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INNOVATION, IMITATION, AND INTELLECTUAL PROPERTY RIGHTS

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ABSTRACT

The debate between the North and the South about the enforcement of intellectual property rights in the South is examined within a dynamic general equilibrium framework in which the North innovates new products and the South imitates them. A welfare evaluation of a policy of tighter intellectual property rights is provided by decomposing a region's welfare change into four components: terms of trade, production composition, available product choice and intertemporal allocation of consumption spending. The paper provides a theoretical evaluation of each one of these components and their relative size. The analysis proceeds in stages. It begins with an exogenous rate of innovation in order to focus on the first two components. The last two components are added by endogenizing the rate of innovation. Finally, the paper considers the role of foreign direct investment.

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1. INTRODUCTION

Companies that engage in the development of new technologies, be it for the manufacturing of new goods, improved performance of existing products, or cheaper production processes, face difficulties in appropriating the fruits of their labor. Competing manufacturers attempt to imitate successful innovations and to adopt them to their own use. In the developed market economies patent, trademark, and copyright laws prevent the abuse of intellectual property rights. But even in those countries legal protection is imperfect, imitation is widespread, and often important information leaks out already during the development process (see Mansfield, Schwartz and Wagner [1981] and Mansfield [1985]). This problem has been exacerbated by developing countries, some of which have not signed international treaties concerning protection of intellectual property rights and others that have laxly enforced domestic laws and regulations designed for this purpose (see Benko [1987]). A number of countries (including South Korea, Mexico and Malaysia) have, however, initiated legislation design to improve their record on this score.

Less developed countries often have a cost advantage in manufacturing, particularly due to low wages. For this reason their access to technologies enables them to effectively compete in product markets. This ability is mostly limited to industries that do not require highly skilled labor. Nevertheless, this has become a problem of major concern, as reflected, for example, in the fact that Trade Related Intellectual Property Rights have been put on the agenda of the recent Uruguay Round of trade negotiations under the GATT. One major reason for this development has been the relatively fast growth during the 1980s of trade in knowledge intensive products. By this I mean patented products, goods that are marketed under trademarks, as well products with copyrights protection, such as pharmaceuticals and videos. Trade in these products has grown much faster than overall trade in manufactures (see Maskus [1990]).

There exists very little evidence on the welfare effects of international infringements of intellectual property rights (IPRs). The US Chamber of Commerce has argued in the mid 1980s that US companies lose profits of about $60. billion per annum as a result of such infringements. This figure was considered to be grossly exaggerated. And indeed in a study conducted by the US International Trade Commission (1988) that asked companies to evaluated their forgone profits on account of foreign infringements of IPRs, the figure was scaled down to about $24. billion for 1986. This too may be too high.

A study by Feinberg and Sousslang (1990) derived a decomposition of welfare effects by modeling the foreign market as consisting of a dominant firm and a competitive fringe. Using 1986 data they concluded that US firms lost $2.3 billions in profits. They also computed aggregate gains of consumer surplus of about $3. billion for foreign and US consumers. Foreign firms gained $.6 billion. This suggests a net gain to the world economy of about $1.3 billion. The study employed strong assumptions. Refinements of these assumptions reduce significantly the net gains from tighter intellectual property rights (see Maskus and Konan [1991]). Moreover, the study builds on a static framework which captures at best the effects of IPRs on existing products, while the effect of IPRs on the rate of innovation has been at the center of the debate.

A major argument in favor of tighter IPRs has been that they encourage innovation from which all the regions of the world benefit. A number of countries do not find this argument convincing, however. The counter argument has been that tighter intellectual property rights only strengthen the monopoly power of large companies that are based in industrial countries, to the detriment of the less developed countries. Brazil and India in particular have voiced concern over this matter in the recent round of trade negotiations.

Not only do there exist very few empirical studies that asses the importance of intellectual property rights in the debate between the developed and less developed countries, there also do not exist enough theoretical studies that provide a suitable framework for such an evaluation. All the studies that I could find employ a static partial equilibrium framework (see Chin and Grossman [1990], Diwan and Rodrik [1991] and Deardorff [1992]). To be sure, they do provide valuable insights. But it appears that the problem at hand is dynamic in nature, and therefore a dynamic analysis is called for.

I develop in this paper dynamic general equilibrium models of two regions, North and South, which embody important elements that are pertinent to an analysis of intellectual property rights. Innovation takes place in the North while the South imitates technologies that have been invented in the North. The models build on the theory of endogenous growth and international trade that has been recently developed by Grossman and Helpman (1991b). This theory seems to be particularly suitable to the problem at hand. I identify four channels through which intellectual property rights affect these regions: (a) terms of trade; (b) interregional allocation of manufacturing; (c) product availability; and (d) R&D investment patterns. I provide welfare evaluations of each one of these effects and compare their relative size whenever they yield conflicting outcomes. Although this type of analysis is required for many policy issues, it is very rare for models of endogenous growth, and in particular for multi–country models.

Section 2 focuses on the first two effects in a simplified framework with an exogenous rate of innovation. Subsequently, in Section 3, I examine all four effects in an expanded framework that allows for endogenous rates of innovation. These two sections abstracts from foreign direct investment. In principle the existence of FDI can modify in important ways the effects of IPRs on North and South. But the empirical evidence shows no relation between IPRs and direct foreign investment (see Maskus and Konan

[1991], who also identify a significant relations between IPRs and trade volumes). Nevertheless, I examine direct foreign investment in Section 4. Conclusions are provided in the closing section.

2. TWO BASIC CONSIDERATIONS

As I have pointed out in the introduction, supporters of tighter intellectual property rights (IPRs) in less developed countries employ the argument that lax IPRs reduce the innovative effort in developed countries and thereby hurt all countries that participate in the world's trading system. I will examine in the next section the contribution of a responsive supply of R&D to the desirability of tighter IPRs. In this section, however, I employ a model with a constant rate of innovation in order to isolate two effects that play an important role independently of whether innovation is responsive to incentives: The interregional allocation of manufacturing and the terms of trade.

Tighter IPRs shift product lines from the less developed to the more developed region. In the event demand for factors of production declines in less developed countries (LDCs) and increases in developed countries, thereby improving the developed countries' terms of trade and worsening the terms of trade of the less developed countries. On this account the developed countries are better off with tighter IPRs while LDCs are worse off. On the other hand, efficiency calls for an allocation of manufacturing to the region with lower prices. Given lower wages in the less developed region, tighter IPRs bring about a shift of production to the higher price region, thereby reducing efficiency. On this account both regions lose. It follows that unless there exist additional considerations (to be discussed later on) the LDCs necessarily lose from tighter IPRs. Developed countries may gain or lose, however, depending on whether their gain from improved terms of trade outweighs their loss from the worsening of the interregional allocation of production. In the latter case both regions lose.

In what follows I construct a model in which only the above mentioned two considerations exist. My analysis reveals structural features that determine the net welfare effects of tighter intellectual property rights. A central result is that in the presence of slow imitation a tightening of IPRs hurts the less developed as well as the developed region. When the rate of imitation is high, however, a tightening of intellectual property rights hurts the less developed region but benefits the developed region. It follows that there exists a conflict of interest about the desired policy change only when imitation is high to begin with.

In this section I use a simple model, based on Krugman (1981). There exist two regions, the industrial North and the less developed South.[1] The North introduces new products at a constant exogenous rate $g = \dot{n}/n$, where n equals the number (measure) of products society knows how to produce.[2] The South imitates Northern products at the exogenous rate $m = \dot{n}^S/n^N$, where n^S represents the number of products that the South knows how to produce while n^N represents the number of products that the South has not yet imitated; $n^S + n^N = n$. The rate of imitation represents the fraction of products being imitated per unit time.

[1]There is some abuse of terminology in this two–region division, because the less developed countries are not homogeneous even for the purpose at hand. Most technological imitation of the type considered in this paper takes place by Newly Industrialized Countries (first and second generation), while the great balk of LDCs engage in this activity only marginally (I thank Alessandro Golio for making this point; see his review in UNCTAD [1991]). The former are, of course, the relevant group for our discussion.

[2]The rate of innovation can also be viewed as endogenously determined in the following way. Suppose human capital is needed for innovation and it has no other use. Let the flow of new products per unit time be given by $\dot{n} = K_n h/a_{nH}$, where K_n represents the stock of available knowledge in innovation (external to the individual innovator), h the employment of human capital in innovation, and a_{nH} a constant. Next suppose that the North has a fixed stock of human capital H and that the stock of knowledge equals cumulative experience in innovation, represented by n. Then assuming full employment yields the constant equilibrium rate of innovation $g = H/a_{nH}$.

Under these circumstances the number of products available at time t equals

$$n(t) = n(0)e^{gt}, \tag{1}$$

while the fraction of goods that have not been imitated, $\zeta = n^N/n$, obeys the differential equation[3]

$$\dot{\zeta} = g - (g + m)\zeta. \tag{2}$$

The solution is

$$\zeta(t) = \bar{\zeta} + [\zeta(0) - \bar{\zeta}]e^{-(g+m)t}, \qquad \bar{\zeta} = g/(g+m). \tag{3}$$

The fraction of goods that have not been imitated represents a state variable, determined by past innovation and imitation. Its long–run steady state value equals $\bar{\zeta} = g/(g+m)$. This fraction attains a higher long–run value the faster the pace of innovation and the slower the rate of imitation.

We may interpret in this model a tightening of intellectual property rights as a decline in the rate of imitation; the stronger legal and administrative actions taken by the Southern government to protect Northern IPRs, the slower the pace of imitation. This view is, of course, incomplete, because it does not specify the mechanism through which government policies affect the rate of imitation.[4] It proves to be useful nevertheless in an attempt to clarify a number of important issues. Be it as it may, a change in m affects the entire trajectory of ζ. Let $m = \tilde{m} - \mu$, where the initial

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[3]By definition, $\dot{\zeta}/\zeta = \dot{n}^N/n^N - \dot{n}/n$ and $\dot{n}^N = \dot{n} - \dot{n}^S$. Together with the definitions of g and m we obtain (2).

