

Costly R&D and Intellectual Property Rights Protection

Amy Jocelyn Glass*
Department of Economics
Ohio State University

Abstract: This paper summarizes some of my product cycle models addressing the role of intellectual property rights (IPR) protection when all forms of R&D, including imitation, are costly. While the settings considered differ, the models all share the feature that a strengthening of IPR protection makes R&D more difficult, and thus causes firms to waste scarce resources ‘reinventing the wheel.’ Taking the perspective that stronger IPR protection increases the cost of R&D demonstrates how weak IPR protection can aid a country’s development by enabling its firms to make efficient use of scarce resources and thus further advance the country’s technology frontier.

Keywords: Innovation, Imitation, Intellectual Property Rights, Foreign Direct Investment

Biographical notes: Dr. Glass specializes in the effect of international trade and foreign direct investment on the incentives for firms to advance the technological frontier. Her dissertation, “International Trade and Product Improvement,” won the William Polk Carey Prize for the best economics dissertation submitted to the University of Pennsylvania in 1993. Prior to joining the Ohio State University, Dr. Glass also worked at the World Bank and Bryn Mawr College.

*1945 North High Street, Columbus, OH 43210-1172, USA; phone (614) 292-1149; fax (614) 292-3906; E-mail glass.29@osu.edu.

1 Introduction

Disputes between countries over intellectual property rights (IPRs) are common. Such disputes are especially common between countries at differing stages of development. Failure to provide proper protection of IPRs has joined damaging the environment and paying low wages as the top objections to international trade between developed and less developed countries. Due to these disputes, the role of IPR protection in the presence of international trade is a hot topic. Since many firms now serve foreign markets by building production facilities there, the role of IPR protection in the presence of foreign direct investment (FDI) is an especially hot topic.

Weak IPR protection keeps the costs of research and development (R&D) low, which avoids wasting scarce resources. Empirical evidence indicates that imitation is costly. Mansfield *et al.* (1981) finds that the costs of imitation average 65 percent of the costs of innovation. Due to the significant cost of imitation, increases in the cost of imitation have significant resource implications. A strengthening of IPR protection increases R&D costs for a given probability of success. The greater use of resources in R&D absorbs scarce resources that could have been used productively elsewhere in the economy. Thus, stronger IPR protection bears a sizable opportunity cost.

This paper surveys a series of my papers emphasizing the resource wasting aspect of stronger IPR protection. In each model, firms in a continuum of high technology industries use resources to advance the quality of their products, similar to Grossman and Helpman (1991b).¹ Successful innovators maintain the unique ability to produce their product designs (for a given quality level). In most of the models considered, firms can also use resources to imitate the designs developed by other firms. The probability of both innovation and imitation is determined by investments in R&D. A fixed supply of resources in each country is allocated between R&D and production. This scarcity of resources provides the downside of stronger IPR protection.

A strengthening of IPR protection increases the cost of R&D. For example, firms may need to devote more effort to satisfy a more stringent standard of uniqueness. The specific attributes of a product design or the judgment of legal authorities may be a random process such that with some positive prob-

¹High technology products are defined as products for which R&D spending is a significant component of firm's operating expenditures.

ability (less than one) the product design is judged legitimate by the patent office or court of law. More stringent IPR protection reduces the probability that any given design is approved, which raises the cost of achieving a given probability of success.

To survey multiple articles, only simple versions of the models are presented here. For brevity, the decision of firms choosing R&D levels based on costs and benefits of R&D, present in the source papers, is skipped here. Nonetheless, these simple versions do capture the resource implications of stronger IPR protection. Stronger Southern IPR protection limits resource availability and thus impedes FDI and innovation. In addition to reducing the aggregate rate of innovation, stronger IPR protection in one country causes the technology used for production in that country to deteriorate relative to the other country. In contrast, weak IPR protection enables firms from lagging countries to improve the mix of products produced in these countries. Thus, less developed countries use weak IPR protection as a means of closing the technology gap with more advanced countries.

Section 2 covers the Glass (1998) international rivalry paper, a model with two innovating countries and two quality levels of each product. Section 3 covers the Glass (1997) market penetration paper, a model with one innovating and one imitating country and also two quality levels of each product.² Section 4 covers the Glass and Saggi (1997) foreign direct investment paper, a model with one innovating and one imitating country, one quality level of each product, and FDI. These models capture how the consequences of strengthening IPR protection vary for countries at different stages of development and also captures the interaction with international trade and FDI.³ Section 5 concludes.

2 International Rivalry

Suppose the world is composed of two countries, the North and the South, and innovation occurs in both countries. The North follows common usage, referring to a developed country with innovating firms. The South commonly refers to a lagging country, such as a less developed country, whose firms

²The Glass and Saggi (1998) technology gap model has a similar structure but adds FDI to examine how IPRs influence the quality of the technology transferred through FDI.

³The role of IPRs under licensing remains an interesting area for future research.

largely cannot innovate but only imitate; however, for the duration of this section, the South represents another developed country. More typical views of the South as a lagging country are constructed in the next sections. For now, the South takes the role of another developed country, whose firms are capable of innovating.⁴

Suppose with probability ι_N a Northern firm *innovates* over a Southern firm, and with probability ι_S a Southern firm *innovates* over a Northern firm. Let n_N and n_S denote the measures of markets that are led by Northern and Southern firms, which must sum to one, so the measure of Northern led markets is just (the full measure) one minus the measure of Southern led markets.

$$n_N = 1 - n_S \tag{1}$$

Each Southern led market is targeted by Northern innovation, while each Northern led market is targeted by Southern innovation. Thus, the flows into Northern led markets are the probability of Northern innovation success times the measure of Southern led markets targeted. Similarly, the flows into Southern led markets are the probability of Southern innovation success times the measure of Northern led markets targeted. In a steady-state equilibrium, the flows into Northern leadership must equal the flows out of Northern leadership.

$$\iota_N n_S = \iota_S n_N \tag{2}$$

The aggregate rate of innovation ι is the sum of innovation success stemming from Northern firms and innovation success stemming from Southern firms.

$$\iota = \iota_N n_S + \iota_S n_N \tag{3}$$

The rate of innovation must be constant in a steady-state equilibrium. The continuum of industries removes any variation in the speed of innovation at the aggregate level.

