The Effects of Coordinating National Patent Policies

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Abstract

This paper quantifies the effects of coordinating national patent policies using a multi-country model of endogenous patent protection. International trade connects country pay-offs via both export markets and foreign imports. I find that all countries use their national patent policies to extract rents from the rest-of-the-world and this effect is more pronounced in developing countries. Efforts by the WTO to establish minimal levels of protection result in a substantial transfer of welfare from developing to developed countries. Coordinating patent policies increases overall welfare and the majority of these gains are attainable in a political equilibrium.

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1 Introduction

As technology has lowered the physical barriers between countries, the degree to which governments can use domestic policy as a mechanism towards, in the words of Adam Smith, "beggaring all their neighbours" has increased. Deardorff (1996) points out that this strategic use of domestic policies is often analogous to the classic "Prisoner's Dilemma" where individual profit-maximizing players generate an outcome which is collectively sub-optimal. Consequently, the response among countries has been the development of international economic integration agreements to coordinate many national policies.[1]

Patent protection is no different as the size of firm export markets depends on the degree to which the destination country protects intellectual property, therefore weak protection abroad may decrease domestic entrepreneurial effort, firm profits, and consumer welfare.[2] Representatives from the United States and Europe acknowledged this issue during the Uruguay Round of World Trade Organization negotiations in the early 1990s and emphasized the need for stronger patent protection in developing countries. The result was the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) which introduced the regulation of intellectual property rights (IPRs) into the WTO for the first time and remains the most comprehensive international agreement on IPRs to date. The general purpose of TRIPS was to define a minimum level of IPR protection across member countries and to harmonize the definition and enforcement of patent regulation.

The creation of TRIPS, and its incorporation into the WTO via the Uruguay Trade Round, suggests that a country's strategic use of IPR protection to extract rents from trading partners is quantitatively important. There is little economic research to support

[1] As Baier, Bergstrand, Egger and McLaughlin (2008) point out, approximately half of the 250 international agreements notified to the WTO and General Agreement on Tariffs and Trade (GATT) between 1947 and 2002 occurred in the last 20 years.

[2] The U.S. Chamber of Commerce estimates that piracy costs the U.S. economy between $200 and $250 billion each year (Brilliant, 2005), and between one to eight percent of Chinese GDP is attributable to counterfeit goods (Asia Business Council, 2005). For example, in 2011 Chinese authorities found 22 fake Apple stores in the Chinese town of Kunming. These "beautiful fakes" were so real that even the sales staff believed they worked for Apple (http://www.bbc.co.uk/news/technology-14503724).

this conjecture, however. The goal of this paper is to fill that void by quantifying both the strategic incentives facing countries and the effects of coordinating national patent policies.

At the core of the analysis is a multi-country model of endogenous IPR protection. Welfare-maximizing governments in each country choose the imitation risk (*i.e.*, level of patent protection) facing all goods sold within their borders.[3] Strong IPR protection increases the return to investment leading to entry of monopolistically competitive firms and more varieties available for consumption, but at higher prices. Weak IPR protection, on the other hand, enables imitation and marginal cost pricing. There are fewer varieties to purchase, but the low prices increase the quantities consumed of the available varieties. For large and innovative countries the returns to strong levels of patent protection are greater as entrepreneurs in these countries are better at producing new firms.

International trade connects country pay-offs via both export markets and foreign imports. The former increases the return to innovation and encourages a country to strengthen its level of IPR protection while the latter encourages a country to weaken its level of IPR protection to lower the price of expensive imports. Both of these effects are captured in the open economy Nash equilibrium where the IPR policy in one country must not only be consistent with domestic firm investment but also the IPR policies and firm investment rates in other countries.

The paper delivers several results. First, differences in education attainment (*i.e.*, innovative ability), GDP, and calibrated trade frictions generate country IPR decisions and trade flows consistent with the data prior to the implementation of TRIPS. Second, I find evidence that all countries strategically use their national IPR policies to extract rents (profits and welfare) from the rest-of-the-world and this effect is more pronounced in developing countries. China, for example, levers its market size to attract imports and chooses artificially

[3] Modeling patent protection in this way is attractive since it enables me to define a "government" as all institutions within a country capable of influencing the application of patent law. For example, US imitation can be a function of both written law passed by Congress (*e.g.*, patent length, breadth, and duration) and the enforcement of such laws by the Court of Appeals for the Federal Circuit (CAFC) which invalidates patent claims approximately 30 percent of the time (Hunt, 1999).

low IPR protection to free-ride off of the innovative effort of firms in developed countries such as the United States.

Third, developing countries have benefited from the historically low level of international coordination in patent policies. Under the first-best set of national IPR policies, all countries increase their level of patent protection, leading to an increase in aggregate welfare of 1.30%. While this aggregate effect is significant, it masks substantial redistribution of welfare as residents in the average developed country experience a 2.56% increase in welfare compared to a 2.03% decrease in welfare for residents in the average developing country.

Fourth, the transfer of utility from developing to developed countries in the first-best allocation results in a welfare loss in nearly every developing country in the sample. This suggests that such an allocation would not occur in a political equilibrium absent explicit transfers. I find that political feasibility is not a substantial constraint, however, as imposing the super-majority voting rule employed by the WTO captures 98% of the total welfare gains by limiting some of the welfare redistribution.

Fourth, implementing a policy floor like the one imposed by TRIPS likely increases total welfare but, again, at a cost to developing economies. Welfare losses in an average developing country after implementation of TRIPS could be as high as 1.70% depending on how one interprets the mapping between TRIPS and the model. Developed countries benefit substantially (up to 2.50% on average) as stronger patent protection in the developing world increases export markets, leading to more innovation and more goods to consume.

2 Literature Review

This paper contributes to the literature on coordination of macroeconomic policies.[4] Staiger (1995) and Bagwell and Staiger (1997) point out that the WTO provides the mechanism by which the players (*i.e.*, countries) can coordinate their policies to maximize the aggregate outcome. This paper builds on this reasoning and is the first to quantify the degree to

[4] See Persson and Tabellini (1995) for a more complete overview of this literature.

which coordination affects both aggregate welfare and the distribution of welfare gains. In comparison to the "Prisoner's Dilemma" metaphor, however, I show that not all countries are better off under such an agreement. Consequently, explicit transfers of wealth, compensating reductions in tariffs, and/ or super-majority voting of WTO member countries would be required to pass such an agreement.

The paper is also related to the literature on the use of domestic policy as a replacement for trade policy. Bhagwati and Ramaswami (1963) show that imperfect substitutability between tariffs and domestic policy in the presence of market failures implies that the optimal solution is to choose the domestic policy that addresses the market failure directly. Ederington (2001) shows this imperfect substitutability also generates a self-enforcement mechanism by which countries optimally choose domestic policies to address domestic distortions and adjust their trade policies to comply with the trade agreement. This paper builds on this literature in two ways. First, I analyze the incentives to change domestic policy in the presence strategic interactions which imply non-pecuniary externalities – a topic for further research noted by Ederington (2001). Second, I use the model to quantify the extent to which different countries use domestic (patent) policy to extract rents from their trading partners conditional on fixed trade policy. To my knowledge, this represents the first empirical evaluation of the strategic incentives facing different countries.

In the literature on intellectual property right protection, Grossman and Lai (2004) study how international trade affects the incentives of governments to protect intellectual property. They use a two-country, North-South model to show that equilibrium IPR protection is increasing in education and market size, both consistent with the data. They also explore the properties of an efficient global IPR regime which internalizes the externalities created in the non-cooperative patent-setting game. Helpman (1993) uses a two country North-South model to study the welfare implications from strengthening IPR protection in developing countries. He finds theoretical evidence that the South is generally worse off but the general equilibrium effects on the North are difficult to pin down. Consequently, quantifying the general equilibrium interactions between the North and the South "cannot be answered by theoretical arguments alone." This paper extends these works by developing a framework which tractably extends theory to data and is capable of quantifying the general equilibrium interactions.

In Thurk (2013) I study the incentives to protect intellectual property when governments choose their level of patent protection each period. I find that discretionary IPR policy leads to weaker protection than optimal and decreases innovation, profits, and welfare. I also find that international trade can act as a commitment device as export markets decrease governments' ability to influence innovation through patent policy, thereby decreasing their incentive to defect from past IPR policy. In this paper, governments can commit to their IPR policy and I focus on quantifying the gains from coordinating national patent policies.

Other papers estimate the effects of TRIPS. Chaudhuri, Goldberg and Jia (2006) estimate the effects of TRIPS implementation on prices, profits, and consumer welfare in the Indian pharmaceutical industry. Using product-level data on pharmaceutical sales, they find that stronger patent protection results in welfare losses of $305 million per year and most of these losses are borne by consumers. The increase in profits for foreign firms, on the other hand, is relatively small ($19.6 million) which indicates a net reduction in welfare holding entrepreneurial effort by pharmaceutical companies constant. This paper extends their analysis to explore the equilibrium effects of TRIPS on innovative effort, firms profits, and consumer welfare in both developing and developed countries.

McCalman (2001) evaluates the royalty transfers implied by TRIPS. He finds that for a given set of innovations, patent harmonization results in significant transfers from developing to developed countries, particularly the United States. While these results are qualitatively similar to my findings, the advantage of the general equilibrium approach employed here is that I can also account for the change in entrepreneurial effort (*i.e.*, innovation) due to the implementation of TRIPS.

The paper proceeds as follows: Section 3 outlines the model and demonstrates key mechanics. Section 4 discusses the empirical strategy and Section 5 presents the results from the benchmark model. Section 6 presents the estimated gains from coordinating national IPR policies. Section 7 provides concluding remarks.

3 Model

The model is a multi-country, non-cooperative model of endogenous IPR protection. Entrepreneurs in each country develop new goods each period. All goods are initially unique but face some risk of imitation each period according to the governments' choices of IPR protection. Consistent with the data, I consider an environment with "national treatment" in which governments choose a single level of IPR protection afforded to all goods sold in the country regardless of country of origin.[5] Strong IPR protection encourages the creation of new, expensive goods while weak IPR protection generates less goods but at lower prices. International trade affects this trade-off by introducing (a) export markets which increases the return to innovation thereby encouraging more protection, and (b) expensive imports which encourages imitation via less protection.

3.1 Timing

Governments simultaneously choose their levels of IPR protection at the beginning of time and are able to commit to their choices. The remaining agents (consumers, entrepreneurs, firms) enter period t with an endogenous distribution of firms around the world. Events occur in the following sequence:

1. All firms enter the period as producers of unique goods.

2. Firms die at a stochastic rate and entrepreneurs create new firms.

3. Firms are imitated stochastically conditional on the level of IPR protection.

[5] The natural question is whether foreign firms do actually receive the same degree of IPR protection as their domestic counterparts. The simple answer appears to be "yes," as this doctrine of "national treatment" is outlined specifically in Article 2 of the 1883 *Paris Convention for the Protection of Industrial Property*:

> Nationals of any country of the Union shall, as regards the protection of industrial property, enjoy in all the other countries of the Union the advantages that their respective laws now grant, or may hereafter grant, to nationals; all without prejudice to the rights specially provided for by this Convention.

There is anecdotal evidence to suggest that this is not always the case. Lerner (2002) notes some of these differences across countries.

4. Firms choose price and realize profit.

5. Agents move to period $t+1$

3.2 Households

Time is discrete and the horizon is infinite. To simplify notation, I suppress time subscripts. There are N countries indexed by $i = 1, \ldots, N$ each endowed with L_i consumers. Each consumer is endowed with a unit of time and supplies labor inelastically. Agents in all countries consume a final, non-traded good constructed with the following production function:

$$Q_i = Z_i^{1-\eta} \left[\sum_{n=1}^{N} M_n^{-\lambda} a_{ni} \int_{\omega \in \Omega_n} q_{ni}(\omega)^{\frac{\epsilon-1}{\epsilon}} d\omega \right]^{\frac{\eta\epsilon}{\epsilon-1}} \tag{1}$$

The first component is a homogeneous, non-traded good Z_i produced with a country-specific constant returns to scale production technology that uses labor as its only input. The second component is a composite good produced with a set of differentiated goods. Define ω as the product variety, Ω_{ni} is the set of all product varieties exported from country n to country i where $M_n = \int_{\omega \in \Omega_n} d\omega$ is the mass of country n goods. The parameter $\eta \in (0,1)$ pins down the expenditure share of composite good while $\epsilon > 1$ is the elasticity of substitution between differentiated goods. Both parameters are common to all countries. The "Armington" parameter a_{ni} determines the weight of country n products in country i consumption.