[4]See Grossman and Helpman (1991a) for a model with endogenous rates of innovation and imitation that are affected by government policies.

value of μ equals zero. Then a tightening of intellectual property rights can be represented by an increase in μ. From (3) we calculate (given the initial value of ζ):

$$(4) \qquad \frac{d\zeta(t)}{d\mu} = \left[1 - e^{-(g+m)t}\right]\frac{d\bar{\zeta}}{d\mu} + [\zeta(0) - \bar{\zeta}]te^{-(g+m)t}, \quad \frac{d\bar{\zeta}}{d\mu} > 0.$$

When the economy begins in steady state $\zeta(0) = \bar{\zeta}$, and the second term on the right hand side equals zero. In this case the fraction of goods that have not been imitated increases at each point in time in response to a tightening of IPRs (except at t=0). Since the total number of goods available does not change (see [1]), it follows that the North manufactures more goods and the South manufactures fewer goods at each point in time. In order to find out how this reallocation of production affects welfare, we need to specify the structure of production and preferences, to which I turn next.

Individuals have identical preferences in both regions. Their welfare equals the discounted flow of utility

$$(5) \qquad U(t) = \int_t^{\infty} e^{-\rho(\tau-t)} \log u(\tau)\, d\tau,$$

where ρ represents the subjective discount rate and $\log u(\tau)$ the flow of utility at time τ. The flow of utility depends on consumption of the above mentioned n products via a CES preference structure

$$(6) \qquad u = \left[\int_0^n x(j)^{\alpha}\, dj\right]^{1/\alpha}, \quad 0 < \alpha < 1,$$

where x(j) represents consumption of product j.[5] A product can be consumed only if

[5]An alternative interpretation would be to view the n products as intermediate inputs and u as a quantity of a homogeneous consumption good.

supplied, and it can be supplied only if it has been invented. For this reason consumers allocate spending only across the available products.

These preferences are homothetic. Therefore aggregate demand can be directly derived from individual preferences. As is well known the resulting demand functions have constant elasticities;

$$(7) \qquad x(j) = p(j)^{-\epsilon} \frac{E}{P^{1-\epsilon}}, \qquad \epsilon = \frac{1}{1-\alpha} > 1,$$

where E represents spending on consumer goods, ϵ the elasticity of demand, and P the price index

$$(8) \qquad P = \left[\int_0^n p(i)^{1-\epsilon} di\right]^{\frac{1}{1-\epsilon}}$$

Substituting the demand functions (7) into (6), and taking account of (8), we obtain the indirect utility function

$$(9) \qquad \log u = \log E - \log P.$$

Namely, the flow of utility equals the logarithm of real spending.

Next suppose that goods are manufactured with one unit of labor per unit output in both regions. A Northern manufacturer that invents a product can charge a monopoly price as long as his product has not been imitated.[6] For the time being also assume that Northern inventors manufacture their products at home; i.e., they do not go

[6]Imitation cannot emanate from Northern companies as long as price competition prevails (as I assume below) and there are positive private costs of imitation (no matter how small). This follows from the fact that in this case the imitator ends up with zero operating profits, because all Northern firms face the same constant unit manufacturing costs (see Grossman and Helpman [1991a]).

multinational (I deal with multinationals in Section 4). In this case the demand functions (7) imply that the monopoly price of every product that has not been imitated equals

(10) $$p^N = \frac{1}{\alpha} w^N,$$

where w^N represents the wage rate in the North (that equals the manufacturer's marginal costs). It follows that the n^N products that have not been imitated are priced with a markup above Northern wages. On the other hand, the technology of a product that has been imitated by the South becomes available to all Southern manufacturers.[7] In the event competition leads to marginal cost pricing of the remaining n^S products;

(11) $$p^S = w^S,$$

where w^S stands for the wage rate in the South. We assume that the wage rate is higher in the North. Therefore the price of goods manufactured in the North is also higher.

Taking account of the pricing practices (10) and (11), the price index P can be represented by (see [8]):

(12) $$P = n^{\frac{1}{1-\epsilon}}\left[\zeta(p^N)^{1-\epsilon} + (1-\zeta)(p^S)^{1-\epsilon}\right]^{\frac{1}{1-\epsilon}}$$

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[7]An alternative specification can also be used. Suppose that the technology of a product that has been imitated becomes available only to the imitator. Then he forms a duopoly with the Northern innovator. Assuming price competition, the Southern imitator (who has a cost advantage by assumption) takes over the entire market for the product. He engages in monopoly pricing if the gap between the Northern and Southern wage rates is large enough, or in limit pricing if it is not large enough (see Grossman and Helpman [1991a]). In the former case our results remain essentially intact.

Since welfare is higher the higher real spending, an increase in the fraction of goods manufactured in the North hurts every consumer with a fixed nominal expenditure level. Because — other things equal — an increase in ζ raises the price index and reduces real spending. Other things do not remain equal, however, when the fraction of goods manufactured in the developed region rises as a result of tighter intellectual property rights. In order to see what additional changes take place we need to consider labor markets.

Denote by x^N output per product in the North and by x^S output per product in the South. In similar vein denote by L^i the labor force of region i, i=N,S. Then we can express the labor market clearing conditions by

$$(13) \qquad n^i x^i = L^i, \quad i = N,S.$$

From the demand functions (7) and the labor market clearing conditions (13) we obtain:

$$(14) \qquad \frac{p^N}{p^S} = \left[\frac{L^S}{L^N}\frac{\zeta}{1-\zeta}\right]^{1/\epsilon}.$$

This shows that shifts in the interregional distribution of manufacturing affects relative prices; the terms of trade improve in the North and deteriorate in the South as a result of tighter intellectual property rights (because the fraction of goods manufactured in the North increases; see the discussion following equation [4]).

We are now in a position to consolidate the welfare effects of tighter IPRs. The formal model has identified two channels of influence on regional welfare levels: (a) the interregional allocation of production; and (b) terms of trade movements. It is quite clear that both lead to a welfare loss for the South. The remaining question is whether they necessarily bring about a welfare gain to the North. In order to answer this question we need to perform some calculations.

Income per worker in the South equals p^S while income per worker in the North equals p^N, despite the fact that the North derives income from both labor services and profits while the South derives income only from labor services.[8] All income is equally distributed across workers within a region and trade is balanced. In this case consumer spending per worker in region i equals p^i, i=N,S. It follows from (9) and (12) that the flow of utility of typical workers in the North and South equal

(15) $$\log u^N = \frac{1}{\epsilon-1}\log n + \frac{1}{\epsilon-1}\log\left[\zeta + (1-\zeta)(p^N/p^S)^{\epsilon-1}\right],$$

(16) $$\log u^S = \frac{1}{\epsilon-1}\log n + \frac{1}{\epsilon-1}\log\left[\zeta(p^S/p^N)^{\epsilon-1} + (1-\zeta)\right],$$

where use has been made of the fact that spending on consumer goods E equals p^N for a Northern worker and p^S for a Southern worker. Since Northern manufacturers charge a higher price than their Southern competitors, it is evident from these equations that for given terms of trade p^N/p^S an increase in the share of goods manufactured in the North reduces welfare of typical workers in both regions. In addition, the induced rise in the reletive price of Northern products (see [11]) benefits Northern workers and hurts Southern workers (recall that $\epsilon > 1$).

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[8]In the South all income derives from labor services and aggregate income equals $w^S L^S$. Therefore income per worker (assuming that L^S represents the number of workers) equals the wage rate. But the wage rate equals the price of a Southern product (see [11]). The North derives income from both labor and profits, and aggregate income equals $n^N \pi^N + w^N L^N$, where π^N represents profits per product. From the pricing equation (10) profits per product equal the fraction $(1-\alpha)$ of revenue, or $\pi^N = (1-\alpha)p^N x^N$. Taking account of the labor market clearing condition (13) and the pricing equation (10) this implies that aggregate income equals $p^N L^N$. Therefore income per worker equals the price of a Northern product.

In order to calculate the overall effect on a Northern worker's welfare we use the intertemporal preference structure (5) to obtain

$$(17) \qquad \frac{dU^N(0)}{d\mu} = \int_0^\infty e^{-\rho t} \frac{d\log u^N(t)}{d\mu} dt.$$

For economies that are initially in steady state (i.e., $\zeta(0) = \bar{\zeta}$), eqution (17) together with (4), (14), (15) implies:

$$(18) \qquad \frac{dU^N(0)}{d\mu} = \frac{1}{K}\left\{ 1 - \left[1 - \frac{\alpha}{\bar{\zeta}}\right] \left[\frac{L^S}{L^N} \frac{\bar{\zeta}}{1 - \bar{\zeta}}\right]^{\alpha} \right\},$$

where

$$K = (\epsilon - 1)\rho(\rho + g + m)(g + m)g^{-1}\left[\bar{\zeta} + (1-\bar{\zeta})^{1-\alpha}\bar{\zeta}^{\alpha}(L^S/L^N)^{\alpha}\right] > 0 .$$

The term in the second parenthesis on the right hand side of (18) is larger than one as long as Northern products command higher prices (see [14]), while $\alpha/\bar{\zeta}$ can be smaller or larger than one [recall that $\bar{\zeta} = g/(g+m)$]. It follows that the term in braces on the right hand side can be positive or negative. If $\alpha/\bar{\zeta}$ exceeds one, for example, Northern workers gain from a tightening of intellectual property rights. In this case their gain from improved terms of trade outweighs their loss from the interregional reallocation of production. When $\alpha/\bar{\zeta}$ falls short of one, however, they may gain or lose. It is instructive to see how these possibilities depend on the initial level of the rate of imitation.