Suppose two quality levels sell of each product and let f denote the income share spent on the high quality level, with the remaining $1 - f$ spent on the

⁴In the source paper for this section, Glass (1998), the North is called the domestic country and the South is called the foreign country to avoid abuse of terms. Here, names are changed for conformity with the subsequent models to assist comparison across sections.

low quality level.⁵ Unit labor requirements in production are normalized to one in each country, so labor is measured in efficiency units. For simplicity, differences in prices and thus sales per capita across market structures are suppressed in this survey.⁶

In Northern led markets, each Northern firm produces fx units of high quality output using Northern labor ($n_N fx$ total), and each Southern firm produces $(1 - f)x$ units of low quality output using Southern labor ($n_S(1 - f)x$ total). In Southern led markets, each Southern firm produces fx units of high quality output using Southern labor ($n_S fx$ total), and each Northern firm produces $(1 - f)x$ units of low quality output using Northern labor ($n_N(1 - f)x$ total). Suppose innovation probability ι_N requires a_N units of Northern labor ($a_N \iota_N n_S$ total) and innovation probability ι_S requires κa_S units of Southern labor ($\kappa a_S \iota_S n_N$ total).⁷

A larger κ represents stronger Southern IPR protection, more resources needed to achieve a specified probability of R&D success. The reduced productivity in R&D with stronger protection of IPRs may stem from various channels. Firms engage in R&D to develop quality improvements of existing products; however, they may be able to add traits to the product that, although these traits do not contribute to the utility gained from consuming the product, nonetheless distinguish the good in the view of legal authorities.

For example, a computer may be designed to complete a calculation at a given speed increment relative to its predecessor (say 333 MHz over 300 MHz Pentiums), and this speed increment has value to consumers; however, additionally, the layout of the components cannot follow too closely another firm's layout to pass the judgment of the legal authorities. Consumers do not value the layout in and of itself, most do not even open the case to look at the inside, but legal authorities would be more likely to deem the computer a unique enough design if the layout differs from competitors' products.⁸

⁵Glass (1996) provides detailed analysis of how multiple quality levels of each product selling in equilibrium can be supported by consumer heterogeneity in valuation of quality.

⁶See the source paper, Glass (1998), for details of the complete model.

⁷R&D is performed by leaders (firms that had the most recent R&D success for that product in that country) rather than followers in this setup, which can be supported by leaders having a sufficient advantage relative to followers in R&D due to their previous R&D success.

⁸This interpretation is all the more plausible when R&D takes the form of imitating a rival's product, as in the following sections.

Alternative channels include firms expending resources persuading the legal authorities to approve their product as sufficiently unique by wining and dining (or just plain bribing) the officials. Also, firms may expend resources to conceal aspects of the design that draw on competitors' designs, such as by locating the copied aspects in hard to access areas. As IPR protection is strengthened, aspects of the design that would have been copied from the current state-of-the-art may have to be innovated anew to avoid legal hassles. Thus κ can be thought of as the fraction of the design that must be unique to satisfy the standard. The important aspect of whatever channel (or channels) firms use is that more resources are spent to achieve a given probability of R&D success.⁹ This reduced efficiency in R&D has important resource implications due to the scarcity of resources.

Finally suppose the North has a fixed supply of L_N units of labor and the South has a fixed supply of L_S units of labor. By (2) and (3), half of all innovation must occur in the North and the other half in the South in a steady-state equilibrium.

$$\iota_N n_S = \iota_S n_N = \frac{\iota}{2} \quad (4)$$

Thus, labor demand for innovation in the North is $a_N \iota_N n_S = a_N \frac{\iota}{2}$. Labor demand for Northern production is $n_N f x = (1 - n_S) f x$ for high quality production in Northern led markets and $n_S (1 - f) x$ for low quality production in Southern led markets. Full employment in the North requires labor demand for Northern innovation and Northern production equal labor supply.

$$a_N \frac{\iota}{2} + (1 - n_S) f x + n_S (1 - f) x = L_N \quad (5)$$

Similarly, full employment in the South requires labor demand for Southern innovation and Southern production equal labor supply.

$$\kappa a_S \frac{\iota}{2} + n_S f x + (1 - n_S) (1 - f) x = L_S \quad (6)$$

These two resource constraints, one for each country, determine the rate of innovation and the measure of Southern leadership in equilibrium.

⁹Thus, R&D success means developing a product that earns product market profits. To earn product market profits, the design must pass the scrutiny of the legal authorities.

Figures One and Two plot the Northern resource constraint (5) as **LN** and the Southern resource constraint (6) as **LS**. The Northern resource constraint is upward sloping (ι increases with n_S) and the Southern resource constraint is downward sloping (ι decreases with n_S) if and only if the share of income spent on high quality is sufficiently large ($f > \frac{1}{2}$).¹⁰ Figure One shows the standard case where $f > \frac{1}{2}$, while Figure Two shows the perverse case where $f < \frac{1}{2}$.¹¹ In either case, stronger IPR protection, by increasing the costs of innovation through κ , shifts the Southern resource constraint down to **LS'**: for a given measure of Southern leadership, Southern resources support a lower rate of innovation due to the reduced efficiency in Southern innovation. The intersection of the Northern resource constraint **LN** and the new Southern resource constraint **LS'** indicates a lower rate of innovation regardless of f as κ increases; however, the measure of Southern leadership falls if and only if $f > \frac{1}{2}$.

