DISCUSSION PAPERS IN ECONOMICS

Working Paper No. 00-12

Trademark Infringement and Endogenous Innovation

Michael Nicholson
Department of Economics, University of Colorado at Boulder
Boulder, Colorado

October 2000

Center for Economic Analysis
Department of Economics

University of Colorado at Boulder
Boulder, Colorado 80309

Trademark Infringement and

Endogenous Innovation

Michael W Nicholson
Department of Economics
University of Colorado, Boulder
nicholso@colorado.edu

Abstract:

This paper introduces trademark infringement into a dynamic, general equilibrium setting. I elaborate the conception of intellectual property rights beyond an incremental rise in imitation costs. An increase in the strength of intellectual property protection increases the rate at which firms shift production to the South. It also increases the innovation rate, regardless of whether technology is transferred by FDI or through imitation. Trademark enforcement may enhance welfare by broadening the gap between the amount some consumers are willing to pay for a good and the actual price charged.

October 2000

1. Introduction

Intellectual Property Rights (IPRs) and their protection have been the subject of intense debate in both academic circles and the arena of public policy. The Millennium Round of the WTO featured IPRs as a central focus of discussion. The technically advanced countries of the world have a large vested interest in the protection of IPRs, due to the fact that a large majority of the world's intellectual property is created within their boundaries. The U.S. International Trade Commission (1988) supports these claims in a

international effects of IPRs that incorporates trademarks and introduces new techniques for modeling IPR protection. I elaborate the conception of IPRs beyond an incremental rise in imitation costs, integrating such aspects the scope of trademark protection.

I show that an increase in the strength of IPR protection that diminishes the threat of trademark infringement tends to increase the innovation rate in the economy. This result holds regardless of whether technology is transferred by FDI or through imitation.

imitation, production of good remains in the North using resources that may otherwise be used in R&D towards the innovation of new goods. A combination of higher prices (due to market power) and slower innovation leads to diminished welfare.

Lai (1998) demonstrates that Helpman's results are sensitive to his assumptions, primarily on the stationary location of production. Lai allows for Northern firms to engage in FDI, while continuing control of their innovation. Northern firms maintain their incentive for innovation in monopoly rents while opening resources in the North for R&D. With these assumptions, an increase in IPRs that leads to a higher rate of FDI also leads to lower prices and a faster rate of innovation; thus, IPR protection improves welfare.[3]

These contrasting results identify an important complexity in discussions of IPRs. Lai's model captures the virtues of comparative advantage – the North specializes its resources in innovation, while the South, with lower wages, specializes in production.

differentiation of goods, where the number of products remains constant, and innovation on each increases its individual quality level.

The fundamental premise holds that consumers are willing to pay a premium for quality (call it q) for the new version of the good. Grossman and Helpman show how this assumption leads to a product cycle where production shifts from the North to the South, and then made obsolete when the new generation of quality is introduced.

Glass and Saggi (1995) incorporate costly, endogenous FDI into the quality-ladders framework. Firms pay an "adaptation" cost to take advantage of lower wages by shifting production overseas. Yang and Maskus (2000a) show how firms can directly license technology to Southern producers under similar assumptions.

The quality-ladders framework is a sensible way to model trademark infringement. I assume that goods encompass two forms of intellectual property. One is the knowledge of production, which represents the intrinsic value of any innovation. This production knowledge is the result of innovative R&D efforts, and is proprietary to the firm.

When firms innovate a new quality level, they must signal its value to potential consumers. To do so, they receive a *trademark* that differentiates it vertically from previous innovations. This trademark indicates the other form of intellectual property embodied by a good, its reputation for quality. The premium q consumers are willing to pay covers both the value of the good and the reputation for quality.

2. Basic Model

2.1 Consumption

The basic model builds on Grossman and Helpman's (1991) quality-ladders model of vertical differentiation. Consumption is determined by the following utility function and budget constraint,

(1) $$U = \int_0^\infty e^{-rt} \log u(t) dt,$$

where ρ is the discount rate. A continuum of goods exists, indexed by j∈ [0,1]. Each good j can be innovated on to yield a new quality premium q^m. Thus, log u(t) is8.25 0 7wmiume5D 4p1]. E consumers can be confident they are buying the latest innovation. Most quality-ladder models implicitly assume this signal. If trademarks can be infringed, however, the signal is imperfect.

Note this concerns only the Southern market. Full trademark protection is offered in the North, so the signal is perfect. An example of the markets under consideration is a quality-sewn name-brand shirt, designated by the trademarked pocket emblem. In the North, every shirt with the emblem is assuredly the quality-sewn variety. In the South, infringing firms sell knock-off shirts of inferior quality, but with the same pocket emblem. The trademark is an imperfect signal.[4]

2.2 Price decision

Trademark infringement affects both the pricing decision and the market share of innovating firms. Firms engage in price competition to maximize profits. In general, this means pricing to capture the full market. All consumers are always willing to pay q for any quality innovation when the nearest alternative is the last generation of the same good. With this q, they are purchasing the intrinsic value of the good *and* the reputation of the trademark. Innovating firms, with a perfect signal, can charge q times the production cost of their nearest competitor. I assume all previous innovations are disseminated to the point that production and consumption takes place at perfectly competitive prices. Since the most nearest competitor faces a marginal cost equal to the Southern wage w_S, innovating firms charge $p^* = qw_S - \varepsilon$ to capture the entire market. As $\varepsilon \to 0$, $p^* = qw_S$. For simplicity, normalize $w_S = 1$, so that $p^* = q$.