First consider a world in which the rate of imitation is very small (close to zero). In this case the share of goods manufactured by the North is close to one and the right hand side of (18) is negative (the price of goods is then necessarily lower in the less developed region). It follows that in this case tightening of intellectual property rights benefits neither the South nor the North. Another way to put it is that a small degree of imitation benefits both regions. As the rate of imitation increases, however, the right hand side of (18) also increases and it attains the value zero for some critical rate of imitation m_c (holding constant all other parameters). The right hand side is positive for all rates of imitations that exceed this critical level. Naturally, the range of feasible rates of imitation is determined by the requirement that wages be lower in the South, or $m \in (0, \alpha^{\epsilon} gL^S/L^N]$ (see [10] and [14]). Therefore if $m_c \in (0, \alpha^{\epsilon} gL^S/L^N)$, there exists a range of feasible imitation rates $m \in (m_c, \alpha^{\epsilon} gL^S/L^N)$ for which tightening of IPRs benefits the North and hurts the South. We have thus established:

PROPOSITION 1: For economies in steady state there always exists a range of feasible imitation rates $0 < m < \min\ \{m_c, \alpha^{\epsilon} gL^S/L^N\}$ in which a tightening of intellectual property rights hurts both regions. If $m_c < \alpha^{\epsilon} gL^S/L^N$, however, there also exists a range of feasible imitation rates $m_c < m < \alpha^{\epsilon} gL^S/L^N$ in which tightening of intellectual propery rights benefits the North and hurts the South.

This proposition establishes conditions under which the tightening of intellectual property rights benefits or hurts the North. As is evident from the proposition the range of imitation rates in which the North loses expands the higher the critical value m_c. On the other hand, an examination of the right hand side of (18) reveals that m_c rises with the relative size of the South L^S/L^N and with the rate of innovation g. Therefore the larger the relative size of the South or the rate of innovation, the larger the range of imitation rates in which the North suffers from tighter intellectual property rights. The North necessarily loses from tighter IPRs whenever the rate of imitation is small.

3. ENDOGENOUS INNOVATION

Our discussion has so far neglected the effects of tighter intellectual property rights on the rate of innovation. As pointed out in the introduction, however, this issue plays a major role in public policy discussions. For this reason I examine in this section the response of the rate of innovation to tighter IPRs in the short–run as well as the long–run, and the overall effect of this response on the welfare of the South and the North. An important result of this inquiry is that the rate of innovation rises initially and subsequently declines. The temporary acceleration of innovation not withstanding, however, the overall welfare effect of the shift in the time pattern of available products proves to be detrimental for both regions. Adding up these effects to the welfare contribution of terms of trade movements and the interregional allocation of production (that were discussed in the previous section), as well as intertemporal shifts in the savings rate in the North, we can calculate overall welfare changes. Although these prove to be ambiguous, the calculations identify structural features that determine the bottom line of this welfare calculus. An important result that emerges is that despite the endogenous response of the rate of innovation, both regions lose from tighter IPRs whenever imitation proceeds at a slow pace.

It proves most convenient to begin this discussion with the help of a simple approach developed by Grossman and Helpman (1991a), in which innovation requires labor input.[9] Let the invention of new products per unit time $\dot{n}$ equal lK_n/a, where $\underline{a}$ represents a productivity parameter in innovation, l labor employed in R&D, and K_n the cumulative stock of knowledge in the inventive activity. The latter is taken to equal n. Therefore $g = l/a$, and the resource constraint for the North becomes

[9]They also assume that imitation requires labor input. For present purposes, however, I maintain the assumption that the rate of imitation depends only on the degree of enforcement of intellectual property rights.

(19) $$ag + n^N x^N = L^N$$

rather than (13) (the latter remains valid for $i = S$). The first term on the left hand side represents employment in R&D while the second term represents employment in manufacturing.

In order to invest in R&D the reward from this activity, which consists of a firm whose value we denote by v^N, has to cover R&D outlays. The equilibrium value of a firm cannot exceed these outlays, because otherwise the demand for labor by innovators becomes unbounded (we assume free entry into innovation). If the value of a firm falls short of R&D costs, however, no rational agent invests in R&D. It follows that in an equilibrium with positive innovation R&D costs just equal the value of a firm. Given the above specified R&D technology, this condition becomes

(20) $$v^N = w^N a/n.$$

Now assume that the developed region has well functioning financial markets, including a stock market. Then the value of a firm equals the present value of its expected stream of profits, because firms face idiosyncratic risks that can be diversified away via portfolio holdings. In fact the only risk faced by a firm is that its product will be imitated by the South. In a time interval of length dt the South imitates a proportion mdt of northern products. Let the firms targeted for imitation be chosen randomly with a uniform distribution. Then every product that has not been imitated so far faces the probability mdt of being imitated in the next time interval of length dt (put differently, m represents the hazard rate of being imitated). Under these circumstances arbitrage in asset markets implies (see Grossman and Helpman [1991a]):

$$\frac{\pi^N}{v^N} + \frac{\dot{v}^N}{v^N} = r^N + m, \tag{21}$$

where π^N represents profits per unit time and r^N stands for the nominal interest rate in the North. This is a standard no arbitrage condition in asset markets. It states that the inverse of the price earning ratio (the first term on the left hand side) plus the rate of capital gain on equity holdings equals the risk adjusted interest rate. Here risk adjustment relates to the instantaneous probability of being imitated.[10]

Northern products are priced according to (10). In the event profits per product equal a fraction $(1-\alpha)$ of revenue; i.e., $\pi^N = (1-\alpha)p^N x^N$. Using the resource constraint (19) it follows that $\pi^N = (1-\alpha)p^N(L^N - ag)/n^N$. Substituting this equation together with (10) and (20) into (21) implies

$$\frac{1-\alpha}{\alpha}\frac{L^N - ag}{a\zeta} + \frac{\dot{v}^N}{v^N} = r^N + m. \tag{22}$$

It remains to derive an expression for the interest rate.

As is well known, a Northern consumer that maximizes welfare with preferences (5) and an indirect utility function (9) subject to an intertemporal budget constraint

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[10]This equation can directly be derived from the observation that the value of a firm equals the expected present value of its profits stream by differentiating this equality. Alternatively one can use the following no arbitrage argument. In a time interval of length dt the firm provides a profit stream of $\pi^N dt$. In addition it provides a capital gain of $\dot{v}^N dt$ if not imitated and a capital loss of v if imitated (the latter results from the fact that profits drop to zero for products that have been imitated, therefore imitation leads to a total capital loss). The probability of being imitated in this time interval equals mdt and the probability of not being imitated equals $(1-mdt)$. Therefore the expected reward for the owners of the firm equals $\pi^N dt + (1-mdt)\dot{v}^N dt - mdtv$. If they were to sell their shares and deposit the money in a bank they would receive interest income of $r^N vdt$ during the same time interval. Arbitrage in asset markets implies that these two forms of asset holdings yield the same reward. Dividing this equality by dt and taking the limit as dt approaches zero implies (21).

chooses a rate of growth of consumption spending that equals the difference between the interest rate and his subjective rate of time preference; i.e.,

$$(23) \qquad \frac{\dot{E}^N}{E^N} = r^N - \rho.$$

Now assume that no financial capital flows between the two regions, so that the North finances investment in R&D with domestic savings. The lack of international capital mobility implies that the trade account is balanced at every point in time, or $E^N = p^N n^N x^N$. Using this relationship together with (10), (20), (22) and (23), we obtain a differential equation in the rate of innovation[11]

$$(24) \qquad \dot{g} = \left[\frac{L^N}{a} - g\right]\left[\rho + m + g - \frac{1-\alpha}{\alpha}\left[\frac{L^N}{a} - g\right]\frac{1}{\zeta}\right].$$

Equation (24) together with the differential equation (2) for the fraction of goods that have not been imitated, that I reproduce here for convenience,

$$(25) \qquad \dot{\zeta} = g - (g + m)\zeta,$$

[11]From the relationship between spending and the value of production, $E^N = p^N n^N x^N$, and the resource constraint (19), we obtain

$$\frac{\dot{E}^N}{E^N} = -\frac{a\dot{g}}{L^N - ag} + \frac{\dot{p}^N}{p^N}.$$

From the valuation of firms on the supply side, however, given by (20), and the pricing of goods (10), the rate of increase in the price of Northern products equals the rate of appreciation of a firm plus the rate of innovation. Substituting this relationship together with the previous equation into (23), we obtain an expression for the interest rate

$$r^N = \rho + g - \frac{a\dot{g}}{L^N - ag} + \frac{\dot{v}^N}{v^N}.$$

Substituting this result into the no arbitrage condition (22) yields the differential equation (24).

form an autonomous system of two differential equations in (g,ζ), in which ζ is a state variable while g is a jump variable.

