The Structure of Payments in Technology Transfer Contracts: Evidence from Spain

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This paper studies the impact of contract duration in determining scheduled payments in international transfers of technology. Analyzing a sample of contracts written by Spanish firms in 1991, the main empirical finding is a positive relationship between contract duration and the probability of the parties including variable payments in the first period of the agreement. This result suggests that the parties choose the type of payments to be made, whether fixed or variable, so as to avoid early termination of the relationship, even in the absence of opportunistic behavior or risk aversion.

1. Introduction

Whenever technology is to be transferred, the parties to the transaction have to estimate, at the time of signing the contract, the value of the technology that is transacted. This value must lie somewhere in between the values of the outside option to the parties, and it depends on the evolution of variables subject to uncertainty, such as demand or production costs. This uncertainty leads to risk in the payoffs to the parties that must be shared, depending on each party's attitude toward risk. In addition, both the buyer and the seller must supply costly transaction-specific inputs in an environment of asymmetric information.

These factors are the focus of the explanations proposed for the kind of payments, whether fixed or variable, that the parties to the transaction will agree on at the time of signing the contract. This paper contributes to the literature on contracting for the transfer of technology by explicitly considering the temporal extent of the relationship and analyzing its effect on scheduled payments. This temporal extent is

I am indebted to helpful comments from Bruno Cassiman, Shane Greenstein, Rob Porter, Yossi Spiegel, Dan Spulber, the coeditor and two anonymous referees, and seminar participants at the University of the Basque Country as well as in EARIE'29 and First IIO conferences. Financial support from MCYT through a grant SEC2002-01839 is gratefully acknowledged. All errors are my own.

Journal of Economics & Management Strategy, Volume 14, Number 2, Summer 2005, 403–429

measured by expected contract duration, which is the number of years the parties agree the relationship to last at the time of signing the agreement, not how long the relationship actually lasts. Through a simple model, an explanation is proposed that relies heavily on the effort of the parties to avoid premature termination of the relationship. The parties will have a greater incentive to preserve the relationship, the longer they expect this relationship to last. Thus, they will more likely choose variable payments, which are better suited to this purpose, the longer this expected duration.

This model motivates the empirical section of the paper. It presents and analyzes a sample of 212 contracts signed by Spanish firms in 1991 to import disembodied technology. Among the observed contract characteristics are duration of the agreement and the type of payments to be made, whether fixed or variable, during the initial 5 years of each contract. The main finding of this empirical section is the existence of a positive relationship between expected contract duration and the probability of scheduling variable payments for the first year of the relationship. This effect is stronger in the case of transfers between unaffiliated firms. Another empirical finding is a positive relationship between expected contract duration and the size of the royalty rate.

These results highlight an important difference between fixed and variable payments. Although fixed fees introduce no output distortions, this mechanism does not adapt payments to unforeseen contingencies: changes in demand, legislation, competitive conditions, input prices, or technology, that might induce the parties to costly renegotiate the terms of the agreement. In this sense, a contract that relies more heavily on royalty payments is better suited to this purpose because it makes payments a function of the value generated by the transfer of technology, which depends on these factors. In addition, under a royalty contract, both parties have the right incentive to provide (second-best) transaction-specific inputs and thus reduce the incentives for opportunistic behavior. The cost of doing so is, by increasing the marginal cost of production, to introduce a wedge between the actual and the first-best level of production. By contrast, fixed payments, although not distorting the technology buyer's output, could lead to early termination of the relationship if scheduled payments differ substantially from the actual value of the technology. For relationships that are scheduled to last longer, the parties may have an incentive to reduce the likelihood of early termination, at the cost of the distortion imposed by the royalty. This is simply because the more periods ahead, the greater the opportunity cost of early termination. In contracts where the time horizon is shorter, the value of the relationship will be easier to estimate, and thus, more likely include fixed payments. This suggests that short-run contracts

would originate fixed payments and long-run contracts would generate royalties from the very beginning of the relationship.

This paper presents a simple model that compares the advantages of output-based and fixed payments depending on the expected duration of the relationship. In the model, premature termination occurs with positive probability because of financial constraints on the buyer's side in the presence of demand uncertainty. The model predicts that the advantages of royalty payments are increasing in the expected contract duration and decreasing in the buyer's size.

The theoretical literature has considered the problems inherent to the transfer of technology. Arrow (1969) first points out a double-sided moral hazard problem in the transmission of technology. On the one hand, the seller may not undertake all the effort necessary for a successful transfer of the technology. On the other hand, the buyer may renege on payments once he masters the technology that he has acquired, or can misreport the profit accruing from the implementation of the technology. Royalty payments arise as a means to provide the parties with the right incentives to perform costly relationship-specific actions.

Focused on this moral hazard problem, Choi (2001) presents a model that predicts that if the seller's effort of revealing codified knowledge is relatively more important for the correct implementation of the technology than marketing efforts, a royalty rate can be used in unaffiliated transfers to induce the seller to provide the appropriate type of technology. If marketing or any other activity performed by the buyer is more relevant, we will more likely observe fixed payments. This model predicts affiliated transfers to originate fixed payments only.

If the seller has more complete information on the technology to be transacted, royalty payments can be used as a signal for better technology (see, e.g., Gallini and Wright, 1990). Fixed payments are predicted to be present in every contract, because they signal bad technology and are a rent-extracting device in royalty payment contracts. Therefore, whenever tacit knowledge is a part of the agreement, we should more often observe output-based payments, because tacitness implies an increased difficulty in describing the technology itself, and thus, more asymmetric information on the seller's side.

In addition to opportunistic behavior, the actual usage of any technology on a specific firm is a risky task. The results, in terms of increased profits, of using a new technology, are subject to uncertainty, especially if it implies the introduction of a new product. Output-based payments can be used as a means of providing insurance to the buyer (see, e.g., Bousquet et al., 1998). Assuming the buyer's risk aversion to be

correlated with size, there should be a negative correlation between the buyer's size and the likelihood of observing output-based payments, as well as between the size and the royalty rate itself. On the other hand, the correlation between the size and the probability of observing fixed payments should be positive.

One important issue in international transfers of technology, in addition to the ones that have been pointed out, is how close payments are to the actual value of the technology to be transacted. In the presence of uncertainty, the parties may have an incentive to choose payments that vary with the actual value of the transferred technology, and that discourage the parties from costly renegotiating or even terminating the contract. In this sense, output-based payments adapt better than fixed payments to the evolving value of the technology, and remove any incentives to renege (see Klein, 1996). By contrast, fixed payments increase the likelihood of costly renegotiation, and even early termination of the relationship.

