Facultad de Ciencias Económicas y Empresariales
Universidad de Navarra

Working Paper nº 05/03

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

Pedro Mendi

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Working Paper No.05/03
January 2003
JEL Codes: O32, F23, L14.

ABSTRACT

I analyze a sample of contracts for the acquisition of technology by Spanish firms, where I observe firm and technology characteristics, as well as the type of scheduled payments, whether fixed and/or variable. I find first that technology type influences the chances of the parties reaching an agreement, and second, that the explanations for observed payments based on moral hazard or risk aversion alone are not satisfactory. I argue that all these theories fail to take into account the fact that the contractual relationship is extended along time and that the parties will choose the kind of payments that better estimate the value of the relationship.

Pedro Mendi
Universidad de Navarra
Departamento de Empresa
Campus Universitario
31080 Pamplona
pmendi@unav.es

1. Introduction

The international transmission of technology often takes the form of bilateral agreements between firms, with the parties signing a binding contract. However, the transmission of technology is subject to some difficulties not present in the transmission of other inputs to production. These difficulties, especially in the case of tacit knowledge, may even prevent the parties to the transaction from reaching a successful agreement. In order to alleviate these problems, they can choose different contract characteristics. In this paper, I study whether there is evidence for scheduled payments being chosen in response to these difficulties.

Inherent to any international transfer of technology, there is a double-sided asymmetric information problem. Since the seller is better acquainted with the technology to be transferred, he will be able to better assess its value. Yet, in the case of international technology transfer, the buyer knows the local market better than the seller: he can more accurately estimate the level of demand, potential competitors, and legal or accounting standards.

This asymmetric information may induce opportunistic behavior by the parties. Arrow (1969) first points out to 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, 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.

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 or there is a high degree of tacit knowledge involved in the transmission. For instance, the implementation of a given cost-saving technology on a specific firm might turn out to be a failure, and no actual reduction in cost is achieved. Moreover, a seller faces a potential selection problem, since he must choose which firm to sell the technology to, with a given degree of uncertainty regarding the buyer's type.

Scheduled payments can be chosen so as to mitigate these problems. The fact that the parties agree on fixed or output-based payments can be a means of providing the right incentives, to screen among potential buyers, or to share risk between the buyer and the seller. This paper studies which, if any, of these explanations is the most consistent with the evidence presented in this paper. In order to do so, I will study a database with 321 contracts for the acquisition of technology by Spanish firms in 1991.

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. He finds that the transfer of know-how is bundled together with other complementary inputs, in order to avoid opportunistic behavior by both parties. However, we have to be careful when extrapolating his conclusions, since this paper studies the chemical industry and the case of a developing country.

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, although they do not provide an accurate measure of the strength of IPRs in each industry.

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. The 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 (2003), using variability across states in legislation on termination of the contract by the franchisor. Furthermore,

in a theoretical analysis, Battacharyya and Lafontaine (1995) argue that, in the presence of double-sided moral hazard, the optimal contract involves a fixed fee plus a royalty. However, while the franchising literature takes this optimal sharing rule (fixed fee plus royalty) as given, we observe many technology licensing contracts that do not include variable payments.

In this paper, I find evidence of technology transferred internally being different from that transferred in arm's-length transactions. Furthermore, after analyzing the firms' choice of scheduled payments, I find that standard moral hazard, risk-aversion or asymmetric information models provide incomplete explanations for observed payment data, and thus miss, if taken separately, an important dimension of the contractual relationship.

The organization of this paper is as follows: section 2 compares the characteristics of fixed and royalty payment contracts for the sale of technology. Section 3 describes data employed in this article. Section 4 analyzes the data relating it to the theoretical models previously discussed. Finally, section 5 presents some conclusions possible extensions.

2. Fixed fees and royalty payments in technology transfer contracts

Fixed payments have been regarded as the most efficient way to transfer the right to use a specific technology. Any variable payment, either a cost-increasing per unit royalty, or a revenue-reducing royalty on the price charged, introduces a distortion on the buyer's output decision, and, therefore, a departure from its first-best level. However, a

majority of contracts include output-based payments, leading us naturally to ask why we observe such pattern.