Labor is mobile between the non-traded homogeneous sector and the traded composite good sector. In equilibrium, wages are pinned down by each country's production technology in the non-traded sector. Hence, wages are insensitive to changes in government IPR policy or changes in bilateral trade. This simplification focuses my analysis on the interaction of international trade and government IPR decisions independent of changing wage differentials.

The typical Dixit-Stiglitz framework exhibits a "love of variety" effect in which the benefit of consuming small amounts of many varieties is preferred to consuming large amounts of few varieties. Here, government IPR policy will amount to trading off variety and quantity to maximize welfare. In order to guarantee concavity of this trade-off, I follow Benassy (1996) and Alessandria and Choi (2007) and introduce the term $M_n^{-\lambda}$ where $\lambda \in [0,1]$ attenuates the variety effect. A λ equal to zero emits the standard Dixit-Stiglitz love of variety effect while a λ equal to one generates preferences where consumers hate variety.

Define ηY_i as aggregate spending on differentiated goods in country i, then demand for good n in country i is:

$$q_{ni}(\omega) = \left(M_n^{-\lambda} a_{ni}\right)^{\epsilon} \times \frac{p_{ni}(\omega)^{-\epsilon}}{P_i^{1-\epsilon}} \cdot \eta Y_i \qquad (2)$$

and P_i is the price index for country i defined as:

$$P_i = \left[\sum_{n=1}^{N} \left(M_n^{-\lambda} a_{ni}\right)^{\epsilon} \times \int_{\omega \in \Omega_{ni}} p_{ni}(\omega)^{1-\epsilon} d\omega\right]^{\frac{1}{1-\epsilon}} \qquad (3)$$

3.3 Firms

Firms supply goods according to the linear production function $q_{ni}(\omega) = l_{ni}(\omega)$. All production for a firm from country n occurs in country n, though the firm may choose to sell goods in other countries. Profits in the country n differentiated good sector occur in a spot market at the end of each period. Firm ω from country n solves the following static pricing problem in country i:

$$\max_{p_{ni}(\omega)} \left[p_{ni}(\omega) - w_n\right] \times \left(M_n^{-\lambda} a_{ni}\right)^{\epsilon} \times \frac{p_{ni}(\omega)^{-\epsilon}}{P_i^{1-\epsilon}} \cdot \eta Y_i \qquad (4)$$

where I assume that firms are sufficiently small such that $\frac{\partial P_i}{\partial p_{ni}(\omega)} = 0$. Optimal pricing is then the constant markup we often see in this class of models.

$$p_{ni}(\omega) = \frac{\epsilon}{\epsilon - 1} \times w_n$$

where $\frac{\epsilon}{\epsilon-1} > 1$ defines the constant mark-up applied by all differentiated goods firms. Profit for a firm from country n trading in country i is

$$\pi_{ni} = \left(M_n^{-\lambda} a_{ni}\right) \times \left[\frac{w_n}{P_i}\right]^{1-\epsilon} \left[\frac{(\epsilon-1)^{\epsilon-1}}{\epsilon^{\epsilon}}\right] \eta Y_i \tag{5}$$

and we see that profit is increasing in competitor prices and market size but decreasing in the wage rate.

3.4 Imitation

Each period, goods sold in country i receive an idiosyncratic imitation shock and are imitated by country i firms at rate $1-\gamma_i \in [0,1]$ where γ_i is the IPR policy chosen by government i. A γ_i choice close to one (zero) is said to have strong (weak) IPR protection. Once imitated, the good is no longer unique and firms compete in prices. Bertrand competition drives price down to marginal cost and quantity demanded increases. If a country n firm is imitated in country n (*i.e.*, it is imitated domestically), the firm cannot export to country i. To simplify the state space, I assume that goods imitated today regain their profitability tomorrow at rate γ_i (*i.e.*, imitation occurs every period but is not permanent).

Suppose a country n good is imitated in country i. There are three possible cases:

Case 1: The wage in country i (w_i) is less than the country n wage (w_n). Bertrand competition implies the equilibrium price is w_i and a country i firm produces the good.

Case 2: The wage in country i (w_i) is greater than the country n wage (w_n) but less than $p_{ni} = \frac{\epsilon}{\epsilon-1} \times w_n$. Bertrand competition implies the equilibrium price is w_i. I assume that the country n firm still produces the good so imitation just limits its markup.

Case 3: The wage in country i (w_i) is greater than $\frac{\epsilon}{\epsilon-1} \times w_n$. Imitation has no effect. The country n firm produces the good and sells it in country i at price $p_{ni} = \frac{\epsilon}{\epsilon-1} \times w_n$.

It is interesting to note that imitation necessarily implies that markups (and profits) are an endogenous function of government IPR policy.

3.5 Innovation

Country n entrepreneurs employ $L_{R,n}$ workers to create new firms using the following production function:

$$F(E_n, L_{R,n}) = L_{R,n}^{\alpha E_n} \tag{6}$$

The term E_n is the time-invariant stock of human capital (*i.e.*, innovative ability) in country n. Define M_n^e as the mass of new firms in country n and $M = [M_1, M_2, ..., M_N]$ as the vector of firms around the world. Define $\gamma = [\gamma_1, ..., \gamma_N]$ as the vector of IPR decisions around the world and γ_{-n} as the vector of all the government IPR choices other than country n. The total value of a country n firm is the sum of discounted domestic and export profits:

$$\begin{aligned} V_n(M,\gamma) &= \sum_{i=1}^{N} \pi_{ni}(M,\gamma) + (1-\delta) \times V_n(M',\gamma) \\ \text{subject to} \\ M' &= \Upsilon(M,\gamma) \end{aligned} \tag{7}$$

where the law of motion for $M \in \mathcal{M}$ is $\Upsilon : \mathcal{M} \to \mathcal{M}$, and firms in all countries exit at an exogenous rate δ. A country n firm trading in country i earns profit $\pi_{ni}(M,\gamma)$ conditional on the vector of IPR policies around the world γ.

Entrepreneurs in country n create new firms until the marginal return is equal to the marginal cost:

$$V_n(M,\gamma) \cdot F_2(E_n, L_{R,n}) = w_n \tag{8}$$

where $F_2(E_n, L_{R,n}) \equiv \frac{\partial F(\cdot)}{\partial L_{R,n}}$.

3.6 Governments

Governments simultaneously choose their level of IPR protection $\gamma_n \in [0,1]$ at the beginning of time to maximize the indirect utility of their consumers.

$$\begin{aligned} \gamma_n^\star &= \underset{\gamma_n}{\operatorname{argmax}}\, U_n(M,\gamma) \\ \text{s.t. } M &= \Upsilon(\gamma_n, \gamma_{-n}) \end{aligned} \tag{9}$$

where the term $U_n(M)$ is the indirect utility function of the country n consumer facing aggregate state M (Equation 1). Feasibility in the labor market requires

$$L_n \geq L_{Z,n} + L_{R,n}(M) + L_{P,n}(M) \tag{10}$$

where $L_{Z,n}$ denotes total employment in production of the homogeneous good Z, $L_{R,n}$ is the labor employed in establishing differentiated firms, and $L_{P,n}$ is total labor employed in the production in the country n composite good sector.

3.7 Equilibrium Definition

Given state M, a *spot market equilibrium* in country n is a set of

1. demand functions:

$$q_{ni} = \left(M_n^{-\lambda} a_{ni}\right)^\epsilon \times \frac{p_{ni}(\omega)^{-\epsilon}}{P_i^{1-\epsilon}} \cdot \eta Y_i;$$

2. price functions:

$$p_{ni} = \begin{cases} \frac{\epsilon}{\epsilon-1} \times w_n & \text{if the good was not imitated or } w_n \times \frac{\epsilon}{\epsilon-1} < w_i \\ w_i, & \text{if the good was imitated but } w_n < w_i < w_n \times \frac{\epsilon}{\epsilon-1}; \end{cases}$$

3. profit functions:

$$\pi_{nn}(M,\gamma) = \gamma_n \times \left[\frac{w_n}{P_n}\right]^{1-\epsilon} \left[\frac{M_n^{-\lambda}(\epsilon-1)^{\epsilon-1}}{\epsilon^\epsilon}\right] \eta Y_n$$

$$\pi_{ni,i\neq n}(M,\gamma) = \begin{cases} \gamma_n \times \left[\frac{w_n}{P_i}\right]^{1-\epsilon} \left[\frac{a_{ni}M_n^{-\lambda}(\epsilon-1)^{\epsilon-1}}{\epsilon^\epsilon}\right] \eta Y_i, & \text{if } \frac{\epsilon w_n}{\epsilon-1} < w_i \\ \gamma_n \times (1-\gamma_i)(w_i - w_n) \times \frac{\left(M_n^{-\lambda}a_{ni}\right)^\epsilon w_i^{-\epsilon}}{P_i^{1-\epsilon}} \cdot \eta Y_i, & \text{if } w_n < w_i < \frac{\epsilon w_n}{\epsilon-1} \\ \gamma_n \gamma_i \times \left[\frac{w_n}{P_i}\right]^{1-\epsilon} \left[\frac{a_{ni}M_n^{-\lambda}(\epsilon-1)^{\epsilon-1}}{\epsilon^\epsilon}\right] \eta Y_i, & \text{otherwise.} \end{cases}$$

4. and price indeces $\{P_n\}$ consistent with Equation 3

such that aggregate spending equals aggregate income ($\eta Y_n = w_n L_n + \Pi_n$) in all countries.[6] As the cross-section of country IPR choices is stable in the data, I restrict my attention to the set of steady-state equilibria.[7] The *Steady-State Open Economy Nash Equilibrium* is a set of government IPR policies $\{\gamma_n\}$ and a firm distribution M such that:

i. M induces a *spot market* equilibrium in each country;

ii. the discounted profit for incumbent firms is defined by Equation 7 $\forall n$;

iii. entrepreneurs generate M_n^e new firms such that Equation 8 holds $\forall n$;

iv. the IPR decision rule γ_n solves the government's problem (Equation 9) $\forall n$;

vi. Labor market mobility within a country and the homogeneous goods sector generates wage rates $\{w_n\}$.