Figure 1 depicts the phase diagram for this system. The shaded area represents a non–feasible region in which either the share of goods not yet imitated exceeds one or R&D employment exceeds the labor force in the North. The dotted area represents a non–feasible region in which the wage rate in the North is lower than in the South, defined by[12]

$$g < \frac{1}{a}\left[L^N - \frac{\zeta}{1-\zeta}\alpha^{\epsilon}L^S\right]. \tag{26}$$

The equation for the heavy line curve $\dot{g} = 0$ can be represented by

$$\zeta = \frac{1-\alpha}{\alpha}\left[\frac{L^N}{a} - g\right]\frac{1}{\rho + m + g}, \tag{27}$$

while the equation for the heavy line curve $\dot{\zeta} = 0$ can be represented by

$$\zeta = \frac{g}{g + m}. \tag{28}$$

The intersection of these two curves at point A describes the steady state long–run equilibrium. All trajectories that do not converge to this point violate an equilibrium requirement over some time interval (see Grossman and Helpman [1991b]). The equilibrium trajectory consists of the saddle path that converges to A. Along this saddle path the rate of innovation declines over time and the fraction of products that have not

[12] From the demand functions (7), the labor market clearing condition (13) for the South and (19) for the North, we obtain
$$\frac{p^N}{p^S} = \left[\frac{L^S}{L^N - ag}\,\frac{\zeta}{1-\zeta}\right]^{1/\epsilon}.$$
Together with the pricing conditions (10) and (11) this equation implies that the wage rate is lower in the South if and only if (26) holds.

been imitated increases over time whenever the latter falls short of its steady state value, and the the rate of innovation increases over time and the fraction of products that have not been imitated declines over time whenever the latter exceeds its steady state value.

As is evident, my discussion has been confined to an economic environment in which there exists long–run innovation and the wage rate is lower in the South. This combination is, of course, of particular interest for the problem at hand. A natural question that arises, however, is whether this combination is likely to emerge; namely, whether point A is likely to be outside the dotted area. The answer depends on structural parameters, and it proves again useful to examine its dependence on the rate of imitation. For this purpose first observe that the dotted area does not depend on the rate of imitation while the location of point A depends on it. In particular, it follows from (27) and (28) that a reduction in the rate of imitation shifts rightwards curves $\dot{g} = 0$ and $\dot{\zeta} = 0$, with the latter shifting proportionately more. The result is that the long–run equilibrium point shifts down and to the right, implying that the long–run rate of innovation $\bar{g}$ declines and the long–run fraction of products that have not been imitated $\bar{\zeta}$ increases. In the limit, as the rate of imitation m approaches zero, $\bar{\zeta}$ approaches one and the rate of innovation approaches $(1-\alpha)\frac{L^N}{a} - \alpha\rho$. This describes the rate of innovation attained by the North when it does not trade with the South, provided it is positive. Otherwise the autarky rate of innovation in the North equals zero (see Grossman and Helpman [1991a]). Assume that an isolated North innovates at a positive rate; i.e., $(1-\alpha)\frac{L^N}{a} > \alpha\rho$. Then for m approaching zero the long–run equilibrium approaches a point on the vertical broken line passing through $\zeta = 1$. This point is necessarily outside the dotted area. We conclude that given the model's parameters there exists an upper bound on the imitation rate, m_{max}, such that point A is in the feasible region outside the dotted area for all $m \in (0, m_{max})$. I confine the following analysis to $m \in (0, m_{max})$.

Our preceding analysis has established in passing that the long–run rate of innovation declines and the long–run fraction of unimitated products increases in response to tighter intellectual property rights.[13] These results are important for what follows and deserve to be stated as a proposition:

PROPOSITION 2: $\frac{d\bar{g}}{d\mu} < 0$ and $\frac{d\bar{\zeta}}{d\mu} > 0$.

The first part of this proposition shows that tighter IPRs need not stimulate innovation in the long run (see, however, the next proposition for short–run effects). In order to understand how this case arises, combine (27) with (28) into a single equation that provides an implicit solution for the long–run rate of innovation:

$$\text{(30)} \qquad \frac{1-\alpha}{\alpha}\left[\frac{L^N}{a} - g\right]\frac{m + g}{g} = \rho + m + g.$$

The left hand side represents the inverse of the price earning ratio. The right hand side represents the effective cost of capital, inclusive of a risk premium. A tightening of intellectual property rights (a reduction of m) reduces the effective cost of capital as well as the inverse of the price earning ratio. Moreover, its impact on the effective cost of capital is smaller in size than on the inverse of the price earning ratio. The result is that it becomes less profitable to innovate, and the rate of innovation declines.[14]

A proper welfare evaluation requires knowledge of the effects of tighter IPRs on the entire trajectory of g and ζ, and not only on their steady state values (see Diamond [1981] and Judd [1982]). We turn now to this calculation. I restrict the analysis to economies that are initially in steady state; namely, $\zeta(0) = \bar{\zeta}$. For

[13] A related result appears in Grossman and Helpman (1991a).

[14] The intuition behind this result will be discussed after the derivation of the short–run effect of a tightening of IPRs on the rate of innovation.

economies of this type we can calculate the first order response of (ζ, g) to a tightening of intellectual property rights from a linearized version of the differential equations (24) and (25) around their steady state values. The linearized system is

$$\begin{bmatrix} \dot{\zeta} \\ \dot{g} \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} \zeta - \bar{\zeta} \\ g - \bar{g} \end{bmatrix}, \tag{31}$$

where

$$a_{11} = -(m + g) ,$$

$$a_{12} = \frac{m}{m + g} ,$$

$$a_{21} = \frac{\alpha}{1 - \alpha} (\rho + m + g)^2 ,$$

$$a_{22} = (\rho + m + g)\left[\frac{\alpha}{1 - \alpha} \frac{g}{g + m} + 1\right] .$$

Since the trace of the matrix on the right hand side is positive and its determinant is negative, it has one positive and one negative characteristic root. To ensure long–run convergence we need to choose a zero value for the free coefficient that multiplies the solution part that is associated with the positive root. Since g is a jump variable while ζ is a state variable, we also have to choose the remaining free coefficient so as to ensure that at time zero the fraction of goods not yet imitated equals their initial value. This procedure leads to the solution

$$\zeta(t) = \bar{\zeta} + [\zeta(0) - \bar{\zeta}]e^{-\lambda t} , \tag{32}$$

$$g(t) = \bar{g} - [\zeta(0) - \bar{\zeta}]\Lambda e^{-\lambda t}, \tag{33}$$

where $-\lambda$ equals the negative characteristic root (i.e., $\lambda > 0$) and $[1,-\Lambda]^T$ represents the characteristic vector associated with the negative characteristic root, with $\Lambda > 0$.[15] This solution describes the same directions in the evolution of ζ and g as does Figure 1. From these equations we now calculate the response of (ζ,g) to a tightening of intellectual property rights. Taking into account the initial condition $\zeta(0) = \bar{\zeta}$, we obtain:

$$\frac{d\zeta(t)}{d\mu} = \left[1 - e^{-\lambda t}\right]\frac{d\bar{\zeta}}{d\mu}, \tag{34}$$

$$\frac{dg(t)}{d\mu} = \frac{d\bar{g}}{d\mu} + \Lambda e^{-\lambda t}\frac{d\bar{\zeta}}{d\mu}. \tag{35}$$

It follows from these equations and from Proposition 2 that the fraction of goods that have not been imitated rises at each point in time following a tightening of IPRs (except for $t = 0$). On the other hand, although the rate of innovation declines in the long run, (35) suggests that it may increase in the short–run, and especially so if the long–run response of the rate of innovation is weak.[16]

A larger share ζ hurts the South on account of a worsening of its terms of trade and a worsening of the interregional allocation of production. The North is also hurt on account of the worsening of the interregional allocation of production, but unlike the South it gains from improved terms of trade. These points, that we discussed in the previous section, also apply in the current setup. Both regions would lose on account of

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[15]By definition $A[1,-\Lambda]^T = -\lambda[1,-\Lambda]^T$, where A is the matrix on the right hand side of (31). Since the second row of the matrix is positive, we have $\Lambda > 0$. I provide explicit formulas for λ and Λ in the appendix.

[16]This observation follows from the fact that the first term on the right hand side of (35) is negative while the second term is positive.

slower growth in the world economy if the rate of innovation were to decline at each point in time.[17] But if the rate of innovation were to rise temporarily, however, both regions might gain on account of a spurt in growth in the world economy, even though eventually the spurt is reversed.

Can the rate of innovation rise temporarily as a result of tighter IPRs? The answer to this question is that it must. In order to develop some intuition for this result consider the limiting case $\rho = 0$.[18] The steady state equations (27) and (28) imply that for $\rho = 0$ a reduction of m shifts both curves $\dot{\zeta} = 0$ and $\dot{g} = 0$ in Figure 1 rightwards by the same proportion. Consequently the long–run equilibrium point A shifts horizontally to B in Figure 2. The new equilibrium trajectory that passes through B slopes downward, as depicted. Therefore initially the system jumps from A to A' and subsequently follows the saddle path to B. Evidently the rate of innovation remains higher at all points in time until it reaches its steady state value. Now continuity implies that for ρ positive but close to zero a tightening of intellectual property rights increases the rate of innovation over a finite time interval.

Next I establish that the rate of innovation has to increase on impact. From the steady state equations (27)–(28) we calculate:

(36) $$\frac{d\bar{\zeta}}{d\mu} = \frac{\bar{g}}{D}\frac{1}{\alpha},$$

(37) $$\frac{d\bar{g}}{d\mu} = -\frac{\bar{g}}{D}\rho,$$

where

[17]Because the first term on the right hand side of (15) and (16) is smaller in this case at each point in time.

[18]The subjective discount rate cannot equal zero, because it would imply unbounded utility U(0). This utility level is, however, finite for all positive values of ρ. For this reason we should think about this exercise as applying to the limit of a sequence of economies with $\rho \to 0$.

$$D = m\rho + \frac{1}{\alpha}(m + \bar{g})^2 .$$

Together with (34) these expressions imply

(38) $$\frac{dg(0)}{d\mu} = \frac{\bar{g}}{D\alpha}(\Lambda - \alpha\rho).$$

I show in the appendix that

(39) $$\alpha\rho < \Lambda < \alpha(\rho + \lambda).$$

It follows from (38) and (39) that the rate of innovation rises on impact. By continuity this also implies:

PROPOSITION 3: For economies in steady state there exists a time interval $[0,T)$ such that $\frac{dg(t)}{d\mu} > 0$ for $t \in [0,T)$.