Solving the resource constraints for ι and n_S and differentiating with respect to κ confirms that a strengthening of Southern IPR protection reduces the rate of innovation

$$\frac{\partial \iota}{\partial \kappa} = -2 \frac{(L_S + L_N - x) a_S}{(a_N + \kappa a_S)^2} < 0 \quad (7)$$

and reduces the measure of Southern technological leadership only if enough income is spent on high quality goods.

$$\frac{\partial n_S}{\partial \kappa} = \left(\frac{a_N}{x(2f - 1)} \right) \frac{\partial \iota}{\partial \kappa} < 0 \iff f > \frac{1}{2} \quad (8)$$

Stronger Southern IPR protection absorbs resources into Southern innovation from Southern production. Resources are freed from Southern production by reducing Southern technological leadership if and only if the income share spent on high quality is sufficiently large.¹² Thus, weak IPR protection is

¹⁰Figures drawn for $L_N = L_S = 2$, $a_N = a_S = 2$, $x = 1$, and $\kappa = 1$. Figure One drawn for $f = \frac{1}{3}$; Figure Two drawn for $f = \frac{2}{3}$. Stronger IPR protection is represented by $\kappa' = \frac{5}{4} > \kappa = 1$.

¹¹The case where demand for high quality is sufficiently large is considered standard because it corresponds to the results for only one quality level.

¹²In the complete model, the lower bound on the high type income share does depend on some parameters of the model, such as the premium for high quality that high type consumers are willing to pay.

not a guaranteed means of furthering technological leadership for developed countries.

Weak IPR protection essentially improves the efficiency of the R&D sector. Here, Southern firms are able to simply copy (rather than redesign) a greater proportion of a product from their rivals when IPR protection is weak.¹³ Intuitively, improving R&D efficiency would seem to provide a sure means of improving a country's technological leadership, the fraction of all products where its firms invented (and thus produce) the state-of-the-art.

However, here production is tied to where R&D success occurred since an innovation success means high quality production for that product will occur in the same country as the innovation was made. If too little income is spent on high quality products, the country's technological leadership will have to decline to absorb the resources freed from R&D due to the increased efficiency of R&D.

If weak IPR protection does not necessarily improve a country's technological leadership, why is IPR standardization such a hot policy issue among developed countries? Since the term involving the high type income share f lies in the denominator, for high type income shares near the threshold (here $f = \frac{1}{2}$), large changes in leadership may be required for small changes in IPR protection, since a single market frees up very few resources when switching from Northern to Southern leadership. This extreme sensitivity could give rise to the emphasis developed countries place on achieving known, stable and uniform IPR protection across like countries.¹⁴ The sensitivity also suggests that achieving such balance through multilateral negotiations such as GATT may be a difficult and delicate process, as indeed it appears to be.

3 Market Penetration

The model developed in Section 2 is clearly most applicable to country pairings where both countries are sufficiently developed that their firms can innovate. However, much of the international policy concern over IPRs involves

¹³For innovation, not all of the product can be exactly copied since some aspect must be improved to yield the quality improvement. Nonetheless, some aspects should be suitable for copying, such as the computer case design. Therefore, for innovations, κ represents the fraction of all components that have the potential to be copied but must be redesigned to pass the standard.

¹⁴For welfare analysis, consult the source paper.

developed countries pressuring less developed countries to strengthen their IPR protection. The firms in the less developed countries likely do not have the ability to advance the technology frontier, but merely attempt to more closely approach the world technology frontier through imitating the designs of firms from developed countries.

To address issues involving countries that lag sufficiently behind the technology frontier, now suppose innovation occurs in the North but imitation occurs in the South (now a less developed country). With probability ι_N a Northern firm *innovates* over a Southern firm, and with probability ι_S a Southern firm *imitates* a product produced by a Northern firm. Because Southern firms only imitate, they can at best only catch up to the Northern technology frontier, but never surpass it. Consider a scenario where Southern firms either have imitated only the low quality level of a good or have imitated the high quality level as well.¹⁵

Let n_N and n_S denote the measures of markets that are led by Northern and Southern firms, which sum to one. As before, the measure of Northern led markets is simply the measure of all markets that are not Southern led.¹⁶

$$n_N = 1 - n_S \tag{9}$$

In a steady-state equilibrium, the flows into Northern leadership must equal the flows out of Northern leadership (and into Southern leadership).

$$\iota_N n_S = \iota_S n_N \tag{10}$$

The rate of innovation is $\iota = \iota_N n_S$, which is constant in a steady-state equilibrium. Innovation stems only from Northern firms now since Southern firms imitate rather than innovate. The rate of imitation is $\iota_S n_N$. The flow condition thus states that the rate of innovation equals the rate of imitation in a steady-state equilibrium.¹⁷

¹⁵The analysis here follows the inefficient Northern followers equilibrium in the source paper.

¹⁶In the source paper, Glass (1997), the Northern led markets are termed North-South split markets to distinguish them from North dominated markets. In Northern dominated markets, Northern firms produce both high and low quality levels of a product, which can occur in the all followers efficient equilibrium or the Southern followers inefficient equilibrium. Also, Southern led markets are termed Southern dominated markets in the source paper.

¹⁷In general, the rate of innovation can exceed the rate of imitation if some innovation is performed by Northern followers.

Suppose again that two quality levels sell of each product and let f denote the income share spent on the high quality level, with the remaining $1 - f$ spent on the low quality level. In Northern led markets, each Northern firm produces fx units of high quality output using Northern labor ($n_N fx$ total), and each Southern firm produces $(1 - f)x$ units of low quality output using Southern labor ($n_N(1 - f)x$ total). In Southern led markets, each Southern firm produces x units of high quality output using Southern labor ($n_S x$ total).¹⁸ No production by Northern firms occurs in markets where the South has caught up to the technology frontier.

Suppose innovation requires a_N units of Northern labor ($a_N \iota_N n_S = a_N \iota$ total) and imitation requires κa_S units of Southern labor ($\kappa a_S \iota_S n_N = \kappa a_S \iota$ total). Again, a larger κ reflects stronger Southern IPR protection, more resources needed to achieve a specified probability of imitation success.