[4] Note this is not a case of multiple quality levels being sold in equilibrium, such as in Glass and Saggi (1998) or Yang and Maskus (2000b), since consumers always prefer to pay the premium for the highest quality good. It is a case of uncertainty. Someone buys a Coca-cola in Caracas and ends up with, say, New

In the presence of trademark infringement, however, firms are unable to perfectly signal the quality premium. The innovating firm has a monopoly on q+, which they market and sell under the trademark. With infringement, competitors are able to produce and market q- under the same trademark. I fix the rate they can do this at τ, which depends on the level of IPP. Thus, τ of all products sold under the trademark are infringed goods.

Infringing firms pay marginal cost w_s, so they will make a positive profit whenever $p^* > w_s$. If they charge $p^* < w_n$, they will not sell anything, because no Northern firm would sell below *its* marginal cost and this low price would signal the low quality of the good. Consumers will also not pay qw_s, the maximum price for the innovating firms, due to the possibility they would be purchasing an inferior product.

The expected value to the consumer is $E\{u(q)\} = (1-\tau)u(q+) + \tau u(q-)$. Assuming risk neutrality, the expected utility is $(1-\tau)q^m + \tau q^{m-1}$. The expected quality premium is $(1-\tau)q$, since q- is otherwise sold at $w_s=1$. Thus, risk-neutral consumers are willing to pay $(1-\tau)q$ for a good sold under the q+ trademark.[5]

If both innovating and infringing firms charge $p^* = (1-\tau)q$, both can steal the market by selling at an incremental discount. The resulting "Bertrand paradox" would drive prices to w_n, leaving no economic profits for the Northern firm. For this reason, I extend the assumption on infringement so that τ represents the *maximum* market share of infringing firms. Neither firm will then charge below $p^* = (1-\tau)q$, as this would lower

---

Coke. Nobody likes New Coke, so the consumer has overpaid, and will pay less for any drink labeled "Coca-cola" in the future.

[5] Risk averse consumers, of course, would be willing to pay less, since by Jensen's inequality $E\{u(c)\} \leq u(E\{q\})$.

their expected profits. Since consumers will not pay more, this price holds as an equilibrium price.

2.3 Market structure

Following an innovation on a quality-level, a single firm in the North holds a monopoly on the production knowledge for q+ as well as its trademark. By investing resources, these firms can "adapt" production to Southern plants to take advantage of lower factor costs. This adaptation represents costly FDI, and firms successful at this adaptation are considered multinational enterprises (MNEs). MNEs face the same rate of trademark infringement as Northern firms who export to the South. I assume no transportation costs, so rate, but the central model focuses on the intellectual property of the quality reputation captured by the trademark.

2.4 Profit equations

Firms selling products in the North do not have to consider the possibility of trademark infringement. Since the trademark works as a perfect signal, consumers with expenditure level E^N pay the maximum price for the quality premium. Northern firms (indexed by N) charge price $p^N = q$, sell quantity E^N/q, and pay marginal cost w_n (or w). Multinationals exporting to the North charge the same price for the same quantity, but pay the lower marginal cost $w_s = 1$. This leads to following profit equations for sales in the North:

(3) Northern firm profits: $$p^{NN} = x_j(p_j - w_n) = \frac{E^N}{q}(q - w_n) = \frac{E^N}{q}(q - w)$$

(4) MNE profits: $$p^{MN} = \frac{E^N}{q}(q - 1).$$

I assume q > w to ensure positive profits for the Northern firm.

In the South, firms must take into account the risk of trademark infringement when pricing their products. Moreover, they earn only (1-τ) portion of the market. The profit equations for sales in the South are:

(5) $(1 \quad) \frac{}{(1 \quad)} (\quad *$)) ((1))

-72 BT 45o757 T7 0- u4S0 -0.5 216 l6u4n Tc 0 0.2079 510.0429 Tc (q)3637 12.085 0.2072145o7575 TD 0.225 Tc (n) Tj -23.25 0 TD 0.2901 Tc ()) Tj

N r 1

The full profits for Northern firms and MNEs are the sum of the two above, which simplify when substituting E = E^N + E^S and E^S = sE, where s represents the share of world income going to Southern consumers.

(7) $$p^N = E(1 - st - \frac{w}{q})$$

(8) $$p^M = E(1 - st - \frac{1}{q})$$

I do not include depictions of the profits of infringing firms, since their R&D processes are given exogenously. They only affect the general equilibrium results through the resources used.

2.5 Reseach and Development

Northern firms invest resources at intensity ι

I assume free entry in innovation, and profit-maximization in adaptation, so that for both R&D equations, the expected gain cannot be greater than the cost. This leads to the following expressions:

(9) $v^N \leq wI$ c.s. $\iota > 0$

(10) $v^M \leq wA + v^N$ c.s. $\alpha > 0$.