We have established that a tightening of intellectual property rights initially raises the rate of innovation, but that the rate of innovation subsequently declines. The intuition behind this result is the following. A reduction in the rate of imitation increases the expected tenure of a monopolistic supplier in the market. If the rate of innovation does not change his risk adjusted cost of capital $\rho + g + m$ declines. At the same time the inverse of the price earning ratio $\pi^N/v^N = (1-\alpha)(L^N/a - g)/\alpha\zeta$ does not change, because the fraction ζ does not change on impact. In that event the profitability of R&D rises, more resources get attracted to innovation and g increases on impact. It thereby raises the price earning ratio and mitigates the decline in the effective cost of capital. As the pace of innovation rises, however, the difference between the inverse of the price earning ratio and the effective cost of capital declines over time as a result of a gradual increase in the share of products that have not been imitated ζ (the latter reduces the inverse of the price earning ratio). These developments lead to a gradual reduction in the rate of innovation until it declines in the long run.

Our results imply that the number of products available to consumers rises in the initial phase but declines in the long run. Since consumers value product choice (i.e., welfare rises with the number of available products; see [15] and [16]), their flow of utility rises in the initial phase on account of the endogenous response of the rate of innovation but declines eventually. In order to obtain the overall welfare effect of these changes we need to expand our calculations.

First observe that the South spends all its income on consumer goods, because there exist no international capital flows and no investment takes place in the South. As a result the utility flow of a Southern worker, whose income equals p^S per unit time, remains the same as in (16). Consequently the increase in the present value of a Southern worker's utility flow, discounted with the subjective rate of time preference, can be calculated as

(40) $$\frac{dU^S(0)}{d\mu} = \frac{1}{\epsilon - 1}(\Delta_n + \Delta_e^S),$$

where

(41) $$\Delta_n \equiv \frac{d}{d\mu}\int_0^\infty e^{-\rho t} \log n(t)\, dt,$$

(42) $$\Delta_e^S \equiv \frac{d}{d\mu}\int_0^\infty e^{-\rho t} \log \left[\zeta(t)[p^S(t)/p^N(t)]^{\epsilon-1} + 1 - \zeta(t)\right] dt,$$

and relative prices equal (see footnote 12):

$$(43) \qquad \frac{p^N(t)}{p^S(t)} = \theta(t)^{1/\epsilon}, \quad \theta(t) \equiv \frac{L^S}{L^N - ag(t)} \frac{\zeta(t)}{1 - \zeta(t)}.$$

The term Δ_n captures the welfare effect of product availability while Δ_e^S captures the effect of real spending for a *given* profile of available products. The latter represents changes that emanate from terms of trade and the interregional allocation of production. The South's terms of trade improve if and only if θ declines.

The calculation for the North is somewhat more complicated, because the North saves and invests in R&D. As I have already pointed out the lack of international capital mobility implies aggregate Northern spending on consumer goods $E^N = p^N n^N x^N$, which together with the resource constraint (19) implies $E^N = p^N(L^N - ag)$. From here spending per worker equals $p^N(1 - ag/L^N)$, where ag/L^N represents the savings and investment rate. In the previous section, where there was no saving and no investment, spending per worker equaled p^N. Now we need to replace the flow of utility equation (15) with

$$(44) \quad \log u^N = \frac{1}{\epsilon-1} \log n + \frac{1}{\epsilon-1} \log \left[\zeta + (1-\zeta)(p^N/p^S)^{\epsilon-1}\right] + \log(1 - ag/L^N),$$

in order to account for savings. The last term on the right hand side represents the effect of savings on the current utility flow; the larger the savings rate the lower current utility. From (44) we calculate the change in the discounted flow of utility of a Northern worker as:

$$(45) \qquad \frac{dU^N(0)}{d\mu} = \frac{1}{\epsilon - 1}(\Delta_n + \Delta_e^N) + \Delta_s^N,$$

where Δ_n is given in (41),

$$(46) \qquad \Delta_e^N \equiv \frac{d}{d\mu}\int_0^\infty e^{-\rho t} \log \left[[1-\zeta(t)][p^N(t)/p^S(t)]^{\epsilon-1} + \zeta(t)\right] dt,$$

$$(47) \qquad \Delta_s^N \equiv \frac{d}{d\mu}\int_0^\infty e^{-\rho t} \log\,[1 - ag(t)/L^N]dt.$$

Here Δ_n captures again the welfare effect of product availability, Δ_e^N represents the welfare effect of real income for a given time profile of available products, and Δ_s^N represents the welfare effect of the endogenous shifts in saving rates.

Using equations (35)–(37) and the fact that $\log n(t) = \log n(0) + \int_0^t g(\tau)d\tau$, we calculate from (41):

$$(48) \qquad \Delta_n = \frac{\bar{g}}{\alpha\rho D(\rho+\lambda)}\,[\Lambda - \alpha(\rho+\lambda)]\,.$$

Together with (39) this equation proves the following:

PROPOSITION 4: For economies in steady state a tightening of intellectual property rights hurts both regions via its effect on product availability; i.e., $\Delta_n < 0$.

This result is quite striking. Since the rate of innovation rises initially and declines subsequently, one would expect product availability to raise welfare for high subjective discount rates and reduce welfare for low subjective discount rates. The reason that this intuition does not apply is that a higher subjective discount rate also leads to a larger long–run decline and a smaller short–run increase of the rate of innovation (see (35)–(37)).

In order to complete our welfare analysis for the South we need to consider the term Δ_e^S that embodies changes in the interregional allocation of production and the terms of trade. It proves in fact useful to decompose this expression into

$$\Delta_{e}^{S} = \Delta_{\zeta}^{S} + \Delta_{\theta}^{S},$$

where the first term on the right hand side represents the effect on (42) of changes in $\zeta(t)$ *holding constant relative prices* and the second term represents the effect on (42) of changes in relative prices *holding constant the weights* $\zeta(t)$ *and* $[1-\zeta(t)]$ in equation (42). These two effects operate here very much in the same way as in the simpler model discussed in the previous section. The difference is that now changes in the rate of innovation also affect the terms of trade (see [43]). In particular, since the rate of innovation rises initially and declines subsequently, it brings about an initial deterioration of the South's terms of trade and a subsequent improvement (because an expansion of R&D raises the demand for Northern labor). I show, however, in the appendix that the endogenous response of the rate of innovation notwithstanding the overall welfare effect of the terms of trade is negative for the South; i.e., $\Delta_{\theta}^{S} < 0$. It is also straightforward to see from (42) that the production reallocation effect reduces the South's welfare; i.e., $\Delta_{\zeta}^{S} < 0$. It follows that:

PROPOSITION 5: For economies in steady state tighter intellectual property rights hurt the South on account of both changes in the interregional allocation of production and changes in the terms of trade; i.e., $\Delta_{\zeta}^{S} < 0$ and $\Delta_{\theta}^{S} < 0$.

Propositions 4 and 5 imply that the South loses from tighter intellectual property rights on account of all the available measures, which proves:

THEOREM 1: For economies in steady state the South loses from tighter intellectual property rights.

This theorem establishes the important result that *the temporary acceleration of the rate of innovation in response to tighter intellectual property rights is never sufficient to compensate the South for its losses.* And as we have seen, the South has no other sources of gain.

Next consider the welfare of the North. We have already seen in Proposition 4 that the North loses as a result of the shift in the time profile of available products. As (45) shows, however, we need to compare this loss to the changes in welfare that result from shifts in real income for a given profile of product availability and the adjustments in the savings rate. From (47) together with (35)–(37) I calculate the contribution of the savings rate to be:

$$(49) \qquad \Delta_s^N = -\frac{\bar{g}}{\alpha D(\rho+\lambda)}[\Lambda - \alpha(\rho+\lambda)]\left[\frac{L^N}{a} - \bar{g}\right]^{-1}.$$

This is positive in view of (39). It demonstrates that adjustments of savings are welfare enhancing. A comparison of (49) with (48) shows, however, that $\frac{1}{\epsilon-1}\Delta_n^N + \Delta_s^N < 0$.[19] which proves the following:

PROPOSITION 6: For economies in steady state a tightening of intellectual property rights raises the North's welfare on account of adjustments in the savings rate, but this welfare gain is smaller than the welfare loss inflicted by the shift in the time profile of available products; i.e., $\Delta_s^N > 0$ and $\frac{1}{\epsilon-1}\Delta_n^N + \Delta_s^N < 0$.

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[19]The sum of these terms is negative if and only if $(1-\alpha)(L^N/a - \bar{g})/\alpha > \rho$, or $g(m=0) > (1-\alpha)\bar{g}$, where $g(m=0) = (1-\alpha)L^N/a - \alpha\rho$ is the steady state rate of innovation when the rate of imitation equals zero. Since the steady state rate of innovation rises with the rate of imitation (Proposition 2), $g(m=0) \geq \bar{g}$ and therefore the second inequality holds.

It remains to evaluate Δ_e^N.

