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Intellectual Property Rights, Factor Proportions and the Pattern of Trade in Developing Countries [¤]

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Abstract

This paper studies the e®ects of Intellectual property rights (IPRs) on the pattern of trade in developing countries. Intellectual property rights, as a type of institutional endowment, could potentially change the pattern of trade through in°uencing the e±ciency of technology transfer and contract enforcement. I develop a theoretical model in which a strengthening of IPRs improves technology transfer through licensing, which expands exports. To test for this, I construct a measure of patent intensity across industries to capture the signi¯cance of intellectual property rights. I ¯nd, both theoretically and empirically, that stronger IPRs expand exports in developing countries. The extent of this e®ect di®ers across industries. For industries with high patent intensities, the e®ects are larger. Moreover, I ¯nd that the e®ects are larger in developing countries with strong learning capacity. This is even true after controlling for other institutional e®ects and alternative determinants of international trade.

JEL Classi¯cation: D23, F13, F14, O34

Keywords: Intellectual Property Rights, International Trade, Specialization, Factor Proportions

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1 Introduction

The issue of intellectual property rights (IPRs)has attracted signi¯cant interest in trade negotiations. An intellectual property right is a government-protected right granted to an inventor or creator to exclude others from using the technology or product in question. The growing interest in IPRs is driven by their potential e®ects on innovation, technology transfer and the pattern of trade. In this paper I think of intellectual property rights as a type of institutional endowment and study the impacts on the exports of intensity as an indicator of the importance of IPRs across industries. This is the ratio of patent grants to the value of shipments of each industry.

To correct the possibility of omitted variable bias, I include some alternative determinants of the pattern of specialization. I find the results remain unchanged after controlling a wide range of alternative features. I also correct for endogeneity of IPRs and patent intensity with their instrumental variables.

Empirical evidence broadly confirms the conclusions drawn from the model. I find that intellectual property rights do boost exports of developing countries. The extent differs across industries depending on the importance of IPRs in the production process. Further, the effect of stronger IPRs on exports in patent-intensive sectors is larger in developing countries with high absorptive abilities. This is the first paper to theoretically and econometrically examine the effect of IPRs on specialization across industries. The findings provide insights into the implications of recent international agreements on intellectual property rights. Moreover, this evidence could be important for developing countries in formulating their intellectual property protection policies.

2 Related Literature

International policies toward protecting intellectual property rights have seen profound changes over the past years. Extensive research has been done in the relationship between IPRs and international trade. However, most of the current literature focuses on the effect of IPRs on the imports of developing countries. Fink and Braga (2000) find that stronger IPRs have a significantly positive effect on total trade. However, the stringency of a country's patent regime is found to be irrelevant to trade in an aggregate of high technology products. Maskus and Penubarti (1995) and Smith (1999) also find a positive trade link. But Maskus and Penubarti (1995) find IPRs have no effect for the industries that are most patent sensitive and Smith (1999) finds IPRs do not affect trade in countries that face no threat of imitation.

There is also a broad strand of literature that ¯nds factor proportions and factor abundances to be important determinants of specialization in international trade. A number of papers discuss factor endowment, factor abundance and factor content of trade. Among the earliest is Baldwin (1971) who gives alternative explanations of the Leontief Paradox based on the factor content of the trade. He classi¯es the labor force involved in export and import competing production by levels of education and by various occupational groups and takes into account the importance of skilled labor in explaining U.S. trade. Bowen, Leamer and Sveikauskas (1987) use factor endowment data to show that the Heckscher{Ohlin propositions and Heckscker-Ohlin-Vanek equations are not supported by these data. Tre°er (1993, 1995) also exploits data on labor endowment, capital endowment and land endowment and ¯nds that a simple modi¯cation of the HOV theorem explains much of the factor content of trade and the cross-country variation in factor prices. He de¯nes aggregate labor endowment as the economically active population as reported in the International Labor O±ce yearbook of Labor Statistics. Davis and Weinstein (1998) consider standard and novel hypotheses regarding the failures of the Heckscher-Ohlin-Vanerk formulation and show how a few simple and plausible amendments su±ce for a striking con¯rmation of the HOV theory.

John Romalis (2004) examines how factor proportions determine the structure of commodity trade. He integrates a many-country version of a Heckscher-Ohlin model with a continuum of goods with model of monopolistic competition and transport cost. He ¯nds that countries capture larger shares of world production and trade of commodities that more intensively use their abundant factors and countries that rapidly accumulate a factor see their production and export structures systematically shift towards industries ulations on specialization in trade. Specifically, he considers how capital, human capital, institutions, cropland, pasture, energy, mineral and forest endowment separately influence

$$p_N = A - q_N \quad (1)$$

$$p_S = B - q_S \quad (2)$$

where $p_N; p_S$ and $q_N; q_S$ are prices and quantities sold in the North and the South respectively.