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 for instance Gallini and Wright, 1990). Considering the case of drastic innovations, in a separating equilibrium, royalty payments are a signal for good technology. Fixed payments are predicted to be present in any contract, since they signal bad technology and are a rent-extracting device in royalty payment contracts. Therefore, whenever tacit knowledge is 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. Moreover, according to this type of models, no output-based payments should be observed in affiliated transactions.

Asymmetric information on the buyer's side can also be a factor increasing the probability of output-based payments. If the buyer, which is already settled in the local market, has a more accurate knowledge of demand characteristics, the seller can choose variable payments to extract information about the local market from the buyer. Under those circumstances, it may be difficult for the seller to determine the size of an upfront fee. Indeed, a fixed fee promptly accepted by the buyer is a signal of it being too low. This could justify the parties agreeing on variable payments, with or without an upfront fee. Both in this case and in the previous one, fixed payments would be mere rent-extracting devices.

Risk-sharing arguments can also be put forth as potential explanations for observed scheduled payments. Specifically, output-based payments can be used as a means of providing insurance to the buyer (see for instance Bousquet et al, 1995). If buyers' risk aversion is correlated with size, we should observe a negative correlation between the buyer's size and the likelihood of observing output-based payments, as well as between size and the royalty rate itself. On the other hand, the correlation between size and the probability of observing fixed payments should be positive. However, this implies the introduction of the bothersome assumption of firms being risk-averse. Within affiliated transactions, risk-sharing considerations should not be influencing observed payments, and thus, size should not have an influence on the likelihood of observing either type of payment.

A negative correlation between the probability of observing variable payments and size (and positive correlation between the probability of observing fixed payments and size can also be the result of the buyer being cash-constrained. If cash availability is correlated with size, the likelihood of a fixed payment being unaffordable for the buyer in some states of the world is higher for smaller firms. Thus, we will more likely observe royalty payments (and less likely fixed payments) the smaller the buyer.

Moral hazard has been widely regarded as a factor influencing the type of payment the parties agree on. In the transmission of tacit knowledge, both parties costly provide noncontractible inputs. On the one hand, the seller must reveal that knowledge to the buyer, which involves a greater effort than in the case of codified knowledge. On

the other hand, the buyer is typically responsible for commercialization and marketing efforts, and has asymmetric information about local demand conditions. If not provided with the right incentives, the parties can perform transaction-specific investments below the optimal level.

If the seller's effort is crucial for the correct implementation of the technology and commercialization is relatively unimportant, a royalty rate can be used in unaffiliated transfers to induce the seller to provide the appropriate type of technology. In the case of commercialization efforts to be relatively more important, we will more likely observe fixed payments. In this line, Choi (2001) builds up a model of technology transfer with double-sided moral hazard, where the first-best outcome, a fixed fee contract and no output distortion due to the presence of a royalty, cannot be implemented. The second-best contract involves a royalty that induces the licensor and the licensee to perform transfer-specific investments. In his model, affiliated transfers are predicted to originate fixed payments only. As it will be seen below, this prediction is at odds with actual practice.

Finally, if there is heterogeneity in buyers' types and this information is unknown to the seller, scheduled payments may also be used in order for screening purposes. If the dispersion of potential buyers' types is high, a fact that can be due either to unobserved heterogeneity on the buyer's side or to the potential buyer's not having enough information regarding the technology to be acquired, then a higher fixed fee and lower

royalty rate should be observed. Furthermore, in the case of affiliated transactions, the first-best contract, i.e. fixed fees only, should always be observed.

All the theoretical models presented predict that technology transfers generate fixed payments only. This fact will clearly be inconsistent with the evidence presented in this paper. As we will observe below, most affiliated contracts include output-based payments. This fact should lead us to consider that more complete explanations. In particular, a transaction-cost approach may provide a more satisfying explanation for the observed data. Bajari and Tadelis (2001) compare cost plus and fixed payments procurement contracts to conclude that the determinant of contract choice is the tradeoff between ex ante incentives and ex post costly renegotiation. In particular, low incentive contracts (cost plus) have the advantage of greater adaptability than high incentive contracts (fixed payment). In their analysis, the characteristics of the project determined contract choice.

