Licensing Policies in North-South Technology Transfers*

Pedro Mendi† Rafael Moner-Colonques‡
José J. Sempere-Monerris§

March 15, 2013

Abstract

Transfers of technology to least developed countries (LDCs) are often hindered by lack of absorptive capacity on the receiving party, the possibility of imitation, and relatively thin markets for the licensed product. We propose a licensing model that considers these problems. A licensor must decide on the amount of know-how to costly transfer to the licensee, taking into account that this transfer may prompt the introduction of an imitation product. We study how this affects know-how transfers and the form of scheduled payments that support these transfers. We provide empirical evidence for the relationship between GDP per capita and imports of disembodied technology that suggest a positive relationship between these two variables.

*We thank comments from seminar participants at Universidad de Navarra and Strathmore University. Financial support from Ministerio de Economía y Competitividad (ECO2010-18680) is gratefully acknowledged. All errors are our own.

†Navarra Center for International Development, Edificio Bibliotecas, Universidad de Navarra. 31080 Pamplona, Spain. Email: pmendi@unav.es

‡Department of Economic Analysis and ERI-CES, Facultad de Economía. Campus dels Tarongers. Avd. dels Tarongers s/n, E-46022-Valencia, Spain. Tel. +34-963828784, e-mail: Rafael.Moner@uv.es

§Department of Economic Analysis and ERI-CES, University of Valencia

1 Introduction

Less developed countries (LDCs) are typically characterized by a low average willingness to pay, and an unequal distribution of income, which dramatically reduces market size for many high-end products. These relative smaller markets reduce firms' incentives to transfer technology, which will translate into a lower volume of technological transactions. Conversely, greater per capita income facilitates licensing agreements that include know-how transfers and thus the profitability of technological transfer from developed to developing countries. In this paper, we propose a theoretical argument that links a country's level of development with its imports of disembodied technology. We further explore the relationship between these two variables making use of data from a large sample of countries. Our findings suggest that greater per capita income is associated with larger imports of technology relative to GDP.

The potential effects of the strengthening of intellectual property right protection in developing economies has been widely discussed in the literature. It is often argued that weaker patent systems make imitation easier in the South and this would eventually reduce the returns from innovation for the North. Thus TRIP agreement supporters under the WTO find it sensible to homogenize protection of intellectual property rights worldwide, as it would increase the rate of innovation. In this context, we wish to study whether weaker protection, as modelled by the possibility of imitation, precludes technology transfers from North to South - note that the potential market is often small in less developed countries (LDCs).

We examine a situation with a Northern innovator who considers licensing its technology to a Southern firm. Know-how transfers from licensor to licensee reduce the licensee's production cost, but increase the likelihood of technological leakages to a third party. This, of course, is detrimental both to the licensor and to the licensee. Know-how is not verifiable and is the source of the moral hazard problem. The Northern licensor proposes a two-part tariff contract to transfer the technology to the Southern licensee, and it must also decide on the amount of know-how to transfer. Regarding the structure of demand, we assume that only a fraction of consumers in the South have a high willingness to pay for the licensor's product; this will indeed constitute the relevant market for the product whose technology is being licensed. Transferring a greater amount of know-how is advantageous to the licensee since he has a deeper knowledge of the product technology in question and can produce at a much lower cost. However, as noted earlier, the transfer of know-how renders an undesirable effect as the probability of imitation increases. In order to mitigate the moral hazard problem on the licensor's side, we expect the optimal contract to include both a fixed payment and a positive royalty whenever know-how is transferred. Fixed payment only contracts are expected when the licensor decides it is optimal not to transfer know-how. This is the case when the high-end market is small relative to the total. Interestingly, the greater the fraction of consumers with a high willingness to pay - which can be interpreted as higher GDP per capita - the more likely that know-how transfers occur. Therefore, technology transfer occurs in equilibrium despite the possibility of imitation and the policy recommendation suggests to look at other indicators of development rather than at the strength of patent protection. These theoretical predictions call for an empirical check. Making use of World Bank data, preliminary regressions confirm that GDP per capita and imports of disembodied technology are positively related when GDP per capita is sufficiently high. Besides, R&D expenditures as a percentage of GDP and payments as a percentage of GDP are found to be positively linked. This suggests that increases in absorptive capacity raise the value of incoming technologies, and thus increases licensing payments.