3.8 Education and IPR Choice

The firm entry condition (8) is at the core of the model since it connects government IPR policy, firm profits, and the mass of entering firms. Rearranging (8) yields the following equilibrium expression:

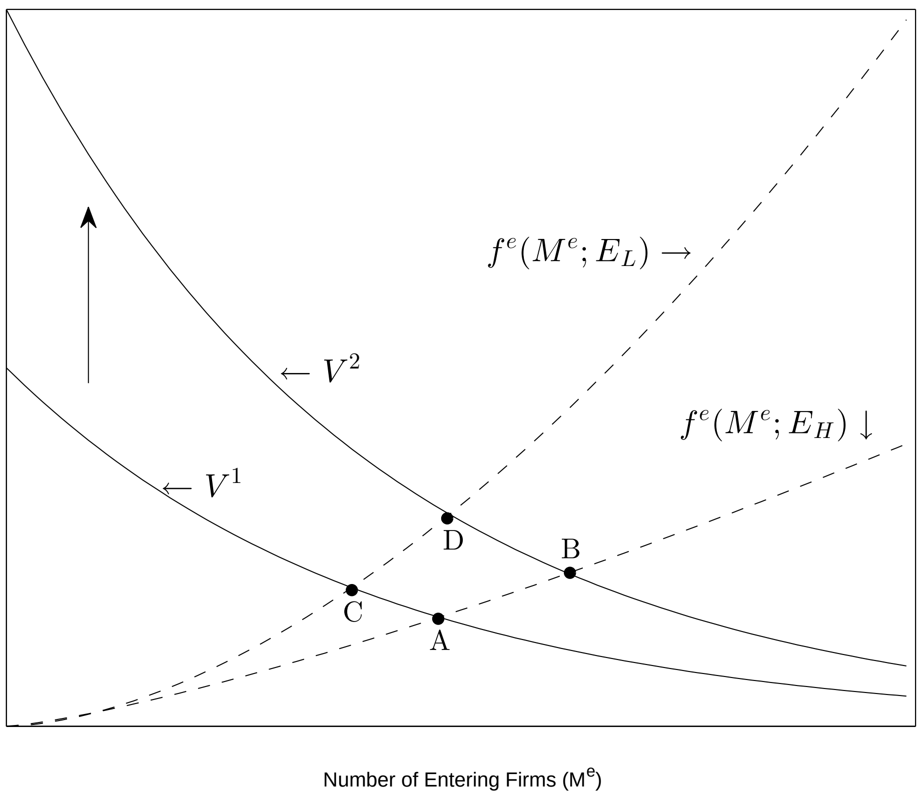
$$V_n(M) = f_n^e \tag{11}$$

[6] Aggregate profit of country n firms is defined as Π_n.

[7] See the appendix for a discussion on the evolution of national IPR policies over time.

where $f_n^e = \frac{w_n}{F_2(E_n, M_n^e)}$. Since firm profit is monotonically decreasing in the number of firms, discounted profits (V) are also monotonically decreasing in the number firms. Hence, we know the left-hand side of (11) is decreasing in the number of entering firms (M_n^e). Further, the "fixed entry cost" f_n^e is monotonically increasing in M_n^e when we constrain $\alpha \times E_n > 0$. Therefore, we know there exists a unique solution (point A) as Figure 1 demonstrates.

Figure 1: Connecting Firm Entry and Profits



Consider two countries H and L facing identical firm value functions V^1 but endowed with different levels of education. Country H is endowed with a higher level of education and therefore faces less decreasing returns to innovative effort since $L_R^{\alpha E_H} > L_R^{\alpha E_L}$ for all values of L_R. This translates to a flatter innovation cost curve f^e. Therefore, there is more entry in Country H than in Country L as we see by comparing points A and C.

Now consider an exogenous shift up in firm profits from V^1 to V^2 due to an increase in government IPR protection. The shift results in an increase in firm entry which increases the number of varieties available for consumption. The increase in firms depends on the slope of the f^e curve which depends on the education endowment in Country n (E_n). In Country H, the increase in protection moves equilibrium entry from point A to point B while in Country L equilibrium entry moves from point C to point D. Since the more innovative Country (H) has a flatter cost curve, the increase in IPR protection leads to a larger increase in entry. Hence, the marginal benefit of increasing IPR is higher in the more educated country and we would expect IPR protection to be positively correlated with education in the full model.

3.9 Patent Protection as a Non-Cooperative Game

Consider two symmetric countries. The fundamental trade-off facing governments is still the same, but now international trade affects country pay-offs. Namely, a country can choose low IPR protection to take advantage of the varieties created abroad, or increase its protection to accommodate the increased responsiveness of its entrepreneurs due to the presence of export markets. Consider the price index for Country 1:

$$\begin{aligned} P_1(M)^{1-\epsilon} &= M_1^{-\lambda\epsilon}\left[\gamma_1 M_1 \times \left(\frac{\epsilon}{\epsilon-1}\right)^{1-\epsilon} + (1-\gamma_1)M_1\right] + \\ & M_{21}^{-\lambda\epsilon} a_{21}^{\epsilon} \times \left[\gamma_1 M_{21} \times \left(\frac{\epsilon}{\epsilon-1}\right)^{1-\epsilon} + (1-\gamma_1)M_{21}\right] \end{aligned} \tag{12}$$

where $a_{11} = 1$, $M_{21} \equiv \gamma_2 M_2$, and I assume $w_1 = w_2 = 1$ for simplicity. Conditional on $M = [M_1, M_2]$, Country 1 has additional incentive to choose a low level of IPR since foreign goods can be imitated by domestic firms. As foreign goods become increasingly important, the marginal benefit from weaker IPR protection increases since countries do not internalize the effects of their IPR protection on others but rather see inventions from other countries as an opportunity to capture rents. This results in countries decreasing their level of IPR protection as they open to trade, ceteris paribus. I call this the “imitation effect.”

On the innovation side, consider the value of a Country 1 idea:

$$V_1 = \left[\underbrace{\gamma_1 \pi_{11}}_{\text{Domestic Profit}} + \underbrace{\gamma_1 \gamma_2 \pi_{12}}_{\text{Export Profit}} \right] \times \frac{1}{\delta} \tag{13}$$

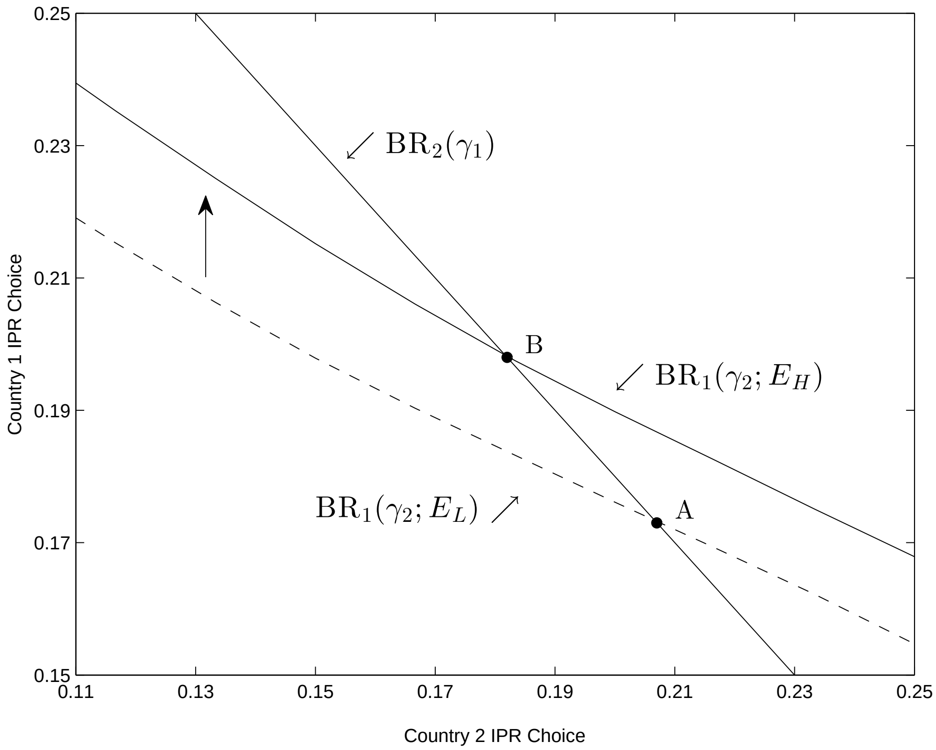
The free entry condition (8) implies that Country 1 research effort is

$$\begin{aligned} L_{R,1} &= (\alpha E_1 V_1)^{1/(1-\alpha E_1)} \\ \Rightarrow \frac{\partial L_{R,1}}{\partial \gamma_1} &= \left[\frac{\alpha E_1}{1-\alpha E_1} \times (\alpha E_1 V_1)^{\frac{\alpha E_1}{1-\alpha E_1}} \right] \times \frac{\partial V_1}{\partial \gamma_1} \end{aligned}$$

The responsiveness of innovation to changes in IPR $\left(\frac{\partial L_{R,1}}{\partial \gamma_1}\right)$ is again greater in more educated countries. With international trade, however, profits are based on both the domestic and export markets – the size of the latter depending on both π_{12} and the IPR protection choice of Country 2. Domestic research effort, therefore, depends not only on the domestic IPR choice but also the IPR choice abroad. Hence, the "innovation effect" depends on the responsiveness of firm profits (domestic and foreign) to increases in IPR protection $\frac{\partial V_1}{\partial \gamma_1}$. If this effect is large (small), then the "innovation effect" ("imitation effect") will dominate and the country will choose to strengthen (weaken) its IPR protection when it opens to trade. Interestingly, both the Country 1 imitation and innovation effects depend on the IPR choice of Country 2 and the converse, of course, is also true. The result is a non-cooperative game in which one country's IPR choice affects the pay-offs and IPR choice of the other countries and international trade acts as the intermediary.

Figure 2 presents the best response curves of each country: $\text{BR}_n(\gamma_{-n}; E)$. Both best response curves are downward sloping regardless of the level of innovative ability indicating that government IPR choices are strategic substitutes. Therefore, an upward shift in the best response curve for Country 1 due to an exogenous increase in innovative ability (E) moves the equilibrium from point A to point B reflecting an increase in the level of IPR protection chosen by Country 1 and a decrease in the level of protection chosen by Country 2. This suggests that increasing the innovative ability of some countries (or just introducing

Figure 2: Best Response Curves



innovative countries) leads other countries to reduce their level of protection in order to extract rents.

The strategic interactions described above are analogous to the classic "Prisoner's Dilemma" game in which strategic players generate an outcome which is collectively sub-optimal. With strategic substitutes, as implied by Figure 2, an increase in the level of patent protection in Country 1 decreases the imitation hazard rate in that country, increasing firm profits, and increasing firm entry. Country 2's response is to lower its level of patent protection to increase the imitation rate of these new foreign imports and decrease prices. This, in turn, decreases export profits of Country 1 firms and decreases the incentive for Country 1 entrepreneurs to create firms, leading to less varieties and welfare for Country 1 residents.

Coordinating these national policies, therefore, may improve upon the aggregate outcome. In the simple two country, symmetric numeric example outlined above, coordination leads both countries to increase their level of patent protection resulting in a 1.3% welfare increase for both countries – a significant amount. In the real world these gains depend on incorporating the complex strategic interactions between asymmetric countries. Assessing the exact welfare impact of coordination is the objective of the remaining sections.

4 Empirical Strategy

The results from Sections 3.8 and 3.9 suggest that patent protection will be positively correlated with innovative ability (E), strategic interactions among countries will have significant effects on the equilibrium, and there are significant gains from coordinating national patent policies. Understanding the extent to which these effects are true and quantitatively important in the data is the objective of the remaining sections.

In order to do this, I first establish a benchmark model that replicates both the national IPR policies and bilateral trade flows observed in the data. I outline the calibration strategy below and discuss results in Section 5. I find that country IPR choices in the benchmark are positively correlated with innovative ability and that trade introduces incentives for countries to use their IPR policy strategically to extract rents from the rest-of- the-world.

Understanding the quantitative importance of international coordination on country-level and aggregate outcomes is the goal of Section 6. Here, the benchmark model provides a baseline to assess the quantitative effects of various forms of international coordination, including TRIPS. These experiments identify not only the impact of different international policies but also the countries which have benefited from the historic lack of coordination.