In this paper, I will compare fixed-payment with variable-payment schedules and discuss whether technology and firm characteristics increase the chances of observing one or the other. While fixed payments introduce no output distortions, this payment scheme is more sensitive to the hazards associated with an extended relationship: changes in demand, legislation, competitive conditions, input prices, or technology. Additionally, it does not provide the seller with the right incentives and, on the other hand, he does not benefit from marketing or commercialization efforts by the buyer. By contrast, the royalty schedule provides both parties with the right incentives to perform costly transaction-

specific actions. On the one hand, it induces the seller to provide the buyer with the best available technology. On the other hand, it induces the buyer to exert (suboptimal) marketing effort, while allowing the seller to directly benefit from such effort. Contracts that stipulate output-based payments are less likely to be renegotiated. If the parties agree on fixed payments and demand is lower (or higher) than expected, there is a clear incentive to renegotiate. Agreeing on output-based payments is a solution to this problem.

The problem the parties face at the time of designing the different contract clauses is how to estimate the value of the relationship. This value, both to the buyer and to the seller, is subject to a high degree of uncertainty, and is not present in the provision of other inputs to production. It is much easier to stipulate the per-unit price at which one party must supply some physical input to the other party, but it is very difficult to estimate the value of the right to use some technology. In this assessment, a number of factors must be taken into account, such as the level of demand, the development of alternative technologies, the degree of tacitness of technology, regulation, or the efforts made by the parties for the correct implementation of the technology on the purchasing firm.

Duration of the contractual relationship between the parties is a dimension that has been often overlooked in the literature. All the theoretical models considered focus on a one-period transaction, and not on a protracted relationship. However, in real practice most contracts have a more extended time horizon, which increases uncertainty

concerning the value of the relationship and increase the likelihood of hazards an unforeseen situations. This may be an unimportant factor in affiliated transfers, but may be crucial in the case of arm's-length transactions.

This temporal dimension makes fixed payment contracts a less attractive instrument than output-based payment contracts, the longer the relationship between the parties. 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. Moreover, output-based payments reduce the probability of costly renegotiation of the contract, by lowering the number of states of nature in which the parties have an incentive to renegotiate a too high (or too low) fixed payment. Output-based payments adjust the value of the relationship to the level of demand, at the cost of introducing a wedge between the actual and the first-best level of production. Then, in contracts where the time horizon is shorter, the value is easier to estimate, and thus, it will be more likely for us to observe fixed payments linked to them.

3. The Data

Description of the database

All Spanish firms that imported technology were required, up to 1992, to report to the Spanish Ministry of Industry the terms of the technology purchase. In order to do that, 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, along with this form, the firms sent other documentation, such as a copy of the contract or bills justifying payments made. However, since this type of control is no longer allowed by the European Union, filing was finished in 1992. A description of the variables included in the form can be found in the Appendix.

The buyer of the technology had to describe the features of the imported technology in his report. This allows us, first, to determine the degree of tacitness in technology, and second, to exclude those transfers with a dubious technological content. Contrary to the case of a patent or a utility model, know-how is noncodified knowledge and it is not protected by law against imitation. Thus, these transfers are more sensitive to opportunistic behavior both by the seller and the buyer: whereas the seller can provide a suboptimal level of know-how, the buyer can imitate the technology transferred and renege on the contract. Furthermore, the outcome of the implementation of this type of technology on a specific firm is expected to be more uncertain than in the case of codified knowledge. For all these reasons, the transfer of know-how is likely to affect scheduled payments.

