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Intellectual Property Rights and Licensing: An Econometric Investigation

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ABSTRACT:
Licensing is an important form of technology transfer that has been virtually ignored in the econometric literature on intellectual property rights (IPRs). We discuss how international variations in IPRs affect decisions to license technology across borders, both within the firm and at arm's-length. Based on a theoretical model of licensing we specify a reduced-form econometric equation relating the volume of U.S. international licensing to an index of patent strength, real GDP per capita, an index of openness, population, and the secondary school enrollment rate in technology-recipient countries. The model is applied to data for 26 countries over three years: 1985, 1990, and 1995. The results indicate that, other things equal, countries with stronger IPRs attract larger volumes of licensed technology and the impact is stronger for arm's-length transactions, as predicted.

Key Words: Licensing, Intellectual Property Rights, Internalization

JEL Classifications: F21, O34

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1. Introduction

How international differences in intellectual property rights (IPRs) affect decisions to license technology is an important question that has attracted virtually no econometric study. Licensing is a crucial component of international technology transfers but we have little systematic evidence about whether it is much influenced by the strength of local patent regimes. In pushing for the recent introduction of global minimum standards in IPRs through the World Trade Organization, governments in technology-exporting nations argued that stronger IPRs would encourage technology transfer and local adaptive innovation, allowing all regions of the world to benefit. However, some developing countries argued that tighter protection would only strengthen the monopoly power of potential licensor firms, largely based in industrial countries, to the detriment of technology-importing nations.

In theoretical models the linkage between IPRs and technology trade is ambiguous and depends on circumstances (Helpman, 1993; Taylor 1994; Glass and Saggi, 1995; Lai, 1998; Markusen, 1998; Yang and Maskus, 1998). What little attention it has attracted in empirical work focused on operations of foreign affiliates of American multinational enterprises (MNEs). Ferrantino (1993) found little impact of IPRs on overseas affiliate sales of U.S. firms to its various trade partners in 1982. Similarly, Maskus and Eby-Konan (1994) could not find any relationship between crude measures of IPRs and the international distribution of foreign direct investment (FDI). In contrast, Lee and Mansfield (1996) examined the relationship between a country's system of IPRs and the volume and composition of U.S. foreign direct investment (FDI) in that country, finding that perceived weaknesses in a country's IPRs are associated with lower FDI volumes.

Foreign direct investment is one indirect channel of technology trade. However, licensing to unaffiliated parties, which is the direct mechanism for technology transfer, has been largely ignored in the empirical literature by economists. Quantitatively, however, licensing is significant. For example, U.S. receipts of unaffiliated royalties and license fees were 20.86% of its total royalties and license fees received from all the countries in the world in 1995. In 1996, royalties and licensing fees from unaffiliated foreigners increased 9%, reflecting an 11% increase in fees for the use of industrial processes and a 7% increase in fees for the right to sell products under a particular trademark, brand name, or signature (U.S. Department of Commerce, 1998).

The aim of this paper is to carry out one of the first studies to investigate the econometric relationship between IPRs and licensing. Three earlier studies are relevant. Survey evidence in Mansfield (1994) indicated that American MNEs are less likely to transfer advanced technologies to unaffiliated firms in countries with weak patent rights. In terms of econometric work, Contractor (1980) examined a sample of 102 technology licenses and showed that total returns on licensing are higher in patented technologies. Ferrantino (1993) used 1982 cross-country data to show that membership in the Paris Convention, which stipulates that patents will be awarded to foreign applicants without discrimination, stimulated flows of U.S. receipts of unaffiliated royalties and license fees from the host country. However, this effect pertained only if the host country's domestic IPRs regime was sufficiently strong as measured by patent duration. These articles give us some evidence about whether patents affected licensing activity in the late 1970's and early 1980's using single cross-country regressions. However, the variables used as proxies for patent strength -- remaining patent life in Contractor (1980) and national memberships in international intellectual-property conventions in Ferrantino (1993) -- are inaccurate measures of the effective strength of local patent laws. We employ more recent time-series data and a more accurate measure of IPRs to investigate the linkage between patents and licensing.