2.6 No-arbitrage

I assume the same rational-expectations stock market valuation as Grossman and Helpman (1991). Individuals invest in firms until they reach the same expected value as a riskless bond earning interest r times the value of the firm. Northern firms earn the profits $\pi^N dt$, with capital gain $\dot{v}^N dt$. Northern firms adapt to FDI at intensity α. When successful, they earn the return v^M, so the expected return is $\alpha v^M dt$. The cost is αA units of labor plus the opportunity cost v^N, giving a total return $\alpha(v^M - v^N - A)dt$. They also face the risk of capital loss $\iota v^N dt$, in which other firms innovate over their quality. MNEs earn profits $\pi^M dt$, with capital gain $\dot{v}^M dt$, and face the risk of capital loss $\iota v^M dt$. When dividing through 125 Tf 0.16j 8.7/F0 12 T0 Tw (v) Tj 5.25 5.25 TD /F0 8.25 Tf 0.0435 Tc (N) Tj 6 -5.25

(13) $$v^N = \frac{p^N}{r+i}$$

(14) $$v^M = \frac{p^M}{r+i}.$$

2.7 Resource constraints

Production and R&D efforts are constrained by the scarce resources available to both regions in the model. Northern labor is used for production and adaptation by Northern firms, and in innovation by firms engaging in R&D. The Northern firms with recent innovations, a measure n_N, produce E^N/q goods to sell in the North and $(1-t)\frac{E^S}{(1-t)q}$ goods to sell in the South, for a total labor use of $n_N E/q$. This same measure of firms expends αA units of labor adapting production to the South.[6] Firms that are engaging in research to achieve new innovations expend ιI units of labor on the full continuum of goods. These lead to the following expression of the Northern resource constraint:

(15) $$L_N = iI + n_N \frac{E}{q} + aAn_N$$

The Southern labor is only used in the production of goods. Infringing firms sell quantity $\frac{E^S}{(1-t)q}$ to proportion τ of the market. MNEs produce E^N/q for sales in the North and $(1-t)\frac{E^S}{(1-t)q}$ for sales in the South, for a total labor use of $n_F E/q$. This yields the following resource constraint:

[6] Many authors, including Glass and Saggi (1995), assume that adaptation uses Southern resources. Appendix A.2 shows how the results are unaffected by the change.

(16) $$L_S = \frac{st}{1-t}\frac{E}{q} + n_F \frac{E}{q}.$$

2.8 Constant measures

In the steady-state, the measures of every firm type must remain constant. That is, the number of firms that become MNEs must be equal to the number of firms who stop being MNEs. These values are summarized in Table 2. Since innovation occurs on all types of firms, at any given time the number of firms becoming Northern firms is $\iota(n_N + n_F) = \iota$. Firms are no longer Northern firms after adaptation or innovation, thus the measure of firms leaving n_N is $(\iota+\alpha)n_N$. Firms become MNEs through adaptation by Northern firms and leave through innovation on the measure n_F.

Table 2: Constant Measures

Firm Type	In	Out
N:	ι	$(\iota+\alpha)n_N$
F:	αn_N	ιn_F
	$n_N + n_F = 1$	

These calculations lead to the following relationships for firm measures:

(17) $$n_M = \frac{a}{i+a}$$

(18) $$n_N = 1 - n_M = \frac{i}{i+a}$$

(19) $$a = i\frac{n_M}{1-n_M}.$$

Notice that (19) was solved by plugging (17) into (18), so that these three equations actually only capture two relationships among the four variables. Knowing the constant measure for n_N and the summation of firm measures to 1 makes the constant measure for F redundant.

2.9 Reduced form equations

The above equations can be combined to provide insight into the economy. Combine the profit equations (7) and (8), the R&D equations (9) and (10), and the value equations (13) and (14) to get:

$$(20) \qquad E(1-\frac{w}{q}-st) = wI(r+i)$$

$$(21) \qquad E(1-\frac{1}{q}-st) = w(A+I)(r+i)\,.$$

Equation (20) shows the values that lead to zero economic profits for innovating firms. The left-hand side is the profits for successful innovations, and the right-hand side shows the cost of innovation weighted by the discount rate and the risk of capital loss. Equation (21) shows a similar relationship for adaptation. I call (20) the "Northern valuation condition" VN and (21) the "MNE valuation condition" VM.

Dividing VN by VM solves the relative wage to be:

$$(22) \qquad w = \frac{qA(1-st)+I}{A+I}\,,$$

which does not depend on the extent of FDI. Firms take w as given (or as a function of τ) when making the decision to adapt. The rent gains from FDI depend on w, but the

When combined with the two constant-measure relationships, the resource constraints (15) and (16) and the valuation conditions (20) and (21) provide equations that can solve for the endogenous variables {E, w, n_N, n_M, ι, and α}. The relative wage

(27) $$p^M = \frac{E}{q}(q(1-st)-1) = \frac{L_S}{\frac{st}{1-t}+n_M}(q(1-st)-1)\,.$$

Clearly, as n_M increases, the MNE profits decline. This means that as more firms take advantage of lower factor costs, the returns decrease. The overall decline in expected value of an innovation causes firms to invest fewer resources in innovation.