I also observe whether the technology to be transferred refers to a specific product or it is a process technology. In principle, a new product implies a higher degree of uncertainty when introduced into a new market than a new process to be applied to an existing product. A process technology implies less variability of revenue if demand-shocks are industry-specific. On the other hand, if a product is explicitly mentioned in the

contract, it will be more likely to the parties to link payments to revenues accruing from that product. Whether ownership of the technology has been transferred is included as well. Regarding the buyer's characteristics, sales in the year before the filing of the form will be used to proxy for its size. I also observe whether the buyer has any linkages with the seller, and whether or not he performs R&D activities. Regarding the seller's characteristics, both the seller's industry and country are observed. The seller's country will be used as an indicator of asymmetric information on the local market.

The sample. Stylized facts

Out of the forms sent to the Ministry in 1991, I have included in the sample 319 observations[1] and 262 of them included the actual contract along with the form. Table 1 presents selected characteristics of the contracts, classified by industry of the buyer. The industry groups correspond to the first digit of the buyer's industry code, according to Spanish classification (CNAE-74). In the final sample, I have only included those transfers that explicitly mention that either a patent, a utility model, an industrial design,

[1] The Spanish Ministry of Industry had no clear classification plan for the forms. They were literally put in boxes as they were received and stored in a basement located in the central offices of the ministry, in Madrid. Therefore, by randomly choosing some of these boxes and copying the forms contained in them, I do not expect any significant bias arising from the sampling procedure.

know-how, or software (not to be resold[2]) is transferred. Thus, I have deliberately excluded 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. This reduces the final sample to 209 valid observations.

As seen in Table 1, most contracts are concentrated in Non-energetic Minerals and Chemicals, Metal Transformation, and Other Manufacturing. There is a moderate degree of heterogeneity between industries in the proportion of unaffiliated contracts, as well as in the proportion of contracts that include the transfer of know-how. There is also high variation between industries in the proportion of firms conducting R&D, being it lower in services, and in size. Finally, the proportion of contracts including royalty payments in the first year is remarkably high in Agriculture and in Other Manufacturing, being it low in Services.

Since the main focus of this study is on scheduled payments contained in the contract, the type of payment to be made, whether fixed or variable, constitutes very valuable information, which is absent in other studies. Expected fixed and variable payments, in monetary terms, had to be reported by the buyer for the five years following the agreement. However, output-related payments are based upon estimates of future

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[2] I have included software only if it is a program to be used by the buyer. There are some contracts in the sample where the buyer merely acts as a commercial agent to sell software in Spain. I have deliberately excluded such contracts from the final sample. The criterion is to include the contract only if the right to sell the software program has not been included in the agreement.

sales, which make them not very accurate and they are most frequently overestimated.[3] Nevertheless, I observe is the royalty rate in those contracts that include output-based payments, which constitutes much more reliable data.

Tables 2a, 2b, and 2c, summarize expected payments recorded in the contracts for the five years following the agreement. This constitutes the time window such information is available. As it can be seen in the third column of Table 2a, the percentage of contracts that include both fixed and variable payments in the first year is only 20% in full sample, and 25% in the subsample of arm's-length transactions. This fact is at odds with the existing theoretical literature, which predicts the widespread use of mixed payments. On the other hand, we can observe that the proportion of contracts that include fixed payments is decreasing in time, both in the case of affiliated and unaffiliated transfers. Thus, if fixed payments are to be made, they are scheduled for the first years of the duration of the contract. Furthermore, it is precisely contracts that involve fixed payments the ones whose duration is the shortest: among the 47 contracts whose duration is only one year, 39 of them are fixed-payment only contracts, and the remaining 8 are contracts that involve output-based payments. No payment that includes a fixed

[3] I suspect royalty payments to be overestimated because if actual payments exceeded the reported amount, the buyer was bound to send a second report to the Ministry. For that reason, firms chose to overestimate upcoming payments in their reports. Indeed, scheduled payments are higher than actual payments recorded by the Bank of Spain. Thus, I do not rely on foreseen royalty payments, but rather on upfront payments and the royalty rate.

part plus a royalty has a duration of one year only. Half of these contracts include variable payments only in the second year.