Lack of adequate data has been an obstacle to the validation of theoretical models of technology transfer. In a pioneering study, Caves et al. (1983) employ survey data to point out the potential failures of the licensing market. These failures stem from small-numbers bargaining, appropriability problems, uncertainty, transaction costs, imperfect information, and opportunism. They claim that specific contract clauses are used to solve these problems. Arora (1996) studies data on the acquisition of technology by Indian chemical firms, finding the transfer of know-how being bundled together with other complementary inputs, in order to avoid opportunistic behavior by both parties. Anand and Khanna (2000) use Securities Data Corporation (SDC) data on licensing agreements to find inter-industry differences in exclusivity, cross-licensing, *ex ante* versus *ex post* technology transfers, and licensing to related versus unrelated parties. They argue that inter-industry differences in the protection of intellectual property rights are driving these results, but no evidence on payments is presented. Macho-Stadler et al. (1996) first study the database used in this paper. They find that know-how is more likely transferred between affiliated parties and that contracts for the transmission of know-how will typically include royalty payments. They suggest that moral hazard on the seller's side is the main force driving these results.

In a related branch of the literature, Lafontaine (1992) examines franchising data to determine that two-sided moral hazard is the theoretical explanation most consistent with the observed data. A similar result is presented in Brickley (2002), using variability across states in legislation on contract termination by the franchisor. Furthermore, in a theoretical analysis, Bhattacharyya and Lafontaine (1995) argue that,

in the presence of double-sided moral hazard, the optimal contract involves a fixed fee plus a royalty.

The organization of this paper is as follows. Section 2 presents a simple model that studies the optimal payment mechanism for different contract durations, in the presence of demand uncertainty and financial constraints on the buyer's side. Section 3 describes the data employed in this article. Section 4 analyzes the data and relating them to the theoretical models previously discussed. Finally, Section 5 presents some conclusions.

2. A Simple Contractual Model

This section presents a simple model of technology transfer where the parties adjust payments in order to avoid early termination of the relationship. The model implies that payments in the first year are sensitive to the expected contract duration. The purpose of the model is to motivate the empirical analysis in Section 4. In the presence of financial constraints on the buyer's side, the seller of the technology will weigh the inefficiency that a royalty introduces against the reduction in the probability of early termination with respect to using a fixed payment. For this reason, introducing a royalty payment will become more advantageous the longer the parties, at the time of signing the contract, expect the relationship to last. Relaxing the assumption of the buyer being cash-constrained allows the buyer to be able to pay a higher fixed fee instead of a royalty, increasing the value of the relationship by the removal of the inefficiency introduced by the royalty.

Royalties reduce the probability of premature termination because they link payments to the actual value of the technology, which is not done if upfront fees are paid. In this model what causes early termination is the buyer's inability to pay a fixed fee back to a third party. Neither the buyer nor the seller chooses to optimally terminate the relationship before the scheduled date: Termination occurs after a low realization of the demand shock if only fixed payments are used. The model could be modified to analyze the case of the seller of the technology choosing to terminate or costly renegotiate the contract. In this case, termination or renegotiation might occur if scheduled fixed fees were much lower than the realized value of the technology. In a similar way, by linking payments to the actual value of the technology, royalties ensure the continuation of the relationship.

Assume a foreign patentee is to license to a domestic firm a new product technology, which will become obsolete after T periods. Both firms are risk-neutral, and the foreign firm does not sell its production in the local market. There is no cost uncertainty, and the buyer of the

technology becomes the exclusive producer of the new product at zero marginal cost. Demand for this product is given by $q_t = \varepsilon_t(1 - p_t)$, where $\varepsilon_t = \{\underline{\varepsilon}, \bar{\varepsilon}\}$ is an exogenous shock. Let p be the probability of a high-demand state in every period. The realization of the demand shock is known to both parties when production takes place, but not at the time of contracting. Only output is observable to third parties, and the only feasible contracts are a fixed fee and/or a per-unit royalty per year.

Extreme cash constraints will be initially assumed: the buyer's shareholders collect the firm's profits at the end of each period, thus making initial cash holdings 0 in every period. Furthermore, if a fixed fee is to be paid, the buyer must borrow the amount of the fixed fee and pay it back after production takes place and the buyer of the technology realizes its sales. Only 1-year loans are available in this economy. In the case of default, the lender receives the outstanding debt from liquidation of the firm's assets, and the relationship is terminated. Thus, if scheduled payments exceed the revenues collected from selling the product minus costs of production, the relationship may be prematurely terminated.

In the case of default, the seller has the option of searching for another, identical, buyer, incurring in a search cost $S(s)$, where s is the number of searches made up to period t, and the search cost function is increasing in s. Therefore, the seller can maintain its stream of revenues, but finding an alternative partner is increasingly difficult. For simplicity, assume both the shareholders' outside option and the interest rate to be 0. Introducing either a positive interest rate or a positive outside option only reduces the maximum fixed fee that the seller can charge.

At time zero, the parties meet to sign a contract for the transfer of the right to use the product technology for T periods, where T is determined by exogenous product characteristics. Assume that the seller has all the bargaining power, and thus makes a take-it-or-leave-it offer to the buyer, which consists on a $2T$-dimensional vector $(F_1, r_1, \ldots, F_T, r_T)$, that is, fixed fees and a per-unit royalties in $t = 1, \ldots, T$. Splitting the bargaining power between buyer and seller will change each party's share of total surplus. However, the result that the likelihood of observing royalty payments in the first year is nondecreasing in contract duration remains unchanged. What drives the result is the difference in the probabilities of early termination associated with fixed and royalty payments. All these payments are constrained to be nonnegative, and cash constraints force period t payments to be financed exclusively by period t revenues.

In $t = 0$, the seller presents the contract to the buyer. Once the initial contract is signed, the timing of the game in $t = 1, 2, \ldots, T$ is as follows:

1. If $t > 1$ and the buyer defaulted at the end of the previous period, the seller may find another buyer, incurring in a search cost $S(s)$. In this case, the seller offers the new partner another contract that lasts for $T - t + 1$ periods.
2. If the contract stipulates that a fixed fee be paid in period t, the buyer borrows the amount of the fixed fee and pays it to the seller, at the beginning of the period.
3. The demand shock is realized and production takes place. Royalty payments, if any, are paid, and the loan is paid back or default occurs. If default occurs, the lender receives the amount of the outstanding debt from liquidation of the buyer's assets, and the relationship is terminated. If there is no default, the relationship continues or ends if $t = T$.