Again suppose the North has a fixed supply of L_N units of labor and the South has a fixed supply of L_S units of labor. Full employment in the North requires labor demand for innovation and Northern production equal labor supply.

$$a_N \iota + (1 - n_S) fx = L_N \quad (11)$$

Full employment in the South requires labor demand for imitation and Southern production equal labor supply.

$$\kappa a_S \iota + n_S x + (1 - n_S)(1 - f)x = L_S \quad (12)$$

Here all production in Southern led markets occurs in the South, while production in Northern led markets is split across countries according to quality, with low quality produced in the South and high quality produced in the North. These two resource constraints, one for each country, determine the rate of innovation and the measure of Southern leadership. Note in contrast to the resource constraints for international rivalry, (5) and (6), here all production of a product occurs in the South once imitation of the high quality of a product has occurred.

¹⁸The product market equilibrium in Southern led markets implies all consumers buy the high quality level, so no low quality level sells. Given the abstraction from pricing here, the labor demand for Southern production is the same regardless of whether only the high quality level or both a high and low quality level sell in Southern led markets, since if the low quality level were to sell, it would be produced by a Southern firm.

Figure Three resembles Figures One and Two by plotting the two resource constraints, now (11) and (12), as the rate of innovation in terms of the measure of Southern led markets to determine the equilibrium.¹⁹ Like Figure One, the Northern resource constraint is upward sloping, the Southern resource constraint is downward sloping, and a strengthening of Southern IPR protection shifts down the Southern resource constraint. Thus, as in Figure One, stronger Southern IPR protection leads to a lower rate of innovation and fewer Southern led markets (in other words, less Southern market penetration).

Unlike the case of international rivalry (where firms from both countries innovate), here the effect of κ on n_S is unambiguous. Here, a greater degree of Southern market penetration definitely involves greater labor demand for Southern production because the low quality level is produced in the South whenever the high quality level is produced in the South. Imitation is a catch up process, so all quality levels below the highest produced in the South are also produced in the South. Thus, less developed countries can count on weak IPR protection to improve their production mix, whereas developed countries cannot.

Solving the resource constraints for ι and n_S and differentiating with respect to κ confirms that a strengthening of Southern IPR protection reduces the rate of innovation

$$\frac{\partial \iota}{\partial \kappa} = -\frac{(L_S + L_N - x) a_S}{(a_N + \kappa a_S)^2} < 0 \quad (13)$$

and also reduces the measure of Southern market penetration.

$$\frac{\partial n_S}{\partial \kappa} = \left(\frac{a_N}{xf}\right) \frac{\partial \iota}{\partial \kappa} < 0 \quad (14)$$

Stronger Southern IPR protection absorbs resources into imitation from production, and resources are freed from Southern production by reducing Southern market penetration. In contrast to the result for international rivalry, here the $2f - 1$ is replaced by just f so the only way to free resources from production is to shift the markets towards Northern leadership

¹⁹Figure Three drawn for previous parameters but $f = \frac{1}{2}$ to pick a middle value and $a_S = 1$ to have lower initial R&D costs in the South since Southern R&D is now imitation, which should be easier than innovation.

(since the North produces nothing under Southern leadership), which reduces Southern market penetration.

The technology gap paper, Glass and Saggi (1998), shares the same structure as the market penetration paper, Glass (1997), at this level of abstraction. The summary here abstracts away from details such as higher prices making the quantity sold x smaller and cost disadvantages of multinationals relative to local firms. The technology gap paper is founded on the premise that the level of development in the South limits the technologies that Northern firms can produce in the South through FDI. Northern firms can locate their production facilities in the South only one step ahead of the Southern technology frontier.

Thus, when a Southern firm succeeds in imitating the low quality level of a product, it creates the knowledge base needed for a Northern firm to produce the high quality level in the Southern country. A strengthening of IPR protection in the South reduces the measure of markets where Southern firms have imitated the low quality level and thus reduces the measure of markets where Northern firms transfer the state-of-the-art technology for production in the South. Stronger IPR protection makes imitation more costly, which in turn impedes development of the knowledge base needed to attract state-of-the-art FDI. Thus, less developed countries also can count on weak IPR protection to improve the mix of multinational production they host.

4 Foreign Direct Investment

Weak IPR protection can attract a more premium mix of FDI to less developed countries, but what about the overall flow of FDI? As with the market penetration model, suppose innovation occurs only in the North and imitation only in the South, but now allow for production to be shifted to the South through FDI. Suppose with innovation probability ι_N a Northern firm innovates over a Southern firm, with adaptation probability ι_F a Northern firm moves its production facility to the South, and with imitation probability ι_S a Southern firm imitates the product of a Northern firm (regardless of where the Northern firm's production facilities are located).²⁰

²⁰The source paper, Glass and Saggi (1997), permits the probability of imitation targeting multinationals to exceed the probability of imitation targeting Northern firms due to

Let n_N , n_F , and n_S denote the measures of Northern, multinational, and Southern production, which must sum to one.

$$n_N + n_F + n_S = 1 \quad (15)$$

The rate of innovation is $\iota = \iota_N n_S$ and the flow of FDI into the South is $\Phi = \iota_F n_N$, which are both constant in a steady-state equilibrium. In a steady-state equilibrium, the flows into Northern production must equal the flows out

$$\iota = \Phi + \iota_S n_N, \quad (16)$$

and the flows into multinational production must equal the flows out

$$\Phi = \iota_S n_F. \quad (17)$$

These conditions give the measures of Northern, multinational and Southern firms expressed in terms of the rate of innovation, flow of FDI and probability of imitation.

$$n_N = \frac{\iota - \Phi}{\iota_S}, n_F = \frac{\Phi}{\iota_S}, n_S = 1 - \frac{\iota}{\iota_S} \quad (18)$$

These market measures are key for determining the demand for labor in each country.

Suppose now only one quality level of each product sells. Each Northern firm produces x units of output using one unit of Northern labor ($n_N x$ total), each multinational produces x units of output using one unit of Southern labor ($n_F x$ total) and each Southern firm produces x units of output using one unit of Southern labor ($n_S x$ total). Suppose innovation requires a_N units of Northern labor ($a_N \iota_N n_S = a_N \iota$ total) and imitation requires κa_S units of Southern labor ($\kappa a_S \iota_S (n_N + n_F) = \kappa a_S \iota$ total).²¹ A larger κ reflects stronger Southern IPR protection, more resources needed to achieve a specified probability of imitation success.