3.2 Decision on Mode of Supply

Only the Northern firm engages in prior R&D, giving it proprietary technological

enforceable patents and trade secrets reduce problems of contracting under asymmetric information and limit the need for private e®orts by the Northern ¯rm to sustain its proprietary knowledge (Taylor 1994; Yang and Maskus 2001a).

The third component of transfer cost is ensuring that local partners gain the tacit knowledge (know-how) needed to produce e±ciently. This cost involves such elements as transferring the process design and the associated process engineering, paying technical personnel to solve unexpected problems and modify the technology to local conditions, and training local production workers (Teece 1977). We assume, therefore, that the costs involved in transferring tacit knowledge increase with the proportion of know-how transferred.

Let x x 2 [0, 1] be be the proportion of maximum know-how transferred. I represent the prior reasoning by letting licensing incur a transfer cost of the form $F(x;k) = Á + G(x;k)$. Here $Á$ is the ¯xed transfer cost,which is independent of the degree of IPR. $G(x;k)$ is the variable transfer cost, which decreases with the strength of intellectual property rights and increases with the proportion of maximum know-how transferred. Therefore, $\frac{@G(x;k)}{@x} > 0$ and $\frac{@G(x;k)}{@k} < 0$. To simplify the model, I assume variable technology transfer cost is linear in the proportion of maximum know-how transferred. That is $\frac{@^2G(x;k)}{@x@k} < 0$ and $\frac{@^2G(x;k)}{@x^2} = 0$.

The ¯xed cost $Á$ includes charges for pre-engineering, investing in plant and equip-

$\frac{\partial r(x;a)}{\partial x} > 0$, $\frac{\partial r(x;a)}{\partial a} > 0$ and $r(0;a) = 0$, $r(a;0) = 0$. For simplicity, we also assume $r(x;a)$ is concave in both x and a. That is $\frac{\partial^2 r(x;a)}{\partial x^2} < 0$ and $\frac{\partial^2 r(x;a)}{\partial a^2} < 0$.

Let L be the lump-sum license fee the Southern ¯rm has to pay to get the patent and know-how from the Northern ¯rm. In the model L is determined by Nash bargaining as explained below. Let ¿ be the bargaining power of the Northern ¯rm. This parameter determines the shares of joint surplus from sales under licensing. The bargaining power of each ¯rm comes from the ability to withhold resources that the other party wants. For example, the bargaining power of the Southern ¯rm re°ects its lower labor cost and valuable local resources; the bargaining power of the Northern ¯rm comes from the extent of the uniqueness of the technology it owns.

3.4 The Decision Structure

In this game, there are two players: the Southern ¯rm (S) and the Northern ¯rm (N). Initially, the Northern ¯rm is the global (two-country) monopoly, having invented the process to make a product, and the Southern ¯rm may imitate the technology through reverse engineering. The time sequence of the game is the following, and is depicted in Figure 1.

In the ¯rst stage, N chooses its mode of supply (export or o®er a license) given the IPR policy of the Southern government. If N chooses to export, in the second stage S can choose to imitate, incurring an imitation cost, or do nothing. If S imitates competition emerges in the third stage and both ¯rms simultaneously choose the optimal quantities produced($\overline{q_N}$ and $\overline{q_S}$)[2]) If the S ¯rm decides not to imitate, the Northern ¯rm remains the global monopoly.

If the N o®ers a license to S, the ¯rms bargain over the licensing fee in the second stage. If the negotiation succeeds, technology is transferred and both ¯rms simultaneously choose the optimal quantities produced in the competition stage. If the negotiation fails,

[2]Here $\overline{q_N} = (q_{NN}; q_{NS})$, and $\overline{q_S} = (q_{SN}; q_{SS})$.

the S firm can choose to imitate or not enter the market in the third stage. If S imitates, both firms maximize profits by choosing optimal quantities in the fourth stage.