In the case of a one-period relationship, the seller of the technology can choose a fixed fee only, a royalty only, or mixed payments (fixed fee plus royalties). The maximum fixed fee that will be accepted by the buyer will be its expected gross profits if using the seller's technology, taking into account that, with probability $1 - p$ the firm will default and therefore be liquidated. This expected profit, which determines the maximum fixed fee that can be charged, is

$$F = p\frac{\bar{\varepsilon}}{4} + (1 - p)\left(\frac{\underline{\varepsilon}}{4}\right). \tag{1}$$

The risk of default can be reduced to 0 by setting the fixed fee equal to the buyer's profits if the low-demand state occurs. This level of profits is $\frac{\underline{\varepsilon}}{4}$, strictly less than F in expression (1), and thus, in a one-period relationship, the seller will never choose this lower fixed fee. The seller can also reduce the probability of default to 0 by introducing royalty payments. From the seller's maximization problem, the optimal per-unit royalty is

$$r = \frac{1}{2}, \tag{2}$$

which is always the optimal royalty due to the simple demand structure used in the model. In addition to this royalty, the seller is able to introduce a fixed fee equal to the buyer's profits if demand is low and its marginal cost is r, the optimal royalty rate. This fixed fee equals $\frac{\underline{\varepsilon}}{16}$. The seller's expected receipts if using this mixed-payments contract are

$$R = \frac{\underline{\varepsilon}}{16} + p\frac{\bar{\varepsilon}}{8} + (1 - p)\frac{\underline{\varepsilon}}{8}. \tag{3}$$

Therefore, the seller of the technology will compare its revenues when using these three options. The seller's revenues will be greatest if a fixed fee only is introduced, i.e.,

$$F > \max\left\{R, \frac{\varepsilon}{4}\right\}. \tag{4}$$

In a one-period relationship, the seller is not concerned about the buyer defaulting, because the relationship will terminate after the first period anyway. The model predicts that the seller will charge a fixed fee equal to F and that default will occur with probability p.

Now the general case of the relationship lasting for T periods is analyzed. Assume for simplicity that the demand shock is identically distributed as in the first period, that is, the probability of the demand shock being high is p, regardless of the history of realizations of the demand shock. Now default plays a crucial role in the seller's choice of its payment schedule because, if the seller chooses a fixed fee that exceeds profits in the low-demand state, default and therefore premature termination occurs with probability p. What will be done is to consider increasing values of T and check whether there is some duration T^* such that the seller uses fixed payments, but not royalties, in the first period if duration is $T^* - 1$ but finds it optimal to use royalties in the first period if duration is T^*.

The contract that the seller will present to the buyer at $t = 0$ always stipulates that the fixed fee F be paid in period T. In the final period, the buyer defaulting causes no loss to the seller, because it already received the fixed payment at the beginning of period T. Now the question is whether the seller will also schedule a fixed fee equal to F in previous periods, or whether it will choose other payment type that reduces to 0 the probability of early termination. Assume first that $T = 2$. In this case, expected profits if the seller demands a fixed fee F in the first period are

$$F + pF + (1 - p)\max\{0, F - S(1)\} < 2F. \tag{5}$$

If scheduled payments for $t = 1$ are F, then the probability of default is $(1 - p)$. In the case of default, the seller will have to search for another buyer, incurring in the cost $S(1)$, where the argument is one because this would be its first search. If this search cost exceeds revenues from the fixed fee that the seller would charge to an alternative partner, the seller will not search for another potential buyer. Alternatively, the seller may be interested in setting the probability of default to 0. This can be accomplished either by reducing the fixed fee to the buyer's profits if demand is low or by introducing mixed payments. Because continuation is guaranteed, the seller will optimally introduce a fixed fee equal to F in the second period, because the seller is never concerned about the

buyer defaulting in period T. Reducing the probability of default to 0 will be optimal as long as

$$F + pF + (1 - p)\max\{0, F - S(1)\} < \max\left\{\frac{\varepsilon}{4} + F, R + F\right\}. \tag{6}$$

Now, if $\max\{\frac{\varepsilon}{4}, R\} = R$, then mixed payments may be chosen by the seller in the first period. Otherwise, the seller will just reduce the fixed fee to the buyer's profits in the low-demand state, and still reduce the probability of termination to 0. In this case, duration neither increases nor reduces the likelihood of observing royalty payments: mixed payments are never introduced. If $\max\{\frac{\varepsilon}{4}, R\} = R$, the condition that must hold for the seller to choose a fixed fee F in $t = 1$ is

$$pF + (1 - p)\max\{0, F - S(1)\} > R. \tag{7}$$

This implies that the range of parameter values that make royalty payments to be scheduled for the first period is greater than in the case of one-period contracts. Thus, the inclusion of variable payments in the first period is more likely to occur if contract duration is 2 years than if it is 1 year. With $T = 3$ and if the optimal payment in the first period was F when $T = 2$, then F will be chosen in the first period if

$$p[pF + (1 - p)\max\{0, F - S(1)\}] + (1 - p)[p\max\{0, F - S(1)\} + (1 - p)\max\{0, F - S(2)\}] > R. \tag{8}$$

Condition (8) makes the seller more likely to include variable payments in the first year than condition (7). Moreover, considering higher values of T makes the condition of the fixed fee F dominating mixed payments more difficult to hold because search costs are increasing in the cumulative number of searches. Therefore, the probability of the seller introducing royalty payments in the first year is nondecreasing in T.

What remains to be verified is whether in a contract that is scheduled to last for T periods, where mixed payments have been chosen in the first period, increasing contract duration to $T + 1$ makes the seller choose F as the first period payment. If, with contract duration T the seller prefers mixed payments in the first period, then, it must be true that

$$R + V \geq F + pV + (1 - p)(V' - S(1)), \tag{9}$$

where V is the optimal value of continuation after the first period, which could include fixed or mixed payments, and V' is the value of continuation after the first period taking into account that there has been

one search, at the beginning of period 2. Of course, this fact increases the cost of future searches, and therefore, $V > V'$. Now, if the relationship is scheduled to last for $T + 1$ periods, then if a fixed fee is introduced in the first period, expected receipts are

$$F + p(R + V) + (1 - p)(R + V' - S(1)), \tag{10}$$

whereas expected receipts in the case of using mixed payments in the first period are just

$$R + R + V. \tag{11}$$

Now, if condition (7) holds, it must be the case that the seller's expected revenues be greater if choosing mixed payments in the first year and contract duration is $T + 1$ instead of T. This implies that, at the time of signing the contract, if the seller schedules payments for some period $T - k$, it will also schedule mixed payments for periods $t = 1, \ldots, T - k - 1$.