Finally suppose again the North has a fixed supply of L_N units of labor and the South has a fixed supply of L_S units of labor. Full employment in

greater knowledge spillovers within a country thanks to geographic (and other measures of) proximity.

²¹In the source paper, imitating multinationals is easier than imitating Northern firms.

the North requires labor demand for innovation and Northern production equal labor supply.

$$a_N \iota + \left(\frac{\iota - \Phi}{\iota_S} \right) x = L_N \quad (19)$$

Full employment in the South requires labor demand for imitation and Southern and multinational production equal labor supply.

$$\kappa a_S \iota + \left(1 - \frac{\iota - \Phi}{\iota_S} \right) x = L_S \quad (20)$$

These two resource constraints, one for each country, determine the rate of innovation and the flow of FDI from the North to the South.²² The model is specified to determine the rate of innovation and the flow of FDI since the effects of Southern IPR protection on these variables are the most hotly contested.²³

Figure Four plots the Northern resource constraint (19) and Southern resource constraint (20) as the rate of innovation supported for various flows of FDI to the South.²⁴ As before, stronger IPR protection in the South shifts down the Southern resource constraint, leading to a lower rate of innovation and now a smaller flow of FDI. The stronger IPR protection in the South increases labor demand in imitation for any given rate of innovation. Thus, the South can host less FDI. A contraction in FDI means more resources must be absorbed into Northern production of products that would have been produced in the South through FDI. The greater labor demand for Northern production in turn crowds out Northern innovation due to the fixed supply of resources in the North.

Solving the resource constraints for ι and Φ and differentiating with respect to κ confirms that a strengthening of Southern IPR protection reduces the rate of innovation

$$\frac{\partial \iota}{\partial \kappa} = - \frac{(L_S + L_N - x) a_S}{(a_N + \kappa a_S)^2} < 0 \quad (21)$$

²²FDI flows do exist between Northern countries and, to a much lesser degree, from Southern back to Northern countries (reverse FDI). The focus here on one-way FDI from the North to the South mirrors the focus of the debate on IPRs on this type of FDI.

²³In place of the flow of FDI, the model could be solved for the extent of multinational production n_F .

²⁴Figure Four drawn for probability of imitation $\iota_S = \frac{3}{2}$, which is determined endogenously in the general model.

and also reduces the flow of FDI into the South.

$$\frac{\partial \Phi}{\partial \kappa} = \left(1 + \frac{a_{N\prime S}}{x}\right) \frac{\partial \iota}{\partial \kappa} < 0 \tag{22}$$

Stronger Southern IPR protection absorbs resources into imitation from FDI, and reduced FDI in turn absorbs resources into Northern production out of innovation.

The advantage of such a simple model is that the fundamental forces at work are clear; the disadvantage is that it is open to criticism for the absence of further adjustment mechanisms, such as a reduction in the probability of imitation. Allowing for more general adjustment including the probability of imitation, the negative effect of stronger Southern IPR protection on FDI and innovation remains.²⁵ The key force at work is that stronger IPR protection impinges on the resources available for FDI and consequently innovation.

The resource effects of stronger Southern IPR protection are especially important in the presence of FDI. FDI occurs when Northern firms, who initially hold the unique ability to produce a new design, are attracted by the abundance of cheap labor in the South. FDI can thus act as a channel for transmitting resource availability in the South back to the North. However, when stronger Southern IPR protection causes the Southern labor market to tighten, FDI also acts as a channel for transmitting resource scarcity in the South back to the North. Resource scarcity in the North then constricts the rate of innovation.

5 Conclusion

Here I have summarized a series of models where IPR protection influences the equilibrium rates of innovation, imitation, flows of FDI, and measures of markets where Southern firms produce using the best technology available. These models share the feature that stronger IPR protection makes R&D more difficult. The increased difficulty absorbs more resources into R&D, leaving fewer resources for production.

Readers are referred to Glass (1998, 1997) and Glass and Saggi (1998, 1997) for the full models where the incentives for innovation, imitation and

²⁵See Glass and Saggi (1997) for details of the complete model.

foreign direct investment are considered. Here I have depicted only the differing assumptions and common results among these models. I encourage readers to further explore the resource implications of IPR protection.

Empirical evidence on the effect of IPR protection on innovation, imitation, and foreign direct investment, such as Maskus and Konan (1994) and Lee and Mansfield (1996), remains mixed. Controlling for all the varied factors affecting FDI decisions is difficult. Since IPR protection varies with development (poor countries have weak IPR protection), many omitted variables are likely correlated with IPR protection (but lack causality). Hence the coefficient on IPR protection may pick up the positive effects of these variables (such as infrastructure and legal systems) on FDI.

The resource conserving benefits of weak IPR protection played an early role in the literature. The models summarized here strive to revitalize the efficient use of resources approach to analyzing the consequences of IPR protection. The results surveyed here provide contrast to the theoretical results of Helpman (1993), Lai (1998) and others that suggest IPR protection attracts FDI and encourages innovation. The conclusions drawn here help provide reasons why the positive effects previously emphasized in the theoretical literature have not emerged in the empirical literature. Plenty more work remains to be done before all the complexities present can be reasonably well understood.

In particular, the case where the South does both innovation and imitation should be considered. The common path of development, increasing IPR protection as more firms do innovation rather than imitation, should be constructed within a model where the innovation versus imitation choice is endogenous. Such a model would help us understand what forces cause countries to adopt stricter IPR protection in the absence of external pressure. As mentioned in the introduction, the influence of IPR protection on licensing decisions also remains to be explored. In each of these potential areas for further research, efficient resource use should play a central role.