Figure 1 summarizes the decision stages

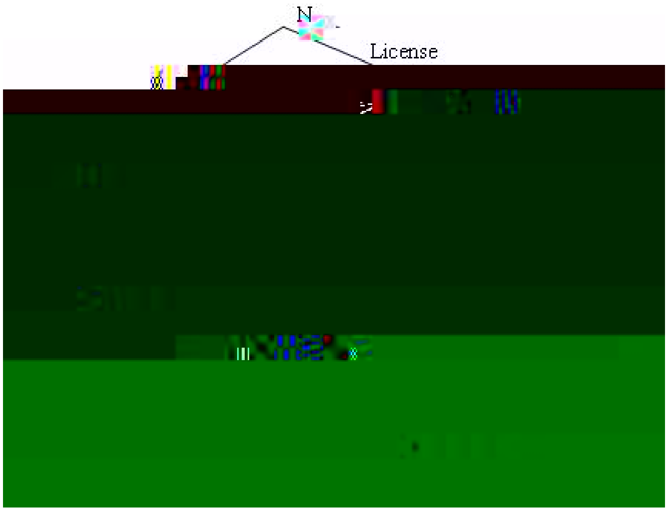

Figure 1 Stages of the Game

3.5 Equilibrium Analysis

I begin by analyzing the equilibrium under exporting, using backward induction from the final stage of the game. Firms maximize profit by choosing quantity in the third stage.

If the Northern firm chooses to export and the Southern firm chooses to imitate, prices in the two countries are given by

$$p_N = A - q_{NN} - q_{SN} \quad (3)$$

$$p_S = B - q_{NS} - q_{SS} \quad (4)$$

Here q_{NN} and q_{NS} are the Northern firm's sale in the North and the South; q_{SN} and q_{SS} are the Southern firm's sales in the North and the South, respectively. The two firms' respective maximization problems under export are

$$\underset{q_{NN},q_{NS}}{Max}\ \pi_{NE} = (A - q_{NN} - q_{SN})q_{NN} + (B - q_{NS} - q_{SS})q_{NS} - c_N(q_{NN} + q_{NS}) \quad (5)$$

$$\underset{q_{SN},q_{SS}}{Max}\ \pi_{SE} = (A - q_{NN} - q_{SN})q_{SN} + (B - q_{NS} - q_{SS})q_{SS} - c_S(q_{SN} + q_{SS}) - I(k,a) \quad (6)$$

Equilibrium profits under exporting are given by

$$\pi^*_{NE} = \frac{A^2 - 4Ac_N + 2Ac_S + 8c_N^2 - 8c_Nc_S + 2c_S^2 + B^2 - 4Bc_N + 2Bc_S}{9} \quad (7)$$

$$\pi^*_{SE} = \frac{A^2 + 2Ac_N - 4Ac_S + 2c_N^2 - 8c_Nc_S + 8c_S^2 + B^2 - 4Bc_S + 2Bc_N}{9} - I(k,a) \quad (8)$$

If the Southern firm chooses not to produce, its profit is 0. Define $k = k^*$ when π^*_{SE}. Since π^*_{SE} decreases with k, the Southern firm will choose to imitate when $k < k^*$ and will choose not to produce when $k > k^*$.

If the Northern firm decides to license and the negation fails, the Southern firm will choose to imitate or not to enter the market. choose either to imitate or not to enter the market. In this case, the equilibrium is the same as the equilibrium under export.

If licensing is offered and the negotiation succeeds, there are multiple equilibrium outcomes. In this paper I focus on the non-collusive equilibrium[3].

The maximization problems in the production stage are

$$\underset{q_{NN},q_{NS}}{Max}\ \pi_{NL} = (A - q_{NN} - q_{SN})q_{NN} + (B - q_{NS} - q_{SS})q_{NS} - c_N(q_{NN} + q_{NS}) \quad (9)$$

$$\underset{q_{SN},q_{SS}}{Max}\ \pi_{SL} = (A - q_{NN} - q_{SN})q_{SN} + (B - q_{NS} - q_{SS})q_{SS} - (c_S - r(x,a))(q_{SN} + q_{SS}) \quad (10)$$

[3]I will discuss other equilibrium cencepts in another paper.

The optimal quantities produced are derived by solving from the first order conditions of (9) and (10) giving

$$q^*_{NN} = \frac{A + c_S - r(x;a) - 2c_N}{3} \tag{11}$$

$$q^*_{NS} = \frac{B + c_S - r(x;a) - 2c_N}{3} \tag{12}$$

$$q^*_{SN} = \frac{A + c_N - 2(c_S - r(x;a))}{3} \tag{13}$$

$$q^*_{SS} = \frac{B + c_N - 2(c_S - r(x;a))}{3} \tag{14}$$

Denote equilibrium production profits under licensing by π^*_{NL} and π^*_{SL}.[4] Therefore, we may derive

$$\begin{aligned} \pi^*_{NL} &= \frac{A^2 - 4Ac_N + 2A(c_S - r(x;a)) + 8c_N^2 - 8c_N(c_S - r(x;a)) + 2(c_S - r(x;a))^2}{9} \\ &\quad + \frac{B^2 - 4Bc_N + 2B(c_S - r(x;a))}{9} \end{aligned} \tag{15}$$

$$\begin{aligned} \pi^*_{SL} &= \frac{A^2 + 2Ac_N - 4A(c_S - r(x;a)) + 2c_N^2 - 8c_N(c_S - r(x;a))}{9} \\ &\quad + \frac{8(c_S - r(x;a))^2 + B^2 - 4B(c_S - r(x;a)) + 2Bc_N}{9} \end{aligned} \tag{16}$$