As in the discussion of the South we can decompose Δ_e^N into the production allocation and the term of trade effects:

$$\Delta_e^N = \Delta_\zeta^N + \Delta_\theta^N,$$

where the first term on the right hand side represents the effect on (46) of changes in $\zeta(t)$ *holding constant relative prices* and the second term represents the effect on (46) of changes in relative prices *holding constant the weights* $\zeta(t)$ and $[1-\zeta(t)]$. Clearly, Δ_ζ^N represents the production reallocation affect while Δ_θ^N represents the terms of trade effect. The former is negative, as can be seen directly from (46). I show in the appendix that the latter is positive, despite the fact that now the terms of trade also change in response to shifts in the rate of innovation. Moreover, I show in the appendix that for imitation rates close to zero $\Delta_\zeta^N + \Delta_\theta^N < 0$. This stems from the fact that for m close to zero the relative price of Southern products is very low and their weight in the price index is close to zero. In this event a further reduction of the relative price of Southern products has a small effect on the standard of living of Northern residents and the other elements, whose effect is negative, dominate the change in North's welfare. This proves the following:

PROPOSITION 7: For economies in steady state a tightening of intellectual property rights brings about welfare losses to the North on account of the reallocation of production and welfare gains on account of changes in the terms of trade. The losses are, however, larger than the gains whenever the rate of imitation is sufficiently small.

Now combine Propositions 6 and 7 in order to obtain:

THEOREM 2: For economies in steady state with small imitation rates tighter intellectual property rights hurt the North.

Theorems 1 and 2 demonstrate an important feature of our world economy: Whenever the rate of imitation is low, there exists no conflict between the two regions with regard to the direction of desired policy changes. On welfare grounds both gain from somewhat lax intellectual property rights. Small amounts of imitation are Pareto superior to no imitation at all.

4. FOREIGN DIRECT INVESTMENT

Companies engage in foreign direct investment for a variety of reasons. Sometimes FDI is driven by low labor costs in the host country, sometimes by vertical integration in resource industries, still other times by opportunities to jump tariff walls, low corporate tax rates or tax holidays. The decision to go multinational is complicated by institutional factors, such as the difference between the parent country's and the host country's legal systems, language barriers that hamper the interaction of the parent and the subsidiary, uncertainty about exchange rate movements and the like (see Caves [1982]). In addition to these difficulties less developed countries suffer disadvantages as hosts of FDI because they provide poor infrastructures, lack minimally required supplies of skilled labor, and often suffer from political instability. Consequently Northern–based multinationals invest in developed market economies more than in less developed countries. And their investment in LDCs is biased towards low labor skill and resource extraction industries.

If follows that a satisfactory analysis of intellectual property rights that accounts for foreign direct investment requires models that are significantly broader than what I have used so far. Such major extensions are beyond the scope of this paper. On the other hand an approach that builds on the notion that whenever wages are lower in the South innovating companies in the North find it profitable to shift manufacturing facilities to the South greatly oversimplifies the problem at hand. It may even lead to misleading conclusions, and especially so in one–factor one–sector frameworks. Nevertheless, in order to obtain some feeling for the role that FDI may play in the evaluation of tighter intellectual property rights I provide in this section a simple analysis that builds on this very notion.

So consider the simple case discussed in Section 2 where innovation takes place at a constant exogenous rate, g, as in equation (1). Unlike in Section 2, however, now suppose that a Northern company can costlessly form a manufacturing subsidiary in the South in order to take advantage of lower labor costs. Assume that the risk of imitation is independent of whether a company goes multinational (a more general approach would allow the rate of imitation to differ between national and multinational corporations, with the risk of imitation perhaps being higher for multinationals). In this event the values of national and multinational companies are the same. Moreover, the differential equation (2) for the fraction of goods that have not been imitated applies to the current framework, as does its solution (3), except that now we split n^N into national companies whose measure is n^{NN} and multinational companies whose measure is n^{NM} $(n^{NN} + n^{NM} = n^N)$.

Under these circumstances the same equilibrium wage rate

$$w = w^N = w^S \qquad (50)$$

prevails in both regions. All products that have not been imitated, manufactured by national or multinational corporations, are equally priced according to (10), while all those that have been imitated are priced according to (11). It follows from (7), (10),

(11) and (50) that relative output levels per product of national, multinational and Southern–based companies are given by:

$$x^{NM} = x^{NN}, \tag{51}$$

$$x^{S} = \alpha^{-\epsilon} x^{NN}, \tag{52}$$

where x^{NN} is the output level of a Northern–based national firm with monopoly power, x^{NM} represents the output level of a Northern–based multinational firm with monopoly power, and x^{S} is the output level of a Southern–based firm.[20] Assuming that all imitated products are produced in the South the full employment conditions now become (compare to [13])

$$n^{NN} x^{NN} = L^{N}, \tag{53a}$$

$$n^{NM} x^{NM} + n^{S} x^{S} = L^{S}. \tag{53b}$$

In the North all employment emanates form Northern–based national companies, while in the South it emanates from both Northern–based multinationals and Southern–based

[20]My use of language presupposes that a product that has been imitated is necessarily manufactured by a Southern–based company. This is not always the case. The original innovator and the imitator face in equilibrium the same marginal manufacturing costs. Therefore if they engage in price competition each one can end up manufacturing the good even if its production takes place in the South. If the Northern firm manufactures the good in the South it means that it is a multinational. Otherwise the good is produced by a Southern–based company. This implies that in addition to the n^{NM} multinationals there also can exist multinationals with products that have been imitated. The latter type of multinationals is inconsequential for our analysis. I therefore assume for simplicity that a product that has been imitated and is manufactured in the South is supplied by a Southern–based company. Another possibility to which I will come back soon is that a product that has been imitated is nevertheless manufactured in the North. For the time being let us, however, disregard this case.

companies. Equations (51)–(53) imply a link between the fraction of Northern–based companies whose products have not been imitated that go multinational, $\mu \equiv n^{NM}/n^{N}$, and the fraction of products that have not been imitated ζ:

$$\mu = \frac{L^S}{L^S + L^N} - \alpha^{-\epsilon}\frac{1-\zeta}{\zeta}\frac{L^N}{L^S + L^N}. \tag{54}$$

This relationship has to be satisfied at each point in time. It shows that a larger fraction of Northern companies with monopoly power go multinational the larger the fraction of products that have not been imitated.

Curve MM in Figure 3 describes the relationship between μ and ζ that is embodied in (54). The world economy has to be on this curve at each point in time as long as $\zeta \geq \zeta_c$. The vertical line $\dot{\zeta} = 0$ describes the rest points of the differential equation (2); the fraction of goods that have not been imitated does not change if and only if it equals $\bar{\zeta} = g/(g+m)$. For higher values of ζ this fraction declines while for lower values it increases. The dynamics of the system are described by the arrowed trajectory; the world economy converges to the stationary point A. The critical value $\zeta_c \equiv \alpha^{-\epsilon}L^N/(L^S + \alpha^{-\epsilon}L^N)$ describes the lower bound on the fraction of goods that have not been imitated for which $\mu > 0$. If the initial value of ζ is smaller than ζ_c then $\mu = 0$ and the North manufactures some of the goods that have been imitated. In what follows I confine the discussion to cases with $\zeta(0)$ and $\bar{\zeta}$ larger than ζ_c.[21]

[21]The economy has to be either on the horizontal axis between 0 and ζ_c or on MM to the right of ζ_c. In the former case the dynamics are along the horizontal axis. Thus, for example, if in Figure 3 the initial value of ζ falls short of ζ_c, then μ remains zero for a while while ζ increases until it reaches ζ_c. Afterwards the trajectory proceeds along MM towards point A. The meaning of the initial phase is that some of the imitated products are produced in the North, but as the fraction of unimitated products increases fewer of the imitated products are produced in the North. Eventually all imitated products are produced in the South (when $\zeta = \zeta_c$) and as ζ further increases Northern companies with unimitated products go multinational in order to take advantage of incipient wage differentials.

Now suppose that the world economy is at point A. A tightening of intellectual property rights reduces m and raises $\bar{\zeta}$. The $\dot{\zeta} = 0$ line shifts to the right and μ and ζ rise gradually along MM from A to the new steady state point. We conclude that a tightening of IPRs gradually increases the fraction of goods that have not been imitated and the fraction of products with monopoly power that are produced by Northern–based multinationals. What are the welfare implications of these comparative dynamics? In order to answer this question we need to examine every region's flow of utility in the presence of FDI.

In every region the flow of utility equals the logarithm of real spending (see [9]). The price index (12) applies to the current case, except that wage rates equal across regions. Taking account of the pricing equations (10) and (11) and the wage structure (50), (12) implies:

$$(55) \qquad P = n^{\frac{1}{1-\epsilon}} w \left[\zeta\alpha^{\epsilon-1} + (1-\zeta)\right]^{\frac{1}{1-\epsilon}}.$$

In the South income per capita equals the wage rate w. Therefore (9) and (55) imply the flow of utility:

$$(56) \qquad \log u^S = \frac{1}{\epsilon-1} \log n + \frac{1}{\epsilon-1} \log \left[\zeta\alpha^{\epsilon-1} + (1-\zeta)\right].$$

This flow declines with the fraction of goods that have not been imitated, because Northern companies with monopoly power price their goods higher than other products. As the fraction of the former increases real spending declines. Since the number of products available at each point in time does not change with tighter IPRs and the fraction of unimitated products increases, we conclude that just as in the case with no direct foreign investment the South loses from tighter intellectual property rights, because its flow of utility declines at each point in time.[22] We have therefore proved:

PROPOSITION 8: For economies in steady state and direct foreign investment tighter intellectual property rights hurt the South.