The central point that this model makes is that the probability of introducing royalty payments in the first period of the relationship is nondecreasing in expected contract duration. Thus, the model predicts a positive relationship between the probability of observing variable payments in the first period and contract duration. Royalty payments, combined with a smaller fixed fee, are optimally introduced in order to guarantee the continuation of the relationship, even though they reduce the seller's profits whenever used. The model also suggests that the optimal contract always includes a fixed fee, and therefore, does not predict the dropping of fixed fees, but its reduction. This is a consequence of the simple demand structure assumed, with only two possible realizations of the demand shock. Considering a continuous demand shock would imply a negative relationship between duration and the likelihood of fixed payments being used. In this case, the proportion of total fixed payments to total variable payments (taking into account the whole of the life of the contract) decreases in contract duration. This implies that the royalty rate should be increasing in contract duration.

Increasing search costs play a crucial role in this result, because in the case of only fixed payments being used, longer relationships imply more searches on average. Indeed, with zero search costs the seller would have no incentive to ensure continuation of the relationship, it would use fixed payments only and let the buyer go bankrupt whenever revenues fall short of the fixed fee.

Finally, holding contract duration fixed, making the buyer less cash-constrained would make the seller less likely to schedule variable payments for the first year. Without cash constraints, period t payments

need not be financed exclusively by period t revenues. This allows the seller to be able to optimally ask for a higher fixed fee without the fear of early termination. Assuming cash holdings to be correlated with size, the model predicts a negative relationship between the buyer's size and the probability of including royalty payments in the first year of the life of the contract.

3. The Data

This section describes the database that will be used for the empirical analysis in next section. First, there is a description of the database, followed by a preliminary discussion of some regularities encountered in the data.

3.1 Description of the Database

All Spanish firms that imported technology were required, up to 1992, to report the Spanish Ministry of Industry the terms of the technology purchase. For this reason, the buyer had to file a form, named "TE-30," with the "Servicio de Información y Transferencia de Tecnología" (Technology Transfer Office), a branch of the Spanish Ministry of Industry. In some cases, in addition to this form, the firm included the actual contract although this was optional. However, because this type of control is no longer allowed by the European Union, filing was terminated in 1992.

The buyer of the technology had to describe in this form some features of the imported technology. In particular, the buyer had to declare whether it was a product and/or a process technology. The buyer also had to report whether there was a transfer of a patent, a utility model, know-how, an industrial design or software. In all these cases, the buyer indicates whether or not these types of technology were transferred, which implies that whenever these variables are used in the empirical section, they will be treated as dummy variables. Know-how is tacit knowledge, not legally protected against imitation, and not contractible upon, in the sense that no contract can be written contingent on the characteristics of such know-how. The remaining technology types are protected by law against imitation. The seller also had to report whether ownership of the technology was to be transferred, or whether the buyer only had the right to use a given technology.

In the form to be sent to the Ministry of Industry, there was also some information on the buyer's characteristics. In addition to the industry of its main activity, the buyer had to report on its sales in the year before the filing of the form. Also included was information on what kind of linkages buyer and seller had, if any. The buyer, when

applicable, had to declare the percentage of its equity owned by the seller, or if both firms had a common parent. Using this information, the observations can be classified into affiliated and unaffiliated. Two parties are affiliated if either there is a direct participation of the seller of 50% or more in the buyer's equity or both buyer and seller have a common owner. The buyer also had to indicate whether it was engaged in R&D activities, although there was no information on the percentage of sales devoted to this activity. Regarding the seller's characteristics, both the seller's industry and country appear on the form. The form also contains the buyer's estimate of scheduled payments to be made during the first 5 years of the contract, distinguishing between fixed and variable payments, and reporting the royalty rate whenever variable payments are scheduled.

In those observations where the contract is filed together with the form, more variables are observable, by inspecting the contract clauses. In particular, the variable that will be of interest in this study is the duration the parties agree on the contract to last at the time of signing it. Whenever the contract was available, the duration variable just takes the value expressed in the contract. If only the form was observable, duration can be inferred by observing the evolution of scheduled payments. In these cases, duration is the last period for which positive payments are scheduled. Direct observation and inference makes contract duration observable in 165 of the 212 observations. For the remaining 47 observations, the exact contract duration is unknown, but it is at least 5 years.

3.2 The Sample Stylized Facts

Out of the 5,168 forms filed in 1991, 212 observations are included in the sample. The Spanish Ministry of Industry did no systematic classification of the forms. They were literally stored in boxes as they were received and sent to the archives in a basement located in the central offices of the ministry in Madrid. This makes one reasonably think that there was no significant bias arising from the sampling procedure, which was to randomly select boxes and inspecting the forms contained in them. The sample size is conditioned by the fact that the author obtained permission only for 2 weeks to copy the contents of the forms manually.

Table I presents selected characteristics of the contracts, classified by industry of the buyer. The data have been classified into five industry groups: agriculture; energy, minerals, and chemicals; metal transformation; other manufacturing and construction; services. These industry groups correspond to industries 0, 1–2, 3, 4–5, and 6–9, respectively,

Table I.
Contract and Firm Characteristics by Industry

Industry	Total	Know-How (%)	Process Technology (%)	Fixed Payments (%)	Variable Payments (%)	Average Royalty Rate (%)
			Panel A.			
Agriculture (0)	11	45.5	0	27.3	90.9	10.2
Energy, minerals, chemicals (1–2)	48	85.4	50	54.2	68.7	4.3
Metal transformation (3)	67	64.2	41.8	59.7	64.2	4.2
Other manufacturing, construction (4–5)	40	50	42.5	35	82.5	4.3
Services (6–9)	46	43.5	67.4	63	47.8	5.7
Total	212	60.8	47.2	52.3	66.5	4.9

Industry	R&D (%)	Unaffiliated (%)	Duration (years)	Average Sales (pta mn)
	Panel B.			
Agriculture (0)	63.6	81.8	7.6	1,568
Energy, minerals, chemicals (1–2)	68.7	68.7	4.7	24,266
Metal transformation (3)	70.1	71.1	4.6	21,414
Other manufacturing, construction (4–5)	35	57.5	5.5	5,284
Services (6–9)	28.3	58.7	3.3	17,217
Total	53.8	65.6	4.6	17,120

according to Spanish classification (CNAE-74). The final sample of 212 observations contains transfers that explicitly mention a patent, a utility model, an industrial design, know-how, or software (not for resale) being transferred. Contracts where the technological content is less clear, for instance those where the buyer is just a software retailer or for the provision of technical assistance have been explicitly excluded from the final sample.[1]

As it can be seen in Panel A of Table I, there is some variation across industries in technology characteristics. Most contracts made in energy, minerals, and chemicals include the transfer of know-how, whereas less

1. Included in the sample are transfers of software only if it is to be used by the buyer. There are some contracts in the sample where the buyer merely acts as a software retailer. These transfers have been explicitly excluded from the final sample.

than half of the contracts in services include the transmission of this type of technology. By contrast, process technologies are prevalent in services, and no contract in agriculture fall into this category. Only one-fourth of all contracts in agriculture and slightly over a third of those in other manufacturing and construction include fixed payments somewhere during the life of the contract. The proportion of contracts in other industries that include fixed payments is around 60%. Agriculture and other manufacturing and construction are the industries where the proportion of contracts that include royalty payments in the first year is highest, above 80% in both cases, whereas in the remaining industries, it ranges from 47% in services to 68% in energy, minerals, and chemicals. The last column in Panel A of Table I reports the average royalty rate in case there are variable payments in the first year. This royalty rate does not seem to vary much across industries, except for agriculture, where it is more than twice the average royalty rate.