In the negotiation stage, the Northern firm also decides how much know-how will be transferred to the Southern firm when they give the contract. The Northern profit equals the sum of the license fee from the Southern firm and the production profit. Its maximization problem is:

$$\begin{aligned} \max_x \pi_N &= \frac{1}{9}A^2 - \frac{4}{9}Ac_N + \frac{2}{9}Ac_S + \frac{8}{9}c_N^2 - \frac{8}{9}c_N c_S + \frac{2}{9}c_S^2 + \frac{1}{9}B^2 - \frac{4}{9}Bc_N + \frac{2}{9}Bc_S + \tau[\frac{2}{9}Ar(x;a) \\ &\quad + \frac{10}{9}r(x;a)^2 + \frac{16}{9}r(x;a)c_N - \frac{20}{9}r(x;a)c_S + \frac{2}{9}Br(x;a) + I(k;a) - F(x;k)] \end{aligned} \tag{17}$$

The first term is N's profit under exports and the second term represents its share of the negotiating bargain. In this case, the Northern firm maximizes the joint surplus of both firms. We denote the first-order condition of (17) as $f(x^*;k;a)$. The equilibrium

[4] For the determination of license fee, please see Appendix A.

know-how transferred satisfies:

$$f(x^*; k; a) = [\frac{2}{9}A + \frac{2}{9}B + \frac{16}{9}c_N - \frac{20}{9}(c_S - r(x^*; a))]\frac{\partial r(x^*; a)}{\partial x} - \frac{\partial F(x^*; k)}{\partial x} = 0 \quad (18)$$

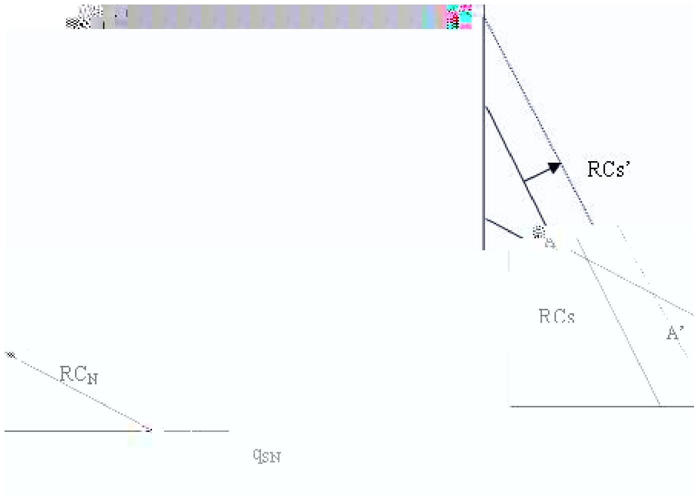

Figure 2 Cournot Equilibrium in the Northern market

The Cournot equilibrium in the Northern market is given by point A. Now consider a stronger intellectual property rights level in the South. We saw $\frac{dx}{dk} > 0$ if the market sizes of both countries and the di®erence between the marginal costs of the Northern ¯rm and the Southern ¯rm is large. Supposing this is true and noting that $\frac{\partial r(x;a)}{\partial x} > 0$ by assumption, it follows that tighter IPR increases $r(x;a)$ and reduces production cost in the South. Therefore, RCs shifts to RCs' and the Cournot equilibrium will shift to point A'. From this analysis we have that stronger IPR would raise the Southern ¯rm's export and decrease the Northern ¯rm's output in the Northern market.

We thus have:

Proposition. *Stronger IPRs in the Southern country would increase its exports to the Northern country if the market sizes of both countries and the di®erence between the marginal costs of the two ¯rms are large. It would decrease its exports and domestic production if the market sizes of both countries and the di®erence between the marginal costs of the two ¯rms are small.*

The intuition is that stronger intellectual property rights in the South increase (decrease) the marginal bene¯t (marginal cost) transferring know-how, raising the amount transferred. Also, there are ¯xed costs of technology transfer and it requires large market sizes to guarantee that the total surplus is positive. Under such circumstances, stronger technology protection would make the S ¯rm more competitive in the international market.

