Trade of Differentiated Products Under Intellectual Property Piracy

Jenny X. Lin*

November 1, 2013

Abstract

Conventional wisdom and theory have it that developing countries' intellectual property rights (IPRs) incentives differ substantially from those of developed countries, especially under technology imitation. This model explores a new channel by which IPRs may affect welfare such that cross-country incentives are aligned even in the short run: the composition of trade. I investigate whether and how IPRs and the threat of imitation may affect trade of differentiated products asymmetrically. Allowing for differing consumer preferences across products implies unique markups and demand elasticities for all differentiated goods. Because products are associated with different profit potential, firms make asymmetric export decisions when faced with the threat of imitation and its spillover effects into the home market. Cross-country incentives can be aligned as product imitators trade off gains from lower prices with losses due to less access to inelastically demanded varieties. The primary predictions of the model find empirical support in the data, where it is shown that a greater proportion of inelastically demanded goods are exported to stronger relative to weaker IPR destinations.

JEL Classification: F12, F43, F55, O34, O43

Keywords: Intellectual Property Rights, IPRs, International trade, differentiated varieties, piracy, technology imitation, welfare

1 Introduction

The traditional discussion around intellectual property right (IPR) protection centers on the time-inconsistency problem of conflicting short-run price versus long-run innovation incentives. A similar trade-off exists between developed nations, the source of most technological innovation, and developing nations who seek greater accessibility of innovative products.

*Department of Economics, University of Michigan, Email: jenxlin@umich.edu. A particular thanks to my advisor, Alan Deardorff, for countless helpful discussions and continual support. I would also like to thank Andrei Levchenko, Jagadeesh Sivadasan, Dmitriy Stolyarov, Peter Neary, Beata Javorczik, Emanuel Ornelas, William Lincoln, Jing Zhang, Wilhelm Kohler, Frank Stähler, Benjamin Jung, Logan Lewis, Matthew Backus, Peter Hudomiet and seminar participants at the University of Michigan, Oxford University, the London School of Economics, Universität Tübingen and the Federal Reserve Board of Governors Trade Working Group for helpful comments. Any remaining errors are entirely my own.

Developing nations have often relied on varying degrees of product imitation as a de facto economic development strategy in a bid to "catch-up" to advanced economies. It is common to assume incentive misalignments between developed nations seeking stronger IPRs versus developing nations which seek lower protection[1], as highlighted by the discussion surrounding the WTO Trade Related Aspects of Intellectual Property (TRIPs) agreement. How is the composition of trade affected by IPRs? Can a country with weak IPRs ever lose in the short run from technology imitation? It is to these questions that this paper is addressed.

In the new trade theory with increasing returns to scale, product variety has important implications for the gains from trade. In these models, welfare gains stem from increasing access to the number of product varieties, founded upon consumers' taste for variety. Yet, the varieties each contribute equally to consumer welfare under the standard CES utility assumption and there is no differential weight due to the type of variety itself. Faced with potential shocks to profit, such as those due to intellectual property (IP) pilferage, firms of comparable productivity should adjust in the same way given CES preferences between varieties. A fundamental question, then, is whether it is indeed the case that shocks such as the threat of IP piracy affect firm exports of different varieties in the same way. In this paper, I explore this question both theoretically and empirically.

I develop a North-South theoretical framework of firm export choice under IP piracy when consumer preferences differ across varieties. To fully incorporate the idea of individuals having differing tastes over a spectrum of varieties, I drop the oft-used CES utility function in favor of a quasi-linear utility with varying preference parameters for each variety. The distinct preference parameters translate into goods associated with unique markups and own-price demand elasticities. The Northern firm export decision is fully endogenized as a trade-off between gains from a larger consumer market and losses from potential piracy of its technology by Southern firms. The model hinges on the fact that firm profits are higher for more inelastically demanded goods. Thus, when faced with the threat of product piracy with spillover effects into the home market, firms producing relatively inelastically demanded goods stand to sustain greater profit losses and are more sensitive to destination market IPRs. This leads to systematically different firm export decisions across products.

An important insight the model delivers is that exports of varieties can differ in the extent to which they are affected by destination IPRs. Exports of relatively homogeneous, highly demand elastic goods are entirely unaffected by the presence of IP piracy. This is because Southern firms either already have the technology to produce the most homogeneous variety or imitation is not profitable. If a variety is highly demand inelastic, however, firm profits for that good are higher and the threat of technological imitation can be a binding constraint for exports. In the model, accessing the South via exports leads to a greater risk of IP piracy, which cuts into profits both at home and abroad. However, this is offset by potential profits gains from selling in the South, which is proportional to the population share of the South. In equilibrium, if the share of the South's population is greater than the increased probability of piracy, then trade is not affected and firms will choose to export as gains from accessing a larger market more than offsets expected losses from piracy.

While there exist several important papers in the theoretical literature on trade with

[1] Grossman and Lai (2004) demonstrate this misalignment theoretically in a game-theoretic framework.

technological imitation, this paper is most closely related to Connolly and Valderrama (2005), which showed that technological spillovers in a model with intermediate goods and imitation can result in properly designed Southern IPR regimes that are welfare-enhancing for both the developed North and the developing South. The primary departures I make from the existing literature are: use of preferences allowing for differing demand elasticities across goods, the presence of explicit firm profit shocks stemming from technological imitation and a focus on short-run impacts rather than the traditional long-term feedback effects on innovation. In this sense, the model can offer short-run incentive compatibility for both trading partners and can flexibly generate positive or negative net gains from trade dependent upon destination country size and IPR regime.

The predictions of the theoretical model find strong empirical support. Using country-product-level world bilateral trade data, I document several new empirical regularities that are consistent with the theoretical framework. In the data, there is greater trade of relatively inelastically demanded products to strong compared to weak IP protection destinations. I find this to be the case both cross-sectionally across countries with differing levels of IPRs and across time for the same country following a number of well-documented IP reforms. This finding also holds under various specifications and sensible subsample checks. This suggests not only that trade of varieties is differentially impacted by the threat of IP piracy, but that differing consumer preferences across these varieties may generate an additional channel through which trade under IP piracy affects welfare, beyond the standard number of varieties effect.

In the empirical section, I evaluate the effect of IPRs on the composition of import varieties in several ways. First, I take a cross-sectional difference-in-difference approach utilizing Park (2008) indices on IPR strength across countries. I use Broda-Weinstein country-specific estimated demand elasticities (σ's) at the HS 3-digit level as a measure of product differentiation. Combining these, I estimate the effect of the interaction between product elasticities and IPRs, controlling for product and bilateral country fixed effects. I also run a number of robustness checks, detailed in the empirical section. Results across all specifications significantly point to the fact that more inelastically demanded goods are more likely to be exported to a destination with stronger IPRs. The magnitudes range from a .447% to 3.2% higher import value of inelastically demanded goods for every one standard deviation decrease in elasticity between countries with the strongest versus weakest IPRs.

I also estimate a panel difference-in-difference model for 6 individual countries well-documented as having had IPR reforms (Branstetter et. al 2006): Argentina, Brazil, China, Colombia, Turkey and Venezuela. I use destination-specific product demand elasticities interacted with a binary reform variable to look at the trade impact on different varieties from the reform for each country individually. I then pool together data from all 6 reforms and rerun the estimation. I find that the signs of the coefficients are broadly consistent with the cross-sectional evidence, but that this effect is only significant in the pooled-sample. The coefficient signs suggest, altogether, that relatively inelastically demanded goods are more likely to be exported to a destination following an IP reform.

The paper proceeds as follows. In Section 2, I set up the baseline theoretical model and highlight some important features of the model. Section 3 explores the closed economy solution and includes some comparative statics. Section 4 explores the open economy solution

with corresponding welfare analysis and comparative statics for both countries. In Section 5, I extend the baseline model to incorporate endogenous IP piracy and incomplete re-exportation. Section 6 presents empirical evidence. Section 7 concludes.

2 A Model of Firm Exports and Trade under IP Piracy

I develop a short-run model of firm export choice under intellectual property imitation. Despite lack of direct exploration of the effect on exports of potential IP piracy, the existing New Trade Theory literature, based almost exclusively on CES consumer preferences, does have something to say about this issue. If the risk of IP piracy were to become non-zero, the standard Melitz model based on CES preferences with its constant markup would see the overall number of varieties traded decrease. But this decrease would be symmetric across all varieties, given the same level of firm productivity, and there would be no reason to expect products of different varieties (much less different elasticities, since all elasticities are the same) to be impacted differentially in the face of varying IPR levels or following an IP reform. As a result, any welfare consequences would be dependent only upon the number of varieties (as differentiated based on firm productivity, not preferences) and not the type of varieties consumers prefer.

In this model, I abstract from firm productivity differences except for those that are cross-country and between homogeneous and differentiated varieties. Instead, I focus on differences in consumer preferences over types of varieties and explore whether and how this dimension generates varietal differences in firm export choice under the threat of IP pilferage. Differences in firm export choice across varieties can stem from differing profits across products due to the varying demand elasticities of the products. Welfare impacts under this framework are then considered for both parties to trade.

2.1 Model Setup

There are 2 types of countries in this model: the high-wage developed (North) and the low-wage developing (South) countries. Labor is the only factor of production with labor productivity differing in the two countries, while the labor force in both countries is assumed to be fixed and exogenous at L_N and L_S, respectively. The North has the unique ability to produce differentiated goods from its exclusive innovative ability, while South is unable to develop new goods, thus we can denote new goods by n_N. The homogeneous goods is tradable and its technology is common property, so that it can be produced in either North or South, though with differing productivity, as discussed later. I assume that the market for the homogeneous good is characterized by perfect competition in both countries.

Let J be the total number of "new" goods currently produced that are still under an active patent. Over time, the set of J changes via a law of motion governed by both Northern innovation and IPR protection, but I abstract from dynamic considerations and focus on short-run effects under a fixed J. Within this framework, we can interpret the products either as different goods altogether or simply as different varieties of the same good. To keep in line with the data in the empirical section, I choose the former interpretation in this

treatment; however the latter interpretation holds equal merit within this framework.

2.2 Consumer Optimization

Let there be a continuum of new goods varieties $j \in [1, J]$. Each economy has measure 1 number of consumers. Each variety is associated with a distinct preference parameter $\theta_j > 1$, with $\theta_j \in (1, \infty)$, which will imply differing own-price elasticities of demand for each good type. Intuitively, this can be thought of as the existence of many assortments of a good, with each differing in its own-price demand elasticity. In this formulation, as I show below, higher values of θ_j always correspond to goods associated with relatively inelastic demands, which can be interpreted as "newer" goods. Without loss of generality, I will also assume that θ_j is monotone increasing in j, that is, goods j are ordered by decreasing demand elasticity. Homogeneous consumers share the same quasilinear instantaneous utility function[2]. Good 0 is the homogeneous numeraire. Consumers in both countries have similar preferences and solve the instantaneous maximization problem

$$\begin{aligned} \max u &= q_0 + \int_1^J \theta_j q_j^{\frac{1}{\theta_j}} dj \\ \text{s.t. } I &= p_0 q_0 + \int_1^J p_j q_j dj \end{aligned}$$

Setting p_0 to unity, as the numeraire, the solution is given by

$$\begin{aligned} q_j &= p_j^{\frac{\theta_j}{1-\theta_j}} \\ q_0 &= I - \int_1^J p_j^{\frac{1}{1-\theta_j}} dj \end{aligned}$$

with each good j's corresponding own-price elasticity of demand given by

$$\sigma_{p_j}^D = \frac{\theta_j}{1-\theta_j}, \ \theta_j > 1$$

This implies that varieties corresponding to higher values of θ_j have demand that is relatively more inelastic. Higher θ_j in this utility function represents varieties of relatively lower elasticity.

2.3 Firm Optimization

2.3.1 The North

Due to the presence of intellectual property right patents, each variety will have only one monopolistic firm producing it. The Northern firm specializing in production of a variety

[2]The usage of quasilinear preferences has precedence set in the literature including Dixit and Norman (1980), Grossman and Helpman (1994), Ottaviano et al. (2002, quadratic quasi-linear), Melitz and Ottaviano (2008, quadratic quasi-linear) and Dinolopoulos (2011). Other specifications allowing for differing demand elasticities across goods would likely yield similar results, but in this paper I employ the simplest possible utility function with this feature.

will thus also be indexed by j, with J total firms. Production in each industry is a simple linear function of labor alone. I assume that production for the firm associated with each variety has a unit labor requirement of 1, thus the production function can be represented by $q_j = l_j$, where l_j is labor input into making that variety of the good. Let us also assume that production of the homogeneous good is linear in the North $q_0^N = l_0^N$. Let q_j^N be the per-consumer demand faced by the Northern firm for its product, p_j^N the price it sets for its product and l_j^N its choice of labor input. Firms for each industry enjoy monopoly profits and face the following closed economy optimization problem, with w_N denoting wages in the North:

$$\pi_j^N = p_j^N q_j^N - w_N l_j^N$$

Because all consumer preferences are symmetric, the per-consumer firm profit maximizing conditions in the North are therefore:

$$\begin{aligned} p_j^N &= w_N \theta_j \\ &\Rightarrow q_j = p_j^{\frac{\theta_j}{1-\theta_j}} = (w_N \theta_j)^{\frac{\theta_j}{1-\theta_j}} \\ q_0 &= I - \int_1^J (w_N \theta_j)^{\frac{1}{1-\theta_j}} \, dj \end{aligned}$$

In equilibrium, if the homogeneous good 0 is produced and all production is linear in labor input, then $p_0 = w_N$ and wages in the North should be unity as well. This implies that prices and per-consumer quantities can be expressed as functions of the preference parameter θ_j:

$$\begin{aligned} p_j^N &= \theta_j \\ q_j &= \theta_j^{\frac{\theta_j}{1-\theta_j}} \\ q_0 &= I - \int_1^J \theta_j^{\frac{1}{1-\theta_j}} \, dj \end{aligned}$$

2.3.2 The South

For simplicity, I will assume that firms in the South cannot develop new products and are only capable of either producing the homogeneous good or imitating Northern products. I show that there will exist a $\hat{\theta}_j$, below which represents the goods exported by the North to the South and above which represents the goods that remain unexported by North. Let n_S denote the set of products both exported to and imitated by South and let n_N denote the set of goods produced and exported by North and not imitated by South.

In order to match the intuition of the South representing developing countries, I assume that $w_S < 1 = w_N$. This relative wage condition holds by assuming that Southern productivity of the non-traded homogeneous good is lower than its Northern counterpart (i.e. $q_0^S = \gamma_0^S l_0^S$ where the productivity $\gamma_0^S < 1$); otherwise only South would produce the homogeneous good. For the $j \in n_S$ products imitated by South, I assume the imitation was

complete and a Southern firm can imitate the good with the same productivity of the originating Northern firm (i.e. $q_j^S = l_j^S \; \forall \; j \in n_S$). This assumption can be easily relaxed and all results would qualitatively go through.

IPRs can be represented by a per-unit expected fine, ϕ, of pirating a Northern product, with higher expected fines associated with stronger IPRs. The per-unit nature of the fine is in line with actual IPR enforcement practices. Expected fines are redistributed back, lump-sum, to North and enters in Northern aggregate welfare. Given that any firm in the South can choose to imitate an imported Northern product, and assuming the homogeneous good is still produced in the South, the market for each imitated variety is perfectly competitive and thus, in the absense of IPR protection, prices in South should equal marginal cost and satisfy $p_j^S = w_S \; \forall \; j \in n_S$. For the unimitated goods $j \in n_N$, prices remain at monopoly prices $p_j^S = p_j^N = \theta_j$. Since the presence of imitation can cause Northern firms to choose not to export certain products to South, I distinguish the total set of products available in the South, i.e. exported by North or produced by South, by denoting this $J^S \subset J$, with $n_S \subseteq J^S$.

The labor market clearing condition in South is given by

$$L_S = \frac{q_0^S}{\gamma_0^S} + \int\limits_{j \in n_S} q_j^S dj$$

where $q_j^S = \left(p_j^S\right)^{\frac{\theta_j}{1-\theta_j}}$ and $q_0^S = w_S L_S - \int_1^{J^S} p_j^S \left(p_j^S\right)^{\frac{\theta_j}{1-\theta_j}} dj$, with $j \in J^S$. Since w_N was pinned down at unity, then if we restrict attention to the case in which the homogeneous good is produced in South in equilibrium, the Southern wage can be determined directly solving the market clearing condition above. In this case, $w_S = \gamma_0^S w_N = \gamma_0^S$.

2.3.3 Timing

Being a static model, the timing of all firm actions happens over a short span in a series of sequential steps. First each Northern firm develops and produces the profit-maximizing quantity of its product for the Northern consumers and observes the probability of being pirated in South. The Northern firm then decides whether or not to export to South. If export occurs, then there is an immediate probability ρ of being pirated by a Southern firm and being forced into Southern perfectly competitive profits, although due to productivity differences this is still above marginal cost for the Northern firm. If its product is pirated, then if the competitive profits are sufficient (which occurs if the technology gap between North and South is very large), a Northern firm will undercut the Souther competitive price by ε, recapturing the market; otherwise the firm will simply exit the market.