References

- Aghion, Philippe and Peter Howitt 1990. "A Model of Growth Through Creative Destruction." *Econometrica* 60: 323-351.
- Aoki, Reiko and Thomas J. Prusa 1993. "International Standards for Intellectual Property Protection and R&D Incentives." *Journal of International Economics* 35: 251-273.
- Deardorff, Alan V. 1992. "Welfare Effects of Global Patent Protection." *Economica* 59: 35-51.
- Diwan, Ishac and Dani Rodrik 1991. "Patents, Appropriate Technology, and North-South Trade." *Journal of International Economics* 30: 27-47.
- Ferrantino, Michael J. 1993. "The Effect of Intellectual Property Rights on International Trade and Investment." *Weltwirtschaftliches Archiv* 129: 300-331.
- Gaisford, James D. and R. Stephen Richardson 1996. "North-South Disputes over the Protection of Intellectual Property." *Canadian Journal of Economics* 29: 376-381.
- Glass, Amy J. 1998. "International Rivalry in Advancing Products." *Review of International Economics*, forthcoming.
- Glass, Amy J. 1997. "Product Cycles and Market Penetration." *International Economic Review* 38: 865-891.
- Glass, Amy J. 1996. "Price Discrimination and Quality Improvement." Ohio State University working paper 96-18.
- Glass, Amy J. and Kamal Saggi 1998. "International Technology Transfer and the Technology Gap." *Journal of Development Economics*, forthcoming.
- Glass, Amy J. and Kamal Saggi 1997. "Intellectual Property Rights, Foreign Direct Investment, and Innovation." Ohio State University working paper 95-06.

Gould, David M. and William C. Gruben 1996. "The Role of Intellectual Property Rights in Economic Growth." *Journal of Development Economics* 48: 323-250.

Greenaway, David and Andre Sapir 1992. "New Issues in the Uruguay Round: Services, TRIMs and TRIPs." *European Economic Review* 36: 509-518.

Grossman, Gene M. and Elhanan Helpman 1991a. "Endogenous Product Cycles." *Economic Journal* 101: 1214-1229.

Grossman, Gene M. and Elhanan Helpman 1991b. "Quality Ladders and Product Cycles." *Quarterly Journal of Economics* 106: 557-586.

Helpman, Elhanan 1993. "Innovation, Imitation, and Intellectual Property Rights." *Econometrica* 61: 1247-1280.

Jensen, Richard and Marie Thursby 1996. "Patent Races, Product Standards, and International Competition." *International Economic Review* 37: 21-49

Jensen, Richard and Marie Thursby 1987. "A Decision Theoretic Model of Innovation, Technology Transfer, and Trade." *Review of Economic Studies* 54: 631-647.

Jensen, Richard and Marie Thursby 1986. "A Strategic Approach to the Product Life Cycle." *Journal of International Economics* 21: 269-284.

Krugman, Paul R. 1979. "A Model of Innovation, Technology Transfer, and the World Distribution of Income." *Journal of Political Economy* 87: 253-266.

Kumar, Nagesh 1996. "Intellectual Property Protection, Market Orientation and Location of Overseas R&D Activities by Multinational Enterprises." *World Development* 24: 673-688.

Lai, Edwin L.C. 1998. "International Intellectual Property Rights Protection and the Rate of Product Innovation." *Journal of Development Economics*, forthcoming.

Lee, Jeong-Yeon and Edwin Mansfield 1996. "Intellectual Property Protection and U.S. Foreign Direct Investment." *Review of Economics and Statistics* 78: 181-186.

Mansfield, Edwin 1994. "Intellectual Property Protection, Foreign Direct Investment, and Technology Transfer." International Finance Corporation Discussion Paper 19.

Mansfield, Edwin, Mark Schwartz and Samuel Wagner 1981. "Imitation Costs and Patents: An Empirical Study." *Economic Journal* 91: 907-918.

Markusen, James R. 1995. "The Boundaries of Multinational Enterprises and the Theory of International Trade." *Journal of Economic Perspectives* 9: 169-190.

Maskus, Keith E. 1997. "Implications of Regional and Multilateral Agreements for Intellectual Property Rights." *World Economy* 20: 681-694.

Maskus, Keith E. and Mohan, Penubarti 1995. "How Trade Related are Intellectual Property Rights?" *Journal of International Economics* 39: 227-248.

Maskus, Keith E. and Denise E. Konan 1994. "Trade-Related Intellectual Property Rights: Issues and Exploratory Results." In Alan V. Deardorff and Robert M. Stern, eds., *Analytical and Negotiating Issues in the Global Trading System*. Ann Arbor: University of Michigan Press.

Mutti, John and Bernard Yeung 1996. "Section 337 and the Protection of Intellectual Property in the United States: The Complainants and the Impact." *Review of Economics and Statistics* 78: 510-520.

Pack, Howard and Kamal Saggi 1997. "Inflows of Foreign Technology and Indigenous Technological Development." *Review of Development Economics* 1: 81-98.

Richardson, Martin 1991. "Intellectual Property Rights: An International Economics Perspective." *Review of Industrial Organization* 6: 247-267.

Saggi, Kamal 1996. "Entry into a Foreign Market: Foreign Direct Investment Versus Licensing." *Review of International Economics* 4: 99-104.

Schwartz, Marius 1991. "Patent Protection through Discriminatory Exclusion of Imports." *Review of Industrial Organization* 6: 231-246.

Segerstrom, Paul 1991. "Innovation, Imitation and Economic Growth." *Journal of Political Economy* 99: 807-827.

Segerstrom, Paul S., T.C.A. Anant and Elias Dinopoulos 1990. "A Schumpeterian Model of the Product Life Cycle." *American Economic Review* 80: 1077-1091.

Stokey, Nancy L. 1991. "The Volume and Composition of Trade Between Rich and Poor Countries." *Review of Economic Studies* 58: 63-80.

Taylor, M. Scott 1994. "TRIPS, Trade and Growth." *International Economic Review* 35: 361-381.

Taylor, M. Scott 1993. "TRIPS, Trade and Technology Transfer." *Canadian Journal of Economics* 26: 625-637.