Regarding Panel B of Table I, other manufacturing, construction, and services are the industries whose firms are the least likely to engage in R&D. Unaffiliated transfers are prevalent in all industries, with agriculture having the highest percentage, over 80%. Duration is also highest in agriculture, and around 5 years in the remaining industries, except for services, with shorter contracts on average. Finally, there is a high degree of heterogeneity across industries in the buyer's sales, with the average firm in energy, minerals, and chemicals being 15 times as big as the average firm in agriculture.

The Spanish firm had to include in the form expected payments to be made during the initial 5 years of the relationship, distinguishing between fixed and variable payments. Panels A, B, and C of Table II report the proportion of contracts that schedule fixed, variable, or mixed payments for each of the initial 5 years of the relationship. Table II (Panel A) presents this information for the full sample of contracts, whereas Panels B and C of Table II present the same information for the sample of unaffiliated and affiliated transfers, respectively.[2]

In both the unaffiliated and the affiliated subsamples, contracts typically evolve from fixed or mixed payments to variable payments only. Indeed in both subsamples, over 80% of the observations schedule only royalty payments for the third and subsequent years. Thus, the typical contract schedules fixed payments for the first and/or second year, and only variable payments for the remainder of the relationship.

2. Royalty payments are suspect to be overestimated because if actual payments exceeded the reported amount, the buyer was bound to send a second report to the Ministry. Thus, it is reasonable to expect firms to overestimate future variable payments in their reports. Indeed, scheduled payments are higher than actual payments as recorded by the Bank of Spain.

TABLE II.
SCHEDULED PAYMENTS FOR THE INITIAL 5 YEARS OF THE RELATIONSHIP

Year	FP Only (%)	RP Only (%)	FP + RP(%)	Total	Average Royalty Rate
			Panel A: Full Sample		
First	33.5	47.2	19.3	212	4.91
Second	20.0	69.7	10.3	165	4.81
Third	12.6	82.2	5.2	135	4.67
Fourth	7.8	87.8	4.3	115	4.75
Fifth	7.3	88.1	4.6	109	4.72
			Panel B: Unaffiliated Subsample		
First	38.1	37.4	24.5	139	5.09
Second	23.8	62.9	13.3	105	4.92
Third	12.2	82.9	4.9	82	4.86
Fourth	7.0	88.7	4.2	71	4.92
Fifth	6.1	89.4	4.5	66	4.93
			Panel C: Affiliated Subsample		
First	24.7	65.8	9.6	73	4.65
Second	13.3	81.7	5.0	60	4.65
Third	13.2	81.1	5.7	53	4.36
Fourth	9.1	86.4	4.5	44	4.47
Fifth	9.3	86.0	4.7	43	4.39

Another remarkable fact is to observe the high proportion of affiliated transfers that schedule variable payments for every period.

Panels A, B, and C of Table II show that the parties will more likely include royalty payments in more distant periods. Therefore, the likelihood of observing royalty payments will be lowest in the first period. For this reason, Panels A, B, and C of Table III present scheduled payments in the first year of the contracts, as a function of expected contract duration. It is interesting to observe that contract duration increases the likelihood of the parties including royalty payments in the first year of the agreement. We can observe that this pattern arises both in the affiliated and in the unaffiliated subsamples, although the increase is more acute in the unaffiliated subsample. Also in this subsample, the proportion of contacts that include fixed payments in the first year also falls with contract duration, but more moderately, from 85% if duration is 1 year to 44% if duration is 5 years or more. The goal of Section 4 is to verify whether there is statistically significant evidence of a positive relationship between contract duration and payments scheduled for the

TABLE III.
FIRST-YEAR SCHEDULED PAYMENTS AND DURATION

Duration (years)	FP Only (%)	RP Only (%)	FP + RP (%)	Total
Panel A. Full Sample				
1	83.0	17.0	0.0	47
2	53.3	26.7	20.0	30
3	35.0	45.0	20.0	20
4	16.7	66.7	16.7	6
5 or more	7.3	65.1	27.5	109
Panel B. Unaffiliated Subsample				
1	85.3	14.7	0.0	34
2	65.2	13.0	21.7	23
3	36.4	36.4	27.3	11
4	20.0	60.0	20.0	5
5 or more	4.9	56.1	39.0	41
Panel C. Affiliated Subsample				
1	76.9	23.1	0.0	13
2	14.3	71.4	14.3	7
3	33.3	55.6	11.1	9
4	0.0	100.0	0.0	1
5 or more	9.3	79.1	11.6	43

first year of the relationship, as suggested in Panels A, B, and C of Table III.

4. EMPIRICAL EVIDENCE

This section presents estimates of the effects of contract duration, as well as technology and buyer's characteristics on the likelihood of observing royalty and/or fixed payments. In addition, in this section, the effects of these same variables on the size of the royalty rate itself are presented. Of central interest will be contract duration, which will be found to have a significant effect both on the likelihood of observing output-based payments from the very beginning of the life of the contract and on the royalty rate. The effects of the transfer of tacit knowledge and the buyer's size will also be discussed.