3 Closed Economy Solution

To begin with, it is helpful to analyze the economic environment in North in autarky. Solving the closed economy equilibirum for North requires budget balance and labor market clearing conditions.

3.1 Price Index

The ideal price index in the North (derivation in Mathematical Appendix) is given by

$$\mathbf{P} = p_0 - \int_1^J p_0^{\frac{\theta_j}{\theta_j - 1}} \theta_j p_j^{\frac{1}{1-\theta_j}} dj + \int_1^J p_0^{\frac{\theta_j}{\theta_j - 1}} p_j^{\frac{1}{1-\theta_j}} dj$$

Plugging in the monopoly price $p_j^N = \theta_j$ and normalizing the price of the homogeneous good $p_0 = 1$, we have

$$\mathbf{P} = 1 - \int_1^J \theta_j^{\frac{2-\theta_j}{1-\theta_j}} dj + \int_1^J \theta_j^{\frac{1}{1-\theta_j}} dj$$

3.2 Budget Balance

I will assume that at a given point in time the number of goods/industries J is fixed and there is no free entry. This makes intuitive sense due to the presence of patents; once a good is invented, patents prevent other firms from producing that particular variety of good. Noting that price normalization for the homogeneous good implies zero profits for that good, let total firm profits per-capita in North at date t be represented by

$$\begin{aligned} \frac{\Pi_N(t)}{L_N} &= \int_1^J \left[p_j^N q_j^N - w_N q_j^N \right] dj \\ &= \int_1^J \left[\theta_j^{\frac{1}{1-\theta_j}} - \theta_j^{\frac{\theta_j}{1-\theta_j}} \right] dj \end{aligned}$$

Since total income, Υ, equals the sum of labor income and monopoly rents, $\Upsilon = w_N L_N + \Pi_N = L_N + \Pi_N$. Individual income, I, then can be expressed as $I = \frac{\Upsilon}{L_N}$, assuming perfect income equality.

Then budget balance in the North implies that total expenditure, E_N, equals total income and satisfies:

$$E_N = L_N + \Pi_N = L_N + L_N \int_1^J \left[\theta_j^{\frac{1}{1-\theta_j}} - \theta_j^{\frac{\theta_j}{1-\theta_j}} \right] dj = \Upsilon$$

It is important to note here that consumption of the homogeneous good will always be positive as long as $1 > \int_1^J \theta_j^{\frac{\theta_j}{1-\theta_j}} dj$. This places no additional restrictions on θ_j or J.

3.3 Market Clearing

In equilibirum, labor supply in North will equal labor demand, the labor required to produce the equilibrium quantity demanded for each Northern good produced. Since Northern production technology is linear for both the differentiated and homogeneous products and the measure of consumers is unity, with all consumers having symmetric preferences, labor market clearing can be expressed as:

$$L_N = I - \int_1^J \theta_j^{\frac{1}{1-\theta_j}} dj + \int_1^J \theta_j^{\frac{\theta_j}{1-\theta_j}} dj$$

This condition, however, is redundant and follows from the budget balance condition due to the fact that the form of utility function implies infinitely elastic labor demand for the homogeneous good. As such, if positive quantities of the homogeneous good are produced, then the wage rate is immediately pinned down and the market clearing condition automatically follows from the goods market clearing condition.

3.4 Welfare

Real wages in the North can be represented by

$$\frac{w}{\mathbf{P}} = \frac{1}{1 - \int_1^J \theta_j^{\frac{2-\theta_j}{1-\theta_j}} dj + \int_1^J \theta_j^{\frac{1}{1-\theta_j}} dj}$$

Welfare can be expressed as real wages plus real profits per worker and is given by

$$\mathbf{W} \equiv \frac{w}{\mathbf{P}} + \frac{\frac{\Pi_N}{L_N}}{\mathbf{P}} = \frac{1 + \int_1^J \left[\theta_j^{\frac{1}{1-\theta_j}} - \theta_j^{\frac{\theta_j}{1-\theta_j}} \right] dj}{1 - \int_1^J \theta_j^{\frac{2-\theta_j}{1-\theta_j}} dj + \int_1^J \theta_j^{\frac{1}{1-\theta_j}} dj}$$

3.5 Comparative Statics

Looking at the evolution of welfare as the number of products J grows, we can see that the real wage increases in the number of varieties. This result is consistent with new products entering positively into the utility function.

Claim 1 *P is decreasing in J and $\frac{w}{\mathbf{P}}$ is increasing in J*

Proof.

$$\begin{aligned} \frac{2-\theta_J}{1-\theta_J} \ln \theta_J &> \frac{1}{1-\theta_J} \ln \theta_J, \forall\ \theta_J > 1 \\ &\Longrightarrow \theta_J^{\frac{2-\theta_J}{1-\theta_J}} > \theta_J^{\frac{1}{1-\theta_J}}, \forall\ \theta_J > 1 \\ &\Rightarrow \frac{\partial P}{\partial J} = -\theta_J^{\frac{2-\theta_J}{1-\theta_J}} + \theta_J^{\frac{1}{1-\theta_J}} < 0 \\ &\Rightarrow \frac{\partial \frac{w}{\mathbf{P}}}{\partial J} > 0, \forall\ \theta_j > 1 \end{aligned}$$

■

Looking at how monopoly rents, and thus monopoly rents per worker, are affected by the number of varieties, we have the following claim

Claim 2 $\frac{\Pi_N}{L_N}$ *is increasing in $J\,(t)$*

Proof.

$$
\begin{aligned}
\frac{\Pi_N}{L_N} &= \int_1^J \left[\theta_j^{\frac{1}{1-\theta_j}} - \theta_j^{\frac{\theta_j}{1-\theta_j}}\right] dj \\
\frac{1}{1-\theta_J}\ln\theta_J &> \frac{\theta_J}{1-\theta_J}\ln\theta_J,\ \forall\ \theta_J > 1 \\
&\Rightarrow\ \theta_J^{\frac{1}{1-\theta_J}} > \theta_J^{\frac{\theta_J}{1-\theta_J}},\ \forall\ \theta_J > 1 \\
&\Rightarrow\ \frac{\partial \Pi_N}{\partial J} = \theta_J^{\frac{1}{1-\theta_J}} - \theta_J^{\frac{\theta_J}{1-\theta_J}} > 0 \\
&\Rightarrow\ \frac{\partial \frac{\Pi_N}{L_N}}{\partial J} > 0,\ \forall\ \theta_j > 1
\end{aligned}
$$

■

Altogether, this implies that aggregate welfare rises as the number of varieties increases, that is, $\frac{\partial \mathbf{W}}{\partial J} > 0$.

Looking at how monopoly rents per worker for a particular firm j, $\pi_j^N = \theta_j^{\frac{1}{1-\theta_j}} - \theta_j^{\frac{\theta_j}{1-\theta_j}}$, are affected by the elasticity, I make the following claim

Claim 3 *π_N rises with θ_j, $\forall\ \theta_j > 1$*

Proof.

$$
\frac{\partial \pi_j^N}{\partial \theta_j} = \left[\begin{array}{c} \left(\frac{1}{\theta_j(1-\theta_j)} + \frac{1}{(1-\theta_j)^2}\ln\theta_j\right)\theta_j^{\frac{1}{1-\theta_j}} \\ -\left(\frac{1}{1-\theta_j} + \frac{1}{(1-\theta_j)^2}\ln\theta_j\right)\theta_j^{\frac{\theta_j}{1-\theta_j}} \end{array}\right] > 0,\ \forall\ \theta_j > 1
$$

■

4 Open Economy Solution

The framework under an open economy is the main one of interest in later analyzing the empirical evidence. All the firm-level properties explored in the previous section, under a closed economy, follow here with some minor modifications.

4.1 Profits

Let q_j^N and q_j^S be the per consumer demand faced in North and South respectively for product j. Under monopoly, $p_j^M = \theta_j$ and $q_j^M = \theta_j^{\frac{\theta_j}{1-\theta_j}}$. Let $\pi_j^M = \left(p_j^M - w_N\right) q_j^M = (\theta_j - 1)\,\theta_j^{\frac{\theta_j}{1-\theta_j}}$ denote Northern firm level profits per consumer, under monopoly. A Northern firm that chooses not to export its product earns the autarky total profit $\Pi_j^M = \pi_j^M L_N$. A Northern firm that exports its product to South and whose product is not imitated

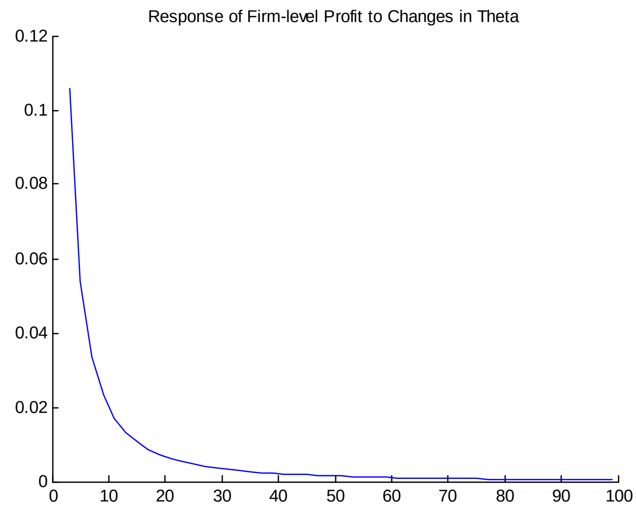


Figure 1: Response of firm-level monopoly profits to increases in θ

faces the same monopoly price and quantity as under autarky and earns the global profits $\pi_j^N = \pi_j^M (L_N + L_S)$.

Southern firms face a per-unit expected fine ϕ of pirating a Northern product. A Southern firm who chooses to imitate a specific Northern firm's product earns expected profit of zero due to perfect competition in the South. Its expected total profit can be expressed as $E\left(\pi_j^S\right) = \left(p_j^S - w_S - \phi\right)\left[q_j^N L_N + q_j^S L_S\right]$. Therefore under perfect competition, the price of product j in South will simply equal the marginal cost $p_j^S = p^S = w_S + \phi$ and expected profits will be zero for all imitated varieties $j \in n_S$. Southern firms will repeat the game every period and can opt to imitate again even if they were caught previously.

I make the assumption that, if imitated, Northern firms face some spillover effects in the home market. That is, when its product is imitated, a Northern firm not only faces competitive prices in the Southern market, but also sees some of its existing domestic market base subject to competitive prices as well, with affected prices and quantities given by $p^S = w_S + \phi$ and $q_j^C = (w_S + \phi)^{\frac{\theta_j}{1-\theta_j}}$. Let $\omega \in [0, 1]$ denote the proportion of Northern consumers that can procure any pirated good j. The case in which $\omega = 0$, then, corresponds to no access to imitated goods by Northern consumers, while $\omega = 1$ corresponds to full access to pirated products; throughout this analysis, I assume $\omega > 0$. Profits for a Northern firm when its product is imitated will be given by $\pi_j^C = \left(p_j^M - w_N\right) q_j^M (1-\omega) L_N + \max\left\{p_j^C - w_N, 0\right\} q_j^C (\omega L_N + L_S)$. Thus as long as $\omega < 1$ or if the expected fine is big enough on IPR infringement by the South, North can still obtain positive profits even under the presence of piracy.

4.2 The North

When the countries open up to trade, each Northern firm must decide whether or not to export its product to South. If a firm exports, it faces an increased probability of its

technology being pirated relative to selling purely domestically. This piracy probability differential is given by $\rho = f\left(\pi_j^N, \phi\right)$, where $f_1 < 0$, $f_2 < 0$. Whenever technology is pirated, the firm associated with that variety is forced into a Bertrand game of perfect competition with all Southern imitators of its product. Let π^D be the profit of a Northern firm from selling only to the domestic market and let π^X be the expected profit of a Northern firm from exporting to South and also selling domestically.

$$\begin{aligned} \pi^D &= \left(p_j^M - w_N\right) q_j^M L_N \\ \pi^X &= \begin{cases} \left(p_j^M - w_N\right) q_j^M \left(L_N + L_S\right) \\ (1-\rho)\left(p_j^M - w_N\right) q_j^M \left(L_N + L_S\right) + \rho\left[\left(p_j^M - w_N\right) q_j^M (1-\omega) L_N + \max\left\{p_j^C - w_N, 0\right\} q_j^C \left(\omega L_N \right.\right. \end{cases} \end{aligned}$$

Since p^S is constant for all θ_j, instances may occur when $p_j^M \leq p^S$ (i.e. $\theta_j \leq w_S + \phi$). In this case, the Northern monopolist knows it can always undercut the price of any potential Southern imitator and secure the entire Southern market. Thus it does not fear being imitated and will always choose to export to gain access to a larger market. This translates mathematically into the piece-wise nature of the π^X function above.

$$\begin{aligned} \Pi_j^N &= \max\left\{\pi^D, \pi^X\right\} \\ \Pi_N &= \int_1^{J(t)} \Pi_j^N dj \end{aligned}$$

Let us define $\Delta \equiv \pi^X - \pi^D$ as the export premium to a Northern firm from exporting compared to selling only to its domestic market

$$\begin{aligned} \Delta &= \left\{ \begin{array}{ll} \Delta_1 \equiv \left(p_j^M - w_N\right) q_j^M L_S & \text{if } p_j^M \leq p^S \\ \Delta_2 \equiv \left[\left(p_j^M - w_N\right) q_j^M \left(\frac{L_S}{\omega L_N + L_S} - \rho\right) + \rho \cdot \max\left\{p^S - w_N, 0\right\} q_j^C\right] \left(\omega L_N + L_S\right) & \text{if } p_j^M > p^S \end{array} \right\} \\ &= \begin{cases} \left(\theta_j - 1\right) \theta_j^{\frac{\theta_j}{1-\theta_j}} L_S & \text{if } \theta_j \leq w_S + \\ \left[\left(\theta_j - 1\right) \theta_j^{\frac{\theta_j}{1-\theta_j}} \left[\frac{L_S}{\omega L_N + L_S} - \rho\right] + \rho \cdot \max\left\{w_S + \phi - 1, 0\right\} \left(w_S + \phi\right)^{\frac{\theta_j}{1-\theta_j}}\right] \left(\omega L_N + L_S\right) & \text{if } \theta_j > w_S + \end{cases} \end{aligned}$$

Since $p_j^C = p^S = w_S + \phi$ and $w_S < w_N = 1$, it is possible that $p^S < w_N$, causing $\max\left\{w_S + \phi - 1, 0\right\} = 0$. This would cause the export premium to be entirely governed by $\left(\theta_j - 1\right) \theta_j^{\frac{\theta_j}{1-\theta_j}} \left[\frac{L_S}{\omega L_N + L_S} - \rho\right]$ for all $\theta_j > w_S + \phi$ (i.e. $p_j^M > p^S$). Thus I make the following claim

Claim 4 *If $p^S < w_N$, then whenever $\frac{L_S}{\omega L_N + L_S} \geq \rho$, all goods will be exported by North and whenever $\frac{L_S}{\omega L_N + L_S} < \rho$, only products corresponding to $\theta_j \leq w_S + \phi$ will be exported.*

Proof. If $p^S < w_N$, then $\pi_j^C = 0$ for all goods with $\theta_j > w_S + \phi$, and thus the sign of the export premium is completely governed by the first term $\left(\theta_j - 1\right) \theta_j^{\frac{\theta_j}{1-\theta_j}} \left[\frac{L_S}{\omega L_N + L_S} - \rho\right]$, i.e. by whether $\frac{L_S}{\omega L_N + L_S} \gtreqless \rho$. When $\frac{L_S}{\omega L_N + L_S} \geq \rho$ then the export premium is positive for all goods

in the domain. When $\frac{L_S}{\omega L_N+L_S} < \rho$ then the export premium is only positive for goods with monopoly prices below the Southern marginal cost of production $\theta_j \leq w_S + \phi$. ■