Solving for E/q from both resource constraints and setting equal to each other yields the “joint resource constraint”, or RC:

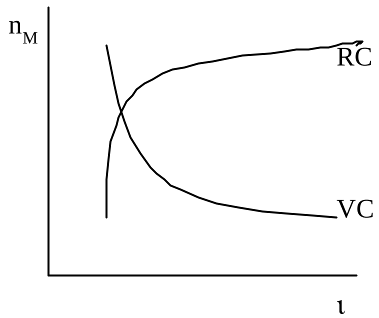
(28) $$\frac{L_S}{\frac{st}{1-t}+n_M} = \frac{1}{1-n_M}(L_N - iI) - aA\,.$$

Fully diff078 T5 16.5 TD (1)9 ch ot9 486. oint rD -0.1236ent reB129-0.1236ent rde /r (1) Tj Tf -0.169 T7

s

of FDI. The lines are curved since the second derivatives have the opposite signs of (26) and (29).

Graph 1



The effects of intellectual property protection that strengthens trademarks against infringement can be seen by the shifts in the curves in graph 1. An increase in trademark protection lowers the infringement τ. For the VC, consider how the curve shifts by taking the derivatives of each variable with respect to τ. Differentiating (25) by ι and τ yields $\left.\frac{di}{dt}\right|_{VC} < 0$. Holding the extent of FDI constant, the innovation rate increases as τ decreases. This implies a shift *right* in the VC curve-0.0664 135g*17.25 TD (d) Tj 5.25 -17.25 TD /F4 12.08* *increase* in the innovation rate. This result compares favorably to the results in Lai (1998) and Yang and Maskus (2000a).

3. Imitation

The above model offers a simple depiction of trademark infringement in a general equilibrium model, with results that are familiar to the literature. For example, the increased extent of FDI following strengthened IPRs compares well to Yang and Maskus (2000a) similar increase in licensing. In particular, the ambiguous effect of increased intellectual property protection on the innovation rate further demonstrates how difficult it is to draw definite conclusions about IPRs. As discussed above, Helpman (1993) and Lai (1998) offer contrasting results using different assumptions. This paper extends the results to include trademark infringement.

To facilitate comparison within the literature, this section adds a product cycle in which the production knowledge in the latest innovations can also be transferred. That is, the South imitates goods at rate μ. For analytical tractability, I assume no FDI takes place. In this section, imitation is the sole method of technology transfer. The first part of this section introduces endogenous imitation to the baseline model with full IPR protection. The second part adds the risk of trademark infringement. The third part considers the present model in the context of exogenous imitation, resulting in relationships identical to Helpman (1993).

3.1 Endogenous Imitation with full IPR protection

As before, firms innovate new quality levels q+ in the North and service Northern and Southern markets under particular trademarks. Consumers are willing to pay q as a premium for the intrinsic quality and the reputation of the good. Previous quality levels, q- and below, are disseminated throughout the world, where they can be produced and sold at marginal cost $w_s = 1$. Southern firms can infringe on the trademark at rate τ.

Now, however, Southern firms are also able to "imitate" the quality innovation. By investing their own resources in R&D, they can duplicate the quality of the good q+, essentially a transfer of production knowledge. I assume *perfect* imitation, so the good produced by a successful imitating firm provides the exact utility of the original.

The goods remain differentiated, however, by their trademarks. The imitating firm, call it the Follower, cannot sell the q+ good under the brand of the innovating firm (the Leader). Followers sell under a new trademark that is *perceived* by consumers to be of less value than the original trademark.

Different consumers assign different values to the trademarks. For simplicity, aggregate all consumers into two groups. The first group perceives the value of the original trademark to be higher than the Follower's trademark, for reasons of reputation, brand loyalty, or first-mover advantage. Call these L-consumers, who prefer the Leader's product. The second group of consumers, the F-consumers, is happy to purchase the q+ good under the "inferior" trademark *as long as it costs less*.[7]

to pay a premium for the reputable trademark, while F-consumers would prefer a discount for the same drug.

To account for different groups of consumers, equations (1) and (2) must be re-written

(30) $$U^w = \int_0^\infty e^{-rt} \log u^w(t) dt,$$

(31) $$\log u^w(t) = \int_0^1 \log\left[\sum_m \left[q^m(j)\right]^w x_{mt}(j)\right] dj\ .$$

where $w \in \{L, F\}$ indexes the type of consumer.[8] I capture the value of trademark perception by assuming $q^L > q^F$. L-consumers, who prefer the Leader's trademark, assign a higher value to the good than F-consumers, although the actual quality level is the same. They receive utility from the trademark itself.

3.1.1 Price decisions

Under full IPR protection, the firms are secure that their trademarks cannot be infringed. After imitation, the Leader and Follower firms compete in prices for each good j that has been imitated. A measure λ of consumers, the L-consumers, are willing to pay q^L for a quality innovation, while a measure f, or $1-\lambda$, prefer to pay q^F for the q+ good when an imitated discount is available. The Follower firm competes against all potential producers of q- by charging $q^F w_s - \varepsilon$, which at the limit is q^F. The Leader firm practices limit pricing against the Follower firm by charging q^L.