4 Estimation Strategy

To test for the e®ect of intellectual property rights on exports, I perform an empirical investigation using panel data. For the empirical speci¯cation, one possibility is the gravity model and another is the factor proportions model. It is well known that the gravity equation can explain much of the variation in bilateral trade volumes. The advantage of the gravity model is that it is empirically successful. However, it is hard to identify the theories underpin its success. Formal theoretical foundations for the gravity equation have been provided in Anderson (1979), Bergstrand (1985, 1989), Krugman (1979), Helpman and Krugman (1985), Deardor® (1997) and Evenett and Keller (2002). Although these studies shed light on the microeconomic foundations of gravity model, its interpretation remains questionable.

The Heckscher-Ohlin model is one of the pillars of international theory. It states that factor proportions are a determinant of the factor content of international trade. Prior factor proportion studies are provided by Baldwin (1971), Wright (1990), Leamer (1980)and Harrigan (1997). Helpman (1981) embeds the monopolistic competition framework into a Heckscher-Ohlin model. Based on Krugman and Helpman's theory, Davis and Weinstein (1998) ¯nds evidence that increasing returns help determine the structure of production and trade.

Romalis (2004) integrates a many-country version of a Heckscher{Ohlin model with a continuum of goods model of monopolistic competition and transport cost due to Krugman's (1980). He examines how factor proportions determine the structure of commodity trade and the three-way relationship between trade shares, factor intensities and factor abundance. His prediction is that countries capture larger shares of world production and

where EXP_{ijt} is the total export of country i in industry j at time t. z_{jt} represents the skill intensity of industry. k_{jt} is the capital intensity of an industry. m_{jt} represents the raw material intensity of an industry. r_{jt} is the patent intensity of an industry. The variables $skill_{it}$, $capital_{it}$, raw_{it} and IPR_{it} are abundance measures for skilled labor, capital, raw materials and intellectual property protection in country i of year t.

The principal coefficient of interest is θ, which measures the effect of the interaction of intellectual property rights and patent intensity on the export volume of a country. A positive and significant θ implies that countries with stronger intellectual property rights specialize in more patent intensive sectors. Since the other coefficients are not of primary interest, my empirical estimates of the effect of IPRs on export performance in developing countries can equivalently be obtained by estimating the following equation:

$$\ln(EXP_{ijt}) = \alpha + \gamma_{it} + \delta_{jt} + \beta_1 skill_{it} \times z_{jt} + \beta_2 capital_{it} \times k_{jt} + \beta_3 raw_{it} \times m_{jt} + \theta IPR_{it} \times r_{jt} + \varepsilon_{ijt} \quad (23)$$

which can be denoted as $y = X\beta + \varepsilon$ with y representing $\ln(EXP_{ijt})$, X the vector of explanatory variables, β the vector of coefficients and ε the error term. Two types of fixed effects are included: The nested country-year effect and the nested industry-year effect. The nested country country-year effect controls for country characteristics such as trade policy, endowments and GDP per capita of a country at a particular time. The nested industry-year effect controls for industry characteristics such as factor intensities and the output of an industry at a particular time. If the nested country-year effects are fully captured by the four factor endowments and factor intensities, the above two specifications will have the same estimates for θ. If some of the nested country-year effects are not captured by the four factor endowments and factor intensities, equation (23) will have a more consistent estimate for θ. Therefore this paper estimates equation (23).

5 The Data

5.1 Constructing Measures of Patent Intensity

As one of the most important measures to test the model, I construct the variable of patent intensity as the ratio of patent grants to the value of shipments of each industry. Data on numbers of patent grants are from the U.S. patent and trademark office. I convert the original patent data, which are classified by the Current US Classification, to the 2-digit U.S. SIC (1987). In the end, the patent data are classified into 20 industries. Data on the value of shipments are from the U.S. Census of Manufactures. I aggregate the original data, which are classified by the Current US Classification, to the 2-digit U.S. SIC (1987).

5.2 Other Data

Export data (2-digit U.S. SIC) are from the NBER trade dataset. For the factor intensities, it is assumed, as in Romalis (2004) that there are no factor intensity reversals and I use U.S. intensity measures. The skill intensity of industry is measured as the ratio of nonproduction workers to total employment in each industry. Raw material intensity of an industry is measured as the value of raw material inputs divided by the sum of raw materials and value added. I define the capital intensity of an industry as the ratio of capital expenditure to its value added. I also assume that factor intensities are fixed for each industry across different countries. Skill intensities, capital intensities, raw material intensities are from the U.S. Census of Manufactures.