Next we calculate the flow of utility of a Northern resident. The North derives income from wages and profits. Profits emanate from national and multinational companies whose products have not been imitated, and they equal a fraction $(1-\alpha)$ of revenue. Therefore income equals $wL^N + (1-\alpha)p^N(n^{NN}x^{NN} + n^{NM}x^{NM})$. Using the pricing equation (10), the wage equalization condition (50), and (51) and (53a), this income level implies that income per capita equals $\alpha^{-1}w[1 + \mu/(1-\mu)]$. Together with (9) and (55) this yields the following flow of utility for a representative Northern worker:

$$(57)\quad \log u^N = \frac{1}{\epsilon-1}\log n + \frac{1}{\epsilon-1}\log\left[\zeta + (1-\zeta)\alpha^{1-\epsilon}\right] + \log\left[1 + (1-\alpha)\frac{\mu}{1-\mu}\right].$$

Tighter intellectual property rights do not affect the first term on the right hand side, because available products are exogenous at each point in time. The second term declines with tighter IPRs, because the fraction of products that have not been imitated increases at each point in time. A rise in this fraction raises the price index of consumption as more goods are priced higher. The last term rises with tighter IPRs at each point in time, because the fraction of companies with monopoly power that go

[22]In the absence of foreign direct investment we distinguished between terms of trade effects and the regional allocation of production. With FDI relative prices are constant and we do not have the usual terms of trade effect. On the other hand, the regional allocation of production is not associated in a simple way with high and low priced goods, because due to the multinationals the South supplies both high and low priced goods. What matters for efficiency is of course the association of relative prices with relative marginal costs. In this section an increase in ζ represents an increase in the fraction of highly priced goods without affecting relative marginal costs.

multinational increases. This raises profit income per capita in the North and thereby the flow of utility. It follows that the North gains from tighter intellectual property rights if the income effect of multinational corporations dominates the consumer price index effect, and it loses otherwise. Are both possibilities viable? The answer is in the affirmative.

First consider the following proposition (see appendix for proof):

PROPOSITION 9: For economies in steady state with direct foreign investment and small imitation rates a tightening of intellectual property rights benefits the North.

A comparison of this proposition with Proposition 1 shows that with exogenous innovation whenever the pace of imitation is very slow the North benefits from tighter IPRs in the presence of direct foreign investment and loses in its absence. This difference can be explained as follows. In both cases an increase in the fraction of the highly priced unimitated products as a consequence of tighter IPRs reduces welfare. Moreover, with m close to zero the steady state fraction of unimitated products is close to one. In this event the welfare effect of terms of trade changes in the absence of FDI is close to zero and there exists no other avenue for welfare changes. Therefore the North loses. In the presence of FDI the terms of trade do not change at all. But now tighter intellectual property rights raise Northern income via an expansion of multinationals. As shown in the appendix this income affect is large enough to offset the need to consume a larger fraction of highly priced products.

We have thus seen that with direct foreign investment and low rates of imitation the North gains from tighter intellectual property rights. Table 1 reports a simulated example with foreign direct investment in which the North gains from tighter IPRs when the rate of imitation is low (ζ is high) and loses when the rate of imitation is high (ζ is low). Since the South always loses from tighter intellectual property rights, it follows that even with direct foreign investment there exist world economies in which both regions lose from tighter intellectual property rights.[23]

Table 1

ζ	μ	$\log u^N$
0.65	0.086	2.135
0.70	0.272	2.070
0.75	0.432	2.027
0.80	0.573	2.020
0.85	0.697	2.070
0.90	0.808	2.231
0.95	0.906	2.657

$L^N = 1$; $L^S = 200$; $\alpha = 0.003$

5. CONCLUDING REMARKS

Who benefits from tight intellectual property rights in less developed countries? My analysis suggests that if anyone benefits it is not the South. This answer is robust with respect to all the variations that I have examined. In the absence of foreign direct investment tighter IPRs move the terms of trade against the South and bring about a reallocation of manufacturing towards higher priced Northern products, which also hurts the South. If the rate of innovation is responsive to this policy, the rate of innovation rises initially but declines subsequently. The initial acceleration of innovation

[23]In the Table 1 example the North loses from tighter IPRs for values of ζ that induce low levels of multi nationality. In most of the simulations that I have examined, however, the flow of utility in the North rises with tighter IPRs for all values of ζ that ensure a positive level of multi nationality. An example of the latter is a world economy with $L^N = 1$; $L^S = 6$; and $\alpha = 0.2$.

is, however, insufficient to compensate Southern residents for its eventual decline. Consequently the shift in the time pattern of available products also hurts the South. The last result may not be robust to model specification. But it shows that endogenous innovation does not guarantee benefits to the South on account of the time pattern of available products. Finally, we have seen in the previous section that the South also loses from tighter intellectual property rights in the presence of foreign direct investment. Because while Northern multinationals mitigate the effects of tighter IPRs on the South's terms of trade, they do not eliminate the negative welfare effect of the reallocation of manufacturing that brings about higher prices for a larger fraction of products.

Does the North benefit from tighter intellectual property rights in the South? Here the answer is that it depends. Unlike in some other models in which there always exists a conflict between the North and the South (see Chin and Grossman [1990] and Deardorff [1992]), we have identified circumstances in which no such conflict exists. In the absence of direct foreign investment both regions benefit from some relaxation of IPRs whenever the rate of imitation is very low. The benefits of this policy for the South are clear from the previous discussion. The benefits for the North are more involved. Similarly to the South the North benefits from a larger fraction of cheaper products and from a more desirable time pattern of available products in case the rate of innovation changes. In the latter case the shift in the North's time pattern of savings cannot produce negative welfare effects that outweigh the beneficial effects of product availability. Therefore the only potential source of welfare losses for the North is in the detrimental response of its terms of trade to more relaxed IPRs. This effect proves, however, to be very small when the rate of imitation is low. Therefore the North necessarily gains under these circumstances.

But absent foreign direct investment high rates of imitation lead to a conflict of interest between the North and the South. Under these circumstances the North prefers tighter intellectual property rights while the South prefers lax. The reason for this conflict is that in this case terms of trade effects become very important and the North secures better terms of trade with tighter IPRs. On the other hand, with active foreign direct investment that eliminates terms of trade effects, there always exists a conflict of interest between the North and the South whenever the rate of imitation is *low*; the North gains from tighter intellectual property rights while the South loses (recall that in the absence of FDI both countries lose from tighter IPRs when the rate of imitation is low). It may also happen that the North always gains from the policy shift, or that it loses just as the South does, when the rate of imitation is high and the degree of multi nationality low.

My analysis suggests that, as it often happens, the question: "Are tighter intellectual property rights desirable?" cannot be answered only by means of theoretical arguments. The theoretical analysis is most helpful in identifying channels through which regions are affected by such policy changes and circumstances in which the answer goes one way or the other. It also helps to identify the empirical estimates that are needed in order to answer the question. And this is a good example of what much of applied theory is all about.

APPENDIX

This appendix contains calculations and proofs that are missing in the main text. Its first part provides computations of the characteristic root $-\lambda$ and a component of the characteristic vector $-\Lambda$. It also establishes qualitative relationships between them, as suggested in equation (39). The second part provides proofs of Propositions 5 and 7 while the third part provides a proof of Proposition 9.

Characteristic Root and Vector

The characteristic equation associated with the matrix on the right hand side of (31) is

$$x^2 - (a_{11} + a_{22})x + (a_{11}a_{22} - a_{12}a_{21}) = 0 .$$

The solution for the characteristic roots is

(A1) $$x_{1,2} = \frac{1}{2}\left[(a_{11} + a_{22}) \pm B\right] ,$$

where

(A2) $$B = \left[(a_{11} - a_{22})^2 + 4a_{12}a_{21}\right]^{1/2} .$$

It follows from the definitions of the coefficients a_{ij} that the root $x_1 = \frac{1}{2}[(a_{11} + a_{22}) + B]$ is positive while the root $x_2 = \frac{1}{2}[(a_{11} + a_{22}) - B]$ is negative. Define $\lambda = -x_2$. Then

(A3) $$\lambda = = \tfrac{1}{2}\,[B - (a_{11} + a_{22})] > 0 \,.$$

Now let $[1, v_2]^T$ be the characteristic vector associated with the characteristic root x_2. Then

(A4) $$a_{11} + a_{12}v_2 = x_2 \,.$$

Define $\Lambda = -v_2$. Taking account of $x_2 = -\lambda$ and the definition of Λ, equations (A3) and (A4) imply

(A5) $$\Lambda = \frac{1}{2a_{12}}\,(B + a_{11} - a_{22}) > 0 \,.$$

Lemma 1: $\Lambda > \alpha\rho$.

Proof: From (A5) we obtain $\Lambda > \alpha\rho$ if and only if $B^2 > 4\alpha^2\rho^2 a_{12}^2 + (a_{11} - a_{22})^2 - 4\alpha\rho a_{12}(a_{11} - a_{22})$. Substituting (A2) and the values of the a_{ij} coefficients from (31) into this inequality, we obtain $\Lambda > \alpha\rho$ if and only if $(\rho + m + g)^2 > \Gamma$, where:

(A6) $$\Gamma = \rho\left[(1-\alpha)\alpha\rho\,\frac{m}{m+g} + (\rho+m+g)\left[1 - \alpha\,\frac{m}{m+g}\right] + (1-\alpha)(m+g)\right] .$$

The right hand side of (A6) attains a maximum over α at a negative value of α. Since α is positive, this implies that Γ does not exceed the value of the right hand side evaluated at $\alpha = 0$; namely:

$$\Gamma < \rho^2 + 2\rho(m+g) < (\rho+m+g)^2.$$

If follows from the second inequality that $\Lambda > \alpha\rho$ □.

Lemma 2: $\Lambda < \alpha(\rho + \lambda)$.

Proof: From (A3) and (A5) we obtain that $\Lambda < \alpha(\rho + \lambda)$ if and only if $B < \frac{2\alpha a_{12}}{1 - \alpha a_{12}}(\rho - a_{11}) + (a_{22} - a_{11})$. The last inequality is, however, satisfied if and only if the square of its left hand side is smaller than the square of its right hand side. Using (A2) the latter is equivalent to $a_{21} < \frac{\alpha^2 a_{12}}{(1 - \alpha a_{12})^2}(\rho - a_{11})^2 + \frac{\alpha}{1 - \alpha a_{12}}(\rho - a_{11})(a_{22} - a_{11})$. By substituting the expressions for the a_{ij} coefficients from (31) into the last inequality one can verify that it holds. It follows that $\Lambda < \alpha(\rho + \lambda)$ □.