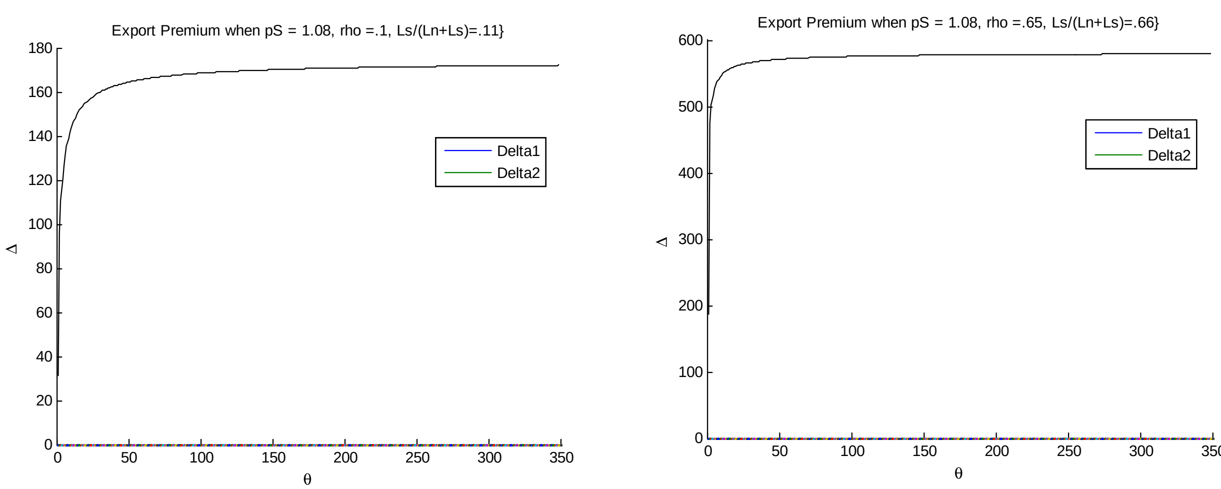
Henceforth, I restrict attention to the case when $p_j^C = p^S > w_N$, both because it is the more interesting case and because the alternative case only provides an all-or-nothing criterion for product exports as we see from Claim 5. Thus the export premium can be simplied to

$$\Delta = \left\{ \begin{array}{cc} \Delta_1 \equiv (\theta_j - 1)\,\theta_j^{\frac{\theta_j}{1-\theta_j}} L_S & \text{if } \theta_j \leq w_S + \phi \\ \Delta_2 \equiv \left[(\theta_j - 1)\,\theta_j^{\frac{\theta_j}{1-\theta_j}} \left[\frac{L_S}{\omega L_N + L_S} - \rho \right] + \rho\,(w_S + \phi - 1)\,(w_S + \phi)^{\frac{\theta_j}{1-\theta_j}} \right] (L_N + L_S) & \text{if } \theta_j > w_S + \phi \end{array} \right\}$$

Proposition 1 *If South's share of world population is larger than the probability of imitation, all differentiated varieties in existence J will be exported for any level of IPR protection*

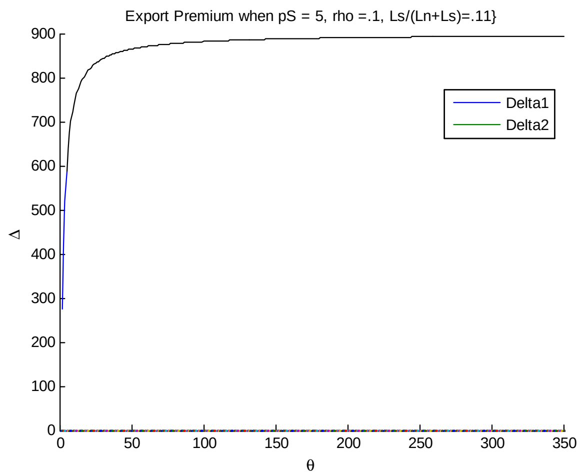
Proof. Only if Δ is positive will a given Northern firm choose to export its product to the South and risk its technology being pirated. The expression above is positive for all values of $\theta_j > 1$ as long as $\frac{L_S}{\omega L_N+L_S} > \rho$. So when South's share of world population is sufficiently large, that is, larger than the probability of Southern firms imitating its technology, all Northern firms have an incentive to export their varieties and all varieties J will be exported. This is entirely independent of the level of IPR protection as measured by ϕ. ■

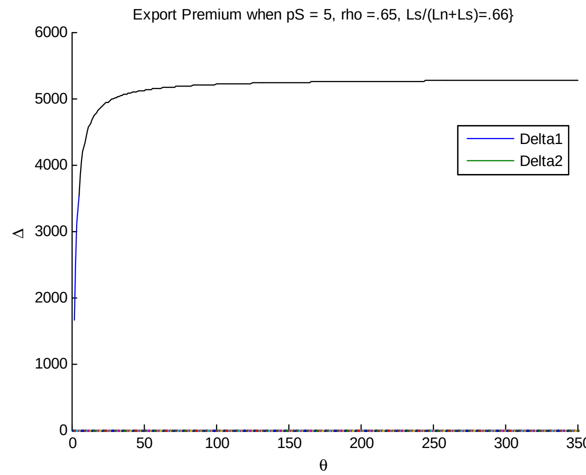
Figure 2. Graphs of Δ when $\frac{L_S}{\omega L_N+L_S} > \rho$



(a) Δ when $p^S = 1.08$ and $\frac{L_S}{\omega L_N+L_S}$ and ρ both low

(b) Δ when $p^S = 1.08$ and $\frac{L_S}{\omega L_N+L_S}$ and ρ both high





(c) Δ when $p^S = 5$ and $\frac{L_S}{\omega L_N + L_S}$ and ρ both low (d) Δ when $p^S = 5$ and $\frac{L_S}{\omega L_N + L_S}$ and ρ both high

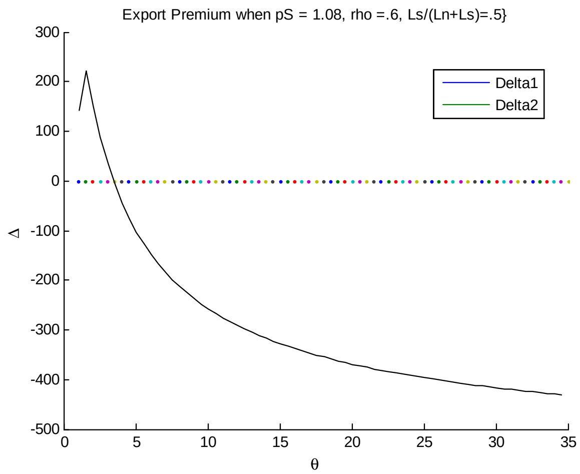
The graphs in Figure 2 highlight that all goods are traded whenever $\frac{L_S}{\omega L_N + L_S} > \rho$. Note the result that this is independent of IPR protection goes away if we assume that IPR protection also impacts ρ. However, when South's share of world population is sufficiently low or when the probability of imitation is sufficiently high, we obtain the following result.

Proposition 2 *When the population share of South is lower than the probability of piracy, $\frac{L_S}{\omega L_N + L_S} < \rho$, if there exists any Northern firm choosing to export (i.e. $w_S + \phi > w_N$), then for any ρ and $\frac{L_S}{\omega L_N + L_S}$ where the relative marginal gain under piracy is lower than the piracy probability, $(w_S + \phi)\frac{L_S}{\omega L_N + L_S} < \rho$, there exists a unique cutoff $\hat{\theta}_j$ such that for all $\theta_j \in (1, \hat{\theta}_j]$ Northern firms corresponding to those varieties will choose to export their product to South, while for all $\theta_j \in (\hat{\theta}_j, \infty)$ Northern firms will not export their product to South. Thus, there exists a convex subset, J^S, of the total product set, J, which is exported by North to South.*

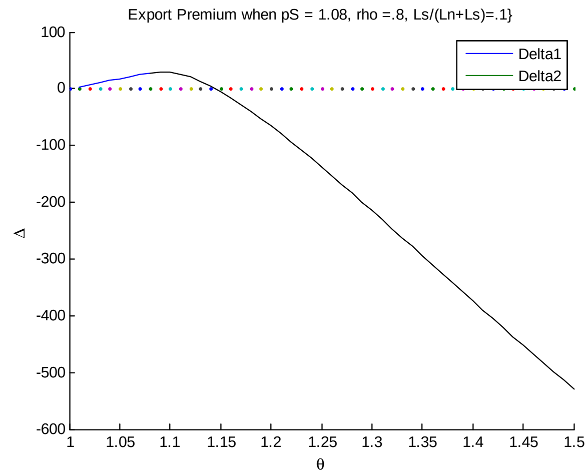
Proof. In Appendix. ■

In Figure 3 below, panels (c), (e), (g) and (h) display graphs of the export premium when the necessary conditions of Proposition 2 are not satisfied; thus they are examples of when North exports all products in existence, J, as is seen by the positive export premium over the entire range of θ_j. The other graphs in Figure 3 highlight various cutoff values, $\hat{\theta}_j$, under different parameter specifications.

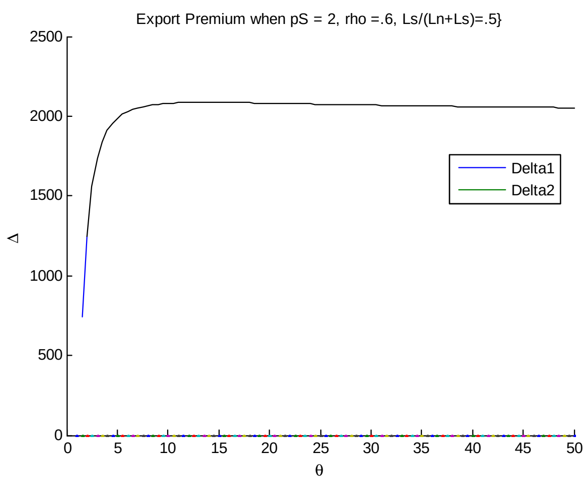
Figure 3. Graphs of Δ when $\frac{L_S}{\omega L_N + L_S} < \rho$ and $w_S + \phi > w_N$



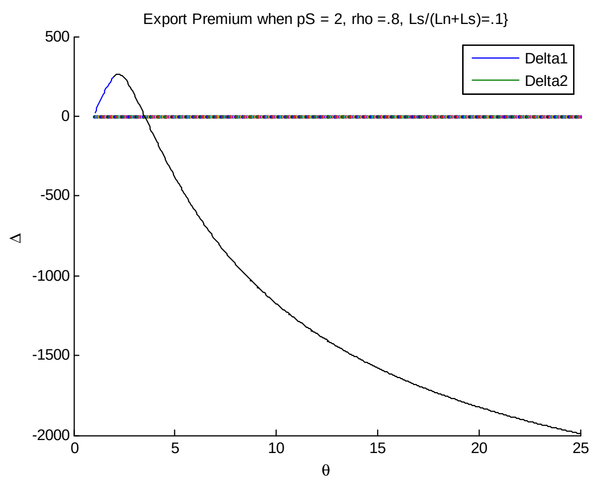
(a) Δ when $p^S = 1.08$ and $\rho - \frac{L_S}{\omega L_N + L_S}$ is low



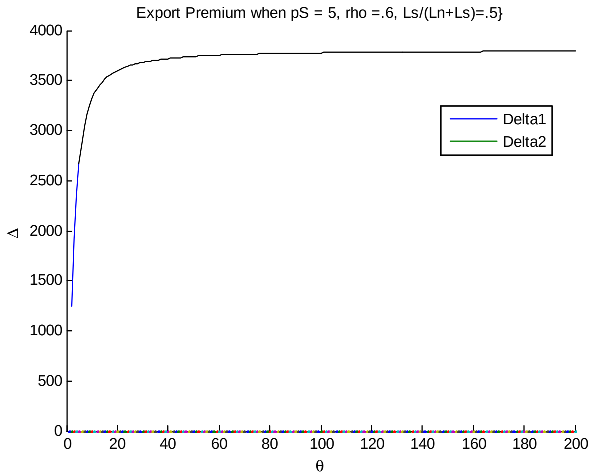
(b) Δ when $p^S = 1.08$ and $\rho - \frac{L_S}{\omega L_N + L_S}$ is high



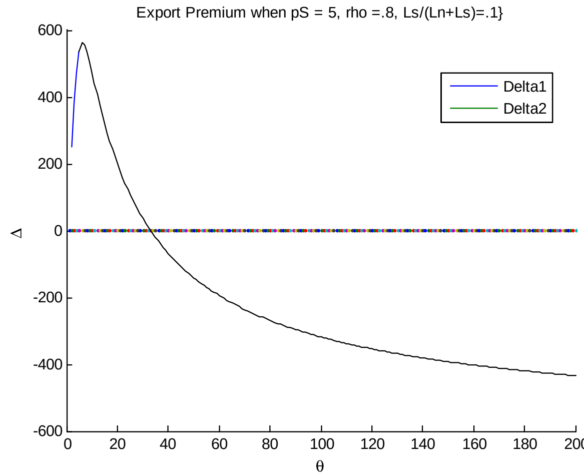
(c) Δ when $p^S = 2$ and $\rho - \frac{L_S}{\omega L_N + L_S}$ is low



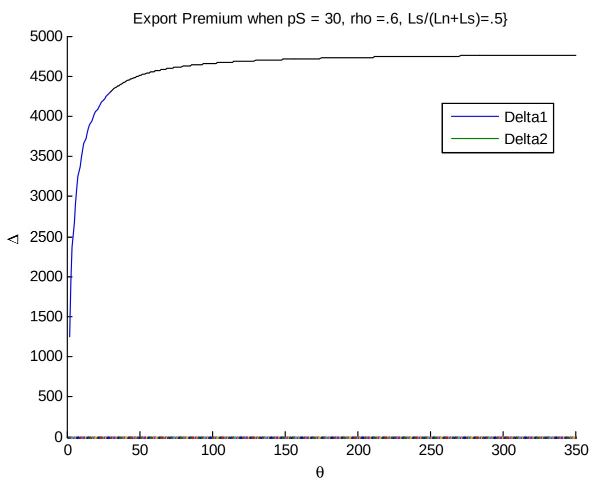
(d) Δ when $p^S = 2$ and $\rho - \frac{L_S}{\omega L_N + L_S}$ is high



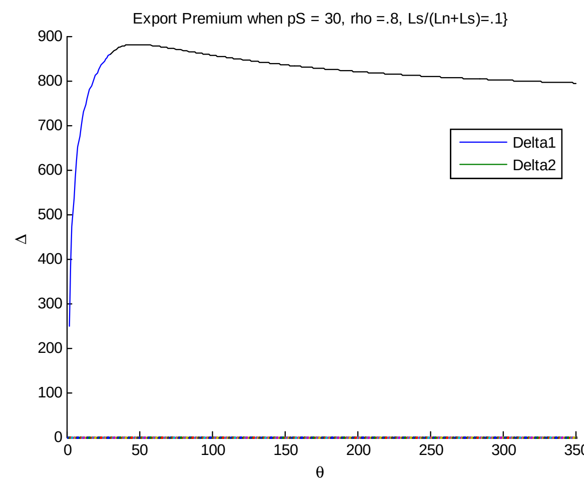
(e) Δ when $p^S = 5$ and $\rho - \frac{L_S}{L_N+L_S}$ is low



(f) Δ when $p^S = 5$ and $\rho - \frac{L_S}{L_N+L_S}$ is high



(g) Δ when $p^S = 30$ and $\rho - \frac{L_S}{\omega L_N+L_S}$ is low



(h) Δ when $p^S = 30$ and $\rho - \frac{L_S}{\omega L_N+L_S}$ is high

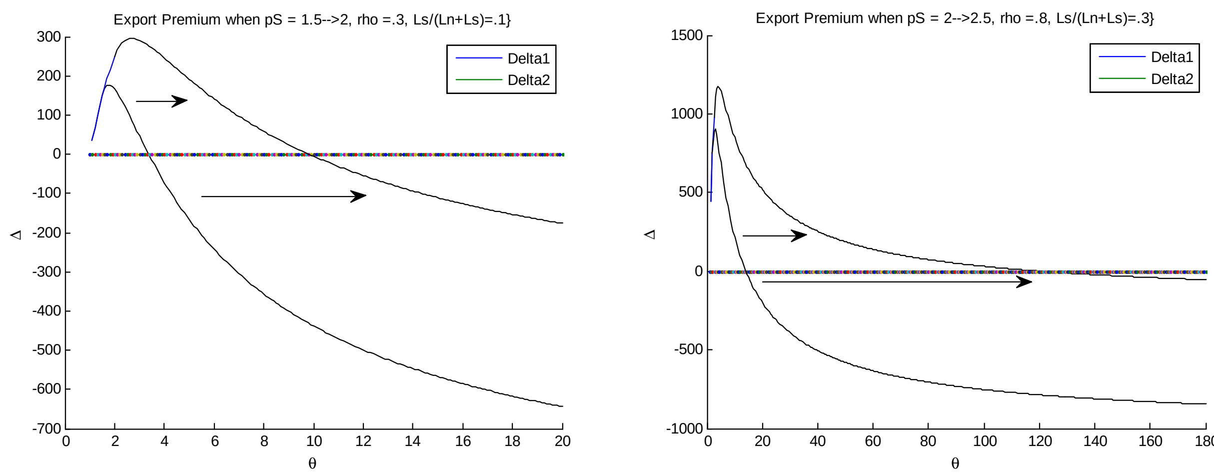
Proposition 3 *A higher level of IPR protection, ϕ, in the South, is characterized by both (1) a greater absolute number of available goods, $J^S(t)$ (characterized by $\Delta > 0$) and (2) the availabiity of more inelastically demanded (higher θ_j) goods*