[8] These utility functions are based on the ones derived by Glass (2000), in which consumers assign different values to the same goods. Glass, however, assumes consumers to differ along the actual quality innovation, so that two quality levels are sold in equilibrium. In the present model, consumers do not differ on quality, but in the value of the trademark. Only one quality-level is sold in equilibrium (except, of course, for the q- goods sold illegally).

If prices are the same and no greater than q^F, all consumers will purchase the Leader's product. The Leader can then capture the entire market by lowering its price to the Follower's price. The Follower, however, will sell to the F-consumers by then lowering its own price in competition. The lowest possible price charged by the Leader firm that will allow non-negative profits is w_N, so by charging $p^F = w_N$ the Follower ensures sales to 1-λ consumers.

The L-consumers, however, are willing to pay q^L for the new product. If the Follower charges w_N, the Leader will charge q^L and sell to measure λ consumers. When the Leader sets price $p^L = q^L$, the Follower can raise its price to q^F

(33) $$p^{F} = (1 - l)E(1 - \frac{1}{q^{F}})$$

As above, I assume $q^F > w$ to ensure positive profits.

A Northern firm with a new quality innovation that has not been imitated competes only against the potential producers of the q- good. The price they charge in this competition depends on assumptions concerning pricing strategy. I consider four price schemes and show in table 3 how the results differ according to different

			pricing	

The costs and benefits of R&D for innovation do not change; Northern firms continue to invest resources at intensity ι with the labor cost I. For imitation, Southern firms invest resources at intensity μ with labor cost M to gain v^F if successful. Notice that imitation draws from Southern resources at marginal cost $w_s = 1$ as opposed to Northern resources as in section 2 above.

Table 4: R&D summary for endogenous imitation

Activity	*Cost*	*Gain*	*Labor Units*
Innovation	wI	ιv^N	ιI
Imitation	M	μv^F	μM

(39) $$v^F = \frac{p^F}{r+i}$$

3.1.4 Resource Constraints

The resource constraints are altered by the inclusion of imitation. Northern labor is used for innovation and production by Northern and Leader firms. Northern firms, of measure n_N, produce E/q^F goods, and Leader firms, of measure n_L, produce $\lambda E/q^L$ goods. Southern labor is used for imitation and production by Follower firms. Southern firms target imitation only at a measure n_N of goods that have not already been imitated, for full labor cost of $\mu M n_N$. Follower firms, of measure n_F, produce $(1-\lambda)E/q^F$ goods.

(40) $$L_N = iI + n_N \frac{E}{q^F} + n_L l \frac{E}{q^L}$$

(41) $$L_S = mMn_N + n_F(1 - l)\frac{E}{q^F}$$

3.1.5 Constant Measures

As before, the measures of firm types must remain constant in the steady-state. Goods are produced by new Northern firms at rate ι, with production shifting to Leader firms or other Northern firms (when innovated over) at rate $(\iota+\mu)n_N$. Firms become Leader firms at rate μn_N and leave at rate ιn_L. Similarly, firms become Follower firms at rate μn_N and leave at rate ιn_F. These are summarized in table 5.

Table 5: Constant Measures with Endogenous Imitation

Firm Type	In	Out
N:	N	$(\iota+\mu)n_N$

:

From this equation, it is easy to show that d(1/w)/dι<0, so that an increase in the innovation rate leads to a decrease in 1/w, or an increase in the relative wage. Similarly [redacted] d(1/w)/dλ<0, so an increase in the measure of L- [redacted] the relative wage. [redacted]

ι [redacted]

(55) $$\left.\frac{dn_F}{di}\right|_{LN} = \frac{I + \frac{M}{1-l}\frac{1}{q^F-1}\left[1 - n_F\,\frac{q^L - l\,q^F}{q^L}\right]}{\frac{M}{1-l}(r+i)\frac{q^L - l\,q^F}{q^L(q^F-1)}} > 0$$

and

(56) $$\left.\frac{dn_F}{di}\right|_{LS} = -n_F\,\frac{q^F}{r + iq^F} < 0$$

As in section 2, the second derivatives are the opposite signs of the first derivatives.

Plotting these lines in (ι, n_F) space yields a graph similar to graph 1:

Graph 2

$l(1-t)\dfrac{E^S}{(1-t)q^L}$ goods to sell in the South, for a total labor use of $\lambda n_F E/q^L$. Thus, the Northern resource constraint can be written

(65) $$L_N = iI + n_N \frac{E}{q^F} + l n_F \frac{E}{q^L}$$

Southern firms use the same resources for R&D in imitation as before. Follower firms now produce $(1-\lambda)E^N/q^F$ goods for to sell in the North, and $(1-l)(1-t)\dfrac{E^S}{(1-t)q^F}$ goods for sell in the South. Infringing firms produce $l\,t\dfrac{E^S}{(1-t)q^F} + (1-l)t\dfrac{E^S}{(1-t)q^L}$ goods, making the resource constraint

(66) $$L_S = mMn_N + n_F(1-l)\frac{E}{q^F} + \frac{t}{1-t}sE\frac{l q^F + (1-l)q^L}{q^L q^F}$$