Our paper contributes at least to two strands of literature. Firstly, to the literature that studies licensing relationships under moral hazard. In Macho-Stadler et al. (1996) know-how is noncontractible whereas Choi (2001) assumes that efforts supplied by the parties are noncontractible. Both these papers provide a rationale for the inclusion of royalty payments in licensing contracts of process innovations as a solution to the moral hazard problem.[1] Their theoretical predictions are consistent with empirical findings. In an international context, papers have compared licensing with other modes of entry in host markets, such as foreign direct investment (FDI) and international joint venture. Saggi (1999) and Sinha (2001) are, respectively, examples of this line of research. Provided that know-how makes imitation possible, our analysis complements this literature by emphasizing the role of high and low-income consumer segments in determining know-how transfers in the licensing of a cost-reducing innovation.[2]

As noted above, economists have extensively discussed the effects of patent protection on the rate of innovation, patterns of foreign direct investment and growth, with particular attention to LDCs. Lai (1998) shows that if FDI is the channel of knowledge transfer, then stronger patent protection is beneficial for the South; the opposite happens if knowledge is transferred through imitation. Glass and Saggi (2002) develop a product cycle model in which innovation, imitation, and FDI are endogenous; they show that FDI flows decrease with a strengthening of Southern protection. In contrast, Branstetter and Saggi (2011), in a similar model where licensing is ruled out, show that stronger protection increases the flow of FDI. The consideration of Southern innovation is taken up by Chen and Puttitanun (2005). A developing country may still have an incentive to protect IPRs in order to encourage innovations by domestic firms. They provide empirical analysis confirming this point. A recent paper by Mukherjee and Sinha (2013) considers strategic interactions in the product market. Firms decide whether to innovate

[1] Royalties are included in the optimal contract under asymmetric information (Gallini and Wright, 1990, Beggs, 1992), for risk sharing reasons (Bousquet et al, 1998), incumbent innovators (Wang, 1998), and product differentiation (Caballero-Sanz et al. 1992). Sen and Tauman (2007) provide a general presentation and offer a good overview of the licensing literature.

[2] Recent contributions by Farrell and Shapiro (2008), Encaoua and Lefouili (2009), and Amir et al. (2011) examine licensing schemes in a weak patent system, this meaning that a patent is likely to be invalidated by a court if challenged.

and imitation allows the Southern firm to sell the product of the competitor Northern firm. Their model suggests that stronger patent protection may not be advantageous to the North, and indeed it may benefit the South: the gain from protecting Southern innovation may outweigh the loss from no imitation. Thus, our paper also contributes to the literature that analyzes the links between intellectual property rights, innovation and trade in North-South models. In contrast, an important feature is that we explicitly model the licensing contract while lending a theoretical basis to empirically examine the relationships between technology transfer and greater per capita income.

The remainder of the paper is organized as follows. Section two describes the model, whereas section three provides some preliminary empirical analysis. Concluding remarks are given at the end.

2 The model

This paper proposes a licensing model that analyzes a firm's decision to license a new product technology to a firm located in a developing country. Know-how transfers from licensor to licensee reduce the licensee's production cost, but increase the likelihood of technological leakages to a third party. For instance, an employee of the licensee may absorb the new technology, come up with a version of the licensor's product that is adapted to the characteristics of the domestic market, and start up its own business. This, of course, is detrimental both to the licensor and to the licensee. Specifically, consider a foreign licensor who owns a technology to produce a given product, henceforth the licensor's product, at a cost c. The licensor is considering licensing its technology to a firm in what we consider the domestic market. It could be the case that the licensor's product be imitated, giving rise to an imperfect substitute for the licensor's product.

Regarding the structure of demand, we assume that only a fraction of consumers in the domestic country have a high willingness to pay for the licensor's product. These consumers constitute the relevant market for the product whose technology is being licensed. Consumers are ranked according to their respective income levels, and only consumers with relatively high income will have access to some complementary goods that provide them with additional value if consuming the product whose technology is being licensed. For instance, consider an electronic appliance that requires a stable source of power to work properly. Only consumers with access to such stable source of electricity -typically high-income consumers- will be willing to pay for the product, whereas the willingness to pay by low-income consumers will be much lower so that they never purchase the product.