International disputes over the protection of IPRs became common in the last decade and numerous industrializing and developing countries have engineered substantial strengthening in their patent regimes since 1986. We exploit this fact by developing a panel data set for the years 1985, 1990 and 1995 and 26 recipient nations to examine the effects of patent strength on the flow of unaffiliated royalties and licensing fees by U.S. firms. Panel data not only provide richer information to estimate the model, but also allow for unobservable individual country-specific effects of technology trade such as persistent differences in institutions, technology level, tastes, and culture.

We begin in the next section by describing the role of IPRs in licensing. The essential point is that licensing could rise or fall with the imposition of stronger IPRs. Given this ambiguity, we go on in the third section to specify an econometric model of licensing. The regressors include variables capturing endowments, openness, the efficiency of local imitation, and a quantitative measure of the strength of patents. Data are discussed in the fourth section, while the fifth section presents the empirical results on licensing. The key finding is that stronger patent laws have positive and significant effects on the flows of U.S. receipts of unaffiliated royalties and licensing fees. Concluding remarks are provided in the final section.

2. Intellectual Property in Licensing

In principle, intellectual property rights play an important role in technology trade. Patent protection is probably the most important means of safeguarding proprietary technology trade. Patent laws vary markedly cross-countries in terms of coverage, membership in international agreements, loss of protection, enforcement mechanisms, and duration (Primo Braga, 1996). These differences in patent laws in host countries might influence licensing through several channels.

First, the degree of IPRs protection could influence the choice of the firm between licensing and FDI (Horstmann and Markusen, 1987). Strong IPRs will probably favor licensing by creating a legal framework for the enforcement of licensing and royalty contracts. In the presence of weak patents, problems of transacting information with licensing, such as the non-excludability property of new knowledge, informational asymmetry, imitation risk and transfer costs, may provide an internationalization motive for foreign direct investment (Markusen, 1995).[1] Among these problems in licensing, Rugman (1986) in particular views the imitation risk faced by the firm from the licensee as a cornerstone of internalization theory. If IPRs are weak in the host country, the licensee may learn the technology quickly and imitate it to start a new domestic firm in competition with the MNE. In response, the MNE exploits its firm-specific assets through internalization. Seen in this light, stronger patents reduce the imitation risk faced by the multinational firm and create a legal framework for the enforcement of licensing contracts, thereby encouraging licensing. Stronger patents will favor licensing also because they reduce the legal costs associated with establishing and policing an arm's-length relationship.

Second, stronger IPRs affect the sharing of rents between the licensor and licensee. Rent sharing is one of the salient features commonly observed in licensing contracts. Caves, *et al* (1983) indicate that licensors earn, on average, 40% of the rents from innovation. One important factor is that license rents are used to deter imitation by the licensor. Stronger IPRs protection makes it harder for the licensee to imitate the licensor's product. Thus, the licensee commits not to imitate at a lower rent share. But lax IPRs require higher rents for the licensee to preclude imitation. Gallini and Wright (1990) show that when imitation is possible and there is asymmetric information, the licensor sacrifices some rents though its share rises with imitation costs. Accordingly, the rent share accruing to the licensor rises with patent strength, raising the returns to licensing.

The internalization and rent-sharing effects suggest that unaffiliated licensing should rise as countries strengthen their patent regimes. However, the ability to license depends on the pace at which new innovations are introduced by potential licensors. Innovative activity could rise with stronger IPRs in licensee countries, expanding licensing. However, it is conceivable in theory that long-run innovation could slow down because the monopoly effect of stronger patents would reduce R&D effort.[2] In turn, licensing could be reduced.

These ideas have been formalized in a dynamic general equilibrium model with endogenous innovation and licensing (Yang, 1998). We overview the predictions of that model now in order to motivate the current empirical work. It specifies a quality-ladders setup in which a high-quality version and a low-quality version of each of a continuum of goods may be produced. Innovative firms in the North develop higher-quality products and choose to license them for production in the South (or retain production in the North). Contract terms are set so that the licensor can reliably signal the true quality level of its good and deter the licensee from imitating the product itself. Thus, the model incorporates asymmetric information and imitation risk in licensing and endogenizes the rent share between licensor and licensee as a function of patent strength. With strong IPRs, imitation costs increase, the licensor's rent share increases, and therefore the returns to innovation also increase.