Thus, as we consider subsequent years, it will be those contracts that included output-based payments those that will survive in the sample, either because included variable payments from the beginning or because the contract stipulated a switch from fixed or mixed payments to variable payments.

The second remarkable fact that can be observed in Table 2c is the high proportion of contracts that include variable payments within affiliated transactions. The theoretical literature has always regarded these transactions to be free from the problems present in arm's-length transfers and has predicted affiliated transfers to originate fixed payments only (see for instance Choi, 2001). Specifically, for a wholly-owned subsidiary, the efficient transfer would involve a zero fixed fee and a zero royalty. Thus, either opportunistic behavior is present in a higher degree in this type of transactions, or fixed payments contracts are not superior to fixed payment contracts as they have always been regarded.

Out of these two explanations, the first one is less plausible than the second. It is hard to imagine that opportunistic behavior is a more acute problem within transactions between related parties. Therefore, we should ask what are the advantages of royalty payments that offset the output distortion that the increase in marginal cost means.

4. Empirical evidence

In this section, I start by checking if internally transferred technology has the same characteristics as technology transferred between unaffiliated firms. I expect affiliated transfers to be absent from the kind of problems present in arm's-length transactions. These problems could be preventing some unaffiliated transfers from being carried out. Thus technology or firm-specific characteristics may be influencing both the likelihood of agreement (and thus of the contract being observed) as well as scheduled payments.

I suspect that, within unaffiliated transfers, contracts that include the transfer of know-how are the ones most likely to suffer from these problems. Since this type of knowledge is tacit and not protected by law against imitation, the incentive problems will be more evident in these transfers. Therefore, it may be case that if know-how is to be transferred, the likelihood of two unaffiliated parties reaching an agreement be lower.

Affiliation and technology type

In order to verify which contract characteristics vary with affiliation, I run several probit regressions where the dependent variable is an indicator of the inclusion of a patent, a utility model, a model or design, and know-how. Among the independent variables, which are firm and contract characteristics, I include an indicator of the transfer being affiliated. The sign and statistical significance of the estimated coefficient for this variable will shed some light on whether technology type varies with affiliation. Some technology types may be difficult to be transferred between two unrelated parties,

because of the problems mentioned above. The most obvious candidate is know-how, since this type of technology is not legally protected against imitation. A positive effect of affiliation on the probability of know-how being transferred is consistent with a positive probability of two unrelated parties not reaching a successful agreement for the transfer of tacit knowledge. If we assume affiliated transfers to be free from these problems, then the proportion of affiliated transfers where know-how is included should be much higher. Another possible explanation is that firms may want to keep their most sensitive technology in-house and are reluctant to sell it to an unrelated firm.

In order to control for industry-specific effects, I have also included five industry dummies. I have merged observations in Commerce, Restaurants, Transport, Communications, Finance, Services to Firms and Other Services into a single group, because their economic activity is services rather than producing physical goods. Additionally, I have included separate dummies for Metal Transformation, Other Manufacturing, Construction and Agriculture. Other regressors are an indicator of the technology referring a specific product, the logarithm of sales, the logarithm of the proportion of Spanish imports coming from the seller's country, and indicators of the performance of R&D by the seller, and whether both firms are in the same industry.

Table 3 reports estimated coefficients in these specifications. As it can be seen, there is no significant effect of affiliation on the likelihood of a patent, utility model or model and design being included in the contract. However, in the specification with know-how as the dependent variable, the coefficient for affiliation is positive and

statistically significant. This result suggests that the technology that is actually transferred is different between affiliated and unaffiliated transfers, specifically, tacit knowledge being more difficult to appear if the transfer is unaffiliated. The buyer's size, on the other hand, does not seem to have an influence on the likelihood of tacit knowledge being transferred.

The fact stressed in the previous subsection may cause problems when estimating the impact of the transfer of know-how on the likelihood of observing output-based payments and on the size of the royalty rate itself. If the technology that is to be transferred includes know-how, the likelihood of the parties agreeing on an actual transfer is lower than if no know-how is included in the transaction. If know-how influences both the likelihood of successful agreement and the contract terms, ignoring this fact may be introducing significant biases in the estimation of the effect of the inclusion of tacit knowledge on the likelihood of the parties setting output-based payments. By contrast, I do not expect affiliated transactions to suffer from this kind of bias.