4.1 Calibration

Matching the model to the data requires choosing parameters $\{\epsilon, \eta, \delta, \lambda, \alpha\}$, a set of countries N, GDP $\{Y_n\}$, wages $\{w_n\}$, bilateral trade weights $\{a_{ni}\}$, and levels of innovative ability

$\{E_n\}$. I use a sample of 35 countries representing about 90 percent of world GDP in 1990,[8] and average number of years of education from Barro and Lee (2000) is used as a proxy for innovative ability $\{E_n\}$. From Section 3.8, government IPR choice is positively correlated with innovative ability (*i.e.*, education) so the rank-ordering of $\{E_n\}$ provides discipline on the rank-ordering of country IPR choices. An increase in α increases the return to protecting IPRs (the "innovative effect") leading to all countries choosing stronger levels of protection so I chose α such that the equilibrium IPR choice by the US government implies an imitation hazard rate of 15% based on Mansfield, Schwartz and Wagner (1981).[9]

The trade weights a_{ni} are pinned down with trade flows. Denote the total trade from country n to country i as T_{ni}, then the model implies the following trade equation:

$$T_{ni} = \begin{cases} \gamma_n\gamma_i X_{ni} \times \left(\frac{\epsilon w_n}{\epsilon-1}\right)^{1-\epsilon} & \text{if } w_i < w_n \\ \gamma_n\gamma_i X_{ni} \left(\frac{\epsilon w_n}{\epsilon-1}\right)^{1-\epsilon} + \gamma_n(1-\gamma_i) X_{ni} w_i^{1-\epsilon} & \text{if } w_i \in [w_n, w_n \times \frac{\epsilon}{\epsilon-1}] \\ \gamma_n X_{ni} \times \left(\frac{\epsilon w_n}{\epsilon-1}\right)^{1-\epsilon} & \text{if } w_n \times \frac{\epsilon}{\epsilon-1} < w_i \end{cases}$$

where $X_{ni} \equiv \left(M_n^{-\lambda} a_{ni}\right)^{\epsilon} P_i^{\epsilon-1} \eta Y_i$. I assume the trade weights are symmetric and take the following log-linear form:

$$\ln(a_{ni}) = a_{const} + a_{dist}\ln(dist_{ni}) + a_{col} colony_{ni} + a_{lang} lang_{ni} + a_{legal} legal_{ni} + u_{ni} \qquad (14)$$

The variable $dist_{ni}$ is the bilateral distance between countries n and i, $colony_{ni}$ is a colony dummy equal to one when country n and i share a colonial history, $lang_{ni}$ is a language dummy equal to one when country n and i share an official language, $legal_{ni}$ is a legal dummy equal to one when country n and i have a common legal system, and u_{ni} is an

[8] The countries included in the sample are Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, China, Colombia, Germany, Denmark, Ecuador, Egypt, Spain, Finland, France, Great Britain, Greece, Indonesia, India, Italy, Japan, Korea, Malaysia, Mexico, Netherlands, Norway, Peru, Portugal, South Africa, Sweden, Thailand, Turkey, United States, and Venezuela.

[9] The authors document that 60% of patented goods in their study were imitated within four years of introduction. In the context of this model, I interpret this to mean 60% of firms experienced imitation at some point during the first four years after introduction.

i.i.d. error term. I identify the parameters $\{a_{colony}, a_{dist}, a_{lang}, a_{legal}\}$ by the corresponding coefficients from a standard log-linear gravity model:

$$\log(T_{ni}) = \text{constant} + \beta_{dist}\ln(dist_{ni}) + \beta_{col}colony_{ni} + \beta_{lang}lang_{ni} + \beta_{legal}legal_{ni} + I_i + E_n + u_{ni} \quad (15)$$

where E_n and I_i are exporter and importer fixed effects, respectively. The constant term a_{const} attenuates the weight applied to all foreign goods independent of location and is identified by average import share.

For the other parameters, I set the elasticity of substitution (ϵ) to 3 which pins down the markup for non-imitated goods. Recall that markups in this model are also a function of the IPR choices of governments. In Section 5, I show that the model generates markups consistent with those found in Broda and Weinstein (2006). International wage data $\{w_i\}$ is from Bureau of Labor Statistics (2012). I follow Eaton and Kortum (2002) in using gross manufacturing output as my input for market expenditure (Y_n) and set the share parameter for the differentiated goods (η) to 0.15 using the average manufacturing expenditure share from United Nations Statistics Division (2007). The firm death rate is set at 10% in line with Bartelsman, Haltiwanger and Scarpetta (2013). The final parameter is the love of variety factor λ which generates concavity in the government's objective function. I use the IPR decisions in the data to reveal the value of λ consistent with these choices.[10]

5 Results

I evaluate the model's ability to replicate the IPR decisions in the data using an index developed by Ginarte and Park (1997) (hereafter GP). The GP index measures the strength of a country's patent regime according to its (1) extent of coverage, (2) membership in international patent agreements, (3) provisions for loss of protection, (4) enforcement mech-

[10]Specific details regarding the calibration are located in the Appendix.

anisms, and (5) duration of protection.[11] While the GP index provides a simple and effective way of mapping the abstract notion of IPR protection into a numerical index, replicating these values is not meaningful. For example, if two countries have GP scores of 2 and 1, respectively, does the first country have a level of protection twice as strong as the first? Not necessarily, but it does imply that Country One chooses a stronger level of IPR protection than Country Two. Accordingly, I evaluate the model by its ability to replicate the ordinal ranking of country IPR choices observed in the data.

Table 5.1: Open Economy Model (Benchmark)

Country	Market Size	Innovative Ability	Wage	Import Share	IPR (γ)	Avg Markup	V	Innovation Elasticity
United States	28.3	1.00	1.00	10.2	0.85	43.0	100.0	1.65
Belgium	0.2	0.70	1.56	77.8	0.37	34.3	19.2	0.62
Great Britain	4.3	0.73	1.02	29.4	0.56	28.9	60.3	0.91
Netherlands	1.6	0.72	1.19	42.3	0.50	32.4	40.5	0.84
Italy	3.8	0.51	1.22	22.0	0.39	29.7	36.2	0.56
Germany	9.0	0.75	1.51	20.1	0.62	39.6	98.1	1.00
Denmark	0.5	0.84	1.15	33.4	0.52	31.4	37.6	1.00
France	4.9	0.63	1.41	26.8	0.50	40.4	57.2	0.76
Japan	19.8	0.77	1.13	3.8	0.65	35.8	118.9	1.04
Sweden	1.1	0.80	1.26	30.9	0.60	38.2	44.8	1.04
Korea	2.3	0.77	0.47	15.2	0.51	36.4	41.0	0.75
Austria	0.9	0.68	1.36	34.6	0.44	37.4	29.3	0.74
Spain	2.7	0.51	1.47	18.3	0.40	41.9	26.4	0.55
Norway	0.5	0.90	1.20	26.8	0.63	37.2	45.9	1.23
Finland	0.7	0.79	1.13	21.7	0.60	33.9	36.1	1.02
Australia	1.4	0.84	0.92	17.0	0.70	36.6	47.5	1.19
Canada	2.9	0.88	0.88	27.2	0.70	36.8	60.3	1.25
South Africa	0.7	0.43	0.42	14.0	0.25	29.0	15.0	0.30
Greece	0.4	0.64	0.65	30.0	0.33	32.7	26.4	0.47
Chile	0.2	0.59	0.39	19.4	0.31	30.8	16.7	0.43
Malaysia	0.4	0.46	0.46	40.2	0.26	29.5	13.2	0.32
Argentina	1.0	0.65	0.42	1.9	0.42	33.8	24.4	0.59
Portugal	0.5	0.36	0.44	32.7	0.16	26.5	27.6	0.20
Indonesia	0.4	0.27	0.20	26.0	0.13	26.7	24.6	0.15
Egypt	0.2	0.30	0.23	21.5	0.13	26.2	39.5	0.16
Mexico	0.5	0.49	0.22	34.1	0.23	28.6	43.7	0.29
China	7.3	0.44	0.14	2.3	0.22	28.2	59.3	0.27
Brazil	0.0	0.31	0.50	2.2	0.15	27.2	7.0	0.17
Thailand	0.8	0.45	0.34	22.0	0.24	28.4	19.1	0.30
Turkey	0.7	0.33	0.58	12.6	0.18	28.7	12.2	0.21
Ecuador	0.0	0.49	0.35	21.9	0.24	28.3	17.4	0.31
Colombia	0.2	0.36	0.38	8.5	0.17	26.6	13.6	0.21
India	1.3	0.31	0.12	5.2	0.14	26.0	62.0	0.16
Venezuela	0.2	0.41	0.62	14.6	0.22	29.8	8.9	0.27
Peru	0.1	0.49	0.30	7.9	0.24	29.4	20.3	0.31
Corr(IPR,X)	0.56***	0.96***	0.70***	0.10	1.00	0.83***	0.66***	0.99***

Notes: Countries presented in descending order according to GP Index. "Market Size" is the country's manufacturing expenditure (Y) as a share of the total sample. "Innovative Ability" is E_n relative to the US value. "Average Markup" is the average markup (% above marina cost) for goods sold in the country after accounting for imitation. All values for the discounted value of a firm (V) are relative to the US value. "Innovation Elasticity" is defined as $\%\Delta M_n^e/\%\Delta\gamma$. Correlation significance indicated by * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

[11] Further specifics are located in the Appendix.

Table 5.1 presents cross-country statistics from the benchmark model, as well as the correlations between these statistics and patent protection. Using the Spearman rank-order correlation (ρ) as a measure for goodness-of-fit, the benchmark model generates heterogeneous IPR decisions consistent with the data ($\hat{\rho} = 0.77$). The correlation is high and statistically significant at one percent so I can reject the null hypothesis that the model's results are uncorrelated with the GP index. Developed, research-intensive countries such as the US, Germany, and Japan choose high levels of patent protection, while developing, imitative countries like India, Brazil, and China choose low levels of patent protection.

The model does a better job at replicating the ordinal ranking of IPR choices among smaller, developing countries. This result indicates that factors outside the model may help explain developed country IPR decisions. For example, while I choose parameters based broadly on observed trade for all manufacturing goods, developed countries may concentrate production and trade within specific manufacturing sub-sectors. The research intensity and IPR sensitivity of these sub-sectors would likely impact the IPR choices of the country.

Markups are 32% on average, consistent with Broda and Weinstein (2006) but they vary as more innovative countries choose stronger IPR protection generating higher markups and profits. The correlation between discounted firm profits (V) and IPR protection is positive and significant (0.66) – consistent with the prediction from Section 3.8. The right-most column indicates that entrepreneurs in countries that choose a high level of patent protection are very responsive to changes in policy reflecting the greater level of innovative ability and higher returns to innovation in these countries. Finally, import share is not significantly correlated with IPR protection suggesting that who a country trades with is more important than its general openness to trade.

5.1 IPR Policy as Strategic Choice

In this section, I compare the benchmark equilibrium to one without international trade. Without trade, the pay-off for country i is independent of the IPR choice of country n so countries choose their level of patent protection based solely on market size (Y) and innovative ability (E). Comparing these equilibria, therefore, identifies the degree to which different countries use their national IPR policy as a strategic mechanism to extract rents from the rest-of-the-world. Table 5.2 presents the equilibrium hazard rates (*i.e.*, one minus the IPR policy chosen), firm profits, and welfare (consumption) effects of moving from autarky to the benchmark open economy model.

Table 5.2: Open Versus Closed Economy Results

		Hazard Rate $(1-\gamma)$			Firm Profit (V)			Welfare
	IM/Y	Open	Closed	Δ	Open	Closed	Δ	$\%\Delta$
All Countries:								
-Mean	22.13	61.32	49.74	11.58	38.57	34.63	3.94	4.36
-Std Dev	14.67	19.94	17.44	6.15	26.33	35.05	18.17	2.24
Developed:								
-Mean	27.31	48.65	39.30	9.35	48.80	56.30	-7.50	3.88
-Std Dev	15.34	17.07	14.24	7.19	28.57	33.99	10.89	2.26
Developing:								
-Mean	15.98	76.36	62.14	14.22	26.43	8.90	17.53	4.94
-Std Dev	11.43	10.34	12.00	3.13	17.37	9.86	15.58	2.15
Model Fit:								
-R^2		0.59	0.54					
-Spearman		0.77	0.73					

Notes: "IM/Y" is the share of total expenditure dedicated to imports. All values for the firm profits (V) are relative to the US value in the open economy model. $\Delta(1-\gamma)$, ΔV, and $\%\Delta$ welfare are the change from the closed economy to the open economy equilibrium.