The model results show that innovation and licensing decisions depend on labor endowments in both the North and South, the efficiency of local imitative production, the effectiveness of the South's IPRs regime in protecting technical information, and consumer's preference parameters. Let n represent the extent of licensing, I represent the intensity of innovation, L_N represent the endowment in the technology exporting country, L_S represent the endowment in the technology recipient country, κ represent the degree of IPRs protection, and C represent the imitation cost of the licensee given a certain level of IPRs protection. Further, letting a represent the unit innovation cost, λ represent the consumer's assessment of quality improvement, and f represent the percentage of consumers who value the quality improvement, we can write the innovation and licensing functions in steady state equilibrium as follows:

$$I = f\,(L_N, L_S, \kappa, C, a, \lambda, f) \qquad (1)$$

$$n = g\,(L_N, L_S, \kappa, C, a, \lambda, f) \qquad (2)$$

The comparative statics show that the sign of $\frac{\partial n}{\partial \kappa}$ is indeterminate in this model. The intuition is as follows. There are two opposite effects of stronger IPRs on licensing and innovation. On the one hand, stronger IPRs reduce the costs of technology transfer through licensing contracts because the licensor has to give up fewer rents to the licensee to deter imitation. This raises the returns to licensing and innovation. In this case, innovators have more incentives to innovate and to license. On the other hand, because imitation risk is reduced, the northern innovator enjoys greater market power. This could reduce licensing because when their market shares are guaranteed, licensors have less incentive to innovate new or higher quality products, and more resources are available for them to produce existing products in their home country. Thus, the theoretical prediction is ambiguous and the sign of $\frac{\partial n}{\partial \kappa}$ depends on which effect dominates.

The effect of northern labor force on licensing is ambiguous theoretically. On the one hand, when it increases a larger northern resource base means that more resources may be deployed in R&D, so the rate of innovation is higher, and the extent of licensing is higher. One the other hand, more resources are available for production of goods in the innovator's home country, which may cause less transfer of production to the South. The effect of southern labor force on licensing is indeterminate also. With an expansion of southern labor supply, the profit rate enjoyed by innovators may be higher, generating more licensing. However, a larger labor force in the South effects greater learning by the South and a greater intensity of imitation, which implies a lower rent share to the innovator and less licensing.

The sign of $\frac{\partial n}{\partial \lambda}$ is expected to be positive. If consumers value quality improvement more, the innovator will get more profits, and therefore has more incentive to innovate and license. The sign of $\frac{\partial n}{\partial f}$ is also expected to be positive. A higher proportion of consumers who value quality increments (that is, who have higher income) means more demand for high-quality goods, and thus more incentive to innovate and license high-quality goods. The sign of $\frac{\partial n}{\partial a}$ is negative. If the cost of innovation is higher, there is less incentive to innovate and to license.

3. An empirical model of the flow of licensing

Since theoretical predictions about the effects of IPRs on licensing are ambiguous, a clear picture can emerge only from empirical work. In principle, a fully specified approach would use the structural forms of equations (1) and (2) to estimate the parameters.[3] However, such a specification would require measurement of several unobservable variables, including market structure issues and consumer's assessments of quality levels. It is also difficult to find data on innovation cost and imitation cost. Thus structural estimation is infeasible here.

Instead, based on the theoretical predictions we specify a reduced form regression of equation (2) to study the effects of IPRs on the flow of licensing. It would be ideal to regress the flow of licensing from different technology exporting countries to recipient countries on relevant characteristics of both the recipient and home countries, including an index of IPRs and both country's endowments. However, data on the flow of licensing to different destinations are not available for countries other than the United States. We use data on the flow of licensing from the United States to its technology trade partners as the dependent variable. We regard this limitation not to be a serious one because the United States is the world's largest supplier of technology licenses. Further, there is no a priori reason to believe that U.S. firms' overseas licensing practices are different from the typical worldwide pattern of technology suppliers. However, since the origin of technology licensing is the same in all cases, we must drop the origin country's characteristics in the regression.

Therefore, we reduce equation (2) to the following simplified specification:

$$n = g\,(L_S, \kappa, C, d) \qquad (3)$$

The vector d includes variables that capture demand characteristics of the technology recipient country.

We use the volume of U.S. firms' receipts of royalties and licensing fees from unaffiliated foreigners in all industries to represent the flow of licensing. Any increase in these receipts could be caused by two possible reasons. First, there could be more firms that license their technology, and second, given the number of licensing firms, each firm could get a higher share of royalties and licensing fees. Unfortunately, we are unable to discriminate in the data between changes in rent share and changes in the number of contracts and must defer this question to future work. For comparative purposes we also include total license fees and fees from affiliated enterprises.