Technology type, firm characteristics, and scheduled payments

In this section, I will estimate the effect of technology type, firm characteristics and a measure of asymmetric information on the probability of the parties including variable payments in the agreement. I carry out all the analysis conditional on the contract being observed. Table 4 reports the coefficient estimates of a probit regression where the dependent variable is an indicator of the parties including royalty payments in the first

year. I focus the analysis on the first year of the life of the contract because, at it could be seen in the previous section, the probability of the occurrence of royalty payments is increasing in the year payments are scheduled for.

Among the regressors, I include indicators of a patent and/or know-how being included in the contract, affiliation between the parties, the technology being a product technology, and the seller being established in a European Union country. I also include the logarithm of the buyer's sales, proxying for its size, as well as the percentage of foreign ownership in the buyer's equity. Finally, I included an indicator of the agreement having a duration of only one year.

In column (i) of Table 4, only the indicators of product technology and duration being one year only are statistically significant at the 1% level. The logarithm of sales is also statistically significant, but only at the 10% level. The negative sign and statistical significance of the indicator of the relationship having a duration of one year is consistent with the claim that the extent of such relationship makes the value of the transaction more difficult to estimate and thus, makes the choice of output-based payments a more attractive choice than fixed payments only. One-sided or double-sided moral hazard models would predict this variable to have no effect on the likelihood of observing royalty payments, whereas risk-sharing arguments would be consistent with this result, since a more extended duration would increase the uncertainty associated with the transaction.

Column (ii) reports estimated coefficients for the unaffiliated subsample. As it can be observed, the results in terms of sign and statistical significance of the coefficients are similar to those encountered in column (i). As in the previous case, the buyer's size seems to be an important factor in the decision of the parties to include output-based payments. For that reason, columns (iii) and (iv) carry out separate analysis, dividing the unaffiliated subsample into two, where the cutoff point is the median value of the buyer's sales in the year previous to the agreement. What I try to check is whether the buyer's size has an influence on the contracts that can be implemented. It may be the case that a small buyer can not afford paying an upfront fee, due to cash constraints, for instance, and thus the parties will more likely agree on royalty payments. By contrast, larger buyers might not face this problem, and a fixed-payments only contract may be a feasible option.

As we can observe comparing columns (iii) and (iv), the coefficient for know-how is positive and statistically significant in the subsample of larger firms, which is consistent with the predictions of double-sided moral hazard models. In the subsample of smaller firms, know-how does not seem to make the occurrence of royalty payments more likely. Actually, most of these contracts include them, regardless of other contract characteristics. More importantly, carrying out a likelihood ratio test, comparing the value of the log-likelihood functions in the unaffiliated subsample (i.e. restricting the value of the parameters to be the same for small and large firms) with the sum of the values of that function in each of the two subsamples, reveals that such difference is statistically

significant at the 5% level. This is consistent with the argument that the buyer's size constrains the choice of feasible contracts.

Table 5 estimates the effect of selected contract and buyer's characteristics on both the likelihood of observing royalty payments and on the size of the royalty rate itself. Moral hazard models predict the royalty rate to be larger the more important the seller's transaction-specific investment. Risk-sharing arguments predict a positive relationship between the royalty rate and the buyer's risk aversion and the inherent riskyness of the relationship.

The econometric specification that I use is a Heckman selection model, where I allow for different variables and heterogeneous coefficients in the selection and regression equations. In all the specifications, the dependent variable is the logarithm of the royalty rate. In columns (i) and (ii) I report estimated coefficients for the selection and regression equations, respectively, for the full sample. By contrast, in columns (iii) and (iv) I use observations of unaffiliated transactions only. In this table, I report robust standard errors, which could modify, in some cases, the inference with respect to the previous table.