In our model, the total number of consumers in this market is normalized to one, and consumers have unit demands for either the licensor's product or a substitute product that is an imitation of the licensor's product. Consumers are ranked according to their willingness to pay, which is ultimately determined by their income levels. In particular, there is a fraction of consumers, m, that have willingness to pay for the new product given by $p_1 = a_1(1 - q_1)$. On the other hand, the willingness to pay for the imitation is given by $p_2 = a_2(1 - q_2)$, with $a_1 > a_2$. The fraction m of consumers with a high-willingness to pay for the new product could be thought of as consumers with access to a complementary good that increases the value of using the licensor's product. It is assumed that only consumers with high income have access to this complementary good.

If the product technology is licensed, the licensor must decide on the amount of know-how to transfer to the licensee. The licensee's cost of producing the new product is $c(1 - k)$, where $k \in [0, 1]$ is know-how transferred by the licensor, at a cost (to the licensor) $\frac{\alpha k^2}{2}$. Since the level of know-how is not observable by a third party, the level of know-how transferred can not be contracted upon. The transfer of know-how has an unintended consequence, namely the possibility that the licensor's product be imitated, for instance by an employee of the licensee who starts up its own business after being exposed to the licensor's know-how. If imitation occurs a new entrant offers the imitation product, whose demand is given by $p_2 = a_2(1 - q_2)$, at zero cost. Imitation occurs with exogenous probability $\gamma > 0$ whenever $k > 0$, and there is no imitation if $k = 0$. Hence, know-how is necessary for imitation to occur and the probability of imitation is independent of the amount of know-how transferred.

If imitation is successful, the imitator introduces a good that is better adapted to the characteristics of the domestic country. For instance, an alternative appliance could be created which works even when there are oscillations in voltage, and with much simpler features. While this good is indeed regarded as inferior by all consumers, it is in fact more useful to those consumers which lack access to a complementary good such as a stable source of electricity.

The transfer of know-how from the licensor to the licensee is costly, which will call for the right incentives for it to take place, specifically variable payments, as in Choi (2001). In his model, the role of variable payments is to mitigate the moral hazard problem on the licensor's side. In fact, if the contract stipulated fixed payments only, the licensor would not carry out any transaction-specific, non-contractible investment.

We thus propose a game with the following stages:

1. The licensor offers the licensee a contract (f, r) for the transfer of the product technology. The licensee accepts or rejects the contract.

2. If the licensee accepts, the licensor chooses $k \in [0, 1]$. The probability of imitation is $\gamma \in [0, 1]$ if $k > 0$, and zero if $k = 0$. If imitation takes place, the imitator's cost is zero, whereas the licensee's cost is $c(1 - k) \geq 0$.

3. Firms choose prices p_1 and, eventually, p_2. Production takes place, and payments are made.

As is usual in this type of games, we analyze the game backwards, thus starting from the production stage. We analyze the different stages of the game in the following subsections.

2.1 Production stage

In the final stage of the game, both contract terms, f and r, as well as the level know-how transfer, k, are fixed. Our goal is to characterize the licensee's output level as a function of k, m, and r. In doing so, we have to consider two alternative scenarios for the production stage, depending on whether or not imitation takes place. Recall that if $k = 0$, imitation occurs with probability zero, whereas if $k > 0$, the probability of no imitation equals $1 - \gamma$.