For the independent variables in the regression, the strength of IPRs is our main focus. We use an index of patent strength developed by Ginarte and Park (1997), discussed further below. A human capital measure is included to capture the efficiency of local imitation. A high human capital abundance means local imitation is efficient and therefore imitation will incur less cost. Population is used to proxy the labor force of the recipient country. A larger labor force in the technology importing country, other things equal, implies that the southern relative wage is initially low, which attracts licensing for local production. Per capita real GDP is used to capture the level of economic development, a control for the demand characteristics of the recipient country. It is reasonable to assume that consumers will value quality improvement more in a higher per capita income country. Finally, in addition to patent strength we include another institutional variable. This is an index of openness, since technology trade cannot be isolated from trade policies on goods and investment.

There are country-specific aspects of technology trade, such as persistent differences in institutions, culture, and tastes, which may not be captured by the included independent variables. Ignoring these country-specific effects in the regression would create omitted variables bias and inconsistent estimators. Thus, we use a panel-data approach in this paper with both country fixed effects and random effects.

Collecting these ideas, the econometric model is specified as follows:

$$y_{it} = \alpha + \beta_1 IPRS + \beta_2 OPEN + \beta_3 POP + \beta_4 GDP + \beta_5 SECOND + u_{it} \quad (4)$$

$$u_{it} = \mu_i + v_{it} \quad (5)$$

Here, y_{it} is the volume of U.S. licensing receipts from abroad. We employ three separate measures of receipts, including unaffiliated royalties and license fees, unaffiliated fees for using industrial processes, and receipts of affiliated royalties and license fees, depending on the specific regression. Unaffiliated fees for using industrial processes form the largest portion of total unaffiliated fees. Since the focus here is to investigate the linkage between the degree of patent protection and the flow of licensing in production of goods, unaffiliated fees for using industrial processes are a relevant dependent variable. The variable IPRs is the index of patent laws, OPEN is the dummy variable indicating whether a country is open or not, POP is population, GDP is real GDP per capita in 1990 US dollars, and SECOND is the secondary school enrollment rate. Error component μ_i denotes the unobservable country specific effects and v_{it} denotes the remaining disturbance. Here we can think of μ_i as the unobservable institutional and cultural factors that affect licensing.

4. The Data

The data are from various sources. The volumes of U.S. receipts of unaffiliated and affiliated royalties and licensing fees are from various issues of *Survey of Current Business*, published by the U.S. Department of Commerce. Royalties and license fees consist of receipts for the use of patented techniques, processes, formulas, and other intangible property rights used in production of goods; transactions involving copyrights, trademarks, broadcast rights, and other intangible rights; and the rights to sell products under a particular trademark, brand name, or signature. While affiliated royalties and license fees are from the multinational firm's foreign subsidiaries, unaffiliated royalties and licensing fees are from "arm's-length" licensing with unrelated foreigners.

A firm with a significant new product may engage in licensing agreements with foreigners covering patents, trademarks, technical assistance, and other matters. Licensing agreements typically call for the licensee to pay a certain percentage of its sales to the licensor, plus a flat fee for technical help in some cases. Ownership of property rights is retained by the licensor. Licenses give permission to do something that would otherwise be an infringement.

Affiliated royalties and license fees in the data are restricted to subsidiaries that are majority-owned by direct investors. This is not restrictive because the data indicate that most U.S. firms have either no equity holding or a majority to complete interest in licensed subsidiaries. Regarding unaffiliated fees, the data for 1986 are the earliest available that are comparable and reliable. Because receipts of unaffiliated and affiliated royalties and licensing fees are reported in nominal U.S. dollars, we deflate them by the U.S. GDP deflator to get the real volumes of license fees in 1990 dollars.

The index of patent strength in different countries comes from Ginarte and Park (1997) and Park (1997). Information on qualifying IPRs protection is from national patent laws. The index takes on values between zero and five, with higher numbers reflecting stronger levels of protection. The index consists of five categories: coverage of fields of technology, membership in international patent agreements, provisions of loss of protection, enforcement mechanisms, and duration. Each category takes on a value between zero and one. The sum of these five values gives the overall value of the IPRs index for a particular country. The resulting data are provided in the Appendix.