Vernon, Raymond 1966. "International Investment and International Trade in the Product Cycle." *Quarterly Journal of Economics* 80: 190-207.

Vishwasrao, Sharmilla 1994. "Intellectual Property Rights and the Mode of Technology Transfer." *Journal of Development Economics* 44: 381-402.

Figure One: International Rivalry
(large demand for high quality)

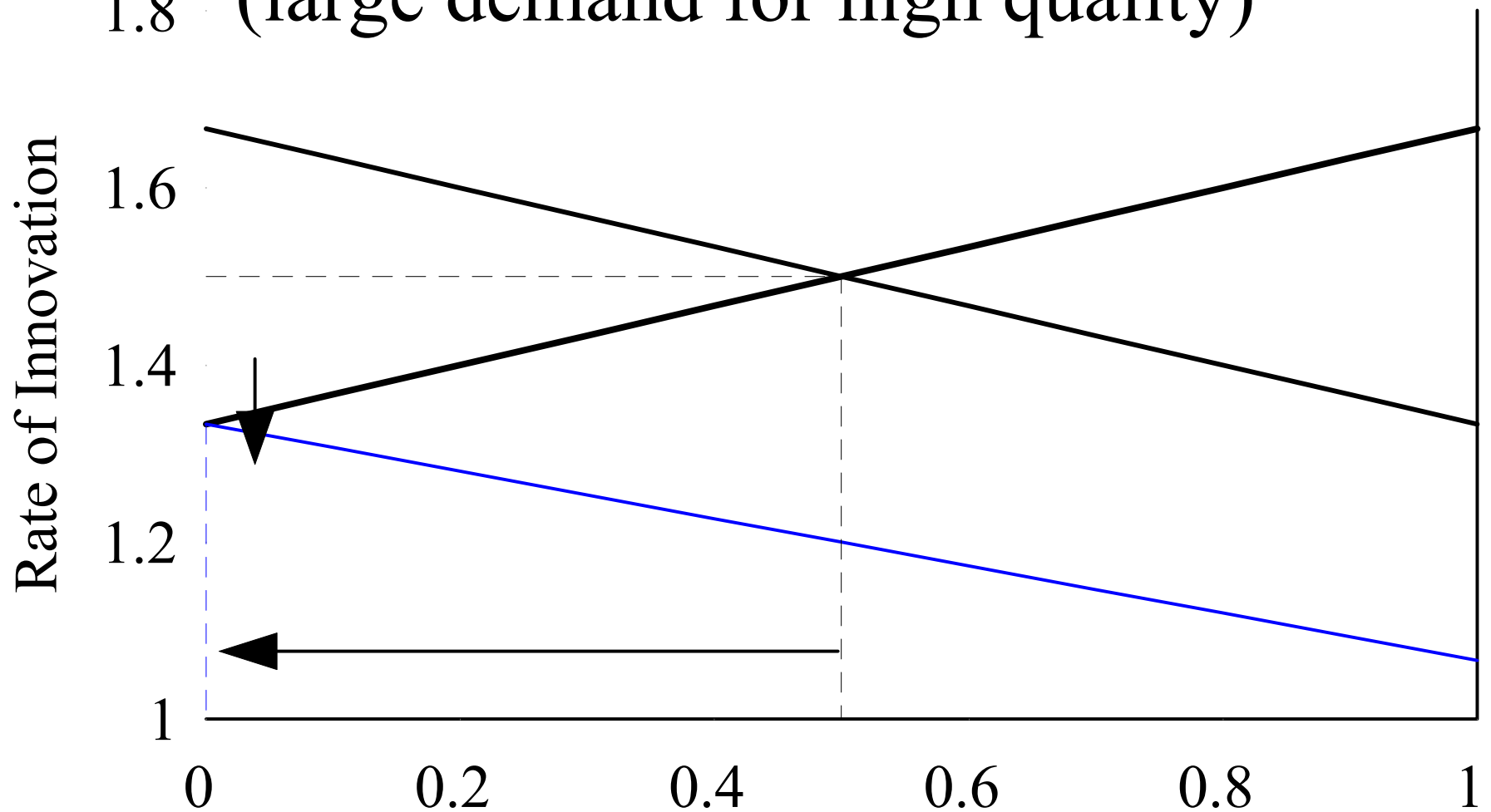


Figure Two: International Rivalry
(small demand for high quality)