Assume first that there is no imitation. Then the licensee is the sole producer in the market and thus chooses the monopoly price for the licensor's product, focusing on the high willingness-to-pay segment. Notice that if m is small enough, then the marginal revenue function is greater than the marginal cost at m, implying that the optimal output level is m. The monopolist would like to choose a lower price so as to expand output beyond m, but this is actually the relevant market size for its product. In other words, the market size constraint is binding. Therefore, the optimal price is:

$$p_1^M(k,m,r) = \begin{cases} a_1(1-m) \text{ if } m \leq \frac{a_1 - c(1-k) - r}{2a_1} \\ \frac{a_1 + c(1-k) + r}{2} \text{ if } m > \frac{a_1 - c(1-k) - r}{2a_1} \end{cases}$$

The output levels associated with these prices are, respectively,

$$q_1^M(k,m,r) = \begin{cases} m \text{ if } m \leq \frac{a_1 - c(1-k) - r}{2a_1} \\ \frac{a_1 - c(1-k) - r}{2a_1} \text{ if } m > \frac{a_1 - c(1-k) - r}{2a_1} \end{cases}$$

Now, if there is imitation, the licensee and the imitator compete in prices p_1 and p_2 respectively. Notice that the licensor's product is deemed superior by every consumer. However, access to complementary goods create the discontinuity in the demand function. The licensee will focus on the high willingness-to-pay consumers, whereas the imitator will target the low willingness-to-pay consumers. In order to compute market shares for the licensor's product and the imitation product, given prices p_1 and p_2, there will be an indifferent consumer $t(p_1, p_2)$ such that

$$a_1(1-t) - p_1 = a_2(1-t) - p_2$$

and this indifferent consumer will define the market shares of the two products such that

$$t\left(p_1,p_2\right)=\min\left\{1-\frac{p_1-p_2}{a_1-a_2},m\right\}$$

and the licensee's production level will be $q_1^I(k,m,r)=t\left(p_1,p_2\right)$. Consumers with highest willingness to pay will be purchasing from the licensee. In contrast, the imitator's output level will be $q_2^I(k,m,r)=1-\frac{p_2}{a_2}-t\left(p_1,p_2\right)$.

Then, the equilibrium prices if imitation takes place depend on whether the indifferent consumer is $t<m$ or $t=m$. In the latter case, the imitator chooses a price $p_2=\frac{a_2(1-m)}{2}$, whereas the licensee's price is $p_1=\frac{2a_1-a_2}{2}(1-m)$, making the consumer with willingness to pay for the licensor's product $a_1(1-m)$ just indifferent between purchasing the licensor's product and the imitation. Of course, the presence of the imitation effectively constraints the licensee's pricing behavior, forcing it to choose a lower price. In this particular case, the licensee's total output is $q_1=m$, and the imitator's output is $q_2=\frac{1-m}{2}$, so that total output is $\frac{1+m}{2}$. Notice that, in this case, the licensee's output is insensitive to changes in its marginal cost, a fact that directly influences the licensor's behavior when choosing how much know-how to transfer.

The other possibility is that the indifferent consumer is such that $t\left(p_1,p_2\right)<m$. This is the case when the proportion of consumers with access to complementary goods is large, i.e. m is high. In this case, the equilibrium prices are $p_1=\frac{2a_1[a_1-a_2+c(1-k)+r]}{4a_1-a_2}$ and $p_2=\frac{a_2[a_1-a_2+c(1-k)+r]}{4a_1-a_2}$. Thus, the level of output produced by the licensee if there is imitation is:

$$q_1^I(k,m,r)=\min\left\{\frac{(a_1-a_2)2a_1-(2a_1-a_2)(c(1-k)+r)}{(a_1-a_2)(4a_1-a_2)},m\right\}$$

which equals output sold by the licensee. Notice that the licensee's output decreases with its marginal cost, which depends on k and r, which have been defined in stages two and one, respectively. Also notice that the lower the value of m, the higher the probability that the licensee's output ends up being m.

2.2 Choice of know-how transfer

In the second stage, the licensor must choose $k \in [0,1]$ to maximize its expected profits in the production stage, given contract terms f and r. Recall that imitation occurs with exogenous probability $\gamma > 0$ if $k > 0$, and there is no imitation if $k = 0$. Notice that, in addition to influencing the probability of imitation, the licensor's choice of k has an effect on the licensee's marginal cost. Let $q_1^M(k,m,r)$ be the licensee's output if there is no imitation, and $q_1^I(k,m,r)$ be the licensee's output if there is imitation, as defined in the previous subsection. In the former case, the licensee faces no competition in the product market. This way, the licensor's problem in this stage may be written as