Because the index of IPRs considers broader categories of the patent system, particularly in the treatment of foreigners, it is more comprehensive and accurate than the dummy variable approach used by Ferrantino (1993). Moreover, the index exhibits greater variability across countries and is likely to support more precise estimation. However, the patent index remains subject to measurement error for IPRs because there are surely gaps between the measured and actual levels of patent protection. Further, there is possible correlation between the index of IPRs and the country specific effects, since a country's system of intellectual property protection is inextricably bound up with its entire legal and social system and its attitude toward private property. We account for this possible correlation in our estimation. A final comment about the index is that the strength of patent laws across countries is highly correlated with the strength of trademark and copyright laws (Rapp and Rozek, 1990). Accordingly, the patent index should be an acceptable measure of IPRs to include as a determinant of royalties and license fees, which include fees for using copyright and trademark rights in addition to patent rights.

The openness index is from Sachs and Warner (1995). They consider a country to have a closed trade policy if it has at least one of the following categories. First, nontariff barriers cover 40 percent or more of import categories. Second, average tariff rates are at least 40 percent. Third, the black market exchange rate premium is 20 percent or more relative to the official exchange rate on average. Fourth, there is a socialist economic system. Fifth, a state monopoly exists on major exports. An open economy is defined as one in which none of the five conditions applies.

Per capital real GDP is measured in 1990 US dollars and is from International Monetary Fund (1997). For this purpose, annual real GDP figures in local-currency terms were converted into dollars using 1990 exchange rates. Population is from the World Bank (1995, 1997) and is measured in thousands. The school enrollment ratio in secondary level is from UNESCO (1997).

Using these definitions, a panel data set is constructed for 26 countries for the years 1985, 1990, and 1995.[4] Table 1 presents summary statistics for the 26 countries and three years in the data. In the table, UNFEE is the volume of U.S. receipts of unaffiliated royalties and licensing fees, PROCESS is the volume of unaffiliated fees for using industrial processes, and AFEE is the volume of receipts of affiliated royalties and licensing fees. The index of IPRS is strongly and positively correlated with per capital real GDP and the secondary enrollment ratio.

5. Estimation Results

Results of a basic pooled OLS regression are listed in the first three columns of Table 2. The coefficient of IPRS is significantly positive at the five-percent level in the regressions of both total unaffiliated royalties and licensing fees and in fees for industrial processes only. It is significantly positive at the ten-percent level in the case of affiliated royalties and licensing fees, suggesting that affiliated fees are somewhat less dependent on IPRs. Population has a positively significant effect at the 95% confidence level in all three regressions.

The next three columns provide estimation with fixed country effects. The row labeled F(25,47) indicates tests of the pooled OLS hypothesis the constant terms are all equal. In all three regressions, the hypothesis that the country-specific fixed effects are the same is rejected at the one-percent significance level. Therefore, pooled OLS is inappropriate since it omits the country-specific effects in estimation and OLS estimates are inconsistent. We first assume that the individual country effects are fixed in nature, so that differences across units may be captured by specific intercepts. Thus, in equation (5), each μ_i is an unknown parameter to be estimated. The remaining error term v_{it} follows standard assumptions.

In the fixed-effects estimation IPRs continue to have a positively significant effect on the receipts of unaffiliated royalties and licensing fees. The implied elasticity of unaffiliated royalties and licensing fees to the change in the degree of IPRs protection is 5.26, which means that U.S. receipts of unaffiliated royalties and licensing fees would increase by 5.26% in response to a one-percent rise in the recipient country's patent index. IPRs also positively affect fees for using industrial processes, with an elasticity of about 5.28. However, the effect on receipts of affiliated royalties and licensing fees is insignificant, confirming that patent rights are more important in promoting arm's-length technology trade. Accordingly, there is evidence that stronger IPRs favor unaffiliated licensing in relation to affiliated technology transfers by virtue of providing a legal system for enforcing licensing contracts.

Real GDP per capita has a positively significant effect on the dependent variable at the one-percent significance level in all three regressions. If a country's per capita GDP is higher, its overall development level is higher and consumers will demand more high-quality goods. In our context, this fact would raise demand for both unaffiliated and affiliated licensing. The coefficient on the dummy variable for openness has a negative sign but is not significant. The negative sign is not a surprise because in a more open economy with less trade barriers in the technology recipient country, other countries may choose to export more to this country instead of raising technology trade.