Proof.

$$\frac{\partial \Delta}{\partial \phi} = \rho\left(\omega L_N + L_S\right)\left[\left(w_S+\phi\right)^{\frac{\theta_j}{1-\theta_j}} + \left(w_S+\phi-1\right)\left(w_S+\phi\right)^{\frac{2\theta_j-1}{1-\theta_j}}\right] > 0$$

As the critical $\hat{\theta}_j$ is unique, increasing ϕ will only shift Δ to the right, leading to a higher critical $\hat{\theta}_j$. Thus all lower θ_j goods exported previously will still be exported, but the set will simply expand to include higher θ_j products. ∎

Figure 4. The effect on Δ of an increase in ϕ



(a) Δ when ϕ increases such that $p^S = 1.5 \rightarrow 2$(b) Δ when ϕ increases such that $p^S = 2 \rightarrow 2.5$

Proposition 4 *A higher piracy rate ρ in the South, is characterized by both (1) a lower absolute number of available goods and (2) the loss in availability of more inelastically demanded (higher θ_j) goods*

Proof. Still assuming that $w_S + \phi \leq \min\{\theta_j\} \Rightarrow (\theta_j - 1)\,\theta_j^{\frac{\theta_j}{1-\theta_j}} > \left(\frac{w_S}{\gamma_1^S} + \phi - 1\right)(w_S + \phi)^{\frac{\theta_j}{1-\theta_j}}$ and thus

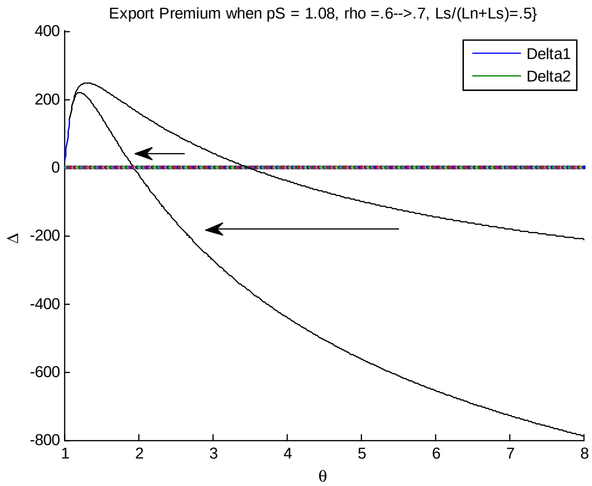
$$\Delta = (\theta_j - 1)\,\theta_j^{\frac{\theta_j}{1-\theta_j}}(\omega L_N + L_S)\left[\frac{L_S}{\omega L_N + L_S} - \rho\right] + \rho\cdot(w_S + \phi - 1)(w_S + \phi)^{\frac{\theta_j}{1-\theta_j}}(\omega L_N + L_S)$$

$$\frac{\partial\Delta}{\partial\rho} = (\omega L_N + L_S)\left[(w_S + \phi - 1)(w_S + \phi)^{\frac{\theta_j}{1-\theta_j}} - (\theta_j - 1)\,\theta_j^{\frac{\theta_j}{1-\theta_j}}\right] < 0$$

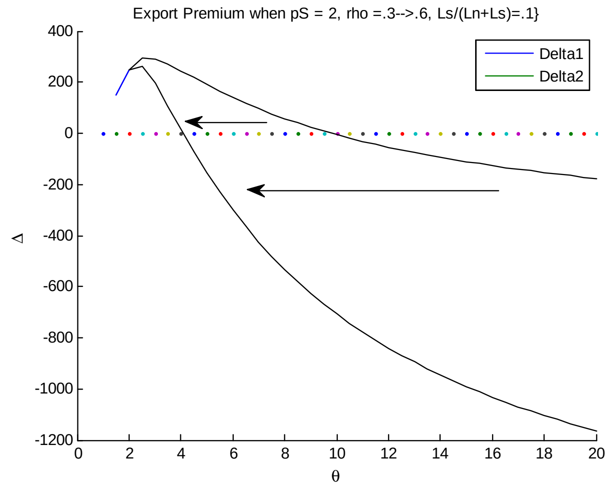
■

Propositions 3 and 4, plus the fact that a higher θ_j corresponds to more inelastic demand, together allow us to conclude that, within the framework of differentiated varieties, Southern consumers sustain welfare losses due to piracy and low IPR protection both in terms of the absolute number of goods as well as the type of good.

Figure 5. The effect on Δ of an increase in ρ



(a) Δ when $p^S = 1.08$ and $\rho = .6 \rightarrow .7$



(b) Δ when $p^S = 2$ and $\rho = .3 \rightarrow .6$

4.3 The South

Restricting attention again to the case in which the homogeneous good is produced in South in equilibrium, we know that $w_S = \gamma_0^S$ and $p_0 = p_S = w_S + \phi = \gamma_0^S + \phi$ where $\gamma_0^S < 1$ is the productivity parameter for South's production of the homogeneous good. Thus, for, n_S, the set of goods exported by North and imitated by South, $p_S = w_S + \phi$, while for the set of goods exported by North but not imitated by South, n_N, the monopoly price still prevails $p^M = \theta_j$. Recall that together these two sets comprise the total set of goods available in the South, that is, exported by North: $n_N + n_S = J^S \equiv \{j : \Delta \geq 0\}$. Thus the cutoff $\hat{\theta}_j = \left\{\theta_j : j = \max\left\{J^S\right\}\right\}$.

Then the ideal price index in the South can be represented by the solution to the expenditure minimization problem

$$\min p_0 q_0 + \int_1^{J^S} p_j q_j dj = p_0 q_0 + \int_{j \in n_N} p_j q_j dj + \int_{j \in n_S} p_j q_j dj$$

$$\text{s.t. } u = q_0 + \int_1^{J^S} \theta_j q_j^{\frac{1}{\theta_j}} dj = 1$$

with the associated first order condition

$$q_j = \left(\frac{p_j}{p_0}\right)^{\frac{\theta_j}{1-\theta_j}}$$

$$\Rightarrow q_0 = 1 - \int_1^{J^S} \theta_j \left(\frac{p_j}{p_0}\right)^{\frac{1}{1-\theta_j}} dj$$

Thus the price index in South is given by

$$
\begin{aligned}
\mathbf{P}^S &= p_0 - \int_1^{J^S} \theta_j p_0^{\frac{\theta_j}{\theta_j-1}} p_j^{\frac{1}{1-\theta_j}} dj + \textstyle\int_1^{J^S} p_0^{\frac{\theta_j}{\theta_j-1}} p_j{}^{\frac{1}{1-\theta_j}} dj \\
&= p_0 - \int_{j\in n_N} \theta_j p_0^{\frac{\theta_j}{\theta_j-1}} p_j^{\frac{1}{1-\theta_j}} dj - \int_{j\in n_S} \theta_j p_0^{\frac{\theta_j}{\theta_j-1}} p_j^{\frac{1}{1-\theta_j}} dj + \int_{j\in n_N} p_0^{\frac{\theta_j}{\theta_j-1}} p_j{}^{\frac{1}{1-\theta_j}} dj + \int_{j\in n_S} p_0^{\frac{\theta_j}{\theta_j-1}} p_j{}^{\frac{1}{1-\theta_j}} dj
\end{aligned}
$$

where the second equality breaks the price index into components depending on whether the good was pirated ($j \in n_S$) or not ($j \in n_N$). Note that for unpirated products $j \in n_N$, monopoly prices $p_j = \theta_j$ remain in place, while for pirated products $j \in n_S$, Southern competitive prices prevail, $p_j^S = \gamma_0^S + \phi$. Plugging back in these differentiated goods prices, as well as the Southern competitive price for the homogeneous good $p_0 = p_j^S = \gamma_0^S + \phi$ (full derivation in Mathematical Appendix) we have

$$
\begin{aligned}
\mathbf{P}^S &= \left(1 + n_S - \int_{j\in n_S} \theta_j dj\right)\left(\gamma_0^S + \phi\right) - \int_{j\in n_N} \theta_j \left(\gamma_0^S + \phi\right)_j^{\frac{\theta_j}{\theta_j-1}} \theta_j^{\frac{1}{1-\theta_j}} dj + \int_{j\in n_N} \left(\gamma_0^S + \phi\right)^{\frac{\theta_j}{\theta_j-1}} \theta_j{}^{\frac{1}{1-\theta_j}} dj \\
&= \left(1 + n_S - \int_{j\in n_S} \theta_j dj\right)\left(\gamma_0^S + \phi\right) + \int_{j\in n_N} (1-\theta_j)\left(\gamma_0^S + \phi\right)_j^{\frac{\theta_j}{\theta_j-1}} \theta_j^{\frac{1}{1-\theta_j}} dj
\end{aligned}
$$

4.4 Welfare Analysis

4.4.1 The South

Together, Claim 2 and Theorem 2 imply that, when IPR protection is lower, Southern consumers are strictly worse off in terms of both the absolute availability of varieties as well as the availability of varieties they demand more inelastically. This result is contrary to the previous literature which finds that the South never has an incentive to increase its IPR protection in the short-run, without invoking dynamic innovation considerations. However, Southern consumers enjoy a lower price for all goods that remain exported by North and are imitated by Southern firms. Thus the presence of piracy is beneficial to Southern consumers along the price margin; some of what was previously producer surplus is then transfered to consumers. The welfare effect of an increase in IPR on the South is essentially a tradeoff of consumer welfare between the intensive margin of prices of available goods and the extensive margin of the availability of product varieties.

Since all imitated products transform into perfectly competitive industries, Southern welfare can be simply defined as real wages and expressed as

$$
\mathbf{W}^S \equiv \frac{w_S}{\mathbf{P}^S} = \frac{\gamma_0^S}{\left(1 + n_S - \int_{j\in n_S} \theta_j dj\right)\left(\gamma_0^S + \phi\right) + \int_{j\in n_N} (1-\theta_j)\left(\gamma_0^S + \phi\right)_j^{\frac{\theta_j}{\theta_j-1}} \theta_j^{\frac{1}{1-\theta_j}} dj}
$$

Claim 5 *An increase in IPR protection, i.e. an increase in ϕ, has an ambiguous overall effect on Southern welfare.*

Proof. Given that the probability of piracy, ρ, is exogenous and constant for all values of θ_j, we know that the strength of IPR protection, ϕ, only affects n_S and n_N directly through its effect on the set of goods exported to South J^S. As established by Propositions 3 and 4, as IPR protection increases, the set J^S expands and thus n_S and n_N expand also.

$$\frac{\partial \mathbf{P}^S}{\partial \phi} = \left(1 + n_S - \int_{j \in n_S} \theta_j dj\right) - \left(\gamma_0^S + \phi\right) \int_{j \in n_S(\phi+\epsilon)} \theta_j dj + \frac{\partial}{\partial \phi} \int_{j \in n_N} \left(\gamma_0^S + \phi\right)_j^{\frac{\theta_j}{\theta_j - 1}} \left(1 - \theta_j\right) \theta_j^{\frac{1}{1-\theta_j}} dj$$

The second term $-\left(\gamma_0^S + \phi\right) \int_{j \in n_S(\phi+\epsilon)} \theta_j dj < 0$, while the third term, though not directly calculable since we cannot precisely define the set n_N, is also negative. This is true because increasing ϕ causes both n_N and $\left(\gamma_0^S + \phi\right)_j^{\frac{\theta_j}{\theta_j - 1}}$ to grow, while $\left(1 - \theta_j\right) \theta_j^{\frac{1}{1-\theta_j}} < 0$ for the entire domain. These both point to the price index decreasing with greater IPR protection and thus overall welfare increasing with greather protection. However, the first term above, $1 + n_S - \int_{j \in n_S} \theta_j dj$, is of ambiguous sign. Thus the overall effect on welfare of an increase in IPR protection is ambiguous and depends on the particular case under examination which would define the sets n_S and n_N. ■

The fact that Southern welfare is potentially non-monotone in IPR protection points to the possible existence of an optimal level of protection with respect to the South.

4.4.2 The North

This model also allows potential welfare gains for North under lowered IPRs. Because I assume that products, once imitated by South, can be partially re-exported back to North at a lower price, Northern consumers can experience welfare gains from higher real wages, even as Northern firms experience profit margin reductions. In addition, Northern firms also stand to gain a share of the expected total IP reparations, $\rho J \cdot \phi$, from instances when South has detected and fined pirates for imitation of their products. Imposing transport costs or other frictional trade barriers to the re-exportation of imitated products by South does not affect the existence of this additional mechanism, only the magnitude for particular cases.

Let $J^N = \{j : \Delta < 0\}$ be the set of goods not exported by North. The general form of the previous closed economy price index in North is reproduced below

$$\mathbf{P}^N = p_0 - \int_1^J p_0^{\frac{\theta_j}{\theta_j - 1}} \theta_j p_j^{\frac{1}{1-\theta_j}} dj + \int_1^J p_0^{\frac{\theta_j}{\theta_j - 1}} p_j^{\frac{1}{1-\theta_j}} dj$$

Plugging in the monopoly price $p_j^N = \theta_j$ for goods that are not exported and goods that are exported and not imitated ($J^N \cup n_N$), in addition to the Southern competitive price $p_j^S = \gamma_0^S + \phi$ for goods that are exported and imitated, we have

$$\begin{aligned} \mathbf{P}^N &= \gamma_0^S + \phi - \int_{j \in J^N \cup n_N} \theta_j p_j^{\frac{1}{1-\theta_j}} dj - \int_{j \in n_S} \theta_j p_j^{\frac{1}{1-\theta_j}} dj + \int_{j \in J^N \cup n_N} p_j^{\frac{1}{1-\theta_j}} dj + \int_{j \in n_S} p_j^{\frac{1}{1-\theta_j}} dj \\ &= \gamma_0^S + \phi + \int_{j \in J^N \cup n_N} \theta_j^{\frac{1}{1-\theta_j}} - \theta_j^{\frac{2-\theta_j}{1-\theta_j}} dj + \int_{j \in n_S} \left(1 - \theta_j\right) \left(\gamma_0^S + \phi\right)^{\frac{1}{1-\theta_j}} dj \end{aligned}$$

Northern per-worker profits, under trade, (more detailed derivation in Mathematical Appendix) are now

$$\begin{aligned}
\frac{\Pi_N}{L_N} &= \int_{j\in J^N} \pi_j^M dj + \int_{j\in n_N} \left(1+\frac{L_S}{L_N}\right)\pi_j^M dj + \int_{j\in n_S}\left(1+\frac{L_S}{L_N}\right)\pi_j^C dj \\
&= \int_{j\in J^N(t)} \left[\theta_j^{\frac{1}{1-\theta_j}} - \theta_j^{\frac{\theta_j}{1-\theta_j}}\right] dj + \int_{j\in n_N}\left(1+\frac{L_S}{L_N}\right)\left[\theta_j^{\frac{1}{1-\theta_j}} - \theta_j^{\frac{\theta_j}{1-\theta_j}}\right] dj \\
&\quad + \int_{j\in n_S}\left(1+\frac{L_S}{L_N}\right)\left(\gamma_0^S+\phi-1\right)\left(\gamma_0^S+\phi\right)^{\frac{\theta_j}{1-\theta_j}} dj
\end{aligned}$$

Thus, combining and simplifying the above, welfare in North in an open economy with piracy can be expressed as

$$\begin{aligned}
\mathbf{W}^N &\equiv \frac{w_N}{\mathbf{P}^N} + \frac{\frac{\Pi_N}{L_N}}{\mathbf{P}^N} + \frac{\rho J\phi}{\mathbf{P}^N} \\
&= \frac{1+\int_{j\in J^N}\pi_j^M dj + \int_{j\in n_N}\left(1+\frac{L_S}{L_N}\right)\pi_j^M dj + \int_{j\in n_S}\left(1+\frac{L_S}{L_N}\right)\pi_j^C dj + \rho J\phi}{\left(\gamma_0^S+\phi\right) + \int_{j\in J^N\cup n_N}\theta_j^{\frac{1}{1-\theta_j}} - \theta_j^{\frac{2-\theta_j}{1-\theta_j}} dj + \int_{j\in n_S}\left(1-\theta_j\right)\left(\gamma_0^S+\phi\right)^{\frac{1}{1-\theta_j}} dj}
\end{aligned}$$

The welfare effect of an increase in IPR protection in North is a tradeoff between static consumer and producer welfare and hinges on the assumption that firm profits can be impacted by piracy through the infiltration of pirated products on a firm's existing market base. Increasing IPR protection simultaneously (weakly) raises consumer prices in North while increasing Northern firm profits.