$$\max_{k\in[0,1]} r \cdot \left[(1-\gamma)q_1^M(r,k) + \gamma q_1^I(r,k)\right] - \tfrac{\alpha k^2}{2}$$
$$\text{s.t. } r \cdot \left[(1-\gamma)q_1^M(r,k) + \gamma q_1^I(r,k)\right] - \tfrac{\alpha k^2}{2} \geq r q_1^M(0,m,r)$$

where $rq_1^M(0,m,r)$ are the licensor's net revenues if the licensor decides not to transfer know-how. This constraint points out the moral hazard problem on the licensor's side. Notice that choosing $k = 0$ implies that there is no imitation, that the licensee operates with a marginal cost equal to c, and that the licensor's costs of transferring know-how are zero. Thus, the constraint reflects the fact that, in order for the licensor to choose a positive transfer of know-how, its net revenues should exceed those if $k = 0$, which represents an inefficient production on the licensee's side, but also prevents imitation from occurring.

Now, if the solution is interior, i.e. if $k > 0$, it is characterized by

$$r \cdot \left[(1-\gamma)\frac{\partial q_1^M}{\partial k} + \gamma \frac{\partial q_1^I}{\partial k}\right] = \alpha k$$

where the signs of the partial derivatives are $\frac{\partial q_1^M}{\partial k} \geq 0$, $\frac{\partial q_1^I}{\partial k} \geq 0$, since the licensee's output never increases with its own cost.

This first-order condition implicitly defines an optimal $k(m,r)$. Consistent with standard moral hazard models, k is non-decreasing in r. Additionally, notice that a necessary condition for $k(m,r) > 0$ is that at least one of the partial derivatives be positive. In order for this to be the case, m has to be high enough, given r, otherwise the solution in both cases is such that the licensee produces an output level m, which is insensitive to variations in the marginal cost. In other words, if the constraint that the size of the high-end market represents is binding, the licensor does not have any incentives to invest in transferring know-how, and thus chooses $k = 0$. This occurs when the proportion of high willingness-to-pay consumers is relatively low.

The transfer of know-how, on the one hand, makes the licensee more efficient, but on the other hand, it makes imitation more likely. Additionally, the transfer of know-how is costly to the licensor, which will increase the likelihood of royalties being used in the licensing contract. Royalties are used to mitigate moral hazard on the licensor's side, since if the transfer involved a fixed fee only, then the licensor would optimally choose $k = 0$, a problem analyzed in Choi (2001). However, in our model there is an additional problem, which is the size of the high-end market, or the proportion of consumers with access to complementary goods. The licensor's incentive to transfer know-how depends crucially on the responsiveness of the licensee's output to cost reductions. If there is no response because the upper bound on market size is reached, the licensor will make no further investments in know-how transfers. Hence, given r, there will be a range of values $[0, \widetilde{m}]$ such that for $m \in [0, \widetilde{m}]$, the licensee chooses $k = 0$. Notice that $\widetilde{m}$ is non-increasing in r, since r raises the licensee's marginal cost, which has a non-positive effect on the licensee's output.

2.3 Choice of contract terms

In the first stage, the licensor must choose the fixed fee f and the royalty r to maximize its expected profits. The licensor must take into account the impact that its choice of r has not its own decision of how much know-how to transfer. This decision influences not only the licensee's marginal cost and the probability of imitation, but also the licensee's output choice, via variation in the marginal cost. When choosing f and r, the licensor must take into account the licensee's acceptance constraint, i.e. that its expected profits be greater than its outside option, which is assumed to be zero, for simplicity.

Bearing all this in mind, let $Eq_1(m,r)$ be the licensee's expected (at the beginning of the game) output, and let $E\pi_1(m,r)$ be the licensee's expected profits. Notice that r will determine k in the second stage, and thus the probability of imitation, as well as the licensee's marginal cost. Then, the licensor's problem at the initial stage reads

$$\max_{f,r\geq 0} f + rEq_1(m,r)$$
$$\text{s.t. } E\pi_1(m,r) - f \geq 0$$

Notice that the fixed fee allows the licensor to extract all of the licensee's profits, leaving it just indifferent between accepting and rejecting the licensor's offer. Therefore, the fixed fee is typically positive. Whether the royalty is also positive, and thus the contract stipulates a mixed payment scheme, depends on the size of the high-end market, m. For sufficiently high m, the royalty is positive and so is the transfer of know-how, k. Finally notice that a necessary condition for $k > 0$ is $r > 0$.