We can observe that the variables that are expected to have an impact on the size of the royalty fee actually alter the likelihood of observing such type of payments, but not the royalty rate itself. While most of the theoretical literature focuses on the optimal sharing rule, and on the effect of asymmetric information or risk on the optimal royalty rate, I find that where they really have an impact is on the decision to include output-

based payments. Once that decision has been made, the size of the royalty rate seems to be insensitive to these factors. There is evidence, though, in favor of risk-sharing arguments, since the effect of the buyer's size is negative and statistically significant. This suggests that smaller technology buyers are willing to pay a higher royalty rate in exchange for not having to pay an upfront fee.

Finally, it is remarkable to observe that the indicator of the seller being established in a European Union country has a negative and statistically significant effect on the likelihood of observing royalty payments being paid in the first year. Therefore, firms located in countries with closer economic ties are more able to assess the value of the relationship ex ante, as well as weigh the risks involved in the relationship and, thus a fixed payment mechanism can be implemented.

5. Conclusions

In this paper, I present a contract-level database of imports of disembodied technology by Spanish firms in 1991. By inspecting the data, I find that the proportion of contracts including both fixed and variable payments in the first year of the agreement is much lower than expected, while the theoretical literature predicts the widespread use of this type of scheduled payments. After the first year of duration of the contract, most of those that survive involve royalty payments only. Furthermore, I find that contracts for the sale of technology between affiliated firms originate mostly output-based payments, a fact which is at odds with the predictions of moral hazard models, which assume these

transfers to be free from such problems. A variable that is important in the determination of scheduled payments is the buyer's size. This can be interpreted as evidence in favor of explanations based on risk-sharing: a parent firm may be willing to provide insurance to its subsidiary or to a cash-constrained small unaffiliated firm.

I also find that the duration of the relationship has a positive, statistically significant effect on the likelihood of encountering output-based payments. I interpret this fact as supporting the hypothesis that the most important factor determining scheduled payments is the ability of the parties to estimate the value of the relationship between them, and all the theories mentioned are just partial, incomplete explanations of the problems that firms located in different countries face when trying to transact disembodied technology. Finally, I only found evidence of the buyer's size having an influence on the size of the royalty rate. This variable seems to be quite insensitive to other factors that have been considered in the literature.

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Appendix. Variables included in the TE30 form

For each transaction involving acquisition of technology by a Spanish firm from a foreign firm, the buyer had to send a form, called TE-30 to the Spanish Ministry of Industry. The variables included in the TE-30 form, and that had to be reported by the firms were the following:

1. Firm's name and address. This variable could not be recorded because the buyer's identity is kept anonymous by law.

2. Declaration number.

3. Industry of the buyer. The code is given according to Spanish classification.

4. Data about the buyer, in millions of pta: a) total equity b) net worth c) sales in previous year.

5. Percentage of foreign ownership in the buyer's equity.

6. a) Does buyer perform R&D activities? (Yes, No).

   b) Does buyer transfer technology abroad? (Yes, No).

7. Country of seller.

8. Industry of seller.

9. Linkages of the seller with the Spanish firm: whether a)there are no linkages, b)they have the same parent firm or c)the seller owns the buyer. A discrete variable has been created that takes, respectively, the value of zero, one and two, if the affiliation between the parties falls into one of the former categories.

10. Data regarding the nature of the transaction. The buyer had to check one or more of the following twelve categories:

Patents	Utility models	Know-how	Software
Trademarks	Models, designs	Franchise contract	Engineering
Databases, documentation	Technical assistance	International R&D consortia	R&D expenditures of foreign parent

11. Transaction type: whether the contract involved a) transfer of ownership b) right to use the technology or c) commercial rights of the product. Three indicator variables, for each transaction type, have been created. These variables are not mutually exclusive.

12. Description of the technology transferred. This is a variable that takes the value zero if it refers to a specific product, one if it is a process technology, or two if both.

13. Scheduled payments. The buyer had to report an estimate of the fixed and the variable payments to be made in the first five years of duration of the contract.