Claim 6 *An increase in IPR protection, i.e. an increase in ϕ, has an ambiguous overall effect on Northern welfare.*

Proof. The numerator in the above, which I denote X, is clearly positive. Its derivative with respect to the final term in X, the expected value of IP violations fines, is $\rho J > 0$. The derivative of the first four terms of X with respect to ϕ is of uncertain sign; we know that π_j^M does not depend on ϕ and π_j^C, n_N and n_S are all increasing in ϕ, thus the third and fourth terms of X are increasing in ϕ, however since J^N is decreasing in ϕ, so is the second term in the numerator, thus the overall sign of X is unknown.

The denominator in the above, denoted Y, is negative since both $\theta_j^{\frac{1}{1-\theta_j}} - \theta_j^{\frac{2-\theta_j}{1-\theta_j}}$ and $\left(1-\theta_j\right)\left(\gamma_0^S+\phi\right)^{\frac{1}{1-\theta_j}}$ are negative along the domain. Its derivative with respect to ϕ is again uncertain since the first term of Y is increasing with respect to ϕ, while the third term decreases with respect to the parameter. With regard to the limits of integration of the second term, since J^N decreases relatively more than n_N increases as ϕ rises (i.e. the number of goods not exported falls more than the number of unimitated products grows, since not all exported goods are imitated), $J^N \cup n_N$ decreases in number and the second term becomes

less negative. Since increasing ϕ causes the set to expand, the third term becomes more negative. The overall effect is ambiguous. Thus we have

$$\frac{\partial \mathbf{W}^N}{\partial \phi} = \frac{Y\partial X - X\partial Y}{Y^2} \gtreqless 0$$

■

5 Model Extensions

5.1 Endogenous Imitation

Suppose the imitation probability ρ was endogenous. Given that higher j (and thus higher θ_j) products are more profitable for Northern firms, it makes sense that Southern imitators would prefer to imitate the highest θ_j goods available first, to capture instanteous, albeit extremely brief, higher profits before other firms enter, driving the market to perfect competition.

Let $\rho = \rho_j$ where $\frac{\partial \rho_j}{\partial j} = \frac{\partial \rho_j}{\partial \theta_j} > 0$. Intuitively, this should only help my result by making more inelastic goods even riskier for N to export. I again define the export premium

$$\Delta = \left\{ \begin{array}{cc} (\theta_j - 1)\,\theta_j^{\frac{\theta_j}{1-\theta_j}} L_S & \text{if } \theta_j \leq w_S + \phi \\ \left[\begin{array}{c} (\theta_j - 1)\,\theta_j^{\frac{\theta_j}{1-\theta_j}} \left[\frac{L_S}{\omega L_N + L_S} - \rho_j\right] \\ +\rho_j \left(w_S + \phi - 1\right)\left(w_S + \phi\right)^{\frac{\theta_j}{1-\theta_j}} \end{array} \right] (L_N + L_S) & \text{if } \theta_j > w_S + \phi \end{array} \right\}$$

Claim 7 *If $p^C < w_N$ then if $p_j^M > p^S$, only goods for which $\frac{L_S}{\omega L_N + L_S} \geq \rho_j$ are exported*

Proof. Obvious. ■

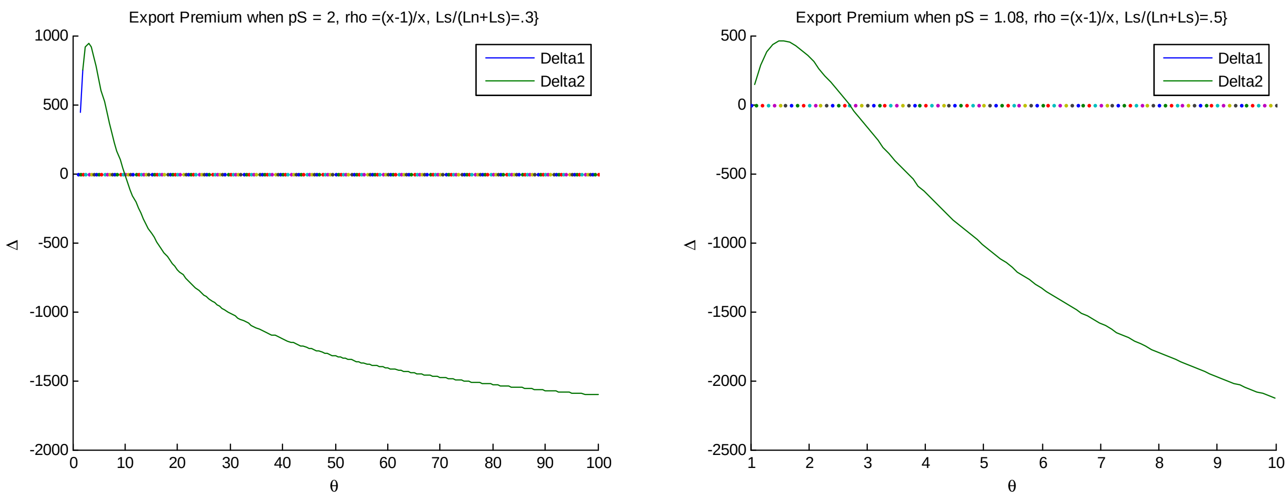
Proposition 5 *If South's share of world population is larger than the probability of imitation, $\frac{L_S}{\omega L_N + L_S} > \rho_j$, then firm j will export its product regardless of the level of IPR protection*

Proof. Omitted; analogous to proof of Proposition 1 ■

Proposition 6 *For firms facing a probability of piracy higher than the population share of South, $\frac{L_S}{\omega L_N + L_S} < \rho_j$, if the Southern competitive price of goods is higher than the Northern wage (i.e. $w_S + \phi > w_N$), then for any w_S, ϕ, $\frac{L_S}{\omega L_N + L_S}$ and strictly increasing piracy probability ρ_j, where the population share of South is less than the marginal cost to benefit ratio of pirated goods, $\frac{L_S}{\omega L_N + L_S} < \frac{1}{w_S + \phi}$, there exists a unique cutoff $\hat{\theta}_j$ such that for all $\theta_j \in (1, \hat{\theta}_j]$ Northern firms corresponding to those varieties will choose to export their product to South, while for all $\theta_j \in (\hat{\theta}_j, \infty)$ Northern firms will not export their product to South. Thus, there exists a convex (strict) subset, $J^S(t)$, of the total product set, $J(t)$, which is exported by North to South.*

Proof. Omitted; analogous to proof of Proposition 2 ∎

Example 1 *Suppose* $\rho_j = \frac{\theta_j - 1}{\theta_j}$, *and thus* $\frac{\partial \rho_j}{\partial \theta_j} > 0$



(a) Δ *when* $p^S = 2$ *and* $\frac{L_S}{L_N + L_S}$ *and* ρ *both low* *(b)* Δ *when* $p^S = 1.08$ *and* $\frac{L_S}{L_N + L_S}$ *and* ρ *both high*

6 Trade and Intellectual Property in the Data

In this section, I explore whether the results of the theoretical model appear in the data. I test whether there is an asymmetric impact on trade of differing product varieties, as distinguished by their respective import elasticities[3], between strong relative to weak IPR destination markets. I conduct both cross-section and panel estimations to explore whether trade product composition varies as a result of differing IPR regimes, and find that the results predicted in the theoretical model are consistent with the data.

Throughout the analysis, I conduct each test for both the full sample and the 95th percentile of the sample in terms of product demand elasticity (keeping 95% of the goods most inelastically demanded and therefore more likely to be differentiated goods). Goods corresponding to the highest 5% of demand elasticities represent the homogeneous good and low-profit differentiated goods in the theory, which correspond to the highest elasticity products and are not theoretically expected to be affected by IPR levels. The results are not sensitive to the precise choice of the subsample percentile, within some range, but logically require that not too many of the most elastic goods are removed as it is difficult to define, elasticity-wise, the exact cutoff for which a good becomes homogeneous as opposed to differentiated[4].

[3] As estimated in Broda, Weinstein and Greenfield (2006) and further discussed later.

[4] I also conduct a test using the Rauch (1999) classification of good homogeneity as a robustness check, with all results qualitatively the same.

Table 1. Descriptive Statistics - Full Bilateral Sample

Variable	*N*	*μ*	*s.d.*	*min*	*max*
ln(Imports)	337280	7480387	1.13E+08	1	1.88E+10
Imports	337280	10.99507	3.454641	0	23.65574
SITC2	337280	6.15E+03	2384.015	1.30E+01	8974
HS3	337280	545.6231	291.203	10	940
σ(Importer)_unnormalized	337280	7.24E+00	2.52E+01	1.07E+00	1560.588
σ(Importer)	337280	-6.76E-11	1	-0.24465	61.67168
IP(Importer)_unnormalized	337280	3.978771	0.643751	2.15	4.88
IP(Importer)	337280	0.7957542	0.12875	0.43	0.976
σ(Importer)*IP(Importer)	337280	-0.001552	0.852535	-0.23445	53.40768
IP(Exporter)	337280	4.034125	0.68358	0.2	4.88
σ(Exporter)_unnormalized	258323	7.074829	28.64071	1.074257	1560.588
σ(Exporter)	258323	3.87E-10	1	-0.20951	54.24144
σ(Exporter)*IP(Importer)	258323	0.0010504	0.806703	-0.20448	50.6615
σ(Trade-weighted)_unnormalized	251810	27.77516	208.895	0.050498	2775.808
σ(Trade-weighted)	251810	-1.36E-09	1	-0.13272	13.15509
σ(Trade-weighted)*IP(Importer)	251810	-0.009503	0.667371	-0.12848	11.94482

6.1 Data

I use annual bilateral UN Comtrade product-level import data for 2005 in the cross-sectional analysis and for the period 1990-2002 in the panel analysis. The trade data contain information on import value and quantity for each of 250 SITC Rev. 2 4-digit products for 73 importing countries trading with 73 origin countries. Utilizing a cross-walk between SITC 4-digit Rev. 2 and HS 6-digit 1998/1992 codes, I match each product-level import to its corresponding Broda-Weinstein country-specific estimated demand elasticity at the HS 3-digit level, resulting in 102 product categories.

Table 1 gives the overall descriptive statistics of the full sample as well as subsamples. Individual product demand elasticities (σ's) differ across countries, thus several measures are employed with the corresponding statistics shown in the table. The average standard deviation of a given product's σ across countries is 17.15. Details of the different elasticity measures used will be discussed in the next section. A detailed description of product categories at the HS 3-digit level is available in the Appendix.

For the cross-sectional estimation, I also use Park (2008) country-level IPR strength estimates. For the panel, I use the IP reforms documented in Branstetter et al. (2006) and defer to their detailed description of the identification of those reforms. Of the 16 national IP reforms they document, I focus on six (Argentina, Brazil, China, Colombia, Turkey and Venezuela), for which there exist both sufficient Commtrade data and Broda-Weinstein country-product elasticities.

Table 2. Import Data: Full & 95pc Sample Estimations

	Full	95 %ile
ln(Imports)	*β/se*	*β/se*
σ(Importer)	0.059*	0.248
	(0.03)	(0.17)
σ(Importer)*IP(Importer)	-0.113*	-0.447*
	(0.06)	(0.19)
Constant	6.192***	6.182***
	(0.14)	(0.14)
Product FEs	Yes	Yes
Country FEs	Yes	Yes
R^2	0.485	0.485
N	406094	384575

* p<0.05, ** p<0.01, *** p<0.001

6.2 Cross-Sectional Evidence

6.2.1 Unilateral Import Data

Using country-product level import data, with importer and product fixed effects, I estimate .

$$\ln(Imports_{ij}) = \beta_0 + \beta_1 \sigma_{ij} + \beta_2 IPIndex_i + \beta_3 \sigma_{ij} \times IPIndex_i + \mu_i + \mu_j + \varepsilon_{ij} \quad (1)$$

where $Imports_{ij}$ are the imports of product j to i, σ_{ij} is country i's demand elasticity for product j, $IPIndex_i$ is a measure of country i's IP protection strength, μ_i is a set of importer fixed-effects and μ_j are product fixed-effects. $IPIndex_i$ is an IPR strength indicator developed in Park (2008) ranging continuously from 1-5, with 5 representing the strongest level. In the estimation, I renormalize the elasticities in terms of standard deviations and the Park IP Index on a 0-1 scale in order for the coefficients to have a more intuitive interpretation. The results are presented in Table 2.

The statistic of interest is the coefficient on $\sigma_{ij} \times IPIndex_i$. These coefficients reflect the relatively lower chance of good j being imported into country i compared to a good which is more inelastically demanded, when the IP Index of country i is higher. The results imply that, relative to countries with the lowest IPR strength (a Park index of 1), countries with the strongest IPRs (an index of 5) observe a .113% lower import value of elastically demanded goods for every one standard deviation increase in elasticity. This implies that, not only are goods of different demand elasticity impacted differently based on the degree of destination IP protection, but the relatively inelastically demanded goods are the ones enjoying greater importation under stronger IPRs.

Restricting the sample to exclude implausibly high estimated elasticities above the 95th percentile of elasticities, which may speak to a high degree of product homogeneity unlikely to be affected by IPRs, consistent with the theoretical model, I find that countries with the strongest IPRs observe a .447% lower import value of elastically demanded goods for every one standard deviation increase in elasticity relative to countries with the weakest IPRs. So

again, higher IPR countries appear to import relatively inelastically demanded (from their standpoint) products more than lower IPR countries.

The coefficients on $\sigma(Importer)$ are all positive and largely significant, suggesting that trade of more elastic goods tends to be greater relative to more inelastically demanded goods when not accounting for destination IPRs. The coefficients also point to the logical result that destinations with higher IPRs receive more imports.

6.2.2 Bilateral Import Data

Full Sample Utilizing bilateral trade data and thus being able to further control for all bilateral gravity variables via fixed-effects, I estimate the following

$$\ln(Imports_{ixj}) = \beta_0 + \beta_1\sigma_{ij} + \beta_2 IPIndex_i + \beta_3\sigma_{ij} \times IPIndex_i + \mu_{ix} + \mu_j + \varepsilon_{ixj} \qquad (2)$$

with the only difference from (1) being the presence of bilateral fixed-effects represented by μ_{ix}.

In my model, I had assumed symmetric consumer preferences in both trading partners. Given that preferences for each good actually dffer across countries, it is not immediately obvious which market's import demand elasticities should be used in the empirical analysis. For example, if the home market was sufficiently large in the model and re-exportation was substantial, a Northern firm might base its export decision more strongly on the profitability (and thus demand elasticity) of its product within the home market. Theoretically, because of symmetric cross-country product preferences, relative market sizes did not play a substantial role. However, given that cross-country preferences actually differ, it is conceivable that an exporting firm would weigh its home market's preferences more heavily in making its decision as its profits may derive mostly from the home market and thus their decision may hinge primarily on the fear of imitation due to price spillover effects into the home market.

For robustness to check on the sensitivity of results to the choice of which market's elasticity is used for a given product, I run the estimation with 3 specifications: $\sigma(Importer)$, $\sigma(Exporter)$ and $\sigma(Trade - weighted)$, each interacted with the IP index. Due to variance of product-level elasticity elements across countries, I construct $\sigma(Trade - weighted)$ as a trade-weighted elasticity measure, from the exporter's point of view. I do this by weighting the relative importance of each market, including the home market, in contributing to the exporter's total trade by using the following formula: $\sigma(Trade - weighted) = \frac{Import_x}{Import_x + Export_x}\sigma(Exporter_x) + \frac{Export_x}{Import_x + Export_x}\sum_{\forall i}\frac{Exports_{xi}}{Export_x}\sigma(Importer_i)$. The exporter's perspective is chosen in this constructed elasticity due to the fact that it is the exporter that determines the traded value based on its customers and their corresponding institutional environment.

The results are presented in Table 3. All coefficients on the various elasticities interacted with $IP(Importer)$ are negative and significant in 4 out of 6 specifications and all coefficients on $\sigma(Importer)$ are positive and significant in 5 out of 6 specifications.

Using the importer elasticities (first two columns), the results imply that, relative to countries with the lowest IPR strength, countries with the strongest IPRs observe a .124% lower import value for every one standard deviation increase in demand elasticity. Restricting

Table 3. Bilateral Import Data: Full & 95pc Sample Estimations

	Full	95 %ile	Full	95 %ile	Full	95 %ile
ln(Imports)	*β/se*	*β/se*	*β/se*	*β/se*	*β/se*	*β/se*
σ(Importer)	0.099**	1.228***				
	(0.03)	(0.36)				
σ(Importer) *IP(Importer)	-0.124**	-1.739***				
	(0.04)	(0.45)				
σ(Exporter)			0.050	2.287***		
			(0.04)	(0.54)		
σ(Exporter) *IP(Importer)			-0.038	-2.319***		
			(0.04)	(0.67)		
σ(Trade-weighted)					1.130***	7.142***
					(0.29)	(1.96)
σ(Trade-weighted) *IP(Importer)					-0.831*	-2.633
					(0.35)	(2.45)
Constant	11.494***	11.424***	11.740***	11.612***	11.674***	11.890***
	(0.08)	(0.09)	(0.09)	(0.10)	(0.09)	(0.10)
Product FEs	Yes	Yes	Yes	Yes	Yes	Yes
Bilateral FEs	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.379	0.380	0.381	0.386	0.398	0.384
N	337280	320295	258323	245345	251810	238956

* p<0.05, ** p<0.01, *** p<0.001

the sample to more sensible elasticity estimates, this effect increases to a 1.74% lower import value for every one standard deviation increase in demand elasticity.