4.1 THE CHOICE OF FIXED AND OUTPUT-BASED PAYMENTS

Because firms simultaneously choose fixed and output-based payments, the econometric specification is a bivariate probit model with the two

dependent variables being indicators of the presence of royalty payments in the first year of the agreement and fixed payments anytime during the life of the contract. Because no contract that does not schedule fixed payments for the first year includes them in subsequent years, the latter variable is equivalent to an indicator of fixed fees being scheduled for the first year. The choice equations in this bivariate probit model are

$$\begin{aligned} V_{1i} &= \alpha_0 + \sum_{j=1}^{4} \alpha_j Ind_{j,i} + \alpha_5 KH_i + \alpha_6 Link_i + \alpha_7 Pcs_i \\ &\quad + \alpha_8 Duration_i + \alpha_9 \ln impts_i + \alpha_{10} \ln sales_i + \varepsilon_{i,1,} \\ V_{2i} &= \beta_0 + \sum_{j=1}^{4} \beta_j Ind_{j,i} + \beta_5 KH_i + \beta_6 Link_i + \beta_7 Pcs_i \\ &\quad + \beta_8 Duration_i + \beta_9 \ln impts_i + \beta_{10} \ln sales_i + \varepsilon_{i,2}. \end{aligned} \tag{12}$$

The error term is distributed $N[\binom{0}{0}, \binom{1\ \rho}{\rho\ 1}]$, and the observed dichotomous dependent variables are simply,

$$\begin{aligned} Fpay_i &= 1(V_{1,i} > 0), \\ Roy_i &= 1(V_{2,i} > 0). \end{aligned} \tag{13}$$

The regressors include four industry dummies, one for each industry except agriculture. The specification includes a dummy that takes the value 1 if know-how is transferred (*KH* variable). This type of knowledge enjoys weaker legal protection against imitation than say, a patent, and is therefore more likely to originate opportunistic behavior by the parties. For this reason, models based on moral hazard based on the seller's side would predict a positive impact on the likelihood of scheduling variable payments, as well as on the size of the royalty rate, and negative impact on the likelihood of scheduling fixed payments in all periods. If moral hazard on the buyer's side is more important, the predictions would be the opposite ones.

Also present in the specification is a dummy indicating whether the parties are affiliated (*Link* variable). Recall that two parties are affiliated if either there is a direct participation of the seller of 50% or more in the buyer's equity or both buyer and seller have a common parent. The specification also includes a dummy that takes the value 1 if the technology is classified as one of a process type (*Pcs* variable). Transfers of process technology involve less demand uncertainty than transfers of product technology, reducing the variability in its value. Furthermore, if the buyer is a multiproduct firm, it will be more difficult to identify

what the contribution of a given technology to the reduction in cost in a given product. These two reasons make this type of technology be more likely to originate fixed payments only.

The ln *impts* variable is the logarithm of Spanish imports from the seller's country as a percentage of total Spanish imports in 1990, the year before the contracts were signed. This is a proxy for asymmetric information on the local market: it is reasonable to expect that if the seller belongs to a country with closer commercial ties there will be less asymmetric information on local market conditions. There is no *a priori* expected sign for this coefficient, because less asymmetric information might favor the parties choosing a fixed fee, but on the other hand, looser ties might make monitoring more difficult, which could favor fixed payments.

Finally, the specification includes the logarithm of the buyer's sales in the period previous to the signing of the contract. This variable can be interpreted as a proxy both for the buyer's cash constraints, assuming size to be correlated with cash holdings, and for the buyer's attitude toward risk, with smaller firms being more risk-averse. In both cases, the expected relationship is that the larger the buyer, the higher the likelihood of observing fixed payments, and the lower the likelihood of observing variable payments. Therefore, concerning this particular variable, both explanations are observationally equivalent.

Expected contract duration is observed whenever the actual contract was filed together with the form, or if no payments are scheduled for the fifth or earlier period. As pointed out in the previous section, using this criterion, expected duration is observed or inferred in 165 out of the 212 observations. The remaining observations are contracts that last for 5 years or more, but in which duration could neither be directly observed nor inferred. The observability of duration limits the number of observations actually used in the estimation to 165.

The model in Section 2 treated contract duration as exogenous, determined by the remaining useful life of the product. It can be argued that in actual practice the parties actually have some room to determine contract duration. However, it will be considered that the parties choose the payment type once contract duration has been set, thus making contract duration predetermined relative to scheduled payments. For this to be a valid procedure, a crucial assumption is that there are no unobserved factors that influence both scheduled payments and contract duration.

Columns (i) and (ii) of Table IV report estimated coefficients using both affiliated and unaffiliated transfers. The effect of the transfer of know-how is negative in the fixed payments equation, and positive in the royalty payments equation, both consistent with the predictions of

TABLE IV.
BIVARIATE PROBIT REGRESSION OF LIKELIHOOD OF FIXED AND VARIABLE PAYMENTS

	Dependent Variables: Indicators of the Presence of Fixed Payments and Output-Based Payments in the First Year			
	Full Sample		Unaffiliated Subsample	
	Fixed Payments (i)	Royalty Payments, First Year (ii)	Fixed Payments (iii)	Royalty Payments, First Year (iv)
Know-how	−0.267	0.303	−0.102	0.047
	0.27	0.361	0.317	0.408
Affiliation	−0.809***	0.435		
	0.263	0.355		
Process technology	0.718***	−0.858***	0.657**	−0.913***
	0.236	0.266	0.292	0.398
Duration	−0.081**	0.442***	−0.076*	0.603***
	0.037	0.146	0.043	0.114
ln(imports)	−0.065	0.09	−0.244	0.177
	0.119	0.145	0.152	0.191
ln(sales)	0.128**	−0.093	0.178***	−0.154**
	0.058	0.058	0.061	0.076
Constant	0.396	0.324	0.852	0.396
	0.826	0.896	1.007	1.06
Log-likelihood	−113.217		−73.706	
Sample size	164		113	

All regressions include industry dummies.
Standard errors reported below the estimated coefficient.
***Indicates statistically significant at the 1% level (two-tailed test).
**Indicates statistically significant at the 5% level (two-tailed test).
*Indicates statistically significant at the 10% level (two-tailed test).

models based on moral hazard on the seller's side. However, in neither case is the effect statistically significant.

Affiliation has a negative, statistically significant effect on the likelihood of observing fixed payments, and a positive, although not statistically significant effect on the likelihood of observing royalty payments. Therefore, there is no evidence of affiliated firms trying to avoid the distortions in the buyer's output choice that royalties introduce. However, the negative, statistically significant coefficient on affiliation in the fixed payments equation should be interpreted with caution, because affiliated firms may be making use of other payment mechanisms not explicitly reflected in the observed contracts. On the other hand, the transfer of process technology increases the likelihood of the parties substituting fixed payments for royalty payments. This result suggests

that new product technologies are subject to more demand uncertainty, making variable payments the preferred payment mechanism.

Duration has a negative, statistically significant effect on the likelihood of scheduling fixed payments, and a positive, significant effect on the probability of scheduling royalty payments for the first year of the life of the contract. This result is especially interesting because it implies that the type of payments that are chosen for the first period depend on the temporal extent of the agreement. It is more likely that the parties agree on introducing variable payments and avoid fixed payments from the very beginning if they consider a long-term relationship than if it is the case of a short-term relationship.

The logarithm of imports from the seller's country has no statistically significant effect either in columns (i) or (ii). By contrast, the logarithm of sales has a positive, statistically significant effect in the fixed payments equation. In column (ii), the effect is negative, but not statistically significant. The signs of the estimated coefficients are consistent with explanations based on risk sharing and on cash constraints on the buyer's side: as the buyer is smaller in size, the parties are more likely to substitute variable payments for fixed payments.