Specifically, taking into account that the constraint is binding and the licensor is able to reap all of the licensee's profits by means of the fixed fee, the licensor's problem may be written as

$$\max_{r\geq 0} E\left[\left(p_1(m,r) - c(1 - k(m,r))\right) q_1(m,r)\right]$$

Recall that k is a function of r and also of m, as studied in the previous subsection, and that k is non-decreasing in r. This way, there will be a threshold value of r, call it $\widetilde{r}$, such that for $r < \widetilde{r}$, then $k = 0$, and for $r \geq \widetilde{r}$, then $k > 0$. Then, the licensor's objective function, as a function of the royalty rate r, may be defined in two parts. In particular, for $r < \widetilde{r}$, there is no imitation, and the licensee's output and profits are as defined in subsection 2.1. Specifically, the licensor's objective function becomes $\left(p_1^M(0,m,r) - c - r\right) q_1^M(0,m,r)$, and if $r \geq \widetilde{r}$ so that $k > 0$, then the licensor's objective function may be written as

$$(1-\gamma)\left[\left(p_1^M(k(m,r),m,r)-c(1-k(m,r))\right)q_1^M(k(m,r),m,r)\right]+$$
$$+\gamma\left[\left(p_1^I(k(m,r),m,r)-c(1-k(m,r))\right)q_1^I(k(m,r),m,r)\right]$$

For a sufficiently low value of m, the licensee's optimal transfer of know-how is zero, and $q_1 = m$. Intuitively, if the high-end market is small enough, then a transfer of know-how has no market expansion effect, in the sense of increasing the licensee's sales. The transfer of know-how merely reduces the licensee's production cost. However, this is something that does not increase the licensor's variable revenues, which are sensitive to the licensee's output only, therefore it optimally chooses $k = 0$. Also notice that this makes the licensor indifferent between a fixed fee and a royalty. Finally, in this case royalties do not distort the licensee's output decision and have no effect on the licensor's moral hazard problem.

As m increases, the licensor has stronger incentives to transfer know-how and thus make the licensee's production more efficient. Thus, as countries develop and relatively more consumers are in the high willingness-to-pay group, production becomes more efficient, which should translate into higher welfare for these consumers. Not only that, but the probability of imitation increases with know-how transfers, benefitting consumers with lower willingness to pay. Thus, in our model economic growth increases expected consumer surplus in both consumer groups.

3 Licensing and development

The model predicts the existence of a positive relationship between economic development and technological payments. In fact, as the proportion of high-income consumers, m in our model, grows, the incentives to invest in transferring know-how are stronger for the licensor, which ends up increasing the volume of payments for the transfer of technology.

In order to test the implications of our model, we make use of World Bank data, specifically that contained in the World Development Indicators (World Bank, 2013). For the list of countries in the Appendix, data on technological payments, GDP per capita, and expenditures on R&D as a percentage of GDP have been used, from 1980 to 2011. However, for some of the countries, some of the series did not include observations for all years, and data on R&D expenditures as a percentage of GDP is reported starting in 1996 only. These factors will reduce the number of observations in some of the econometric specifications to be estimated.

We have tested the existence of a relationship between the volume of technological payments as a percentage of GDP and GDP per capita, using the cited country-level data. Table 1 displays the results from a specification where the dependent variable is the logarithm of payments as a percentage of GDP. As dependent variables, we include GDP per capita and GDP per capita squared, to allow for the possibility of the effect being non-linear. The regression includes country and time fixed-effects. Country fixed effects control for country-specific, time-invariant characteristics, which include time-invariant differences in the construction of the technological payments series. Column (i) in Table 1 presents estimated coefficients of this econometric specification. The effect of the logarithm of per capita GDP on the share of technological payments in GDP is non-linear, with a negative coefficient on the logarithm of per capita GDP and a positive coefficient on that variable squared. Hence, the net effect is positive only if the logarithm of per capita GDP is above some threshold value. A similar result is obtained in column (ii), which makes use of observations from 1996 to 2011. In this case, the coefficient on the logarithm of GDP per capita is also negative, statistically significant, and larger in absolute value than that in column (i), and so is the coefficient on the logarithm of GDP per capita squared. Again, the effect of GDP per capita is negative for lower values of this variable, becoming positive after some level.