Using the exporter elasticities (middle two columns), the results show that, relative to countries with the lowest IPR strength, countries with the strongest IPRs see a .038% lower import value for every one standard deviation increase in demand elasticity. Restricting the sample to more sensible elasticity estimates, this effect increases to a 2.319% lower import value for every one standard deviation increase in demand elasticity.

Using the computed trade-weighted elasticities (last two columns), the results also imply that, relative to countries with the lowest IPR strength, countries with the strongest IPRs observe a .831% lower import value for every one standard deviation increase in demand elasticity. Restricting the sample to more sensible elasticity estimates, this effect increases to a 2.633% lower import value for every one standard deviation increase in demand elasticity, though this estimate is statistically insignificant.

The results arising from the 3 different specifications speak to the fact that the choice of which market's product elasticities to use affects the magnitude but not the direction of the effects. More inelastically demanded goods appear to enjoy a higher amount of trade in strong IPR conditions relative to more elastic goods, regardless of the choice of which country's product elasticity estimates are used. In terms of magnitude, this effect appears dependent upon the relative weights exporters place on the importance of different markets

Table 4. High Exporter IP Protection Sample

	Full	95 %ile	Full	95 %ile	Full	95 %ile
ln(Imports)	*β/se*	*β/se*	*β/se*	*β/se*	*β/se*	*β/se*
σ(Importer)	0.184***	1.539**				
	(0.05)	(0.50)				
σ(Importer) *IP(Importer)	-0.222***	-2.058***				
	(0.06)	(0.62)				
σ(Exporter)			-0.001	1.848*		
			(0.04)	(0.85)		
σ(Exporter) *IP(Importer)			-0.017	-3.235**		
			(0.05)	(1.05)		
σ(Trade-weighted)					0.086	0.802**
					(0.05)	(0.31)
σ(Trade-weighted) *IP(Importer)					-0.158**	-1.203**
					(0.06)	(0.37)
Constant	11.483***	11.426***	11.765***	11.871***	11.766***	11.805***
	(0.09)	(0.10)	(0.11)	(0.13)	(0.11)	(0.13)
Product FEs	Yes	Yes	Yes	Yes	Yes	Yes
Bilateral FEs	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.420	0.422	0.446	0.451	0.448	0.449
N	164226	156014	107582	102195	105415	100005

* p<0.05, ** p<0.01, *** p<0.001

within their trading portfolios.

High Exporter IP Sample Since IPRs are likely to affect primarily origin countries that already have strong IPRs, I also estimate (2) for the sample restricted to exporters with IPR strength indices above the 50th percentile of the sample, for a conservative estimate. I again run the estimation with 3 specifications: $\sigma(Importer)$, $\sigma(Exporter)$ and $\sigma(Trade-weighted)$, each interacted with the IP index.

The results are shown in Table 4. All coefficients on the various elasticities interacted with $IP(Importer)$ are negative and all are significant but for one specification and all coefficients on $\sigma(Importer)$ are positive but significant in 4 of 6 specifications.

Using the importer elasticities (first two columns), the results imply that, relative to countries with the lowest IPR strength, countries with the strongest IPRs see a .222% lower import value for every one standard deviation increase in demand elasticity. Restricting the sample to more sensible elasticity estimates, this effect increases to a 2.058% lower import value for every one unit increase in demand elasticity.

Using the exporter elasticities (middle two columns), the results show that, relative to countries with the lowest IPR strength, countries with the strongest IPRs observe a .017% lower import value for every one standard deviation increase in demand elasticity. Restricting the sample to more sensible elasticity estimates, this effect increases to a 3.235% lower import value for every one standard deviation increase in demand elasticity.

Table 5. Rauch Non-Homogeneous Sample Estimation

	(1)	95 %ile	(2)	95 %ile
ln(Imports)	*β/se*	*β/se*	*β/se*	*β/se*
σ(Importer)	0.010*	1.273*	0.109*	1.539**
	(0.05)	(0.53)	(0.05)	(0.54)
σ(Importer)*IP(Importer)	-0.127*	-1.956**	-0.133*	-2.260***
	(0.05)	(0.65)	(0.06)	(0.68)
Constant	10.579***	10.507***	10.494***	10.423***
	(0.11)	(0.13)	(0.12)	(0.13)
Product FEs	Yes	Yes	Yes	Yes
Bilateral FEs	Yes	Yes	Yes	Yes
R^2	0.409	0.410	0.451	0.452
N	203982	193983	161289	153099

* p<0.05, ** p<0.01, *** p<0.001

Using the computed trade-weighted elasticities (last two columns), the results imply that, relative to countries with the lowest IPR strength, countries with the strongest IPRs observe a .158% lower import value for every one standard deviation increase in demand elasticity. Restricting the sample to more sensible elasticity estimates, this effect increases to a 1.203% lower import value for every one standard deviation increase in demand elasticity.

Again, the results from the 3 different estimations highlight the fact that the directional effect of inelastically demanded goods seeing a greater positive impact from strong IPRs relative to more elastic goods, though the magnitude can vary depending upon the relative importance placed on different markets.

Rauch Classification Sample One might be interested only in the subset of goods which are objectively classified as differentiated. Rauch (1999) constructed a classification system of goods by SITC 4-digit Rev. 2 product codes into 3 categories: Homogeneous, Reference-Priced and Differentiated. I match the bilateral data at the product-level to these Rauch indicators. I then estimate (2) for both the sample (i) excluding Rauch Homogeneous goods and (ii) excluding Rauch Homogeneous and Reference-Priced goods (leaving only Rauch Differentiated products). Again, because Rauch's classification is based on U.S. products and classifications can differ considerably across countries, this approach must be interpreted with caution. Thus, it is still useful to consider results without improbably high elasticity estimates. The results are shown in Table 5, with results for (i) in the first two columns and results for (ii) in the last two columns.

The coefficients on $\sigma(Importer) \times IP(Importer)$ are both negative and significant and imply that, relative to countries with the lowest IPR strength, countries with the strongest IPRs observe a .127% and a .133% lower import value, respectively, of higher relative to lower elasticity goods that differ by one standard deviation. Restricting the sample to the 95th percentile of elasticity estimates, this effect increases to, respectively, a 1.96% and 2.26% lower import value for every one standard deviation increase in demand elasticity. The coefficients on $\sigma(Importer)$ are both positive and significant, implying, as before, that higher elasticity goods are unconditionally more likely to be traded.These results are, again, consistent in sign

with the previous cross-sectional results for other samples. The difference in magnitude is also only marginal.

Let us now briefly consider other potential explanations for the empirical evidence. It could be that products with a higher productivity gap between exporter and importer are goods that are both more likely to be sensitive to IP regimes and more likely to be inelastically demanded in the destination. Then, the result is somewhat built in. It could also be that an IP reform itself is triggered by a structural change in demand towards more inelastically demanded goods. However, this does not quite get at why the cross-sectional impact across countries should vary.

6.3 Panel Evidence

Panel analysis was conducted for the following six reforms, Table 6, documented in Branstetter et al. (2006):

Table 6. Timing of Major Patent Reforms

Country	Year of Reform	Pre-Reform	Post-Reform
Argentina	1996	1991-1995	1997-2001
Brazil	1997	1992-1996	1998-2002
China	1993	1900-1992	1994-1996
Colombia	1994	1990-1993	1995-1998
Turkey	1995	1990-1992	1998-2000
Venezuela	1994	1990-1993	1995-1998

The choice of these 6 reforms out of the original 15 national IP reforms documented in Branstetter et al. (2006) came down to the availability of an adequate panel length of at least 3 years pre- and post-reform, as well as the availability of country-product-level demand elasticities as estimated by Broda, Greenfield and Weinstein (2006). I estimate a panel difference-in-difference model of whether products of differing elasticity are differentially impacted by a reform. Defining the Pre-Reform period conservatively, I use all country-product observations from the years immediately before the reform; this amounts to between 3-5 years worth of the sample defined as Pre-Reform. Similarly defining the Post-Reform period conservatively, I use all observations in years immediately following a reform, resulting in 3-5 years worth of each sample defined as Post-Reform.

6.3.1 Panel Analysis by Country

For each reforming importing country i, I estimate :

$$\ln(Imports_{xjt}) = \beta_0 + \beta_1 \sigma_j(Importer) \times Reform_t + \beta_2 Reform_t + \mu_x + \mu_j + \mu_x \times Reform_t + \varepsilon_{xjt}$$

where $Imports_{xjt}$ are the imports of product j from x in period t, σ_j is country i's demand elasticity for product j, $Reform_t$ is an indicator for the Post-Reform period, μ_x is a set of exporter fixed-effects and μ_j are product fixed-effects. The $\mu_x \times Reform_t$ control captures potential differences in how individual exporting countries may react to the destination country reform. Results without this added control are identical in all substantive respects.

Table 7.1 Panel Difference-in-Difference Estimations

	Argentina	95 %ile	Brazil	95 %ile	China	95 %ile
ln(Imports)	*β/se*	*β/se*	*β/se*	*β/se*	*β/se*	*β/se*
σ(Importer) *Reform	-0.020	-0.191	-0.029	0.190	-0.026	-0.475
	(0.02)	(0.20)	(0.02)	(0.31)	(0.04)	(0.37)
Reform	0.462***	0.420**	0.368***	0.400***	0.431*	0.344
	(0.13)	(0.15)	(0.11)	(0.12)	(0.17)	(0.19)
Constant	10.695***	10.741***	11.686***	8.923***	9.622***	9.817***
	(0.45)	(0.46)	(0.37)	(0.80)	(0.40)	(0.43)
Exporter*Reform	Yes	Yes	Yes	Yes	Yes	Yes
Product FEs	Yes	Yes	Yes	Yes	Yes	Yes
Bilateral FEs	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.116	0.110	0.148	0.151	0.200	0.207
N	41734	38468	45907	43118	27350	25881

* p<0.05, ** p<0.01, *** p<0.001

Tables 7.1 and 7.2 give the individual country estimation results for the six reforming countries, both for the full country sample and for the sample excluding the top 5% of import goods based on elasticity. This exclusion is again based on the idea that exceptionally high import elasticities (reaching a value over 1500 at its max) may point to either measurement error in the initial elasticity estimate (see Broda, Weinstein and Greenfield 2006 for estimation details) or an extremely high degree of product homogeneity unlikely to be affected by any IP reforms.

Table 7.2 Panel Difference-in-Difference Estimations

	Colombia	95 %ile	Turkey	95 %ile	Venezuela	95 %ile
ln(Imports)	*β/se*	*β/se*	*β/se*	*β/se*	*β/se*	*β/se*
σ(Importer) *Reform	0.022	-0.317	-0.033	-0.172	-0.019	-0.091
	(0.03)	(0.22)	(0.02)	(0.11)	(0.02)	(0.13)
Reform	0.421***	0.359***	0.402***	0.387**	0.235*	0.230*
	(0.09)	(0.09)	(0.12)	(0.12)	(0.10)	(0.11)
Constant	9.559***	9.494***	10.714***	10.718***	9.632***	9.749***
	(0.43)	(0.41)	(0.26)	(0.26)	(0.35)	(0.30)
Exporter*Reform	Yes	Yes	Yes	Yes	Yes	Yes
Product FEs	Yes	Yes	Yes	Yes	Yes	Yes
Bilateral FEs	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.142	0.130	0.144	0.142	0.109	0.112
N	24585	22951	44788	41600	26254	23961

* p<0.05, ** p<0.01, *** p<0.001

The individual results consistently show that, not surprisingly, the IP reforms themselves contribute positively and significantly in increasing bilateral imports. The primary coeffi-

Table 8. Pooled Panel Estimation

	Full	95 %ile
ln(Imports)	*β/se*	*β/se*
σ(Importer)*Reform	-0.004	-0.265**
	(0.02)	(0.10)
Reform	0.366***	0.329***
	(0.05)	(0.06)
Constant	10.376***	10.241***
	(0.17)	(0.18)
Exporter*Reform	Yes	Yes
Product FEs	Yes	Yes
Bilateral FEs	Yes	Yes
R^2	0.107	0.106
N	210618	199584

* p<0.05, ** p<0.01, *** p<0.001

cients of interest here, those on $\sigma(Importer) \times Reform$, can be interpreted as the differential trade impact of the IP reform on more elastically demanded goods relative to more inelastically demanded ones. Those coefficients are mostly negative, suggesting that, following an IP reform, more inelastic goods are more often imported relative to more elastically demanded goods, however none are statistically significant.

6.3.2 Pooled Panel Analysis

Pooling together all 6 country-level reforms, I estimate the following:

$$\ln(Imports_{ixjt}) = \beta_0 + \beta_1 \sigma_{ij}(Importer) \times Reform_{it} + \beta_2 Reform_{it} + \mu_{ix} + \mu_j + \varepsilon_{ixjt}$$

where $Imports_{ixjt}$ are the imports of product j from x to i in period t, σ_{ij} is country i's demand elasticity for product j, $Reform_t$ is an indicator for the Post-Reform period, μ_{ix} is a set of bilateral fixed-effects and μ_j are product fixed-effects.

Table 8 presents the results of estimating (3) using pooled data from all 6 IP reforms to test the combined effect of the IP reforms. Here, again, I find that the reform has a significant positive impact on bilateral imports. The coefficients on $\sigma_{ij}(Importer) \times Reform_{it}$ remain negative for both the full and 95-percentile samples, but is only significant in the 95-percentile sample. The negative signs again suggest that IP reforms have a greater impact in increasing imports of inelastically demanded products relative to elastically demanded ones.

To summarize, evidence in the panel data appears to support the cross-sectional results, but are generally not significant on the $\sigma_{ij}(Importer) \times Reform_{it}$ coefficient, except in the pooled 95 percentile sample. The reform variable itself appears to have a significant and positive impact on import value in every specification.

7 Conclusion: Linking Theory and Empirics

In this paper, I outlined a theoretical framework with which to analyze the effect of intellectual property rights on the composition of trade and welfare. The model is based on consumer preferences over differentiated products uniquely identified by their individual demand elasticities and explores whether and how IPRs affect the set and composition of goods traded.

A main conclusion of the theoretical section is that relatively inelastically demanded products should be more often exported to stronger IPR destinations relative to weaker ones. This is driven by consumer preferences allowing for differing demand elasticities across goods. Relatively inelastically demanded goods translate into higher profits for the firms associated with those products, ceteris paribus, and thus higher incentives to protect those products under threat of IP piracy. In the empirical section, I documented this to be robustly the case across various subsamples of the cross-sectional data and broadly supported by panel data as well.

A second insight of the theoretical section is that imports of relatively homogeneous or elastically demanded goods should not be impacted by destination IPRs, even if they are among the "differentiated" products as opposed to the entirely homogeneous goods. Those are the products for which the profit margin is low enough due to the exporters' higher productivity relative to destination-country firms, that imitation is not profitable. Empirically, this is also supported in both the cross-section and the panel when comparing the full sample to samples excluding the top 5% most demand elastic products or Rauch "reference-priced" goods.

A third insight of the theory is related to destination market size. If the destination market is a big enough share of an exporter's trade portfolio relative to the risk of IP piracy faced by the product, destination IPRs should also not matter for the firm export decision. Although the bilateral fixed effects in the empirical section prevent direct exploration of the destination size effect, anecdotal evidence on the large import variety enjoyed by frequent IPR violators such as China and India appears generally to support this.

Standard trade theory assumes a CES utility function with constant markups for which only the number of varieties matters for consumers' taste for variety. In that environment, firms of comparable productivity should adjust in the same way to threats of IP piracy on profits, regardless of which variety they produce. Therefore, trade composition should be symmetrically affected across varieties and welfare harmed via only the classical number of varieties channel. In Proposition 2, I showed that this is not the case when consumer preferences, and thus demand elasticities, differ across products. The data also support the idea that effects on trade composition are asymmetric across varieties.

Welfare is found in the theory to be potentially non-monotonic in IPR protection for both North and South. The results differ from the current literature in the following respects: (1) the developing South has the potential to gain from tightened IPRs even in the short-run, via the additional channel of gaining varieties for which it possesses more inelastic demand, (2) welfare in the North trades off static consumer and producer welfare and is also ambiguously affected by stronger IPRs in the South, and (3) there is the possibility of compatible short-run incentives and the existence of an optimal IPR level even ignoring long-run innovation

effects. An important implication is that when a developing country is small in terms of consumer market share, has high IP piracy rates, or both, its stands to lose the availability of goods its consumers care the most about.