Columns (iii) and (iv) report estimated coefficients for the unaffiliated subsample. The reason to focus on this subsample is that affiliated and unaffiliated data could be behaving in different ways. First, because whereas in affiliated transfers some payments might not be reflected in the contract, it is reasonable to assume all payments to be specified in the contract if the transfer is unaffiliated because the relationship between the firms is likely to be confined to this specific transfer of technology. Second, because the problems that two affiliated parties face when transferring technology might be inherently different form those faced by unrelated parties. Thus, mixing the two subsamples may be masking the effects of the variables of interest.

Using the subsample of unaffiliated transfers, the effects of the transfer of tacit knowledge have the same signs as in columns (i) and (ii), neither is statistically significant. Thus, the introduction of tacit knowledge, which presents more difficulties when contracting on it, does not influence scheduled payments. The sign, size, and statistical significance of the coefficients on process technology in columns (iii) and (iv) are similar to those in columns (i) and (ii). The coefficient on duration in the fixed payments equation is negative and statistically significant at the 10% level. In the royalty payments equation it is positive, statistically significant at the 1% level, and greater in absolute value than that in column (ii), which uses the full sample of contracts. These results suggest that the parties attempt to avoid early termination of the relationship, and they try harder the longer the relationship is expected to last. The

results also suggest that these considerations are more important if buyer and seller are unaffiliated. Within affiliated transfers, duration has a less important effect on scheduled payments.

The effects of the logarithm of imports variable have the same sign as in columns (i) and (ii), and they are not statistically significant. Finally, the effect of the buyer's size is positive and statistically significant at the 1% level in the fixed payments equation, and negative and statistically significant at the 5% level in the royalty payments equation. This means that the substitution of variable payments for fixed payments as the buyer's size is reduced is also present within unaffiliated transfers. Moreover, the size of the estimated coefficients are greater in absolute value than those in columns (i) and (ii). Thus, in a similar way as in the effect of contract duration, the buyer's size is a more important issue for unaffiliated parties transferring technology.

The effects of contract duration and the buyer's size on scheduled payments are consistent with the model presented in Section 2. The model predicts that longer expected duration induces the parties to choose royalty payments, although the model does not predict the dropping of fixed payments. The latter result follows from the simple demand structure, with only two possible realizations of the demand shock. This setting allows the seller to always include a fixed payment, because positive fixed fees are consistent with zero probability of termination. In the case of a continuum of realizations of the demand shock, fixed fees may be dropped altogether. Concerning the effect of the buyer's size, the model predicts that as the size of the buyer is increased, fixed payments substitute for royalty payments, because bigger buyers are less cash-constrained, and thus less likely to default.

The results obtained in this paper also have some implications for explanations that build on arguments previously used in the literature. Explanations based on moral hazard or risk sharing have been widely used to analyze contracts for the transfer of technology, although the implications of the temporal extent of the relationship on payments have not been considered. The estimated coefficients on contract duration in columns (i)–(iv) of Table IV imply that an explanation based on risk sharing should take into account that extending the temporal dimension of the relationship has an effect on risk in the first period, making variable payments in this period more likely. Similarly, moral hazard-based models would need to argue that the moral hazard problem in the first period is worsened as the expected duration of the relationship increases.

Table V is a robustness check of the previous results. It excludes contracts whose duration is only 1 year have been excluded from the sample and analyzes whether the results are similar to those obtained in

Table V.
Bivariate Probit Regression of Likelihood of Fixed and Variable Payments. Duration > 1 Year

	Dependent Variables: Indicators of the Presence of Fixed Payments and Output-Based Payments in the First Year			
	Full Sample		Unaffiliated Subsample	
	Fixed Payments (i)	Royalty Payments, First Year (ii)	Fixed Payments (iii)	Royalty Payments, First Year (iv)
Know-how	−0.311	0.605	−0.044	0.462
	0.291	0.422	0.36	0.551
Affiliation	−1.104***	0.329		
	0.301	0.353		
Process technology	0.668**	−0.845**	0.474	−1.503***
	0.283	0.404	0.334	0.537
Duration	−0.041	0.382***	−0.036	0.669***
	0.039	0.092	0.045	0.198
ln(imports)	−0.021	−0.081	−0.12	0.04
	0.12	0.128	0.154	0.287
ln(sales)	0.139**	−0.025	0.183***	−0.114
	0.057	0.056	0.068	0.105
Log-likelihood	−91.084		−60.796	
Sample size	123		83	

All regressions include industry dummies.
Standard errors reported below the estimated coefficient.
***Indicates statistically significant at the 1% level (two-tailed test).
**Indicates statistically significant at the 5% level (two-tailed test).
*Indicates statistically significant at the 10% level (two-tailed test).

Table IV. As it could be seen in Table III, 1-year contracts are more likely to include fixed payments only because, for instance, they may include a high proportion of contracts where ownership of the technology is transferred. Then, Table V tries to find out whether the positive relationship between duration and the likelihood of including royalty payments is driven by the existence of these short-lived contracts that typically generate fixed payments only.

As it can be observed in Table V, the results obtained are robust to the exclusion of contracts that are scheduled to last for only 1 year.[3] Again, the effect of the transfer of know-how is not statistically

3. The constant terms in these specifications have been dropped because of nonconcavity of the likelihood function that prevented the standard error of the constant to be estimated. The sign, size, and statistical significance of the remaining coefficients are not affected by dropping the constant term.

significant in the unaffiliated subsample. The effect of process technology on the likelihood of observing fixed payments now loses its statistical significance in the unaffiliated subsample. The estimated effects of duration on the likelihood of observing variable payments are similar to those reported in Table IV, and considerably stronger for the unaffiliated subsample. However, the effect of duration on the likelihood of scheduling fixed payments is insignificant both in columns (i) and (iii). The estimated coefficients on the logarithm of sales are comparable with those obtained in the previous table, although the effect of the buyer's size on the probability of including variable payments loses its statistical significance both in columns (ii) and (iv).

The effect of duration on the likelihood of scheduling variable payments for the first year is positive, stronger if considering unaffiliated transfers only, and robust to the exclusion of short-term contracts. However, the effect of duration on the probability of including fixed payments is not robust to this sample truncation. Thus, although there is strong evidence of the parties more likely introducing variable payments if the relationship is a long-term one, the evidence of the parties actively avoiding fixed payments is weaker.