Table 1. Technological payments and GDP per capita

	(i)		(ii)		(iii)		(iv)	
ln(GDP)	−3.266	***	−7.095	***	−3.831	***	−2.612	*
	0.798		1.166		1.421		1.424	
$(\ln(GDP))^2$	0.204	***	0.428	***	0.314	***	0.243	***
	0.045		0.067		0.08		0.08	
ln(R&D/GDP)					0.137	*	0.146	*
					0.08		0.085	
Constant	10.672	***	26.562	***	6.321		1.14	
	3.608		5.157		6.421		6.431	
Observations	2757		1839		888		857	

Columns (iii) and (iv) of Table 1 include in the specifications the logarithm of R&D expenditures as a percentage of GDP. The inclusion of this variable controls for variations in absorptive capacity in the different countries in the sample. In both columns, the coefficient on the logarithm of R&D expenditures as a percentage of GDP is positive, as expected, and statistically significant at the 10% level. This suggests a positive relationship between absorptive capacity and licensing: increases in absorptive capacity raise the value of incoming technologies, and thus increases licensing payments. The inclusion of absorptive capacity as an additional control does not qualitatively alter the results, although the estimated coefficients on both the logarithm of GDP per capita and this variable squared are smaller in absolute value, although they remain statistically significant. The difference between columns (iii) and (iv) is that to estimate the coefficients in column (iv) only observations with a logarithm of GDP per capita of 7 or more are used. As it may be seen in columns (iii) and (iv), the coefficients have the same sign, although they are smaller in absolute value in column (iv).

4 Conclusions

Two important problems that firms in least developed countries (LDCs) encounter when accessing foreign technology are lack of absorptive capacity and weak protection of intellectual property rights. Lack of absorptive capacity implies that more intense efforts must be made to efficiently transfer a given technology. On the other hand, weak protection of intellectual property rights increases the likelihood of imitation, which may discourage the owner of the technology to transfer it to a LDC. These factors increase the transaction costs of technology transfer. Additionally, the potential market is often small in the case of LDCs. In fact, LDCs are typically characterized by a low average willingness to pay, and an unequal distribution of income, which dramatically reduces market size for many high-end products. This reduces the likelihood of North-South technological transfers taking place.

This paper has presented a model of technology transfer that allows for the possibility of imitation. In the model, imitation takes place as an unintended consequence of the transfer of know-how to a licensee. This know-how leaks outside of the licensee, for instance by means of worker's mobility, and permits the introduction of an imitation product, which steals market from the product that is being licensed. This reflects the situation common in many developing countries, of a small segment of the population with high income, which is able to consume goods similar to those in more developed countries, and a large segment of the population that lacks access to complementary goods that prevent those same goods from being consumed by the bulk of the population.

If the prime market is small relative to the total, then know-how is not transferred, which implies that, on the one hand, production is inefficient, and, on the other, that imitation does not take place. Welfare in the domestic country is lowest, since total output is minimized and all profits are transferred back to the foreign licensor. As the prime market grows, so do the licensor's incentives to costly transfer know-how, even at the cost of its own effort and at the added cost of potential imitation. The theoretical predictions are supported by the empirical evidence provided since a positive relationship between GDP per capita and imports of disembodied technology is found.