Further work could be done to extend the model. One major technical issue that prevents analytical quantification of welfare effects is the unspecified process of the piracy probability, ρ. Because this probability is exogenous and piracy can target any variety with equal probability, regardless of its profit potential, it is not possible to precisely characterize the set of pirated products and thus determine net welfare effects. In particular, it would be beneficial to explore the case when pirates target a convex range of goods, so that analytical characterization of the pirated set n_S is possible. Another possible consideration would be to include the effect of IPR protection on the Northern innovation process, which would require laying out the innovation process more carefully and exploring dynamic, longer run effects. Under interpretations of South as a small developing country this may make less sense than if South is interpreted as a large country that can affect the world market.

While several of the empirical findings are consistent with the framework of varying consumer preferences and IP piracy risk, there is much more that can be done. An ideal test of whether consumer preferences are the underlying mechanism is to control for potential exporter variance by using firm-product-level data that can account for productivity and other exporter-level differences. Such data are not readily available. Further research on the underlying mechanisms driving asymmetric trade composition effects as well as potentially better functional forms for preferences capturing the essence of differing preference over variety is needed, but beyond the scope of this paper.

Mathematical Appendix

Proof. Closed Economy Northern Price Index Derivation

The ideal price index in the North can be represented by the solution to the expenditure minimization problem

$$\min p_0 q_0 + \textstyle\int_1^J p_j q_j dj$$
$$\text{s.t. } u = q_0 + \int_1^J \theta_j q_j^{\frac{1}{\theta_j}} dj = 1$$

with the associated first order condition

$$q_j = \left(\frac{p_j}{p_0}\right)^{\frac{\theta_j}{1-\theta_j}}$$
$$\Rightarrow \quad q_0 = 1 - \int_1^J \theta_j \left(\frac{p_j}{p_0}\right)^{\frac{1}{1-\theta_j}} dj$$

Thus the price index is given by

$$\mathbf{P} = p_0 - p_0^{\frac{\theta_j}{\theta_j - 1}} \int_1^J \theta_j p_j^{\frac{1}{1-\theta_j}} dj + \textstyle\int_1^J p_0^{\frac{\theta_j}{\theta_j-1}} p_j^{\frac{1}{1-\theta_j}} dj$$

Plugging in the monopoly price $p_j^N = \theta_j$ and normalizing the price of the homogeneous good $p_0 = 1$, we have

$$\mathbf{P} = 1 - \int_1^J \theta_j^{\frac{2-\theta_j}{1-\theta_j}} dj + \int_1^J \theta_j^{\frac{1}{1-\theta_j}} dj$$

■

Proof. Proposition 2

(Existence)

First note that no Northern firm would choose to export under threat of piracy if $w_S + \phi \leq w_N$ when $\frac{L_S}{\omega L_N + L_S} < \rho$ as this would generate negative expected export premium

$$\Delta = \left[(\theta_j - 1)\, \theta_j^{\frac{\theta_j}{1-\theta_j}} \left[\frac{L_S}{\omega L_N + L_S} - \rho \right] + \rho \cdot \max\{w_S + \phi - 1, 0\}\, (w_S + \phi)^{\frac{\theta_j}{1-\theta_j}} \right] (\omega L_N + L_S) < 0$$

So in order for any Northern firm to export when $\frac{L_S}{\omega L_N + L_S} < \rho$ we need $w_S + \phi > w_N = 1$, so that we can restrict attention to

$$\Delta = \left\{ \begin{array}{cc} (\theta_j - 1)\, \theta_j^{\frac{\theta_j}{1-\theta_j}} L_S & \text{if } \theta_j \leq w_S + \phi \\ \left[(\theta_j - 1)\, \theta_j^{\frac{\theta_j}{1-\theta_j}} \left[\frac{L_S}{\omega L_N + L_S} - \rho \right] + \rho \cdot (w_S + \phi - 1)\, (w_S + \phi)^{\frac{\theta_j}{1-\theta_j}} \right] (\omega L_N + L_S) & \text{if } \theta_j > w_S + \phi \end{array} \right\}$$

In order for there to exist such a cutoff, we need the export premium to be positive for lower values of θ_j and negative as $\theta_j \to \infty$. Since we focus on the case where $w_S + \phi > w_N = 1 \Rightarrow \exists$ some $\theta_j > 1$ such that $\theta_j \leq w_S + \phi$. This means that $\Delta = (\theta_j - 1)\, \theta_j^{\frac{\theta_j}{1-\theta_j}} L_S > 0$ for the lowest values of θ_j in the domain $\theta_j > 1$, where $\theta_j \leq w_S + \phi$.

The limit of Δ as θ_j eventually increases such that $\theta_j > w_S + \phi$ is given by $\lim_{\theta_j \to \infty} \Delta = \left[\frac{L_S}{\omega L_N + L_S} - \frac{\rho}{w_S + \phi} \right] (\omega L_N + L_S)$. So to ensure that the export premium, which was initially positive for low values of θ_j, eventually becomes negative for the high values of θ_j, we need $\left[\frac{L_S}{\omega L_N + L_S} - \frac{\rho}{w_S + \phi} \right] (\omega L_N + L_S) < 0 \Rightarrow (w_S + \phi) \frac{L_S}{\omega L_N + L_S} < \rho$ where $(w_S + \phi) \frac{L_S}{\omega L_N + L_S}$ is the relative marginal gain to a Northern firm of exporting when their product is pirated.

Since $\frac{\partial \Delta}{\partial \theta_j}$ exists, we know Δ is a continuous function, thus, invoking the Intermediate Value Theorem, we know that there must exist a critical point $\hat{\theta}_j$ such that $\Delta\left(\hat{\theta}_j\right) = 0$, where $\Delta > 0$ for some range $(\underline{\theta}, \hat{\theta}_j]$ and $\Delta < 0$ for some range $(\hat{\theta}_j, \bar{\theta})$.

(Uniqueness)

We know $\Delta > 0$ for lower values of θ_j and that it is continuous on the entire domain. Since $\frac{\partial \pi^M}{\partial \theta_j} > 0$ and $\Delta = \pi^M L_S$ for $\theta_j \leq w_S + \phi$, we know that Δ is monotone increasing in that range. Thus, if under the conditions $\theta_j > w_S + \phi$ when $w_S + \phi > w_N = 1$ and $(w_S + \phi) \frac{L_S}{\omega L_N + L_S} < \rho$, we have that when $\Delta > 0$ for some θ', it is positive-valued for all $\theta_j < \theta'$ and once $\Delta < 0$ for some θ^*, it is negative-valued for all θ_j thereafter, then uniqueness of the critical cutoff follows. Let us denote $\Delta_2 \equiv \left[(\theta_j - 1)\, \theta_j^{\frac{\theta_j}{1-\theta_j}} \left[\frac{L_S}{\omega L_N + L_S} - \rho \right] + \rho \cdot (w_S + \phi - 1)\, (w_S + \phi)^{\frac{\theta_j}{1-\theta_j}} \right] (\omega L_N + L_S)$,

the value of Δ when $\theta_j > w_S + \phi$.

$$\begin{aligned}
\Delta &> 0 \\
\Rightarrow & \ \rho \cdot (w_S + \phi - 1)(w_S + \phi)^{\frac{\theta_j}{1-\theta_j}} > (\theta_j - 1)\,\theta_j^{\frac{\theta_j}{1-\theta_j}} \left[\frac{L_S}{\omega L_N + L_S} - \rho\right] \\
\Rightarrow & \ \frac{\rho \cdot (w_S + \phi - 1)}{\frac{L_S}{\omega L_N + L_S} - \rho} > \frac{(\theta_j - 1)\,\theta_j^{\frac{\theta_j}{1-\theta_j}}}{(w_S + \phi)^{\frac{\theta_j}{1-\theta_j}}} = \frac{\pi^M}{q^C}
\end{aligned}$$

Note that the LHS of the inequality is constant. Let $RHS = \frac{\pi^M}{q^C}$; taking the FOC of RHS

$$\begin{aligned}
\frac{\partial RHS}{\partial \theta_j} &= \frac{q^C \partial \pi^M - \pi^M \partial q^C}{(q^C)^2} \\
&= \frac{(w_S+\phi)^{\frac{\theta_j}{1-\theta_j}} \left[\begin{array}{c} \left(\frac{1}{\theta_j(1-\theta_j)} + \frac{1}{(1-\theta_j)^2}\ln\theta_j\right)\theta_j^{\frac{1}{1-\theta_j}} \\ -\left(\frac{1}{1-\theta_j} + \frac{1}{(1-\theta_j)^2}\ln\theta_j\right)\theta_j^{\frac{\theta_j}{1-\theta_j}} \end{array}\right] - (\theta_j - 1)\,\theta_j^{\frac{\theta_j}{1-\theta_j}} \left[(w_S+\phi)^{\frac{\theta_j}{1-\theta_j}} \left[\frac{\ln(w_S+\phi)}{(1-\theta_j)^2}\right]\right]}{(w_S+\phi)^{\frac{2\theta_j}{1-\theta_j}}}
\end{aligned}$$

$$\begin{aligned}
-\ln\theta_j &< -\ln(w_S+\phi) \\
\frac{\theta_j}{1-\theta_j}\ln\theta_j - \frac{1}{1-\theta_j}\ln\theta_j &< -\ln(w_S+\phi) \\
1 + \frac{\theta_j}{1-\theta_j}\ln\theta_j - \left(1 + \frac{1}{1-\theta_j}\ln\theta_j\right) &< -\ln(w_S+\phi) \\
\left(\frac{1}{\theta_j} + \frac{1}{1-\theta_j}\ln\theta_j\right)\theta_j - \left(1 + \frac{1}{1-\theta_j}\ln\theta_j\right) &< (\theta_j - 1)\left[\frac{\ln(w_S+\phi)}{1-\theta_j}\right] \\
\left(\frac{1}{\theta_j(1-\theta_j)} + \frac{1}{(1-\theta_j)^2}\ln\theta_j\right)\theta_j - \left(\frac{1}{1-\theta_j} + \frac{1}{(1-\theta_j)^2}\ln\theta_j\right) &> (\theta_j - 1)\left[\frac{\ln(w_S+\phi)}{(1-\theta_j)^2}\right] \\
\left[\begin{array}{c} \left(\frac{1}{\theta_j(1-\theta_j)} + \frac{1}{(1-\theta_j)^2}\ln\theta_j\right)\theta_j^{\frac{1}{1-\theta_j}} \\ -\left(\frac{1}{1-\theta_j} + \frac{1}{(1-\theta_j)^2}\ln\theta_j\right)\theta_j^{\frac{\theta_j}{1-\theta_j}} \end{array}\right] &> (\theta_j - 1)\,\theta_j^{\frac{\theta_j}{1-\theta_j}} \left[\frac{\ln(w_S+\phi)}{(1-\theta_j)^2}\right] \\
&\Rightarrow \frac{\partial RHS}{\partial \theta_j} > 0
\end{aligned}$$

Since RHS is increasing in θ_j, if $\Delta > 0$ for some θ', we know it will be positive-valued

for all $\theta_j < \theta'$. Alternatively

$$
\begin{aligned}
\Delta &< 0 \\
&\Rightarrow \rho\cdot(w_S+\phi-1)(w_S+\phi)^{\frac{\theta_j}{1-\theta_j}} < (\theta_j-1)\,\theta_j^{\frac{\theta_j}{1-\theta_j}}\left[\frac{L_S}{\omega L_N+L_S}-\rho\right] \\
&\Rightarrow \frac{\rho\cdot(w_S+\phi-1)}{\frac{L_S}{\omega L_N+L_S}-\rho} < \frac{(\theta_j-1)\,\theta_j^{\frac{\theta_j}{1-\theta_j}}}{(w_S+\phi)^{\frac{\theta_j}{1-\theta_j}}} = \frac{\pi^M}{q^C}
\end{aligned}
$$

Again, knowing the LHS is constant and that RHS is increasing in θ_j, if $\Delta < 0$ for some θ^*, it will remain negative-valued for all θ_j thereafter. Thus, single crossing obtains. ■

Proof. Derivation of Open Economy Price Index in South

The price index in South is given by

$$
\begin{aligned}
\mathbf{P}^S &= p_0 - \int_1^{J^S}\theta_j p_0^{\frac{\theta_j}{\theta_j-1}} p_j^{\frac{1}{1-\theta_j}}dj + \int_1^{J^S} p_0^{\frac{\theta_j}{\theta_j-1}} p_j^{\frac{1}{1-\theta_j}}dj \\
&= p_0 - \int_{j\in n_N}\theta_j p_0^{\frac{\theta_j}{\theta_j-1}} p_j^{\frac{1}{1-\theta_j}}dj - \int_{j\in n_S}\theta_j p_0^{\frac{\theta_j}{\theta_j-1}} p_j^{\frac{1}{1-\theta_j}}dj + \int_{j\in n_N} p_0^{\frac{\theta_j}{\theta_j-1}} p_j^{\frac{1}{1-\theta_j}}dj + \int_{j\in n_S} p_0^{\frac{\theta_j}{\theta_j-1}} p_j^{\frac{1}{1-\theta_j}}dj
\end{aligned}
$$

Note that for $j\in n_N$, $p_j=\theta_j$ and for $j\in n_S$, $p_j^S=\gamma_0^S+\phi$. Plugging in these and the Southern competitive price $p_0=p_j^S=\gamma_0^S+\phi$ (full derivation in Mathematical Appendix) we have

$$
\begin{aligned}
\mathbf{P}^S &= \gamma_0^S+\phi-\int_{j\in n_N}\theta_j\left(\gamma_0^S+\phi\right)_j^{\frac{\theta_j}{\theta_j-1}}\theta_j^{\frac{1}{1-\theta_j}}dj-\int_{j\in n_S}\theta_j\left(\gamma_0^S+\phi\right)dj \\
&\quad+\int_{j\in n_N}\left(\gamma_0^S+\phi\right)^{\frac{\theta_j}{\theta_j-1}}\theta_j^{\frac{1}{1-\theta_j}}dj+\int_{j\in n_S}\left(\gamma_0^S+\phi\right)dj \\
\mathbf{P}^S &= \gamma_0^S+\phi-\int_{j\in n_N}\theta_j\left(\gamma_0^S+\phi\right)_j^{\frac{\theta_j}{\theta_j-1}}\theta_j^{\frac{1}{1-\theta_j}}dj-\left(\gamma_0^S+\phi\right)\int_{j\in n_S}\theta_j dj \\
&\quad+\int_{j\in n_N}\left(\gamma_0^S+\phi\right)^{\frac{\theta_j}{\theta_j-1}}\theta_j^{\frac{1}{1-\theta_j}}dj+n_S\left(\gamma_0^S+\phi\right) \\
\mathbf{P}^S &= \left(1+n_S-\int_{j\in n_S}\theta_j dj\right)\left(\gamma_0^S+\phi\right)-\int_{j\in n_N}\theta_j\left(\gamma_0^S+\phi\right)_j^{\frac{\theta_j}{\theta_j-1}}\theta_j^{\frac{1}{1-\theta_j}}dj+\int_{j\in n_N}\left(\gamma_0^S+\phi\right)^{\frac{\theta_j}{\theta_j-1}}\theta_j^{\frac{1}{1-\theta_j}}dj \\
&= \left(1+n_S-\int_{j\in n_S}\theta_j dj\right)\left(\gamma_0^S+\phi\right)+\int_{j\in n_N}(1-\theta_j)\left(\gamma_0^S+\phi\right)_j^{\frac{\theta_j}{\theta_j-1}}\theta_j^{\frac{1}{1-\theta_j}}dj
\end{aligned}
$$

■

Proof. Derivation of Open Economy Price Index and Profit per-worker in North

Let $J^N=\{j:\Delta<0\}$ be the set of goods not exported by North. The general form of the previous closed economy price index in North is reproduced below

$$
\mathbf{P}^N = p_0-\int_1^J p_0^{\frac{\theta_j}{\theta_j-1}}\theta_j p_j^{\frac{1}{1-\theta_j}}dj+\int_1^J p_0^{\frac{\theta_j}{\theta_j-1}}p_j^{\frac{1}{1-\theta_j}}dj
$$