As before, I can solve for the relative wage from the valuation conditions

(67) $$w\left[I(r+m+i) + \frac{E}{q^F}\left(\frac{q^L(r+i) + ml\,q^F}{(r+i)q^L}\right)\right] = E(1-st)\left(\frac{r+i+ml}{r+i}\right)$$

which, plugging in for E and inverting, gives

(68) $$\frac{1}{w} = (1-l)\frac{I}{M}\left(\frac{r+i+m}{r+i+ml}\right)\frac{1-1/q^F - st}{1-st} + \frac{q^L(r+i) + q^F ml}{q^F q^L(r+i+ml)(1-st)}$$

The imitation valuation condition and the two resource constraints give a system of three equations for {E, ι, n_F}. Substituting $E = \dfrac{M}{1-l}\dfrac{r+i}{q^F(1-st)-1}$ into the resource constraints yields

[9] Continuing “whole-market” pricing for Northern firms.

(70) $$L_N = iI + \frac{M}{1-l}\frac{r+i}{q^F(1-st)-1}\left(1-n_F\frac{q^L-lq^F}{q^L}\right)$$

(71) $$L_S = in_F M + n_F M \frac{r+i}{q^F(1-st)} + \frac{st}{1-t}\frac{M}{1-l}\frac{r+i}{q^F(1-st)}\frac{lq^F+(1-l)q^L}{q^L q^F}$$

Fully differentiating these equations yields the following derivatives

(72) $$\left.\frac{dn_F}{di}\right|_{LN} = \frac{I+\frac{M}{1-l}\frac{1}{q^F(1-st)-1}\left(1-n_F\frac{q^L-lq^F}{q^L}\right)}{\frac{M}{1-l}\frac{r+i}{q^F(1-st)-1}\frac{q^L-lq^F}{q^L}} > 0$$

(73) $$\left.\frac{dn_F}{di}\right|_{LS} = -\frac{n_F M[q^F(1-st)-1]+n_F M+\frac{st}{1-t}M\left(\frac{l}{1-l}\frac{q^F}{q^L}+1\right)}{M[r+iq^F(1-st)]} < 0\ .$$

Since the second derivatives are opposite signs, when graphed in (n_F, ι) space the LN and LS lines are identical to graph 2.

Consider a change in the IPR regime that lowers the rate of infringement τ. Holding the measure of firms constant, and differentiating (70) with respect to ι and τ, yields

(74) $$\left.\frac{di}{dt}\right|_{LN} = -\frac{\frac{M}{1-l}\frac{r+i}{[q^F(1-st)-1]^2}sq^F\left(1-n_F\frac{q^L-lq^F}{q^L}\right)}{I+\frac{1}{[q^F(1-st)-1]^2}\left(1-n_F\frac{q^L-lq^F}{q^L}\right)} < 0\ .$$

Similarly, holding the rate of innovation constant and differentiating (70) with respect to n_F and τ yields

(75) $$\left.\frac{dn_F}{dt}\right|_{LN} = \frac{sq^F q^L}{q^F(1-st)}\frac{1-n_F\frac{q^L-lq^F}{q^L}}{q^L-lq^F} > 0$$

A decrease in τ shifts the LN curve right.

(8.6 Tc ()) 0395(0 TD -0.2163 Tc ()) T72(76)).

Comparable differentiation for the LS curve shows

FF D (-(76)) T LS j = − E T q (+) F (1−) − 1 [ ] F [F (1−) − 1] + F + 1− (1− q^F q^L + 1) 2 9 9 . 2 5 < 0 6 6 3 T j 2 1 tsMDD (-) Tj 0 - .Tc ()) 1437s.425 1TD (F) T Tc

This section facilitates comparison of the present model to Helpman (1993) by assuming an exogenous imitation rate that can be directly affected by the IPR regime.[10] Imitation serves as the only manner in which technology is transferred to the South. I assume that Southern firms obtain the production knowledge at the Poisson arrival rate $\mu\Delta t$, where μ is determined by the level of IPR protection. That is, any increase in the strength of IPRs leads to one-for-one decrease in μ. For simplicity, I assume that imitated goods receive the same trademark as the original innovation, or close enough that consumers do not distinguish between the two. This diffuses all profits, since withoud differentiation Bertrand competition drives all prices to marginal cost.

The value equation and the profit equation for innovating firms remain the same, giving

(78) $$p^N = E(1 - st - \frac{w}{q})$$

as in (57) above. Since the firm loses all economic profits through both innovation and imitation, with no potential return, the value equation becomes

(79) $$v^N = \frac{p^N}{r + m + i}$$

which, with (60) and (78), yields

(80) $$E(1 - st - \frac{w}{q^L}) = wI$$
.

The Northern resource constraint simplifies to

(81) $$L_N = iI + n_N \frac{E}{q}$$

(82) $$L_S = \frac{st}{1-t}\frac{E}{q} + n_S \frac{E}{q}$$

which is identical to (16) above with Southern firms in place of MNEs.