The coefficient on population is negative but insignificant. Comparing the fixed-effects estimation with the pooled OLS estimation, the population variable becomes insignificant but per capita real GDP becomes significant after introducing the country specific fixed effects. Demand characteristics of the recipient country seem to play an important role in licensing with country effects.

The coefficient on the secondary school enrollment rate in the regression of unaffiliated fees has a negative sign, which is the expected sign from theory. Its sign is positive in the regression of affiliated fees, but none of these effects is significant. In principle, the effects of education level on technology trade are two-fold. On the one hand, a higher education level implies higher efficiency of imitation and therefore less technology trade due the higher risk of imitation. On the other hand, a higher educational level also means lower technology transfer cost in terms of training local workers, and thus more technology trade. In the case of unaffiliated licensing, the first effect may dominate because of the higher imitation risk in licensing. Under FDI, the firm can exploit its firm-specific assets by internalization. Even if it still faces imitation risk through hiring away workers, the imitation risk is smaller and the second effect may dominate. Therefore the signs before the school enrollment ratio are reasonable, if imprecisely estimated.

We next consider a random-effects specification, in which the individual error terms are randomly distributed across cross-sectional units. In this case, in equation (5) μ_i is the random disturbance characterizing nation i and is constant over time. Assume that E(μ_i) = E(v_{it}) = 0,

$E(\mu_i^2) = \sigma_\mu^2$, $E(v_{it}^2) = \sigma_v^2$, $E(\mu_j v_{it}) = 0$ for all i, j, and t, $E(\mu_j \mu_i) = 0$ for $i \neq j$, and $E(v_{it} v_{js}) = 0$ for $i \neq j$ or $t \neq s$. Since σ_μ^2 and σ_v^2 are unknown we first estimate the disturbance variances and then follow the feasible GLS procedure.

The random-effects estimation results are presented in the final three columns of Table 2. Under this specification, the strength of patent laws still has positively significant effects on unaffiliated royalties at the ten-percent significance level and on unaffiliated industrial process fees at the five-percent level. Its effect on affiliated royalties and licensing fees is insignificant. These results are similar to those from the fixed-effects model, but coefficient magnitudes are smaller. The elasticity of unaffiliated royalties and licensing fees with respect to a change in the degree of patent protection is here estimated to be 2.88 and the elasticity of fees for using industrial processes is 3.07. Both impacts are smaller than in the fixed-effects case. Per capita real GDP continues to have a positively significant effect on licensing, but the coefficients are roughly cut in half.

We use the Lagrange multiplier (LM) test for the presence of random effects. Under the null hypothesis that no random effects exist, LM is distributed as chi-squared with one degree of freedom. The LM ratios are presented at the bottom of Table 2. The one-percent critical value from the chi-squared distribution with one degree of freedom is 6.64. Therefore we can reject the null hypothesis and the evidence is in favor of the presence of random effects.

In the model with random effects, the key assumption is that the country-specific effects are uncorrelated with the exogenous variables included in the model. If they are correlated, the random-effects estimator may suffer from inconsistency due to omitted variables. Such correlation is likely in the present case. For example, the index of IPRs is likely correlated with the individual effects due to institutional and cultural factors. Therefore we need to test for the orthogonality of the random effects and the regressors before we can rely on the estimation results. We use the specification test devised by Hausman (1978), under the hypothesis of no correlation. The test is based on the Wald criterion and is asymptotically distributed as chi-squared with K degrees of freedom, where K is the number of regressors not including the constant. The calculated test statistics, labeled W, are presented in Table 2. The ten-percent critical value is 9.24. Thus, we cannot reject the hypothesis that there is no correlation between the country-specific random effects and the included regressors. The GLS estimation with the random effects is permissible.

The issue to decide is which model, fixed effects or random effects, is more reliable in this case. The disadvantage of the random-effects model is that we must assume there is no correlation between the effects and other regressors to avoid inconsistency. The fixed-effects specification does not suffer from this problem, but does use up many degrees of freedom in estimating nation-specific coefficients.

