is where we seek to contribute to the North–South trade literature. In the paper we present the computational analysis of how government intervention in the flow of South-bound FDI affects international technology gaps, international wage gaps, and global/national welfare, respectively. We provide both transitional dynamics and steady-state analysis. In the real world FDI regulations take a variety of forms. In the paper we consider FDI regulations as a policy tool that the middle economy uses to affect the cost of resources required to establish a FDI firm in the South.

From our numerical simulations, tightening South-bound FDI enables the Middle to redirect domestic resources away from the South and into imitative R&D. This helps the middle economy narrow its technology gap with

4 In Krugman's North–South model, innovating occurs only in the higher wage North introducing newer (horizontally differentiated) goods over time at an *exogenous* innovation rate, while the lower wage South keeps imitating Northern technologies and displacing Northern innovators at an *exogenous* imitation rate. The North therefore exports newer goods for older goods from the South, and the North–South technology gap is reflected in the share of goods that the South has become able to produce domestically.

5 See Dollar (1986), Jesen and Thursby (1987), Chin and Grossman (1990), Diwan and Rodrik (1991), Grossman and Helpman (1991), Deardorff (1992), Helpman (1993), Grinols and Lin (1997), Grinols and Lin (2006), Zigic (1998), Lin (2002), Grossman and Lai (2004), and others. Most of these works assume innovation occurs only in the North, but Grossman and Lai (2004) allow innovation to take place both in the North and South. For a brief survey of the earlier extensions of Krugman (1979), see Lin (2002).

6 Grinols and Lin (1997, 2006) show that when Northern and Southern goods are not identical, the South may lose and the North may gain if a lower IPR standard is enforced in the non-innovating South. In Grinols and Lin (1997), goods for Northern consumers and goods for Southern consumers are *perfectly unsubstitutable*, while in Grinols and Lin (2006) Southern and Northern goods are *imperfectly substitutable*. That is, Grinols and Lin assume a bi-directional innovation process, in contrast to Helpman's uni-directional process inventing goods that are not designed to regional markets.

7 The channels through which international technology transfer or diffusion may take place include FDI, international trade in intermediate goods, licensing, and imitative activities; see Rivera-Batiz and Romer (1991), Grossman and Helpman (1991), Eaton and Kortum (2002), Keller (2004), and Tanaka et al. (2007). How these channels work is generally subject to the regime of international intellectual property rights protection.

8 The present paper differs substantially from a companion working paper Lin (2006) in terms of FDI firms' pricing behavior and welfare analysis. Lin's (2006) welfare analysis is confined to the Middle but this paper extends to each of the North, Middle, South. Specific differences will be mentioned in the text.