Capital endowment data from 1975 to 2000 is estimated by the perpetual inventory method using investment data in Penn World Table 6.1. Following Hall and Jones (1999), the current physical capital stock, K_t, is determined as follows:

$$K_t = I_{t-1} + (1 - \delta)K_{t-1}$$

where ± is the depreciation rate, which is assumed to be 6 percent, and I_{t-1} and K_{t-1} are investment and capital stock at previous period respectively. The initial capital stock, K_0, is estimated by

$$K_0 = I_0 = (g + \pm)$$

where g is average annual growth rate of per capita income for initial physical capital stock. The initial year is 1970.

Following Hall and Jones (1999), skilled labor endowment is based on the data on average educational attainment for the population aged 25 and over as reported by Barro and Lee (2000).[7] With respect to skilled labor, I use the return-to-schooling estimates from Psacharopoulos (1994). Speci¯cally, for the ¯rst 4 years of education, I assume a rate of return of 13.4 percent. For the next 4 years, I assume a value of 10.1 percent.

abundant in IPRs will capture a large export share of industries that intensively use IPRs endowment. Therefore I predict that $\mu > 0$. Using these definitions, a panel data set that cover 58 countries and 20 industries is constructed for years 1975, 1980, 1985, 1990, 1995 and 2000. However, an observation is only included in the regression if a country exports a non-zero amount in that industry. Since I only include positive exports, the question I

Table 1: Industries with extreme factor intensities

5 Most Patent -Intensive Industries	5 Most Skill-Intensive Industries
Electronic and other Electric Equipment	Instruments and Related products
Instruments and Related products	Print and Publishing
Chemicals and Allied Products	Chemicals and Allied Products
Industrial Machinery and Equipment	Electronic and other Electric Equipment
Fabricated Metal Products	Industrial Machinery and Equipment
5 Most Capital-Intensive Industries	5 Most Raw Material-Intensive Industries
Tobacco Products	Petroleum and Coal Products
Petroleum and Coal Products	Food and Kindred Products
Chemicals and Allied Products	Primary Metal Industries
Food and Kindred Products	Textile Mill Products
Paper and Allied Products	Transportation Equipment

Table 1 lists the ¯ve industries that most intensively use each factor. Many of the most patent-intensive industries are also skill-intensive industries. Many of the most capital-intensive industries are also industries that most intensively use raw materials.

Descriptive Statistics of the data set are summarized in Table 2.

Table 2: Descriptive Statistics

Variables	Observations	Mean	Std. Dev.	Min	Max
ln(Export)	6202	1.918	3.466	-6.907	11.105
Capital Intensity	6202	0.073	0.033	0.012	0.181
Skilled-Labor Intensity	6202	0.267	0.010	0.128	0.493
Raw Material Intensity					

3 reports the results of regressing the interaction of intellectual property rights on the

7 Econometric Issues

7.1 Endogeneity

The results reported in Table 3 are potentially biased by an endogeneity problem. Countries that have more exports in patent-intensive industries may have a stronger intellectual property rights. To correct for endogeneity error, I reestimate equation (23) using an instrumental variable approach. To perform the instrumental variable approach, I choose instruments that correlated with IPRs but uncorrelated with unobserved errors in exports. The instrumental variables are composed of prior indicators of the level of economic development. They include GDP per capita, primary exports as a share of total exports, secondary enrollment ratios, the infant mortality rate and dummy variables for former British and French colonies. Data on all of the above variables are lagged for

Table 4: Basic Results with Instrumental Variables

	(1)	(2)
$IPR_{it} \times r_{ikt}$	13.09	14.16
	(7.54)	(3.41)
Capital Interaction	14.02	13.66
	(9.42)	(9.15)
Skilled-Labor Interaction	23.75	23.26
	(14.81)	(16.17)
Raw Material Interaction	0.74	0.82
	(7.06)	(7.84)
γ_{it}	Yes	Yes
δ_{jt}	Yes	Yes
R^2	0.77	0.77
Number of observations	6202	6202
t-statistics are in parentheses.		

The first stage of the IV estimation suggests that the instruments are sound. The R^2 of the first stage is 0.89. An F-test for the irrelevance of the instrumentals is strongly rejected: the F-statistic is 10091. Column (1) and (2) summarize the results of OLS and IV estimations. For the IV estimation, he R^2 is 0.77. The coefficients are all significant and the signs are as predicted. The coefficients on other interactions remain largely unchanged. The coefficient of the interaction term of intellectual property rights is positive and significant.