4.2 Choosing the Royalty Rate

Table VI reports estimated coefficients of the effect of the contract and buyer's characteristics that we have considered so far on the size of the royalty rate for the first year of the agreement. The econometric specification employed is a Tobit model, where the dependent variable is the royalty rate as a percentage of sales. Thus, the specification to be estimated is

$$Roy_i = \alpha_0 + \sum_{j=1}^{4} \alpha_j Ind_{j,i} + \alpha_5 KH_i + \alpha_6 Link_i + \alpha_7 Pcs_i + \alpha_8 Duration_i + \alpha_9 \ln impts_i + \alpha_{10} \ln sales_i + \varepsilon_i, \quad (14)$$

if the right-hand side is positive, and 0 otherwise. *Roy* is the royalty rate as a percentage of sales in the first year, and the regressors are the same as in equation (12). As it was done in Tables IV and V, the regression has been run using the full sample first and then the unaffiliated subsample only.

The conclusions extracted from the analysis of the coefficients in Table VI are consistent with those obtained in the previous tables. The coefficient on the transmission of know-how is positive, although statistically insignificant both in columns (i) and (ii). Similarly, the effect of affiliation, reported in column (i), is positive, although not

Table VI.
Tobit of Royalty Rate on Selected Contract Clauses

	Full Sample (i)	Unaffiliated Subsample (ii)
Know-how	1.052	0.862
	0.801	0.99
Affiliation	0.585	
	0.753	
Process technology	−2.243***	−2.494***
	0.736	0.912
Duration	0.584***	0.633***
	0.114	0.141
ln(imports)	0.089	0.842*
	0.347	0.444
ln(sales)	−0.541***	−0.569***
	0.17	0.196
Constant	1.979	−0.272
	2.641	3.25
Log-likelihood	−307.903	−195.362
Sample size	161	110

All regressions include industry dummies.
Standard errors reported below the estimated coefficient.
***Indicates statistically significant at the 1% level (two-tailed test).
**Indicates statistically significant at the 5% level (two-tailed test).
*Indicates statistically significant at the 10% level (two-tailed test).

statistically significant. The coefficient on process technology is negative and statistically significant, whereas that on the logarithm of imports is positive but not statistically significant in column (i), although it increases its value and becomes statistically significant in column (ii).

The main finding of this empirical analysis is that there is a positive, statistically significant effect of duration on the royalty rate. This is interpreted as the parties substituting royalty payments for fixed payments as they consider relationships with longer expected duration: increasing the royalty rate increases the weight of variable payments relative to fixed payments. The parties have a greater interest to do so the longer they expect the relationship to last. The fact that duration has a positive effect on the royalty rate suggests that the substitution of variable payments for fixed payments is done in a progressive way.

The coefficient on the logarithm of sales is negative and statistically significant, both in the case of the full sample and in the unaffiliated subsample. This is consistent with models based on risk sharing, because the buyer's profit variability is a decreasing function of the royalty rate, and also consistent with explanations based on cash constraints on the

TABLE VII.
TOBIT OF ROYALTY RATE ON SELECTED CONTRACT CLAUSES. DURATION > 1 YEAR

	Full Sample (i)	Unaffiliated Subsample (ii)
Know-how	0.6*	0.629
	0.741	0.923
Affiliation	0.661	
	0.69	
Process technology	−1.589**	−1.771**
	0.693	0.862
Duration	0.253**	0.383***
	0.112	0.139
ln(imports)	−0.417	0.337
	0.342	0.461
ln(sales)	−0.508***	−0.495**
	0.162	0.188
Constant	6.364	3.016
	2.664	3.314
Log-likelihood	−268.828	−171.947
Sample size	120	80

All regressions include industry dummies.
Standard errors reported below the estimated coefficient.
***Indicates statistically significant at the 1% level (two-tailed test).
**Indicates statistically significant at the 5% level (two-tailed test).
*Indicates statistically significant at the 10% level (two-tailed test).

buyer's side. There is no substantial difference between the coefficients on the logarithm of sales reported in columns (i) and (ii).

Finally, as a robustness check analogous to that carried out in Table V, Table VII presents Tobit estimates for the royalty rate, excluding contracts whose duration is only 1 year. The results are similar, in sign and statistical significance, to those in Table VI, although the coefficients on process technology and duration are now smaller in absolute value. Therefore, the conclusions reached concerning the choice of the royalty rates are also robust to the removal of the shortest-lived contracts.

5. CONCLUSIONS

This paper presents evidence on the determination of scheduled payments in technology transfer contracts drawn from a contract-level database of imports of disembodied technology by Spanish firms in 1991. In order to motivate the empirical analysis, a simple model that relates scheduled payments with contract duration is presented.

In the model introduced in Section 2, what causes premature termination is the buyer being cash-constrained. Compared with fixed payments, royalty payments assure an ongoing relationship, at the cost of increasing the buyer's marginal cost of production, and thus reducing production from its first-best level. Because royalty payments reduce the probability of early termination, the seller optimally schedules them starting from the very first period. Royalty payments are a safeguard against early termination because they adapt payments to the actual value of the technology. The model focuses on the case where the fixed fee is too high, but the model could be modified to analyze the case of the fixed fee being too low compared with the actual value of the technology. In this case, the seller may be inclined to renegotiate or terminate the relationship and find another partner, and royalty payments also reduce the probability of the seller wanting to renegotiate or even terminate the relationship.

Regarding the empirical results, the transfer of know-how is not found to have a statistically significant effect on the type of scheduled payments that are included in the contract, as predicted by models based on moral hazard. If moral hazard on the seller's side was the main determinant of scheduled payments, then the transfer of know-how should increase the probability of introducing royalty payments in every period. If the threat of imitation was the most important issue, then the transfer of know-how should induce the seller to substitute fixed payments for royalty payments.

The fact that the smaller the buyer, the more likely will we encounter royalty payments, is predicted by risk-sharing models, assuming that risk aversion is correlated with size, measured by sales. This result is also consistent with cash constraints on the buyer's side. In the latter case, fixed payments may prompt early termination of the relationship, which can be avoided by substituting royalty payments for fixed payments.

However, the most interesting result presented in this paper is that expected duration of the relationship is found to increase the likelihood of the parties scheduling output-based payments instead of fixed payments from the very beginning of the life of the contract. This finding is interpreted as evidence of the parties having an interest in choosing the type of payments that best protect the relationship from early termination. They do so by linking payments to the buyer's output, which is correlated with the actual value of the technology. The longer the expected duration of the relationship, the greater the interest of the parties in making sure it will not be disrupted. This observation should provide further guidance when modeling the international transmission of technology, because the length of the relationship has not received

much attention as a potential factor influencing the choice of payments to be made. Instead, most theoretical models focus on one-period transfers, ignoring the temporal extent of the relationship.

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