While both approaches are both permissible here, we argue that the specification of the fixed-effects model is better given the sample and the problem we have at hand. First, the fixed-effects model is a reasonable approach when we can be confident that the differences between units may be viewed as parameter shifts of the regression function. Our sample of 26 countries covers the most important licensing partners of the United States and therefore it seems appropriate to specify that differences across units are captured in differences in the constant term. Second, even if we cannot reject the hypothesis that there is no correlation between the individual effects and other regressors in the random-effects model, the power of the Hausman test is often low.

Furthermore, from a practical point of view, if there is heteroskedasticity of unknown forms, estimation becomes more complicated in the random effects model because it is difficult to know whether there is heteroskedasticity in the specific effects (μ_i), the remainder error term (v_{it}), or both.

Even if we could tell which error term has heteroskedasticity we must find consistent estimators of each country's error variances in order to perform GLS. The conventional way is to divide the summation of OLS squared residuals across time periods for each country by (T-1) to get the estimator of the error variance. However, since we only have a sample of three periods, we doubt that this estimator would be accurate.

In the fixed-effects model we may avoid this problem, and still make appropriate inferences without specifying the type of heteroskedasticity, by using the White estimator of the variance-covariance matrix of the coefficient estimators. The corrected t-ratios are presented in Table 3 and suggest that the positive effect of IPRs is more precisely estimated. The t-ratios on per capita real GDP are smaller but still indicate positively significant impacts at the five-percent level. In the regression involving fees for using industrial processes the openness dummy becomes negatively significant, which suggests that an open economy will attract more exports from other countries and less licensing in production of goods. The coefficient on population also becomes significantly negatively, indicating that a larger labor force will induce more imitation and thus less technology transfer.

6. Concluding Remarks

In this paper we undertake an initial investigation of how international variations in the strength of patent laws affects flows of international technology trade through licensing, using data on U.S. receipts for intellectual property from foreign unaffiliated firms and U.S. affiliates overseas. The principal findings are as follows. First, U.S. receipts of unaffiliated royalties and licensing fees are likely to be higher with stronger IPRs in the technology recipient countries. Second, IPRs have less significant effects on U.S. receipts of affiliated royalties and licensing fees, which is consistent with internalization theory of MNEs. This finding is different from the results in Ferrantino (1993). A third finding is that U.S. receipts of both affiliated and unaffiliated royalties and licensing fees are higher if the technology recipient country has a higher per capita GDP level. Finally, there is weak evidence that openness to trade encourages export trade in relation to licensing.

These empirical results support the hypothesis that stronger IPRs favor licensing through easing the enforcement of licensing contracts and raising imitation costs. The increase in receipts for using intellectual property could be due either to higher licensor rents per contract or to a greater number of contracts. Unfortunately, it is impossible to distinguish these effects in the data as they currently exist. Nonetheless, making such a distinction is important in understanding the full implications of stronger patent rights for technology transfer and should be on the agenda for future research.

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Table 1. Summary Statistics and Correlation Coefficients (NT = 78)

A. Summary Statistics

	Mean	St. Dev.	Maximum	Minimum
UNFEE	111.6	248.1	1686	2.34
PROCESS	79.9	206.6	1350	1.52
AFEE	399.3	604.8	3035	2.56
IPRS	3.023	0.977	4.33	0.33
OPEN	0.821	0.386	1.00	0.00
POP	75629	162448	929400	2483
GDP	12782	9466	34039	300
SECOND	81.18	26.64	147.0	24.0

B. Correlation Coefficients

	IPRS	OPEN	POP	GDP	SECOND
IPRS	1.000	0.330	-0.375	0.676	0.779
OPEN		1.000	-0.426	0.455	0.451
POP			1.000	-0.342	-0.360
GDP				1.000	0.670
SECOND					1.000