As described earlier, of the 58 countries, 40 are developing countries and 18 are developed countries. It is of interest to see if different factor endowments have different effects the effects of capital, skilled labor and intellectual property rights on exports are smaller in developing countries than developed countries. However, the effect of raw materials is greater in developing countries. Such findings are consistent with the comparative advantages of developing countries and developed countries.

Table 5: Developed Countries vs Developing Countries

	(1) Developed Countries	(2) Developing Countries
$IPR_{it} \times r_{ikt}$	16.91	14.05
	(3.35)	(7.49)
Capital Interaction	20.67	12.12
	(4.98)	(7.36)
Skilled-Labor Interaction	24.71	21.00
	(3.46)	(11.22)
Raw Material Interaction	0.55	0.88
	(3.21)	(6.33)
γ_{it}	Yes	Yes
δ_{jt}	Yes	Yes
R^2	0.77	0.75
Number of observations	1434	4768
t-statistics are in parentheses.		

The prediction in my theoretical model is that stronger intellectual property rights in the South increase exports if the developing country has high absorptive ability. To test for this, I divide the 40 developing countries into two groups: skilled-labor abundant countries and skilled-labor scarce countries. I define the skilled-labor abundant countries to be any country with skilled-labor endowment greater than the mean of the skilled-labor endowments of the 40 countries. The results of IV estimation are presented in Table 6.

group with high absorptive ability is greater than that of the group with low absorptive ability. This result suggests that intellectual property rights are more important in determining the pattern of specialization in countries with high absorptive abilities, which is consistent with my theoretical prediction. For developing countries, high absorptive abilities assure more marginal benefit of technology transfer from the developed countries and less marginal cost, which impels technology transfer and increases the local firm's competitiveness in international markets.

Table 6: Developing Countries with High Absorptive Ability
vs Developing Countries with Low Absorptive Ability

	(1) Low Absorptive Ability	(2) High Absorptive Ability
$IPR_{it} \times r_{ikt}$	11.45	21.16
	(2.66)	(7.35)
Capital Interaction	22.36	12.52
	(4.29)	(6.21)
Skilled-Labor Interaction	21.70	22.31
	(3.25)	(6.60)
Raw Material Interaction	2.13	0.65
	(4.29)	(5.19)
γ_{it}	Yes	Yes
δ_{jt}	Yes	Yes
R^2	0.72	0.77
Number of observations	1991	2777

t-statistics are in parentheses.

Table 7: Controlling for other determinants.
Dependent Variable is ln (Export)

	(1)	(2)	(3)
IPR_{it} ¤ r_{ikt}	13.08	13.25	13.09
	(7.64)	(7.58)	(7.54)
Capital Interaction	8.58	15.86	11.09
	(5.54)	(10.01)	(6.88)
Skilled-Labor Interaction	15.35	21.24	11.04
	(8.85)	(12.27)	(5.81)
Raw Material Interaction	0.69	0.78	0.76
	(6.64)	(7.40)	(7.26)
Log income, intra-industry trade	1.42		1.56
	(11.64)		(12.31)
Log income, value added		1.06	1.86
		(3.14)	(5.49)
$°_{it}$	Yes	Yes	Yes
$±_{jt}$	Yes	Yes	Yes
R^2	0.77	0.77	0.77
Number of observations	6202	6202	6202
t-statistics are in parentheses.			

7.3 Robustness analysis

7.3.1 Tobit Estimation

For equation (23), the dependent variable contains some observations at zero, but is roughly continuous otherwise. We can use a Tobit speci¯cation to estimate equation (23). Table 8 presents the results of the Tobit estimation.

The results of the Tobit estimation are consistent with the results of the OLS estimation. Countries that are blessed with various endowments will specialize in goods that use those endowments intensively.

Table 8: Results with Tobit Estimation

	Tobit
$IPR_{it} \times r_{ikt}$	11.42
	(6.89)
Capital Interaction	12.14
	(8.92)
Skilled-Labor Interaction	25.06
	(16.32)
Raw Material Interaction	0.89
	(9.18)
γ_{it}	Yes
δ_{jt}	Yes
$Pseudo R^2$	0.33
Number of observations	6960
t-statistics are in parentheses.	

7.3.2 Sensitivity to alternative samples

My final step of the robustness check is to test the sensitivity of my results to alternative samples. As mentioned in section 7.1, these results remain significant in both developed countries and developing countries, which implies that the effects of intellectual property rights on specialization hold both in countries with strong intellectual property rights and weak intellectual property rights. I also drop each country from the sample in turn and the results change very little. To check if the results are being driven by some particular industries, I drop each industry from the sample in turn and find the

Appendix A: Determination of Licensee fee.