5 Appendix

The empirical analysis in Section 3 makes use of data from the following countries: Albania, Algeria, Angola, Antigua and Barbuda, Argentina, Australia, Austria, Azerbaijan, Bahamas, Bangladesh, Barbados, Belarus, Belgium, Belize, Benin, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Brunei, Bulgaria, Burkina Faso, Cambodia, Cameroon, Canada, Cape Verde, Chile, China, Colombia, Costa Rica, Cote d'Ivoire, Croatia, Cyprus, Czech Republic, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Eritrea, Estonia, Ethiopia, Faeroe, Islands, Fiji, Finland, France, Georgia, Germany, Ghana, Greece, Grenada, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hong Kong, Hungary, Iceland, India, Indonesia, Iraq, Ireland, Israel, Italy, Jamaica, Japan, Kasakhastan, Kenya, Korea, Kyrgyz Republic, Latvia, Lesotho, Lithuania, Luxembourg, Macao, Macedonia, Madagascar, Malawi, Malaysia, Mali, Malta, Mauritius, Mexico, Moldova, Morocco, Mozambique, Namibia, Netherlands, New Zealand, Niger, Nigeria, Norway, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Romania, Russian Federation, Rwanda, Samoa, Senegal, Seychelles, Singapore, Slovak Republic, Slovenia, Solomon Islands, South Africa, Spain, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Sudan, Suriname, Swaziland, Sweden, Syria, Tajikistan, Tanzania, Thailand, Togo, Tonga, Trinidad and Tobago, Tunisia, Turkey, Uganda, Ukraine, United Kingdom, United States, Uruguay, Vanuatu, Venezuela, West Bank and Gaza, Yemen, Zambia, and Zimbabwe. For these countries, data on technological payments have been collected from 1980 to 2011, although for some of them the series is incomplete. Additionally, there is information on GDP per capita, and R&D expenditures as a percentage of GDP, although this series is available starting only in 1996.

References

[1] Amir, R., Encaoua, D. and Y. Lefouili. 2011. Per-unit royalty vs fixed fee: the case of weak patents. Working Papers halshs-00595493.

[2] Beggs, A. 1992. The licensing of patents under asymmetric information. *International Journal of Industrial Organization*, 10(2): 171-191.

[3] Bousquet, A., H. Crémer, M. Ivaldi, and M. Wolkowicz. 1998. Risk sharing in licensing. *International Journal of Industrial Organization*, 16(5): 535-554.

[4] Branstetter, L. and K. Saggi (2011), "Intellectual property rights, foreign direcct investment and industrial development", *Economic Journal*, 121, 1161-1191.

[5] Chen, Y. and T. Puttitanun. (2005). Intellectual property rights and innovation in developing countries. *Journal of Development Economics*, 78, 474–93.

[6] Choi, J.P. 2001. Technology transfer with moral hazard. *International Journal of Industrial Organization*, 19(1-2): 249-266.

[7] Caballero-Sanz, F., R. Moner-Colonques and J.J. Sempere-Monerris. 2002. Optimal licensing in a spatial model. *Annales d'Economie et de Statistique*, 66, 257–279.

[8] Encaoua, D. and Y. Lefouili. 2009. Licensing weak patents. *Journal of Industrial Economics* 57, 492-525.

[9] Farrell, J. and C. Shapiro. 2008. How strong are weak patents? *American Economic Review* 98, 1347-1369.

[10] Gallini, N. and B. Wright. 1990. Technology transfer under asymmetric information. The Rand Journal of Economics, 21(1): 147-160.

[11] Glass, A. J. and K. Saggi. (2002). Intellectual property rights and foreign direct investment. *Journal of International Economics*, 56, 387–410.

[12] Lai, E. L.-C. (1998). International intellectual property rights protection and the rate of product innovation. *Journal of Development Economics*, 55, 133–53.

[13] Macho-Stadler, I., X. Martínez-Giralt and D. Pérez-Castrillo. 1996. The role of information in licensing contract design. *Research Policy*, 25, 43-57.

[14] Mukherjee, A. and U.B. Sinha (2013), "Patent protection, Southern innovation and welfare in a North-South trade model", *Economica*, forthcoming.

[15] Saggi, K. (1999). Foreign direct investment, licensing and incentives for innovation. *Review of International Economics*, 7(4), 699-714.

[16] Sen, D. and Y. Tauman. 2007. General licensing schemes for a cost-reducing innovation. *Games and Economic Behavior* 59: 163-186.

[17] Sinha, U.B. (2001). International joint venture, licensing and buy-out under asymmetric information. *Journal of Development Economics*, 66, 127-151.

[18] Wang, X.H. 1998. Fee versus royalty licensing in a Cournot duopoly model. *Economics Letters* 60, 55–62.