Terms of Trade

First we compute Δ_θ^S and Δ_θ^N. From the definitions of Δ_θ^i we obtain:

(A7)
$$\Delta_\theta^S \equiv -\frac{\alpha\bar{\zeta}/\bar{\theta}}{\bar{\zeta} + (1 - \bar{\zeta})\bar{\theta}^\alpha}\int_0^\infty e^{-\rho t}\frac{d\theta(t)}{d\mu}\,dt,$$

(A8)
$$\Delta_\theta^N \equiv \frac{\alpha(1 - \bar{\zeta})(\bar{\theta})^{\alpha-1}}{\bar{\zeta} + (1 - \bar{\zeta})\bar{\theta}^\alpha}\int_0^\infty e^{-\rho t}\frac{d\theta(t)}{d\mu}\,dt,$$

where $\bar{\theta}$ is the steady state value of $\theta(t)$ (see [43]). From the definitions of $\theta(t)$ in (43) and (34)–(37) we calculate

(A9)
$$\int_0^\infty e^{-\rho t}\frac{d\theta(t)}{d\mu}\,dt = \frac{a\bar{g}\bar{\theta}^2}{D\bar{\zeta}L^S}\Delta_\theta,$$

where

$$\Delta_\theta = (1-\bar{\zeta})\left[-1+\frac{\Lambda}{\alpha(\rho+\lambda)}\right]+\frac{\lambda(\rho+g+m)}{\rho(1-\alpha)(\rho+\lambda)}.$$

Lemma 3: $\Delta_\theta^S < 0$ and $\Delta_\theta^N > 0$.

Proof: From (A7)–(A9) it suffices to prove that $\Delta_\theta > 0$. If follows frnm the definition of Δ_θ and (39) that

$$\Delta_\theta > -1+\frac{\Lambda}{\alpha(\rho+\lambda)}+\frac{\lambda(\rho+g+m)}{\rho(1-\alpha)(\rho+\lambda)} >$$

$$-1+\frac{\alpha\rho}{\alpha(\rho+\lambda)}+\frac{\lambda(\rho+g+m)}{\rho(1-\alpha)(\rho+\lambda)} = \frac{\lambda(m+g+\alpha\rho)}{\rho(1-\alpha)(\rho+\lambda)} > 0 \ \square.$$

Lemma 4: For m close to zero $\Delta_\zeta^N + \Delta_\theta^N < 0$.

Proof: From the definition of Δ_ζ^N we compute:

$$\Delta_\zeta^N \equiv -\frac{\bar{\theta}^\alpha - 1}{\bar{\zeta}+(1-\bar{\zeta})\bar{\theta}^\alpha}\int_0^\infty e^{-\rho t}\frac{d\zeta(t)}{d\mu}\,dt, \qquad \bar{\theta} > 1.$$

Together with (34) and (36) this implies:

$$\text{(A10)} \qquad \Delta_\zeta^N \equiv -\frac{\bar{\theta}^\alpha - 1}{\bar{\zeta}+(1-\bar{\zeta})\bar{\theta}^\alpha}\,\frac{\lambda\bar{g}}{D\alpha\rho(\rho+\lambda)}.$$

It follows from (A8)–(A10), (27), (28) and (43) that

$$\text{(A11)} \qquad \Delta_\zeta^N + \Delta_\theta^N = \frac{\bar{g}\bar{\theta}^\alpha}{D[\bar{\zeta} + (1 - \bar{\zeta})\bar{\theta}^\alpha]}\Gamma_e,$$

where

$$\Gamma_e = -\frac{[1 - (\bar{\theta})^{-\alpha}]\lambda}{(\rho + \lambda)\alpha\rho} + (1-\bar{\zeta})\left[-1 + \frac{\Lambda}{\alpha(\rho + \lambda)}\right]\frac{\alpha a}{L^N - a\bar{g}} + \frac{\lambda}{\rho\bar{\zeta}(\rho + \lambda)}.$$

Next observe that $m \to 0$ implies $\bar{\zeta} \to 1$ and $\bar{\theta} \to +\infty$. It is also easy to verify that λ and Λ remain finite as $m \to 0$. Therefore

$$\Gamma_e \to -\frac{\lambda(1 - \alpha)}{(\rho + \lambda)\alpha\rho} < 0 \quad \text{as} \quad m \to 0.$$

It follows from (A11) that $\Delta_\zeta^N + \Delta_\theta^N < 0$ for m sufficiently small □.

Foreign Direct Investment

In this part I prove Proposition 9, which states that for economies in steady state with FDI and low rates of imitation the North gains from tighter intellectual property rights. In view of the fact that tighter IPRs lead to an increase in ζ at each point in time and in view of the relationship between ζ and μ given in (54), it is sufficient to show that the derivative of the right hand side of (57) with respect to ζ is positive for $m \to 0$. Evaluated at $\zeta = \bar{\zeta}$ this derivative equals:

$$\text{(A11)} \qquad \frac{d \log u^N}{d\zeta} = \frac{1 - \alpha}{(1 - \alpha\bar{\mu})(1 - \bar{\mu})}\frac{d\mu}{d\zeta} - \frac{1 - \alpha}{\alpha}\frac{1 - \alpha^{\epsilon-1}}{\bar{\zeta}\alpha^{\epsilon-1} + (1-\bar{\zeta})},$$

where $\bar{\mu}$ represents the steady state value of μ. Using (54) to calculate $d\mu/d\zeta$ and evaluating the right hand side of (A11) at $m = 0$ (i.e., $\bar{\zeta} = 1$), we obtain

(A12) $$\left.\frac{d \log u^N}{d\zeta}\right|_{m=0} = \frac{(1 - \alpha)\alpha^{-\epsilon}}{1 - \alpha\theta^S}\left[1 - (1 - \alpha\theta^S)(1 - \alpha^{\epsilon-1})\right] > 0,$$

where $\theta^S \equiv L^S/(L^S + L^N)$ represents the share of the South in the world's labor force

□.

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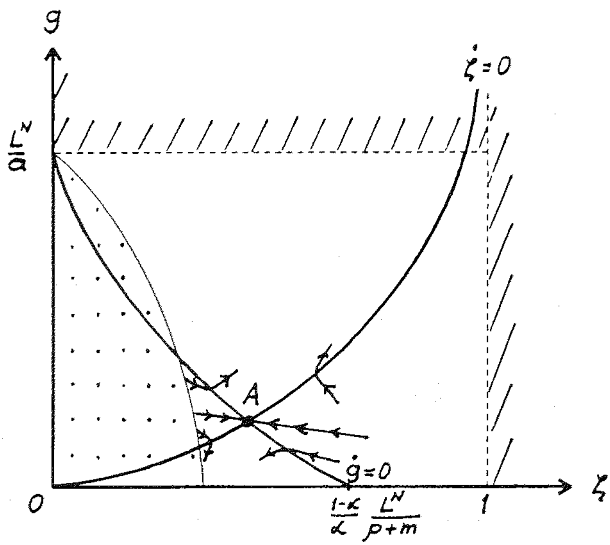

Figure 1

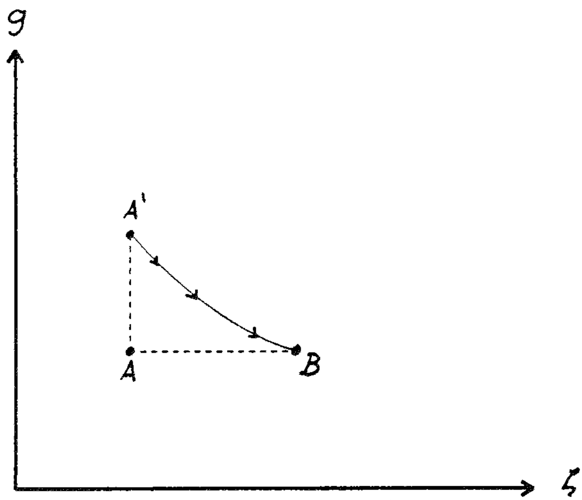

Figure 2

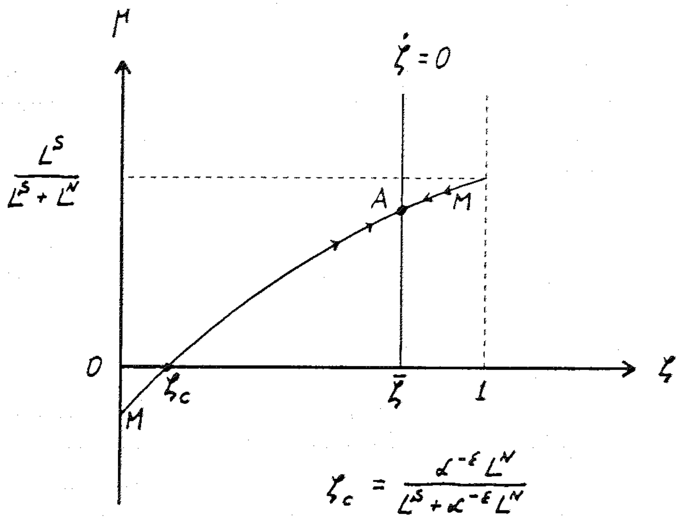
μ
$\dot{\zeta} = 0$
$\frac{L^S}{L^S + L^N}$
A
M
0
ζ_c
$\bar{\zeta}$
1
ζ
M
$\zeta_c = \frac{\alpha^{-\varepsilon} L^N}{L^S + \alpha^{-\varepsilon} L^N}$

Figure 3