The Generalized Nash Bargaining Solution is

$$\mu_N = d_N + \tau(\pi - d_N - d_S)$$
$$\mu_S = d_S + (1 - \tau)(\pi - d_N - d_S)$$
$$\pi = \pi^*_{NL} + \pi^*_{SL} - F(x;k)$$
$$d_N = \pi^*_{NE}$$
$$d_S = \pi^*_{SE}$$

Where μ_A and μ_B are the Nash Bargaining Solution; τ is the bargaining power of player A, and 1-τ is the bargaining power of player B; d_A and d_B are the disagreement point; π is the total utility.

When the Northern firm and the Southern firm bargain over the license fee, the total utility (π) is the sum of production profits of the Northern firm and Southern firm. The reservation value for the Northern firm is the Northern firm's profit under export. The reservation value for the Southern firm is the Southern firm's profit under imitation. We denote the equilibrium profits of the Northern firm and the Southern firm under licensing by π^*_{NL} and π^*_{SL}.

Therefore, the Nash bargaining solutions of the two firms are:

$$\mu_N = \pi^*_{NE} + \tau(\pi^*_{NL} + \pi^*_{SL} - \pi^*_{NE} - \pi^*_{SE})$$
$$\mu_S = \pi^*_{SE} + (1 - \tau)(\pi^*_{NL} + \pi^*_{SL} - \pi^*_{NE} - \pi^*_{SE})$$

And we can get

$$\pi^*_{NL} = \frac{A^2 - 4Ac_N + 2A(c_S - r(x;a)) + 8c_N^2 - 8c_N(c_S - r(x;a)) + 2(c_S - r(x;a))^2}{9} + \frac{B^2 - 4Bc_N + 2B(c_S - r(x;a))}{9}$$

$$\pi^*_{SL} = \frac{A^2 + 2Ac_N - 4A(c_S - r(x;a)) + 2c_N^2 - 8c_N(c_S - r(x;a))}{9} + \frac{8(c_S - r(x;a))^2 + B^2 - 4B(c_S - r(x;a)) + 2Bc_N}{9}$$

We now determine the license fee in the negotiation stage. The N and S profits after negotiation are, respectively

$$\mu_N = \pi^*_{NL} + L$$

$$\mu_S = \pi^*_{SL} - L$$

Therefore, the license fee is:

$$\tilde{L} = \mu_N - \pi^*_{NL}$$

Appendix B: Proof for Proposition 1.

$$f = [\frac{2}{9}A + \frac{20}{9}r(x^*;a) + \frac{16}{9}c_N - \frac{20}{9}c_S + \frac{2}{9}B]\frac{\partial r(x^*;a)}{\partial x} - \frac{\partial F(x^*;k)}{\partial x}$$

Taking partial derivative of f with respect to k and $x$respectively in equation (22), we have

$$\frac{\partial f}{\partial k} = - \frac{\partial^2 F(x^*;k)}{\partial x \partial k} > 0$$

$$\frac{\partial f}{\partial x} = (\frac{2}{9}A + \frac{20}{9}r(x^*;a) + \frac{16}{9}c_N - \frac{20}{9}c_S + \frac{2}{9}B)\frac{\partial^2 r(x^*;a)}{\partial x^2} + \frac{20}{9}[\frac{\partial r(x^*;a)}{\partial x}]^2 + (-\frac{\partial^2 F(x^*;k)}{\partial x^2})$$

Here the first term is negative and the second term is positive. The third term (- $\frac{\partial^2 F(x^*;k)}{\partial x^2}$) is zero based on our assumption. And we get

$$\frac{\partial f}{\partial x} < 0 \; if \; A + B + 8c_N - 10(c_S - r(x^*;a)) > \frac{10[\frac{\partial r(x^*;a)}{\partial x}]^2}{-\frac{\partial^2 r(x^*;a)}{\partial x^2}}$$

Let $m(x^*;a) =$ $10[\frac{\partial r(x^*;a)}{}$

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Countries in the Sample

Argentina	Hong Kong	Panama
Australia	Hungary	Peru
Austria	Iceland	Philippines
Bangladesh	India	Poland
Belgium	Indonesia	Portugal
Bolivia	Iran	Romania
Canada	Ireland	Singapore
Chile	Italy	South Africa
Colombia	Japan	Spain
Costa Rica	Jordan	Sri Lanka
Cyprus	Kenya	Sweden
Denmark	Korea	Switzerland
Ecuador	Malawi	Thailand
Egypt	Malaysia	Trinidad and Tobago
Finland	Mexico	Turkey
France	Morocco	UK
Germany	Netherlands	Uruguay
Greece	New Zealand	Venezuela
Guatemala	Norway	
Honduras	Pakistan	