Only measures for Northern and Southern firms remain, and they can be reduced to relationships between the innovation and imitation rates by the following:

(83) $$n_N = \frac{i}{i+m}$$

(84) $$n_S = \frac{m}{i+m}.$$

Combining (80) – (84) yields the following system of equations for the endogenous variables {E, w, ι}.

(85) $$E(1 - \frac{w}{q} - st) - wI(r + m + i) = 0$$

(86) $$L_N - iI - \frac{i}{i+m}\frac{E}{q} = 0$$

(87) $$L_S - \frac{E}{q}\left[\frac{st + i(1-t)}{(1-t)(i+m)}\right] = 0$$

Fully differentiating the above system, and applying Cramer's Rule, yields the following result:[11]

(88) $$\frac{di}{dm} = 2q(1-t)(i+m)\frac{\frac{E}{q}\frac{i}{(i+m)^2}\frac{st + (1-t)}{q(1-t)(i+m)}}{(1-t)iI + st\left(\frac{E}{q}\frac{i}{i+m} + I\right)} > 0.$$

As the rate of imitation goes down, which can be considered a result of tighter IPRs, the rate of innovation decreases, just as in Helpman (1993).

[11] Appendix A.4 shows the method.

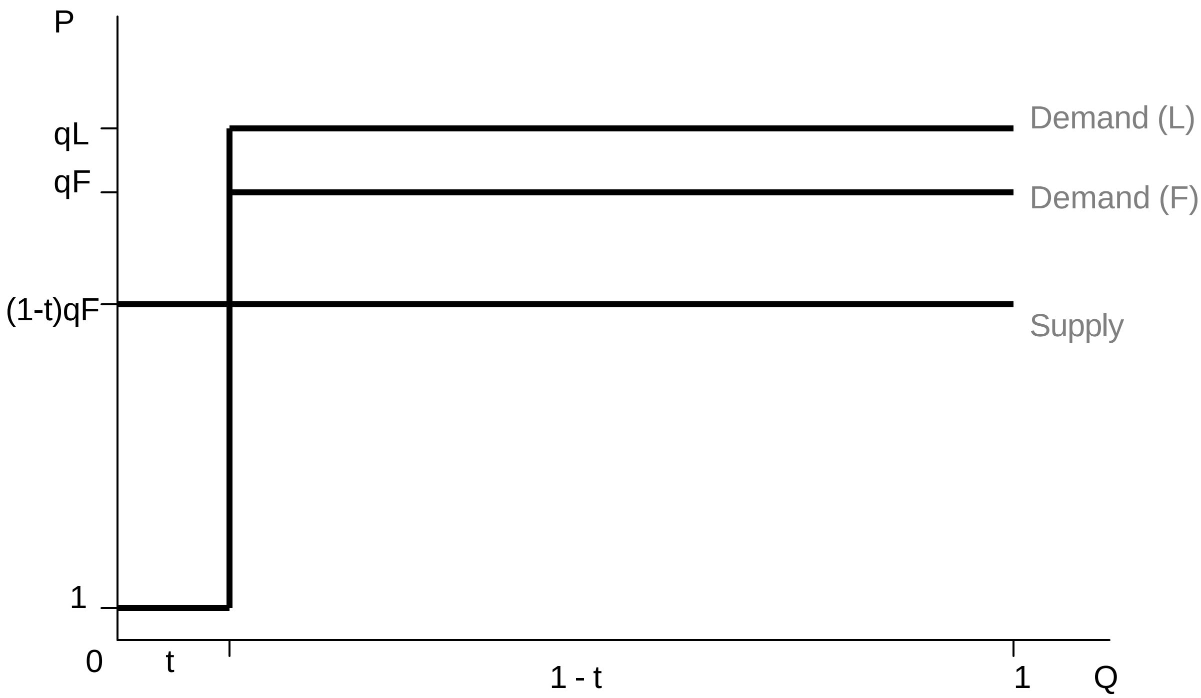
4 Welfare effects

This section investigates the potential welfare consequences of trademark enforcement. The baseline model of section 2 emphasizes the lost return to R&D in weak IPRs. Infringement lowers the profits of innovating firms and reduces the signaling power of the trademark for consumers who desire the quality goods. The only welfare gains, however, are in the profits of infringing firms that obtain economic rents using improper labeling.[12]

Of the four pricing schemes discussed in section 3.1.1, the only one that yields consumer surplus is the "whole-market" strategy used throughout the section. By definition, with perfect price discrimination firms are able to capture the full willingness to pay by consumers. If I relaxgnessout l6 -27 w,eBoue52.5 -3uation, in which firms charge q^L for all consumers, F-consumers actouely face a pseudo-welfare loss sincegnesy would onesrwise only wish to pay q^F for nessgood. With "high-end" pricing, L-consumers pay nesir full -3uation q^L, and F-consumers pay nes perfectly competitive price for asgoodgnesy -3ue atw_S.