Plugging in the monopoly price $p_j^N = \theta_j$ for goods that are not exported and goods that are exported and not imitated $(J^N \cup n_N)$, in addition to the Southern competitive price $p_j^S = \frac{\gamma_0^S}{\gamma_1^S} + \phi$ for goods that are exported and imitated, we have

$$\begin{aligned}
\mathbf{P}^N &= \gamma_0^S + \phi - \int_{j\in J^N\cup n_N} \theta_j p_j^{\frac{1}{1-\theta_j}} dj - \int_{j\in n_S} \theta_j p_j^{\frac{1}{1-\theta_j}} dj + \int_{j\in J^N\cup n_N} p_j^{\frac{1}{1-\theta_j}} dj + \int_{j\in n_S} p_j^{\frac{1}{1-\theta_j}} dj \\
&= \gamma_0^S + \phi - \int_{j\in J^N\cup n_N} \theta_j^{\frac{2-\theta_j}{1-\theta_j}} dj - \int_{j\in n_S} \theta_j \left(\gamma_0^S + \phi\right)^{\frac{1}{1-\theta_j}} dj + \int_{j\in J^N\cup n_N} \theta_j^{\frac{1}{1-\theta_j}} dj + \int_{j\in n_S} \left(\gamma_0^S + \phi\right)^{\frac{1}{1-\theta_j}} dj \\
&= \gamma_0^S + \phi + \int_{j\in J^N\cup n_N} \theta_j^{\frac{1}{1-\theta_j}} - \theta_j^{\frac{2-\theta_j}{1-\theta_j}} dj + \int_{j\in n_S} (1-\theta_j)\left(\gamma_0^S + \phi\right)^{\frac{1}{1-\theta_j}} dj
\end{aligned}$$

Northern per-worker profits, under trade, are now

$$\begin{aligned}
\frac{\Pi_N}{L_N} &= \int_{j\in J^N} \pi_j^M dj + \int_{j\in n_N} \left(1 + \frac{L_S}{L_N}\right) \pi_j^M dj + \int_{j\in n_S} \left(1 + \frac{L_S}{L_N}\right) \pi_j^C dj \\
&= \int_{j\in J^N} \left[p_j^N q_j^M - w_N q_j^M\right] dj + \int_{j\in n_N} \left(1 + \frac{L_S}{L_N}\right) \left[p_j^N q_j^M - w_N q_j^M\right] dj \\
&\quad + \int_{j\in n_S} \left(1 + \frac{L_S}{L_N}\right) \left[p_j^S q_j^C - w_N q_j^C\right] dj \\
&= \int_{j\in J^N(t)} \left[\theta_j^{\frac{1}{1-\theta_j}} - \theta_j^{\frac{\theta_j}{1-\theta_j}}\right] dj + \int_{j\in n_N} \left(1 + \frac{L_S}{L_N}\right) \left[\theta_j^{\frac{1}{1-\theta_j}} - \theta_j^{\frac{\theta_j}{1-\theta_j}}\right] dj \\
&\quad + \int_{j\in n_S} \left(1 + \frac{L_S}{L_N}\right) \left(\gamma_0^S + \phi - 1\right) \left(\gamma_0^S + \phi\right)^{\frac{\theta_j}{1-\theta_j}} dj
\end{aligned}$$

■

8 Appendix

HS 3-digit level product descriptions

HS3	N	Percent	σ(average)	Description
10	1,262	0.49	16.658	Live Animals
20	4,268	1.65	8.529	Fresh, Chilled, Frozen Meat
21	376	0.15	51.324	Meat of bovine and swine
30	4,396	1.7	8.151	Seafood
40	2,374	0.92	6.276	Animal Byproducts (Eggs, milk, etc.)
71	2,246	0.87	6.150	Dried/Frozen Beans and Vegetables
80	364	0.14	7.878	Nuts and Fresh Fruit
81	1	0	2.601	Dried/Preserved Fruits
90	10,038	3.89	7.590	Tea, coffee and seasonings
91	1,877	0.73	9.503	Spices
120	2,688	1.04	5.738	Edible Seeds
121	1,281	0.5	6.011	Roots and Vegetable products
130	820	0.32	7.211	Pectin substances and Gum
140	419	0.16	9.767	Raw vegetable materials
150	1,538	0.6	5.855	Animal Fats and Oils
151	4,104	1.59	7.120	Vegetable Fats and Oils
160	3,201	1.24	6.374	Meat and Seafood preparations
170	7,353	2.85	6.370	Glucose, fructose, cane, molasses
190	979	0.38	8.224	Couscous, flour, pasta, cereals
200	1,228	0.48	6.893	Fruit juices and preserves
210	1,007	0.39	5.170	Yeasts, meal, flour, sauces
230	1,298	0.5	21.224	Other vegetable materials
240	1,374	0.53	14.156	Cigarettes and Tobacco
250	1,255	0.49	5.130	Crude sulphur, silica, graphite, sodium
252	1,148	0.44	4.463	Cement and lime products
270	425	0.16	10.822	Coal, tar, peat, etc.
284	723	0.28	5.439	Aluminates, silicates, Manganites, chromates
290	764	0.3	3.211	Benzene, Butene, etc.
291	1,334	0.52	3.601	Acetone, Carboxylic acids, etc.
292	3,391	1.31	3.608	Amino-acids, etc.
293	2,948	1.14	9.676	Compounds containing chemicals
320	3,727	1.44	5.363	Pigments and preparations based on chemicals
321	1,459	0.56	3.684	Ink
330	5,266	2.04	4.279	Essential oils, makeup, personal products
340	4,922	1.91	3.783	Waxes and polishes
360	427	0.17	7.314	Prepared explosives, powders, fuses
381	1,050	0.41	5.658	Chemical elements and preparations
390	1,809	0.7	4.625	Resins and polymers
391	2,832	1.1	4.150	Cellulose products
392	3,786	1.47	3.496	Houseware (doors, tableware, etc.)
401	3,958	1.53	3.962	Rubber products
410	2,537	0.98	12.464	Leather products
420	2,021	0.78	3.610	Leather, catgut apparel and accessories
430	3	0	5.405	Fur apparel and accessories
440	1,183	0.46	4.321	Wood products
441	3,733	1.45	4.774	Plywood products
460	728	0.28	4.476	Plaiting materials
470	601	0.23	6.892	Chemical pulp
481	3,465	1.34	5.212	Paper products
482	1,917	0.74	5.210	Stationary materials
490	1,482	0.57	5.454	Print products
500	957	0.37	12.859	Woven fabrics of silk
510	979	0.38	14.926	Wool and yarn products
520	1,833	0.71	5.736	Thread
530	1,409	0.55	9.183	Flax, jute yarn, etc.
551	1,293	0.5	5.145	Woven fabrics
580	2,034	0.79	5.952	Narrow woven fabrics
600	1,614	0.62	6.116	Knitted or crocheted fabrics
610	4,233	1.64	3.958	Apparel
611	9	0	2.208	Apparel accessories

620	7,837	3.03	3.259	Garments and clothing of wool and fine animal hair
621	2	0	3.511	Garments and clothing of other textiles
630	2,783	1.08	5.509	Furnishing articles of other textiles
680	4,144	1.6	9.601	Articles of plaster or compositions, building boards
691	5,155	2	4.522	Articles of ceramics
700	5,847	2.26	5.685	Glass products
701	2,173	0.84	4.645	Other glassware, kitchenware
710	1,663	0.64	15.020	Base metals, Precious or semi-precious stones
711	950	0.37	23.869	Articles of gold or silver jewellery
720	311	0.12	4.512	Ferrous, iron products
721	677	0.26	4.892	Bars and rods
730	7,488	2.9	5.132	Fittings, pipe or tube
731	1,602	0.62	3.339	Chain, welded link, wire - iron or steel
732	2,464	0.95	3.403	Iron or steel appliances
750	488	0.19	7.238	Articles of nickel
760	791	0.31	6.392	Foil, aluminium products
761	1,340	0.52	6.738	Articles of aluminium
790	578	0.22	17.154	Articles of zinc
800	488	0.19	20.579	Tin articles
840	5,871	2.27	7.935	Engines, diesel, parts
841	11,056	4.28	5.227	Air or gas compressors, fans, turbines, furnaces
842	5,826	2.26	7.294	Machinery for cleaning or drying, bulldozers, Derricks/cranes
843	3,679	1.42	4.901	Construction equipment, Machinery for manufacture
844	1,169	0.45	12.545	Machines for moulding articles, weaving, printing, etc.
845	878	0.34	7.802	Automatic sewing machines, milling, washing, cleaning, etc.
846	4,223	1.63	8.803	Automatic typewriters and word-processorcs, machine tools
847	2,424	0.94	4.676	Machinery for calculating, assembling, moulding, treating, etc.
848	3	0	9.911	Bearings, moulds, etc.
850	1,477	0.57	7.485	Generators
851	4,988	1.93	4.121	Electro-thermic appliances, Sound reproducing and telephonic apparatus
852	5,623	2.18	7.658	Magnetic, radio, transmission appliances
853	4,480	1.73	5.255	Electrical capacitors, resistors, etc.
854	8,446	3.27	3.827	Electric conductors, Semiconductor devices, etc.
860	169	0.07	25.334	Rail locomotives, cars, parts
870	7,109	2.75	33.694	Automobiles and parts
871	1,209	0.47	9.574	Vehicle parts and other vehicles
880	1,465	0.57	24.161	Aircraft propellers and rotors, Helicopters
890	327	0.13	18.344	Motorboats, marine vessels
901	3,942	1.53	5.514	Apparatus and equip for automatical measurement
902	6,178	2.39	6.013	Apparatus based on the use of X-ray
903	2,309	0.89	5.908	Automatic regulating or controlling instruments
940	944	0.37	4.205	Articles of bedding/furnishing

References

Arkolakis, Costas, . Market penetration costs and trade dynamics.

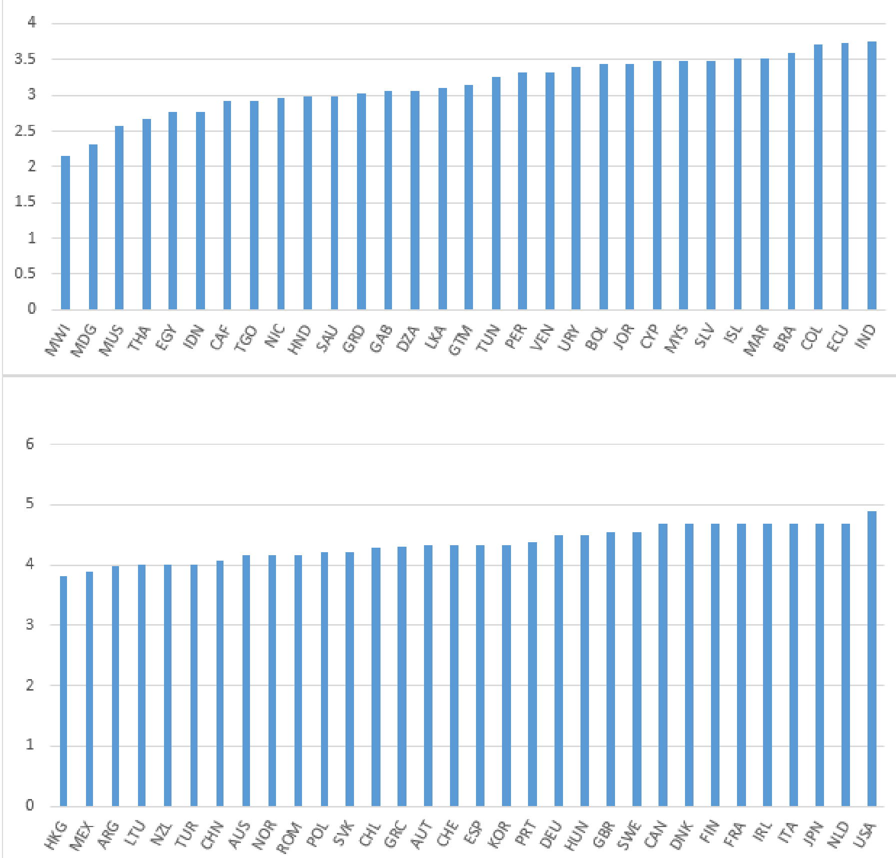
Grossman/Shapiro. Informative Advertising with Differentiated Products.

Arnold, Lutz, 1998. Growth, welfare, and trade in an integrated model of human-capital accumulation and research. *Journal of Macroeconomics* 20, 81–105.

Arnold, L.G., 2002. On the growth effects of North–South trade: The role of product market flexibility. *Journal of International Economics* 58, 451–466.

Branstetter L., Fisman R. and Foley F., 2006. Does stronger intellectual property rights increase international technology transfer? Empirical evidence from U.S. firm-level panel data. *Quarterly Journal of Economics* 321–349 (February).

Figure 2. IP Index by Country



Branstetter L., Fisman R., Foley F., and Saggi K., (2007), Intellectual property rights, imitation, and foreign direct investment: theory and evidence, Southern Methodist University, August, mimeo.

Broda, C., J. Greenfield and D. Weinstein, 2006. From Groundnuts to Globalization: A Structural Estimate of Trade and Growth. NBER Working Paper No. 12512.

Chui, M., Levine, P., Pearlman, J., 2001. Winners and losers in a North–South model of growth, innovation and product cycles. *Journal of Development Economics* 65, 333–365.

Connolly, M., Valderrama, D., 2005. Implications of intellectual property rights for dynamic gains from trade. *American Economic Review* 95, 318–322.

Currie, D., Levine, P., Pearlman, J., Chui, M., 1999. Phases of imitation and innovation in a North–South endogenous growth model. Oxford Economic Papers 51, 60–88.

Dinopoulos, E. and Segerstrom, P. (2010) "Intellectual Property Rights, Multinational Firms and Economic Growth," *Journal of Development Economics*, pp. 13-27.

Dinopoulos, Elias, Gungoraydinoglu, Ali, Syropoulos, Constantinos, 2008. Patent protection and global Schumpeterian growth. In: Dinopoulos, Elias, Krishna, Pravin, Panagariya, Arvind, Wong, Kar-yiu (Eds.), Trade Globalization and Poverty. Routledge, London, pp. 105–129. Chapter 5.

Dinopoulos, Elias, Kottaridi, Constantina, 2008. The growth effects of national patent policies. *Review of International Economics* 16 (3), 499–515.

Dinopoulos, Elias and Segerstrom, Paul, (2007), "North–South trade and economic growth," Stockholm School of Economics, mimeo.

Dinopoulos, Elias, Thompson, Peter, 1999. Scale effects in Schumpeterian models of economic growth. *Journal of Evolutionary Economics* 9, 157–185.

Glass, Amy, Saggi, Kamal, 2002. Intellectual property rights and foreign direct investment. *Journal of International Economics* 56, 387–410.

Glass, Amy,Wu, Xiaodong, 2007. Intellectual property rights and quality improvement. *Journal of Development Economics 82*, 393–415.

Grossman, G., Helpman, E., 1991a. Quality ladders in the theory of growth. *Review of Economic Studies* 58, 43–61.

Grossman, G., Helpman, E., 1991b. Endogenous product cycles. *The Economic Journal* 101, 1229–1241.

Grossman, G., Helpman, E., 1991c. Innovation and growth in the global economy. MIT Press, Cambridge, MA.

Grossman, Gene M. and Lai, Edwin L.-C. (2004) "International Protection of Intellectual Property," *The American Economic Review*, 94(5), 1635-1653.

Gustafsson, P. and Segerstrom, P. (2010) "North-South Trade with Increasing Product Variety," *Journal of Development Economics*, pp. 97-106.

Helpman, Elhanan. (1993) "Innovation, Imitation, and Intellectual Property Rights," *Econometrica*, 61(6), 1247-80.

Jones, C.I., 1995. R&D-based models of economic growth. *Journal of Political Economy* 103 (4), 759–784.

Kortum, Samuel, 1997. Research, patenting and technological change. *Econometrica* 65, 1389–1419.

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

Kwan, Y.K. and Lai, E.L. (2003) "Intellectual Property Rights Protection and Endogenous Economic Growth," *Journal of Economic Dynamics & Control*, Vol. 27, pp. 853-873.

Lai, Edwin, 1995. The product cycle and the world distribution of income: A reformulation. *Journal of International Economics* 39, 369–382.

Lai, Edwin, 1998. International intellectual property rights protection and the rate of product innovation. *Journal of Development Economics* 55, 133–153.

Maskus, Keith, 2000. Intellectual Property Rights in the Global Economy. Institute for International Economics, Washington, D.C.

McCalman, Phillip, 2001. Reaping what you sow: an empirical analysis of international patent harmonization. *Journal of International Economics* 55, 161–186.

Mondal, D., Gupta, M.R., 2008b. Innovation, imitation and multinationalisation in a North–South model: A theoretical note. *Journal of Economics* 94 (1), 31–62.

Sala-i-Martin, Xavier, 2006. The world distribution of income: falling poverty and... convergence period. *Quarterly Journal of Economics* 121, 351–397.

Segerstrom, Paul, 1998. Endogenous growth without scale effects. American Economic Review 88, 1290–1310.

Vernon, Raymond, 1966. International investment and international trade in the product cycle. *Quarterly Journal of Economics* 80, 190–207.

Yang, Guifang, Maskus, Keith, 2001. Intellectual property rights, licensing, and innovation in an endogenous product-cycle model. *Journal of International Economics* 53, 169–187.