Introducing trade generates four primary results. First, it increases the model's fit from 0.73 to 0.77 indicating that trade is an important determinant to understanding country IPR choices. Second, all countries reduce their level of IPR protection leading to a 11.58% increase in the average imitation hazard rate; hence the *imitation effect* dominates the *innovation effect* (Section 3.9). The use of IPR policy as a strategic tool to extract rents is greater in developing countries as trade leads to a 14.22% increase in the hazard rate for developing, imitative countries (*e.g.*, Brazil, China, Mexico) compared to a 9.35% increase for developed, innovative economies (*e.g.*, United States, Germany, Japan).

Third, opening to trade has a large effect on firm profitability, which is not obvious since trade introduces foreign competition as well as export markets. Introducing trade increases the value of a firm in most countries (3.94%, on average), though firms in developed countries generally see their profits decrease (7.50% on average) while average profits for firms in developing countries increase 17.53% on average. Hence, trade liberalization appears to have a disproportionately large benefit for entrepreneurs in developing countries as trade gives them access to large foreign markets. Firms in developed countries, in contrast, are already located in relatively large markets so a reduction in trade barriers introduces more competition than it does market potential.

Fourth, international trade increases average welfare by 4.36%, on average. Developing countries generally benefit more from trade (4.94%) than developed countries (3.88%). Large countries with relatively low openness to trade like the US experience smaller increases in welfare while smaller countries that trade a lot such as Austria, Belgium, Denmark, and Mexico generally experience large increases in welfare.

Isolating the degree to which different countries use their IPR policies strategically is difficult since there are several forces at play in the general equilibrium. For example, given the IPR choices of the rest-of-the-world and the implied distribution of firms (M) in the closed economy equilibrium, country i may choose to modify its IPR choice when exposed to trade. Other countries, however, can respond to this modification and change their own IPR policies. In the equilibrium, each country's IPR decision maximizes welfare conditional on the actions of the rest-of-the-world. Consequently, the strategic play and the resulting welfare of country i may be confounded if we just compare the closed economy and open economy equilibria. To address this issue I compare the change in welfare of opening economies to trade (using the calibrated trade weights) when (a) country IPR policies are fixed at their closed economy level and when (b) countries are allowed to change their IPR policies in response to trade.

The first column of Table 5.3, shows that opening to trade conditional on the IPR choices in the closed economy model (*i.e.*, "IPR Fixed") generates welfare gains of 4.77%, on average. This exercise is the analog to the standard "gains from trade" experiment in the international trade literature and yields results consistent with that literature.[12] In the second column are the equilibrium results from Table 5.2 when countries can change their IPR policies (*i.e.*, "IPR Flexible").

[12]For example, see Eaton and Kortum (2002) and Arkolakis, Costinot and Rodriguez-Clare (2012).

Table 5.3: Decomposing the Gains from Trade

		%Δ Welfare from Closed Economy Model		
	IM/Y	IPR Fixed	IPR Flexible	Difference
All Countries:				
- Mean	22.1	4.77	4.36	-0.41
- Std Dev	14.7	2.36	2.24	0.66
Developed:				
- Mean	27.3	4.73	3.88	-0.85
- Std Dev	15.3	2.62	2.26	0.59
Developing:				
- Mean	16.0	4.82	4.94	0.12
- Std Dev	11.4	2.09	2.15	0.20

Notes: "IM/Y" is the share of total expenditure dedicated to imports. Country-specific results located in the Appendix.

The third column of Table 5.3 compares the first two and reveals that opening to trade and allowing countries to re-optimize their IPR policy yields lower average welfare gains (4.36% versus 4.77%). This suggests that countries do indeed use IPR policy as a strategic mechanism to extract rents and these actions lead to a sub-optimal aggregate outcome – consistent with the "Prisoner's Dilemma" analogy put forth by Deardorff (1996).[13]

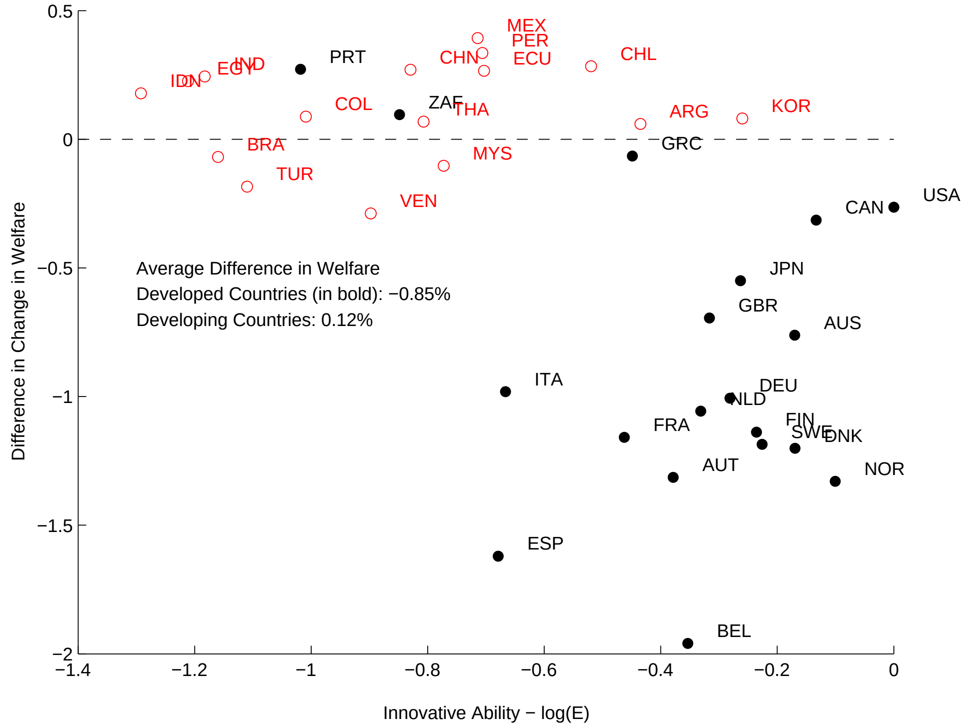
Not all countries are worse off, however, as Figure 3 illustrates that many countries (14 of 35) experience net welfare increases. Of these, most (12) are developing countries which provides evidence that these countries use their domestic IPR policy to "beggar" their neighbors from the North.

6 The Gains From Coordination

The above results indicate that strategic use of national IPR policies by countries has led to a suboptimal aggregate outcome and this suggests there may be significant welfare gains of coordinating these policies. Understanding the extent to which international agreements like

[13]The idea is that moving from autarky to an open economy introduces strategic incentives between countries. The degree to which different countries adjust their IPR policy in the equilibrium identifies the extent to which they use their domestic IPR policy as a strategic lever to potentially extract rents from their neighbors.

Figure 3: Effects of Strategic Play by Country



TRIPS affect innovative effort, firm profits, and welfare across countries and in aggregate is the goal of this section.

First, I identify the Pareto optimal allocation by solving an unconstrained Planner's problem. This experiment quantifies the total welfare gains of coordination absent any implementation costs. Next, I impose individual rationality constraints and solve for the set of IPR policies acceptable to both developed and developing countries. This experiment identifies the optimal allocation when governments must approve the agreement as in the WTO. In both of these experiments, I assume the Planner maximizes total welfare which necessarily ignores issues of cross-country equity. Finally, I evaluate the potential effects of TRIPS on innovation, firm profits, and welfare.

6.0.1 *The First-Best Policy* The natural question is the degree to which coordinating these policies via an international economic agreement can improve aggregate welfare and whether all countries benefit. To answer this question, I solve a Planner's Problem in which the

Planner chooses the set of national IPR policies $\{\gamma_n^{fb}\}_{n=1}^N$ to maximize total welfare. Since the Planner internalizes all of the externalities countries place on each other, the result is the optimal allocation. As with the governments in the benchmark model, I assume the Planner makes its choice at the beginning of time and commits to this policy for the indefinite future. Hence, the Planner's problem is

$$\begin{aligned} \{\gamma_n^{fb}\}_{n=1}^N &= \underset{\{\gamma_n\}_{n=1}^N}{\text{argmax}} \left[\sum_{n=1}^N U_n(M^{fb}, \gamma_n) \right] \\ \text{s.t. } M^{fb} &= \Upsilon(\gamma) \end{aligned} \tag{16}$$

where Υ is the law of motion implied by the set of national IPR policies and M^{fb} is the steady-state distribution of firms around the world. Table 6.1 presents the results.

Table 6.1: Equilibrium Effects of the Pareto Optimal IPR Policies (%Δ)

	Hazard		Discounted Profits (V)		Welfare	
	Avg. Δ	%Δ < 0	Small Economy	Equilibrium	Small Economy	Equilibrium
All Countries:						
-Mean	-44.0	100.0	33.8	30.3	0.11	0.46
-Std Dev	26.7	0.0	38.1	37.9	2.73	2.99
Developed:						
-Mean	-28.7	100.0	8.2	4.3	2.03	2.56
-Std Dev	22.7	0.0	22.3	21.7	1.90	2.13
Developing:						
-Mean	-62.2	100.0	64.1	61.0	-2.16	-2.03
-Std Dev	18.7	0.0	29.8	28.8	1.55	1.62
Total Welfare						1.30

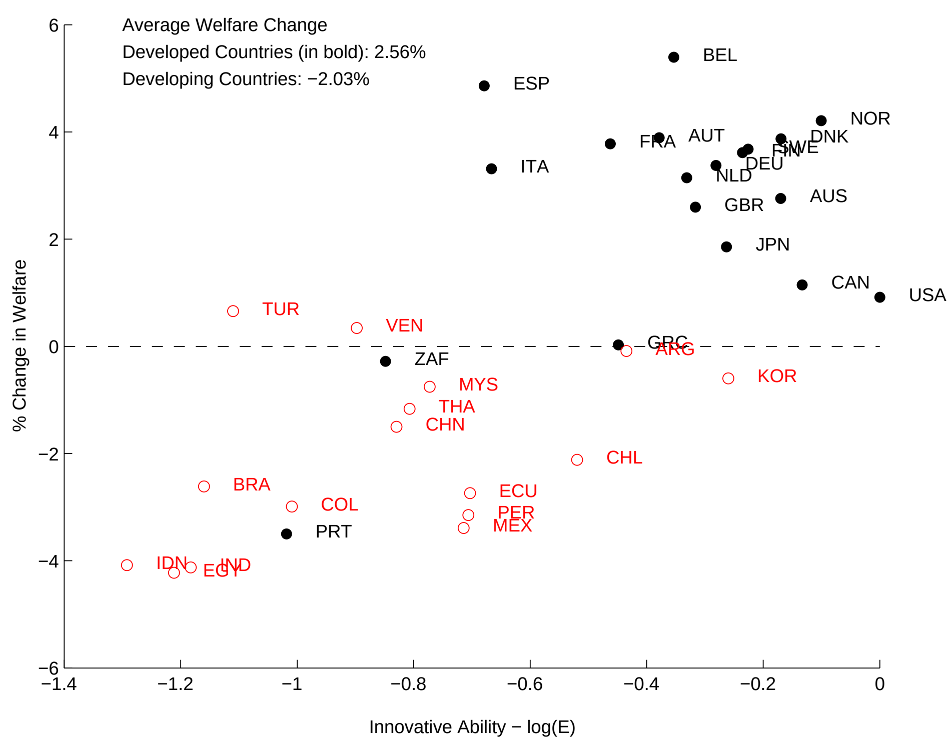
Notes: Country-specific results located in the Appendix. "Hazard" refers to the imitation hazard implied by the model: $1 - \gamma_i$. "Avg. Δ" is the average change in the hazard rate across countries. "%Δ < 0" is the percent of countries in which the hazard rate decreases (*i.e.*, patent protection becomes stronger).