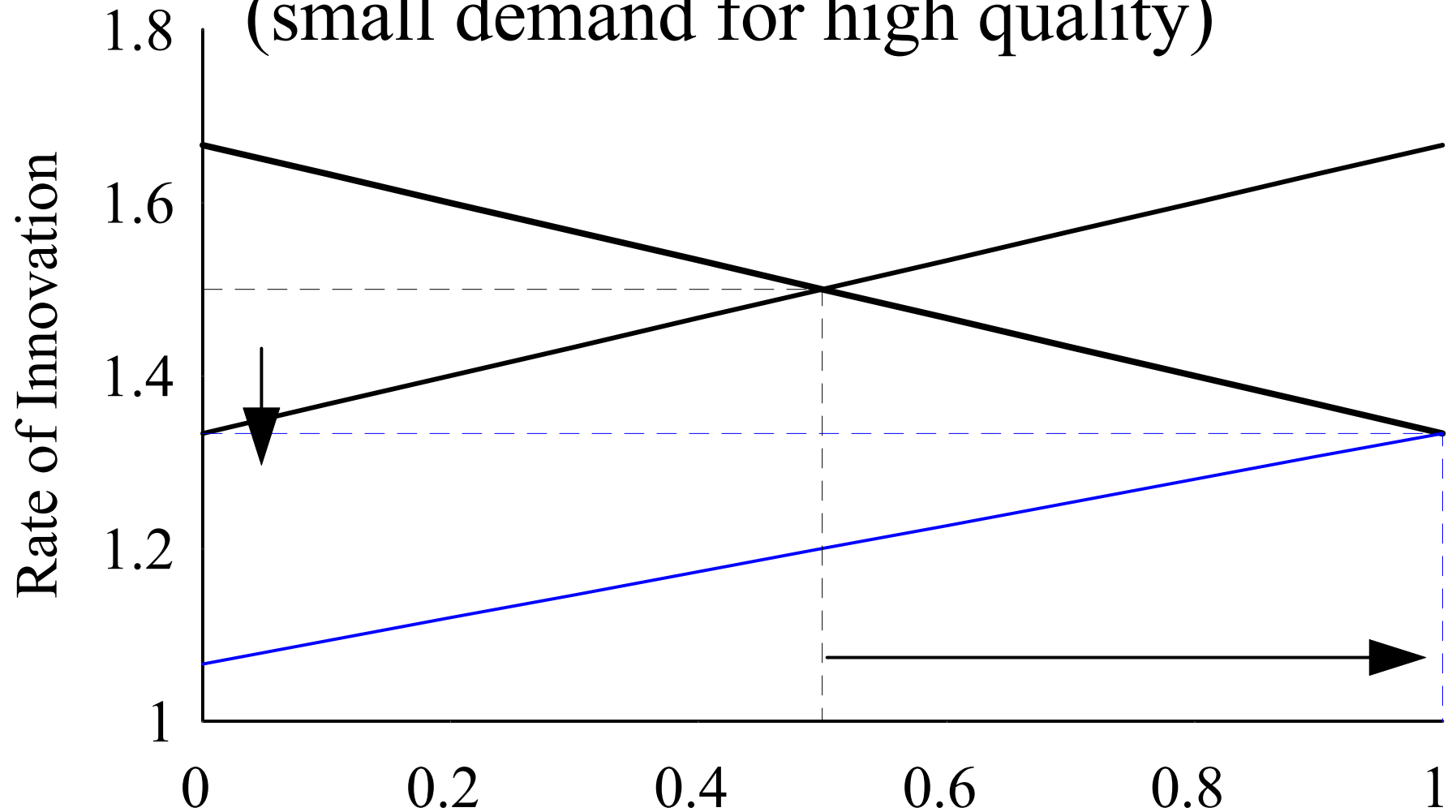


Figure Three: Market Penetration

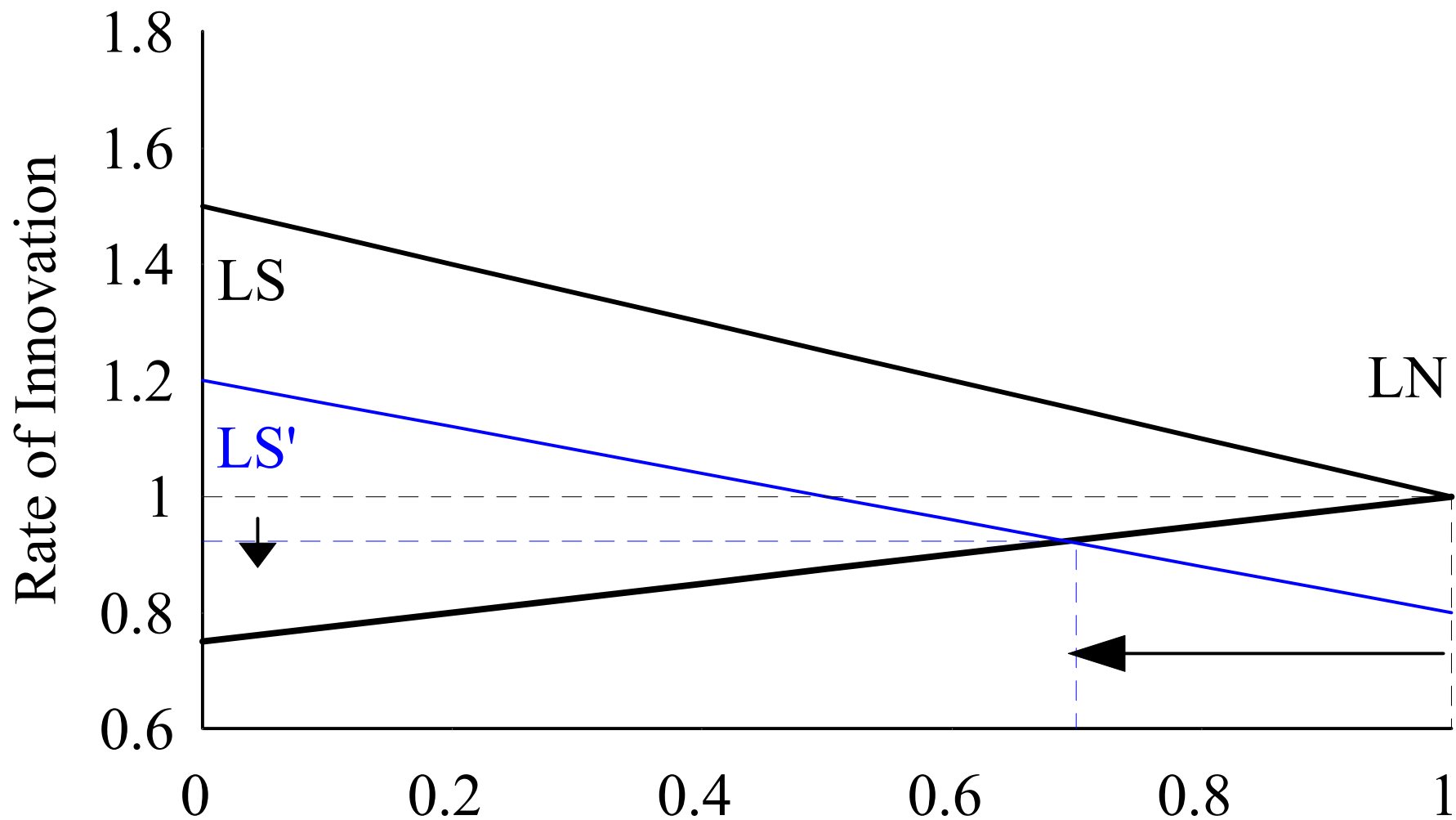


Figure Four: Foreign Direct Investment