Table 2. Estimation of Determinants of Licensing Volumes

	Pooled			*Fixed Effects*			*Random Effects*		
	UNFEE	PROCESS	AFEE	UNFEE	PROCESS	AFEE	UNFEE	PROCESS	AFEE
CONS	-230.5**	-189.6***	-697.4*				-419.7*	-296.1*	-890.2*
	(-1.91)	(-1.87)	(-2.61)				(-16.9)	(-15.1)	(-8.77)
IPRS	98.94**	88.71**	141.9***	194.2**	139.7**	330.2	106.4**	81.12***	90.78
	(2.14)	(2.28)	(1.38)	(2.19)	(1.93)	(1.16)	(1.72)	(1.61)	(0.55)
OPEN	90.23	71.29	216.8	-23.82	-22.76	-45.81	-15.37	-17.70	-13.45
	(1.08)	(1.01)	(1.17)	(-0.54)	(-0.63)	(-0.32)	(-0.39)	(-0.55)	(-0.10)
POP	0.0004**	0.0003**	0.0008**	-0.0003	-0.0003	0.0004	0.0004	0.0003	0.0012
	(1.95)	(1.91)	(1.90)	(-0.36)	(-0.44)	(0.14)	(1.10)	(0.91)	(1.30)
RGDP	0.0040	0.0029	0.0168***	0.0269*	0.0205*	0.1068*	0.0170*	0.0134*	0.0492*
	(0.94)	(0.81)	(1.79)	(3.13)	(2.93)	(3.86)	(2.69)	(2.59)	(2.94)
SECOND	-1.349	-1.439	2.650	-0.607	-0.773	1.870	-0.335	-0.589	3.819
	(-0.76)	(-0.97)	(0.68)	(-0.50)	(-0.79)	(0.48)	(-0.31)	(-0.77)	(1.11)
R^2	0.17	0.16	0.32	0.91	0.91	0.84	0.21	0.18	0.25
F(25,47)				15.16	16.12	6.20			
LM							45.94	48.22	39.98
W							5.69	4.36	9.15

Note: Figures in parentheses are t-values. Significance levels are indicated by * (1%), ** (5%), and *** (10%). These are one-tailed tests except for CONS and SECOND.

Table 3. Fixed-Effects Model with Heteroskedasticity-Consistent Standard Errors

	UNFEE	PROCESS	AFEE
IPRS	194.2**	139.7**	330.2**
	(2.37)	(2.16)	(1.53)
OPEN	-23.82***	-22.76**	-45.81
	(-1.47)	(-1.73)	(-0.88)
POP	-0.0003	-0.0003**	0.0004
	(-1.16)	(-1.86)	(0.37)
RGDP	0.0269**	0.0205**	0.1068*
	(2.31)	(2.21)	(3.38)
SECOND	-0.607	-0.773	1.870
	(-0.75)	(-1.23)	(0.63)
R^2	0.91	0.91	0.84
F(25,47)	15.16	16.12	6.20

APPENDIX: PATENT INDEXES

Country	Year	Patent	Country	Year	Patent
Argentina	85	2.26	N. Zealand	85	3.32
	90	2.26		90	3.32
	95	2.86		95	3.42
Australia	85	3.23	Norway	85	3.29
	90	3.32		90	3.29
	95	3.63		95	3.29
Brazil	85	1.85	Philippines	85	2.67
	90	1.85		90	2.67
	95	1.85		95	2.67
Canada	85	2.76	Singapore	85	2.57
	90	2.76		90	2.57
	95	3.05		95	2.57
France	85	3.90	South Africa	85	3.57
	90	3.90		90	3.57
	95	4.05		95	3.57
Germany	85	3.71	Spain	85	3.29
	90	3.71		90	3.62
	95	4.05		95	3.62
Hong Kong	85	2.57	Sweden	85	3.47
	90	2.57		90	3.90
	95	2.71		95	3.90
India	85	1.62	Switzerland	85	3.80
	90	1.48		90	3.80
	95	1.96		95	3.80
Indonesia	85	0.33	UK	85	3.57
	90	0.33		90	3.57
	95	0.33		95	3.57
Israel	85	3.57	Venezuela	85	1.35
	90	3.57		90	1.35
	95	3.57		95	1.90
Italy	85	4.05			
	90	4.05			
	95	4.05			
Japan	85	3.94			
	90	3.94			
	95	4.33			
R. of Korea	85	3.61			
	90	3.94			
	95	4.05			
Malaysia	85	2.90			
	90	2.37			
	95	2.37			
Mexico	85	1.40			
	90	1.63			
	95	1.95			
Netherlands	85	4.24			
	90	4.24			
	95	4.24			

ENDNOTES

[1] See also Ethier (1986) and Dunning (1983) for discussions of internalization theory.

[2] This possibility was first pointed out by Helpman (1993) in a theoretical model of imitation in a dynamic product cycle.

[3] The structural equations are in Yang (1998) and are highly non-linear.

[4] Because the 1985 data on unaffiliated royalties and licensing fees are not comparable to later years, we use 1986 figures.