The Planner's choice of national IPR policies increases the average level of patent protection in the world – amounting to a 44.0% decrease in the average imitation rate. Further, all countries adopt a stronger level of IPR protection though the change in hazard rate for developed countries is less stark (28.7%) than it is for developing countries (62.2%).

Entrepreneurs in most countries are better off due to the stronger level of protection, particularly if located in a developing country (61.0% vs 4.3%). Average country welfare increases 0.46%, about 10% of the estimated average gains from trade, and total welfare increases 1.30%.

It is important to note that firm profits and consumer welfare in the general equilibrium are a function of both the direct effect of the policy change and general equilibrium effects as entrepreneurs in all countries modify their innovative efforts in response to the policy change. Consequently, it is difficult to disentangle the various forces in the general equilibrium. The "Small Economy" columns in Table 6.1 attempts to do this by presenting the profit and welfare response when a country adopts the Planner's choice but all other countries remain at the IPR choice in the benchmark model. Comparing these columns to the general equilibrium columns reveals that the interactions between countries in the general equilibrium decreases firm profit (from 33.8% to 30.3%) but increases welfare (from 0.11% to 0.46%) and these results are robust across developed and developing countries. Hence, country interactions in the general equilibrium lead to increased firm entry across countries which decreases profits (relative to the partial equilibrium) but increases welfare.

Figure 4: Welfare Effects by Country (First-Best)



But could this set of policies result from an international agreement? Not likely since maximizing total welfare has significant redistributive effects. The average resident in a developing country experiences a 2.03% decrease in welfare under this policy while the average resident in a developed country experiences a 2.56% increase in welfare. Only two (of 16) developing countries are better off under this set of IPR policies compared to 17 (of 19) developed countries. Hence, even in the first-best allocation I find that coordinating national patent policies results in a substantial redistribution of welfare. These results provide further evidence that developing countries are substantially better off in an environment in which countries do not cooperate in setting their IPR policies. This seems consistent with the reluctance of developing countries to negotiate on IPR policy historically.

6.0.2 The Optimal Feasible Policy As already noted, the large redistribution of welfare from developing to developed countries in the first-best allocation suggests that such an agreement would not result in a political equilibrium. Quantifying the welfare gains when the solution must maximize welfare and also be politically feasible is the goal of this section. Accordingly, I solve for the allocation which maximizes total welfare (Equation 16) subject to political agreement among the member countries. For the WTO this amounts to three-quarters majority rule. Table 6.2 presents the results.

Table 6.2: Equilibrium Effects of the Optimal, Feasible IPR Policies (%Δ)

	Hazard		Discounted Profits (V)		Welfare	
Country	Avg. Δ	%Δ < 0	Small Economy	Equilibrium	Small Economy	Equilibrium
All Countries:						
-Mean	-31.0	88.6	20.5	18.4	0.39	0.71
-Std Dev	30.6	32.3	37.8	38.4	2.58	2.83
Developed:						
-Mean	-18.5	78.9	0.4	-2.8	2.04	2.54
-Std Dev	27.2	41.9	23.6	23.2	1.80	2.01
Developing:						
-Mean	-45.8	100.0	44.5	43.4	-1.57	-1.46
-Std Dev	28.2	0.0	37.9	38.1	1.93	2.00
Total Welfare						1.27

Notes: Country-specific results located in the Appendix. "Hazard" refers to the imitation hazard implied by the model: $1-\gamma_i$. "Avg. Δ" is the average change in the hazard rate across countries. "%Δ < 0" is the percent of countries in which the hazard rate decreases (*i.e.*, patent protection becomes stronger).

The best, politically-feasible agreement increases average welfare 0.71% and captures 98% of the potential total welfare gains.[14] Further, 27 of the 35 countries experience increases in welfare. As in the first-best allocation, the Planner chooses stronger IPR rates for most countries (88.6%) and particularly in developing countries (100.0%), leading to greater profits and a transfer of welfare from developing to developed countries. The addition of the political-feasibility constraint (*i.e.*, super-majority rule) leads to a less stark change in IPR for developing countries (45.8% decrease in the hazard rate versus 62.2% in the first-best) and less severe transfer of utility (−1.46% versus −2.03%). The change in utility for the average developing country, however, is still large and negative as a handful of countries experience significant welfare losses. In the political equilibrium, however, countries like Egypt (−4.55% loss in welfare), India (−4.46%), and Mexico (−3.71%) are not numerous enough to block passage.

6.1 TRIPS

The final task is to evaluate the quantitative effects of TRIPS on country innovation, firm profits, and welfare - both the distribution of changes in country welfare and the aggregate effect. My approach to quantifying the degree to which TRIPS affects the distribution of country welfare is not to contrast a specific equilibrium implied by TRIPS, which is difficult since there isn't a clear mapping between the agreement and the model, but rather to show how the equilibrium changes as we increase the minimum level of IPR protection exogenously. In order to isolate the effects of the floor on equilibrium firm and consumer behavior, I assume that all countries, even those unconstrained by the policy floor, are unable to change their IPR policy. Table 6.3 presents the results.

The first set of columns shows the share of countries constrained as I increase the policy floor. Since developing countries tend to choose weaker levels of patent protection in the benchmark model, these countries become constrained first and nearly all developing

[14] The gain in average welfare is more here than the change generated by the first-best policy due to the fact that Planner maximizes total welfare in a world composed of asymmetric countries rather than average country welfare.

Table 6.3: Potential Effects of TRIPS

	Countries Constrained (%)		Average %Δ in Profit			Average %Δ in Welfare		
Policy Floor	Developed	Developing	All	Developed	Developing	All	Developed	Developing
One-Quarter	5.3	37.5	0.9	-1.5	3.7	0.1	0.2	-0.0
One-Half	31.6	87.5	8.8	-4.7	24.8	0.5	1.2	-0.3
Three-Quarters	68.4	100.0	20.1	0.2	43.8	0.7	1.9	-0.8
USA IPR Policy	94.7	100.0	34.5	11.8	61.5	0.6	2.5	-1.7

Notes: "Policy Floor" is defined as the minimal IPR policy allowed by the WTO relative to the benchmark IPR policy chosen by the USA.

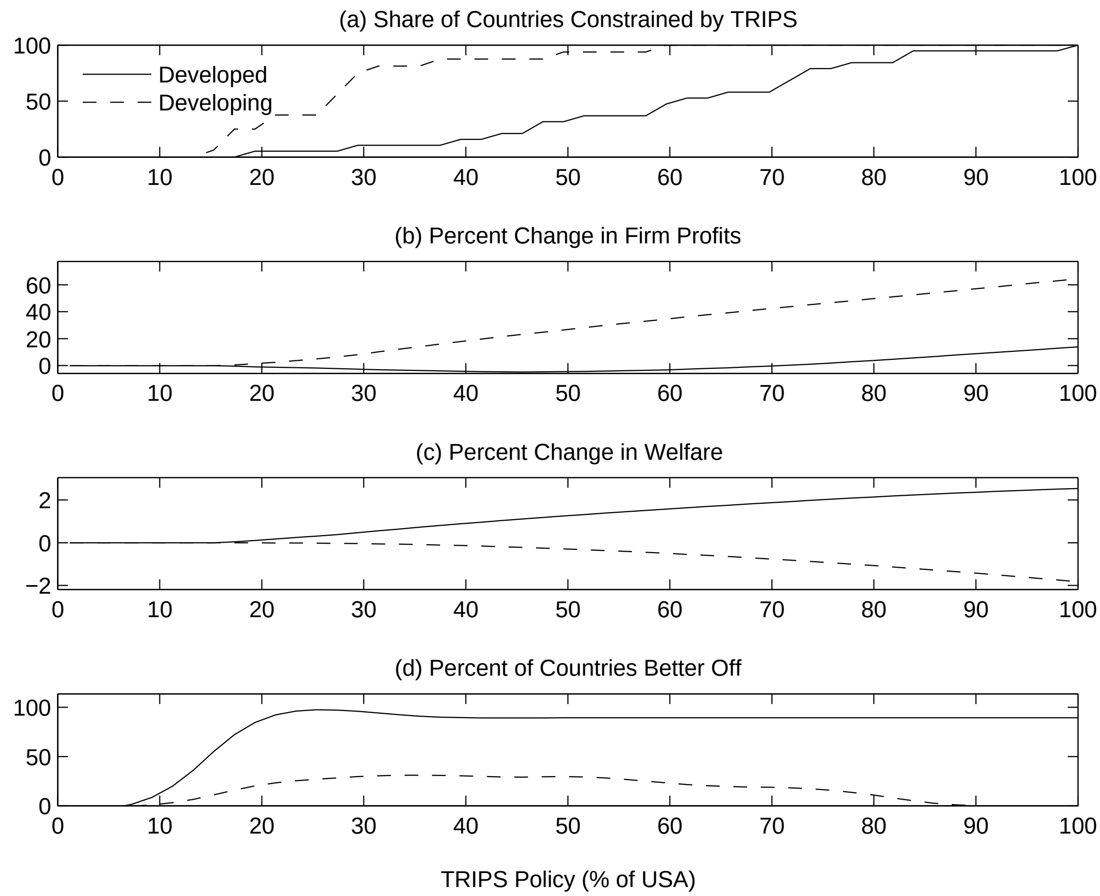
countries are constrained when the policy floor is equal to one-half of the benchmark value chosen by the United States. Developed countries, in contrast, choose both higher levels of IPR protection in the model and are more evenly distributed so they are constrained at a higher floor and the rate at which countries become constrained is more linear.

The next set of columns shows that firm profitability in developing countries increases substantially as stronger levels of IPR protection both at home and with trading partners lead to higher profits. At low policy floors, the effect is more pronounced in developing countries – profits increase 24.8% on average for a policy floor half the value of the IPR policy chosen by the United States. This indicates that governments in developing countries trade off a lot of foregone profits in order to decrease the price of foreign goods.

The story is more interesting in the developed world. In the equilibrium, the large increase in profitability in developing countries leads to more firm entry in these countries and more foreign competition for firms in the North. The increase in competition leads to a decrease in firm profitability in developed countries for all but the highest policy floors. This is an interesting result because it suggests that the equilibrium effect of TRIPS could be to actually *decrease* profits for developed country business leaders – a major proponent of stronger IPR protection in the South.

The natural question is "how does TRIPS affect welfare in different countries?" The final columns of Table 6.3 show that imposing a policy floor has a significantly negative welfare effect on developing countries even when few countries are actually constrained. Figure 5 demonstrates that nearly all of the developed countries in the sample are better off when a policy floor is implemented; even when the policy floor constrains only a small fraction ($< 25\%$) of the countries in the sample. Developing countries are generally worse off though

Figure 5: Equilibrium Effects of a Policy Floor



the welfare effects are more heterogeneous. At a low policy floor, welfare improves for some developing countries and the average effect is nearly zero. As the the policy floor increases and more developing countries are constrained, we observe a decrease in both the number of countries better off and the average change in welfare. When the IPR floor is set at the level chosen by the US in the benchmark economy, the average developing country experiences a 1.7% decrease in welfare and all developing countries are worse off. In comparison, developed countries experience, on average, a 2.5% increase in welfare and nearly all of these countries are better off.

Of course the exact quantitative impact depends on mapping between the model and TRIPS, but the qualitative effect is clear – residents in developed countries benefit from a policy floor. This comes at the expense of residents in developing countries whose welfare losses could be substantial. Incorporating technology spillovers would likely amplify these effects as shown by Atkeson and Burstein (2011), though disciplining these effects with data is difficult.

7 Conclusion

The creation of the TRIPS agreement as part of the WTO Uruguay Trade Round suggests there may be significant gains to coordinating national patent policies but there exists little research to support this conjecture. This paper fills that void by quantifying the potential gains of coordination. At the core of the analysis is a multi-country, non-cooperative model in which governments choose their level of patent protection and international trade acts as the intermediary connecting country pay-offs via both export markets and foreign imports. I use differences in educational attainment, GDP, and calibrated trade frictions to generate country IPR decisions and trade flows consistent with the data prior to the implementation of TRIPS. I then use this as a benchmark to quantify the effects of coordinating national IPR policies.