Consider the situation prior no imitation, when Nornesrn firms maintain a monopoly on nesir innovation but face the problem of infringement in the Soutesrn market. With "whole-market" pricing, L-consumers are paying only q^F for asgoodgnesy -3ue at q^L. Consequently,gnesy enjoy consumer surplus. Graph 4 shows demand and supply curves in this pricing scenario. The horizontal axis graphs the full continuum of goods from zero no one. The propornion τ (labeled "t" in the graph) of thesssgoods are knock-offs, for which consumers are only willing to pay the marginal cost 1. The rest of the goods, proportion 1-τ, are legitimate goods, for which L-consumers are willing to pay q^L and F-consumers are willing to pay q^F. Both the Northern firms and the infringing firms supply the goods at price $(1-\tau)q^F$.

Graph 4 Consumer surplus with trademark infringement



The areas between the F-demand curve and the supply curve are equal to each other. For infringed goods, F-consumers face a $\tau(1-\tau)q^F$ welfare loss, but for legitimate goods they gain $(1-\tau)[q^F-(1-\tau)q^F]$ consumer surplus, for an overall gain of zero. L-consumers face the same welfare loss on infringed goods, but gain $(1-\tau)[q^L-(1-\tau)q^F]$ in consumer surplus. The overall welfare gain for L-consumers is $(1-\tau)(q^L-q^F) + (1-\tau)^2q^F$. Notice that after imitation, the supply curve for L-consumers shifts to $(1-\tau)q^L$, taking away all consumer surplus.

[12] Welfare gains could be accrued if trademark infringement lowered production in the North, opening resources for innovation, but these benefits are small relative to the costs consumers face when paying a

The relationship between consumer surplus and the infringement rate is given by

$$\frac{d(c.s.)}{d(1-t)} = q^L - q^F + 2(1-t)q^F > 0 . \quad (89)$$

As IPRs are strengthened, raising (1-τ), the consumer surplus for L-consumers increases. In this situation, IPRs are welfare-enhancing.

4. Conclusion

This paper introduces trademark infringement into a dynamic, general equilibrium setting. I elaborate the conception of intellectual property rights beyond an incremental rise in imitation costs. An increase in the strength of intellectual property protection increases the rate at which firms shift production to the South. It also increases the innovation rate, regardless of whether technology is transferred by FDI or through imitation. Trademark enforcement may enhance welfare by broadening the gap between the amount some consumers are willing to pay for a good and the actual price charged.

premium for an inferior good.

Works Cited

Besen, Stanley and Leo Raskind. 1991. An Introduction to the Law and Economics of Intellectual Property. *Journal of Economic Perspectives* 5(1): 3-27.

Feinberg and Rousslang. 1990. *Journal of Business.*

Glass, Amy and Kamal Saggi. 1995. Intellectual Property Rights and Foreign Direct Investment. Ohio State University Working Paper 95-06.

Glass, Amy and Kamal Saggi. 1998. International Technology Transfer and the Technology Gap. *Journal of Development Economics* 55: 369-398.

Grossman, Gene and Elhanan

Appendix A.1 Cramer's Rule for the sign of dι/dt

In section 2, equations (15), (16), (20), and (21) provide a system of four equations for the four endogenous variables {E, w, ι, n_M}. Fully differentiating these equations for these variables and the rate of infringement τ yields the following:

$$\begin{bmatrix} 1-st-\frac{w}{q} & -\frac{E}{q}-I(r+i) & -wI & 0 \\ 1-st-\frac{1}{q} & -I(r+i) & -wI-A & 0 \\ -(1-n_M) & 0 & -I & \frac{E}{q} \\ -\frac{st}{1-t}-n_M & 0 & -n_M A & -\frac{E}{q}-iA \end{bmatrix} \begin{bmatrix} dE \\ dw \\ di \\ dn_M \end{bmatrix} = \begin{bmatrix} sE \\ sE \\ 0 \\ \frac{sE}{q(1-t)^2} \end{bmatrix} dt$$

Using Cramer's Rule, the sign for dι/dτ can be found with $\frac{di}{dt}=\frac{|A_i|}{|A|}$, where

$$|A_i| = -sE\frac{E}{q}\left[\frac{E}{q}\left(\frac{st}{1-t}+1\right)+(1-n_M)iA\right]-\left(\frac{E}{q(1-t)}\right)^2 s\left[I(r+i)\frac{w-1}{q}+\frac{E}{q}\left(1-st-\frac{1}{q}\right)\right]<0$$

and

$$|A| = \left[\frac{E}{q}(wI+A)+(r+i)AI\right]\left[\frac{E}{q}\left(\frac{st}{1-t}+1\right)+(1-n_M)iA\right]$$

$$+\left[\frac{E}{q}(n_M A+I)+iAI\right]\left[I(r+i)\frac{w-1}{q}+\frac{E}{q}\left(1-st-\frac{1}{q}\right)\right]>0\,.$$

Thus, dι/dτ < 0.

Appendix A.2 Adaptation costs from Southern resource constraint

The expression for dι/dτ derives from $\frac{di}{dt} = \frac{|B_i|}{|B|}$ where

$$|B_i| = -sE\left(\frac{E}{q} - A(r + i)\right)\left((\frac{E}{q} - iA)(1 + \frac{st}{1-t}) + iA(1 - n_M)\right)$$

− —− —— − (+ − + − —− +(+ 1)((+) −—))

If all consumers are willing to pay q^L for a new innovation, Northern firms earn the profits

$$— (q \quad w)$$