I find that all countries use their patent policies strategically to extract rents (profits and welfare) from others and that this effect is more pronounced in developing countries. Under the first-best allocation, all countries increase their level of patent protection leading to greater profits and more innovation. Aggregate welfare increases but not all countries are better off as stronger levels of patent protection leads to higher consumer prices and lower utility in developing countries.

Whether these gains are attainable in the real world is another question as the substantial redistribution of welfare from developing to developed countries in the first-best allocation suggests that such an allocation is not politically feasible. Imposing political-feasibility has little effect on the overall gains, however, as the majority of the aggregate welfare gains are attainable in a political equilibrium. Further, implementation of a policy floor as in TRIPS also increases aggregate welfare by the same mechanism – transferring welfare from developing to developed countries. These results also suggest that developing countries have benefited substantially from the historically low level of international coordination of national patent policies.

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Appendix

A Intellectual Property Rights

In contrast to tariffs, IPR protection is a national policy that applies to all goods sold in that country, regardless of origin, and it refers to any protection afforded to the creator of an idea. In this paper I am interested primarily in the protection of technology (i.e, utility patents), but IPR protection can also refer to copyrights, trademarks, or even trade secrets. How these ideas are protected is equally broad, encompassing fundamental issues such as the definition of a patent right, the duration of that right, breadth of patentability, viability of enforcement institutions, and penalties for infringement. Further, a firm choosing not to patent an idea can also gain from increased IPR protection. For example, non-disclosure agreements are a form of protection intended to prevent the employees of one firm from divulging trade secrets to other firms. Therefore, a firm in one country has to file for a patent in each country it desires protection. The inability of countries to discriminate their level of IPR protection based on national origin also limits the strategic interactions between two specific countries but strategic incentives between one country and the rest-of-the-world still exist.

Figure A.1 presents the average GP index for each country from 1960 to 1990. We see that developed countries such as the US, Germany, and Japan choose high levels of IPR protection, while developing countries like China, Brazil, and Mexico have lower levels of IPR protection. Table A.1 demonstrates that the cross-section of government IPR protection is relatively stable across time, though the average GP index does increase.

The sharp increase in IPR protection after 1990 is due to the implementation of the TRIPS agreement.[15] The creation of TRIPS and its inclusion in the WTO suggests the existence of large externalities between countries. In particular, weak levels of IPR

[15] While developed countries weren't required to adhere to the new IPR standards until 1996, the increase in IPR protection in 1995 suggests that countries began modifying their IPR policies in preparation. Most developing countries were required to adhere by 2001.

Figure A.1: GP Index by Country (1960-1990)

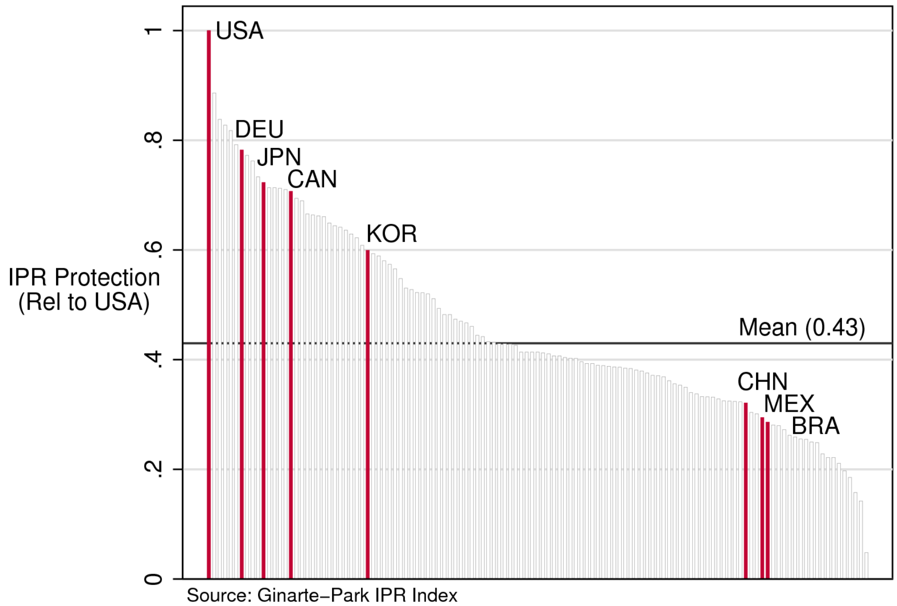

Table A.1: The GP Index Across Time

Year	Mean	Median	Std Dev
1960	0.46	0.41	0.17
1970	0.48	0.44	0.19
1980	0.46	0.41	0.19
1990	0.46	0.41	0.20
2000	0.63	0.63	0.20
2005	0.69	0.69	0.18

Source: Ginarte and Park (1997) where I normalize the GP index by the US. Special thanks to Walter Park for providing updated scores for 2000 and 2005.

protection chosen by developing countries may have significant negative effects on the returns to innovation for firms in developed countries.

A.1 *IPR Policy Across Time* The analysis in the paper focused on comparative statics in the steady-state but the results also have dynamic implications – particularly related to the tension between openness to trade and innovative ability. The model predicts that the increase in world trade since 1960 will encourage countries to decrease their level of patent protection while the observed increase in education attainment (*i.e.*, innovative ability) for

Table A.2: Breaking Down the GP IPR Index

Category / Criteria		
(1) Coverage (COV)	Available	Not Available
Patentability of pharmaceuticals	1/7	0
Patentability of chemicals	1/7	0
Patentability of food	1/7	0
Patentability of plant and animal varieties	1/7	0
Patentability of surgical products	1/7	0
Patentability of microorganisms	1/7	0
Patentability of utility models	1/7	0
(2) Duration of Protection (DUR)	Full	Partial or No Protection
where full duration is 20 years from the date of application (or 17 years from the date of grant, for grant-based patent systems) and f equals the duration of protection as a fraction of the full duration.	1	$0 < f < 1$
(3) Enforcement (ENF)	Available	Not Available
Preliminary Injunctions	1/3	0
Contributory Infringement	1/3	0
Burden-of-Proof Reversal	1/3	0
(4) Membership in International Treaties (MEM)	Available	Not Available
Paris Convention and Revisions	1/3	0
Patent Cooperation Treaty	1/3	0
Protection of New Varieties (UPOV)	1/3	0
(5) Restrictions on Patent Rights (RIG)	Does Not Exist	Exists
Working Requirements	1/3	0
Compulsory Licensing	1/3	0
Revocation of Patents	1/3	0
Total Points Possible	5	0

both developed and developing countries will encourage countries to strengthen protection.[16] The fact that patent protection (as measured by the GP index) has increased over time for most countries (though the cross-section is stable) indicates that the increase in innovative ability is the dominant force.[17] This result is consistent with Kortum and Lerner (1998) who show that improvements in the management of research & design resources over time are responsible for the observed increase in firm patenting since the late 1980s.

[16]See Barro and Lee (2000).

[17]Lerner (2002) documents this increase but also notes that some developing countries chose to decrease their level of patent protection during the 1960s and 1970s.

B Data Sources

Table B.1: Data Sources

Variable	Description	Source
IPR_n	Patent regime strength	Ginarte and Park (1997)
w_n	Wage	US Bureau of Labor Statistics
E_n	Innovative ability (avg yrs of education)	Barro and Lee (2000)
Y_n	Manufacturing expenditure	INDSTAT (2010)
T_{ni}	Bilateral trade flows	Feenstra et al. (2005)
colony_{ni}	Colonial heritage dummy	Helpman et al. (2008)
dist_{ni}	Distance (capitals)	Helpman et al. (2008)
lang_{ni}	Common language dummy	Helpman et al. (2008)
legal_{ni}	Common legal system dummy	Helpman et al. (2008)

C Calibration – The Nitty Gritty

Define the set of remaining parameters as $\theta = \{\lambda, \alpha, a_{const}\}$ which I pin-down by jointly estimating θ using via a method of moments approach. Specifically, I solve the model for a given θ and compute a set of moments M_θ. The optimal set of parameters $\hat{\theta}$ is defined as:

$$\hat{\theta} = \underset{\theta}{\operatorname{argmin}}[M'_\theta M_\theta] \tag{C.1}$$

where

$$M_\theta = \begin{bmatrix} 1-\rho(\hat{\theta}) \\ (1-\gamma^d_{USA}) - (1-\gamma_{USA}(\hat{\theta})) \\ \text{Imp. Share}^d - \text{Imp. Share}(\hat{\theta}) \end{bmatrix}$$

The moment ρ is the Spearman rank order correlation discussed in Section 5 and is identified by λ. The parameter α scales the innovative ability of all countries, increasing the returns to protecting intellectual property. It is identified by the imitation hazard rate generated by US patent law $(1-\gamma_{USA})$. The final parameter is the trade weight constant a_{const} which changes the attractiveness of foreign goods to domestic consumers independent of the location of the exporting country. Hence, it's identified by the average import share in the country sample. Since the model is just- identified and the identification is strong, I can choose the parameters the exactly match the moments. That said, equation C.1 is non-linear which makes finding a global minimum difficult. I mitigate this issue by searching for $\hat{\theta}$ using a simulated annealing minimization algorithm to limit the risk of falling into local minima. Table C.1 presents the results of the calibration.

Table C.1: Calibration Strategy

Variable	Description	Identification Rationale	Value
N	Number of Countries	Selected share of world GDP	35
ϵ	Elasticity of substitution	Broda and Weinstein (2006)	3
η	Average Mfg share of GDP	United Nations Statistics Division (2007)	0.15
δ	Firm death rate	Bartelsman, et al (2013)	0.10
a_{colony}	Trade weight – colonial history dummy	$\beta_{colony} = 0.376$ from gravity model (15)	1.1318
a_{dist}	Trade weight – bilateral distance	$\beta_{dist} = -1.03$ from gravity model (15)	-0.3252
a_{lang}	Trade weight – language dummy	$\beta_{lang} = 0.300$ from gravity model (15)	1.1203
a_{legal}	Trade weight – legal dummy	$\beta_{legal} = 0.347$ from gravity model (15)	1.1077
λ	Love of variety preference parameter	Spearman rank-order statistic (ρ)	0.1498
α	Scaling factor for innovative ability	US imitation hazard rate $(1 - \gamma_{USA}) = 0.15$	1.7284
a_{const}	Average import share	24% based using Y_n and T_{ni}	0.5634

D Existence Proof

Proposition 1 *(Existence) There exists an equilibrium.*

Proof

Given the IPR decision rules of governments Ψ, standard techniques show the value functions exist conditional on M. As for entry, the left-hand side of Equation (8) is continuous, monotonically decreasing, and takes a value of infinity when $L_{R,n} = 0$ and zero when $L_{R,n} = \infty$. Since the right-hand side is fixed, there exists a unique solution $L^{\star}_{R,n}(M)$.

Define the function $f_n : [0,1]^{N-1} \to [0,1]$ as the country n best response function and f as the corresponding vector-valued function. Without loss of generality, look at the problem for country n and consider a small change in protection choices for the other countries. Firm innovation decisions are clearly continuous in the protection level, hence the distributions (M) are also continuous. The small change leads to a continuous change in country n's IPR policy and the function is continuous.

The set $[0,1]^N$ is a closed ball by construction. Therefore, we have a continuous function f on a closed ball, and there exists at least one fixed point by Brouwer's Fixed Point Theorem. ■

Appendix - For Online Publication Only

E Solution Algorithm

In this section I outline the algorithm to solve the equilibrium where agents (governments, firms, consumers) make decisions taking the aggregate state as given. The loop terminates when policy, trade, and innovation decisions and the set of country firm distributions (M) are consistent.

1. Given a guess for the aggregate state $\{\gamma_n, M_n\}$
   (a) Solve for the steady-state IPR choices around the world $\{\gamma'_n, M'_n\}$. All agents in country n take M as given. Each government chooses the utility maximizing level of IPR protection. This amounts to searching for the γ'_n that maximizes steady-state welfare and the result is the steady-state IPR choice and mass of firms in country n (γ'_n, M'_n).
2. Compute the distance between the old and new aggregate states: $\| M - M' \|_\infty$. Note that M is a monotonically increasing, continuous function of γ so checking $\| \gamma - \gamma' \|_\infty$ is also small is redundant.
3. If the new aggregate state is sufficiently close to the old guess then we've found the equilibrium. If not, update the guess for the aggregate state and return to (1a).

F Detailed Results

Table F.1: Open Versus Closed Economy Results by Country

		IPR Policy (γ)			Firm Profit (V)			Welfare
Country	IM/Y	Open	Closed	Δ	Open	Closed	Δ	%Δ
United States	10.19	0.15	0.14	0.51	100.00	102.10	-2.10	0.62
Belgium	77.76	0.63	0.40	23.21	19.18	27.11	-7.93	10.60
Great Britain	29.43	0.44	0.38	6.49	60.26	70.47	-10.21	2.30
Netherlands	42.28	0.50	0.39	11.74	40.55	53.03	-12.48	3.92
Italy	21.99	0.61	0.56	4.72	36.24	48.49	-12.25	3.11
Germany	20.07	0.38	0.35	2.79	98.10	121.38	-23.28	2.93
Denmark	33.35	0.48	0.28	20.56	37.59	47.67	-10.08	5.49
France	26.81	0.50	0.46	3.87	57.17	78.12	-20.95	3.54
Japan	3.81	0.35	0.34	0.36	118.87	131.47	-12.60	1.46
Sweden	30.95	0.40	0.32	8.23	44.77	56.73	-11.96	3.86
Korea	15.22	0.49	0.34	15.23	40.96	35.59	5.37	2.89
Austria	34.61	0.56	0.41	14.82	29.33	42.02	-12.69	5.53
Spain	18.31	0.60	0.57	3.24	26.36	42.58	-16.21	5.25
Norway	26.85	0.37	0.23	14.73	45.94	57.32	-11.38	4.77
Finland	21.69	0.40	0.32	7.66	36.07	44.82	-8.75	3.64
Australia	16.97	0.30	0.28	2.41	47.50	53.22	-5.73	2.11
Canada	27.21	0.30	0.25	4.58	60.35	63.85	-3.50	1.19
South Africa	13.98	0.75	0.63	11.90	14.96	8.71	6.25	2.51
Greece	29.99	0.67	0.45	21.18	26.38	15.81	10.57	6.00
Chile	19.42	0.69	0.49	19.41	16.74	8.08	8.66	5.27
Malaysia	40.21	0.74	0.61	13.82	13.22	7.09	6.14	3.68
Argentina	1.90	0.58	0.45	13.67	24.44	20.49	3.95	2.49
Portugal	32.67	0.84	0.69	14.62	27.60	4.86	22.74	4.88
Indonesia	26.05	0.87	0.77	10.46	24.56	2.21	22.35	4.05
Egypt	21.54	0.87	0.75	12.16	39.48	1.80	37.68	5.68
Mexico	34.11	0.77	0.58	18.76	43.69	7.01	36.68	7.24
China	2.29	0.78	0.63	14.90	59.29	25.74	33.55	3.10
Brazil	2.19	0.85	0.76	9.34	7.04	0.05	6.99	9.47
Thailand	22.02	0.76	0.62	13.66	19.11	9.35	9.76	3.35
Turkey	12.62	0.82	0.72	10.51	12.18	6.14	6.04	2.91
Ecuador	21.94	0.76	0.58	18.56	17.35	2.21	15.14	8.63
Colombia	8.52	0.83	0.69	13.83	13.57	2.73	10.84	4.72
India	5.15	0.86	0.74	12.33	62.00	5.52	56.48	4.58
Venezuela	14.59	0.78	0.65	12.63	8.86	4.65	4.21	3.76
Peru	7.87	0.76	0.58	18.28	20.33	3.68	16.65	7.17
Model Fit:								
-R^2		0.59	0.54					
-Spearman		0.77	0.73					

Notes: Countries in descending order according to Ginarte-Park Index. "IM/Y" is the share of total expenditure dedicated to imports. All values for the firm profits (V) are relative to the US value in the open economy model. $\Delta\gamma$, ΔV, and %Δ welfare are the change from the closed economy to the open economy equilibrium.

Table F.2: Decomposing the Gains from Trade by Country

		%∆ Welfare from Closed Economy Model		
Country	Import Share	IPR Fixed	IPR Flexible	Difference
United States	10.2	0.88	0.62	-0.26
Belgium	77.8	12.56	10.60	-1.96
Great Britain	29.4	2.99	2.30	-0.69
Netherlands	42.3	4.97	3.92	-1.06
Italy	22.0	4.09	3.11	-0.98
Germany	20.1	3.94	2.93	-1.01
Denmark	33.4	6.69	5.49	-1.20
France	26.8	4.70	3.54	-1.16
Japan	3.8	2.01	1.46	-0.55
Sweden	30.9	5.05	3.86	-1.19
Korea	15.2	2.81	2.89	0.08
Austria	34.6	6.84	5.53	-1.31
Spain	18.3	6.87	5.25	-1.62
Norway	26.8	6.10	4.77	-1.33
Finland	21.7	4.78	3.64	-1.14
Australia	17.0	2.87	2.11	-0.76
Canada	27.2	1.51	1.19	-0.31
South Africa	14.0	2.42	2.51	0.10
Greece	30.0	6.07	6.00	-0.07
Chile	19.4	4.99	5.27	0.28
Malaysia	40.2	3.79	3.68	-0.10
Argentina	1.9	2.43	2.49	0.06
Portugal	32.7	4.61	4.88	0.27
Indonesia	26.0	3.87	4.05	0.18
Egypt	21.5	5.45	5.68	0.23
Mexico	34.1	6.85	7.24	0.39
China	2.3	2.83	3.10	0.27
Brazil	2.2	9.53	9.47	-0.07
Thailand	22.0	3.28	3.35	0.07
Turkey	12.6	3.09	2.91	-0.18
Ecuador	21.9	8.36	8.63	0.27
Colombia	8.5	4.63	4.72	0.09
India	5.2	4.33	4.58	0.24
Venezuela	14.6	4.04	3.76	-0.29
Peru	7.9	6.83	7.17	0.34

Notes: Countries in descending order according to Ginarte-Park Index.

Table F.3: Effects of the Pareto Optimal IPR Policies by Country (%Δ)

		Firm Discounted Profits (V)		%Δ in Welfare	
Country	Hazard	Small Economy	Equilibrium	Small Economy	Equilibrium
United States	-1.2	-2.0	-2.8	0.70	0.92
Belgium	-57.2	27.6	21.8	4.50	5.39
Great Britain	-8.5	-7.0	-10.0	2.14	2.60
Netherlands	-45.3	18.9	13.9	2.50	3.14
Italy	-7.4	-11.1	-15.6	2.75	3.31
Germany	-7.9	-11.5	-15.1	2.77	3.37
Denmark	-42.5	8.7	5.2	3.15	3.87
France	-9.7	-12.6	-17.1	3.12	3.78
Japan	-0.5	-9.2	-11.6	1.46	1.86
Sweden	-34.5	4.3	0.1	2.99	3.68
Korea	-42.7	22.1	21.6	-0.74	-0.60
Austria	-51.1	22.2	16.6	3.16	3.89
Spain	-15.1	-11.5	-17.6	4.03	4.86
Norway	-32.1	0.5	-2.8	3.46	4.21
Finland	-32.8	3.5	-0.6	2.93	3.61
Australia	-25.2	1.0	-2.1	2.21	2.76
Canada	-7.2	-1.2	-2.4	0.90	1.15
South Africa	-26.9	28.9	26.5	-0.35	-0.28
Greece	-61.6	27.8	23.8	-0.33	0.03
Chile	-63.4	42.0	39.5	-2.22	-2.12
Malaysia	-66.5	71.4	67.4	-1.05	-0.75
Argentina	-25.8	16.0	14.3	-0.20	-0.09
Portugal	-78.7	78.8	72.5	-3.56	-3.50
Indonesia	-82.0	121.7	116.6	-4.09	-4.08
Egypt	-81.8	95.1	89.2	-4.22	-4.22
Mexico	-72.0	57.2	58.8	-3.44	-3.39
China	-44.7	50.4	49.3	-1.50	-1.50
Brazil	-80.3	90.4	84.9	-2.86	-2.61
Thailand	-55.6	63.5	60.3	-1.31	-1.17
Turkey	-29.0	37.5	32.4	0.42	0.66
Ecuador	-71.2	49.1	46.4	-2.88	-2.74
Colombia	-77.7	94.8	90.8	-3.14	-2.99
India	-81.2	102.4	100.2	-4.12	-4.12
Venezuela	-50.6	60.2	55.7	-0.04	0.34
Peru	-71.2	51.8	49.0	-3.20	-3.15

Notes: Countries in descending order according to Ginarte-Park Index. "Hazard" refers to the imitation hazard implied by the model: $1 - \gamma_i$.

Table F.4: Effects of the Optimal, Feasible IPR Policies by Country (%Δ)

		Firm Discounted Profits (V)		%Δ in Welfare	
Country	Hazard	Small Economy	Equilibrium	Small Economy	Equilibrium
United States	-0.5	-2.1	-2.8	0.66	0.87
Belgium	-60.0	22.4	18.2	4.26	5.09
Great Britain	-8.8	-6.9	-9.6	2.07	2.51
Netherlands	-7.2	-11.5	-14.7	2.90	3.47
Italy	3.2	-26.2	-29.6	2.70	3.25
Germany	-3.4	-14.5	-17.7	2.71	3.28
Denmark	-30.2	1.6	-1.2	3.19	3.85
France	-11.7	-10.5	-14.8	3.00	3.61
Japan	1.2	-10.2	-12.3	1.42	1.77
Sweden	-39.0	6.0	2.0	2.81	3.47
Korea	-19.4	5.8	5.6	-0.13	0.01
Austria	-52.8	21.5	16.4	3.03	3.74
Spain	-19.4	-5.6	-11.7	3.80	4.58
Norway	26.8	-28.7	-30.6	3.50	4.21
Finland	11.8	-25.1	-27.8	3.10	3.75
Australia	-2.5	-11.4	-13.9	2.34	2.85
Canada	-10.7	0.9	-0.3	0.82	1.05
South Africa	-13.3	6.7	5.5	-0.06	0.01
Greece	-61.7	27.3	24.4	-0.37	0.01
Chile	-60.8	39.4	37.9	-2.17	-2.08
Malaysia	-36.9	32.5	31.0	0.10	0.36
Argentina	-16.0	6.4	5.2	-0.08	0.02
Portugal	-73.4	72.9	68.2	-3.19	-3.14
Indonesia	-85.7	123.4	122.6	-4.43	-4.40
Egypt	-85.6	97.7	94.8	-4.57	-4.55
Mexico	-76.0	60.2	62.9	-3.77	-3.71
China	-46.8	52.2	52.8	-1.63	-1.61
Brazil	-22.3	20.7	18.6	-0.13	0.02
Thailand	-23.8	18.6	17.6	-0.13	0.01
Turkey	-32.4	42.9	39.2	0.30	0.55
Ecuador	-9.4	-5.7	-6.8	-0.11	0.00
Colombia	-13.5	6.6	5.2	-0.07	0.02
India	-85.1	105.3	106.3	-4.47	-4.46
Venezuela	-44.5	52.3	49.8	-0.22	0.05
Peru	-74.9	53.9	52.5	-3.63	-3.59

Notes: Countries in descending order according to Ginarte-Park Index. "Hazard" refers to the imitation hazard implied by the model: $1 - \gamma_i$.