In some cases, the actual contract signed by the parties is available for inspection. Whenever this is the case, the following variables are also included:

14. Territoriality clauses: countries where the product could be sold. A discrete variable was constructed with the value of zero if it was Spain, one if a larger territory – generally Western Europe- and two if the product could be sold anywhere in the world.

15. Exclusivity: whether the buyer had the exclusive right to use the technology in the territory agreed upon. When explicit mention of exclusivity was made in the contract, this variable took the value zero if the contract was non-exclusive, one if semiexclusive and two if exclusive.

16. Duration of the contract in years.

17. Confidentiality clause: a dummy variable with a value of one was created if such clause was present in the contract, and zero otherwise.

18. Improvements. If the contract explicitly considered the obligation of the parties to inform the other party about new discoveries relative to the technology transferred, a discrete variable was constructed. In the case of only the seller having the obligation to keep the buyer informed, the variable took the value of zero. If it was the other way around, one, and two if both parties had the obligation to keep the other party updated.

19. No competition. In the case of express ban by the seller to produce or sell any product that might compete against the seller's product by the buyer, this variable takes the value of one.

20. Sublicensing. If the buyer can sublicense the other firm, this variable takes the value of one, and zero if an explicit prohibition to sublicense was made.

21. Royalties increasing or decreasing in quantity or time. In the case of the royalty rate not being constant, if it was increasing, the value is zero. It was one if decreasing.

22. Input tying. In some cases, the contract specifies that the buyer must buy a particular input from the seller. If that was the case, this variable took the value of one, and zero otherwise.

23. Legal defense. In the case of third parties litigating about the transferred technology, the value of the variable is zero if the legal defense was to be made by the seller. If the defense had to be carried out by the buyer, the variable takes the value of one.

24. Minimum royalties. If there was a clause by which the buyer was obliged to pay the seller a minimum amount in concept of royalties (excluding fixed payments), a discrete variable with a value of one was recorded, and zero otherwise.

I do not expect, however, any significant bias coming from the way the sample was drawn. The files were stored in the same order as they were received, without any intermediate classification according to sector or any other criteria. The files were selected by just opening consecutive boxes in which they were stored. This procedure actually alleviates selection problems caused by the way the sample was chosen.

All the contracts included in the sample refer to transactions made in 1991. Pérez (1996) provides summary statistics for the contracts submitted to the Ministry in 1991 (see Table A.1). 5,168 forms were filed in 1991, with 4,611 of them reporting about first-time contracts, 525 extensions of existing agreements, and 32 modifications of previously signed contracts. The number of Spanish firms signing contracts that year was 1,955, thus averaging 2.6 contracts per firm, with 1,267 firms signing just one contract. Regarding the

type of technology purchased, transfers of technology involving a patent represent less than 3% of the total, while software includes about 23% of the contracts. Ownership of the technology is transferred in 22% of the total, and in 68%, only the right to use the technology was transferred.

Regarding the characteristics of the buyers, less than half of the firms – exactly 46% of them- have no foreign ownership in their equity. These firms sign on average more contracts per firm, but these contracts involve lower payments. In fact, firms with no foreign ownership have scheduled payments of pta 24.6m per contract, whereas firms with a majority (more than 50%) of foreign ownership, have payments of pta 111m per transaction. Firms with direct or indirect linkages to the seller of the technology represent 23% of the total, with higher payments per contract.

Only 35% of the firms purchasing technology from abroad declare to be performing R&D activities. Firms doing R&D are much more active in terms of number of transactions (2.7 vs 2.1) but not in payments per transaction (60.5 vs 68.5). Most technology imported by Spanish firms comes from OECD countries. The U.K. leads in total transactions (21%), with the U.S. being the main destination of payments (23%) for the acquisition of technology.

If we look at payments by industry and by source country, some countries appear to be the main source of technology in specific industries. For instance, most computer-related technology is imported from the U.S. whereas Germany is the main source of motor vehicles technology.

The data was collected manually and by inspection of the contracts and the forms. For this reason, some observations of specific variables can be missing in the data while actually being present in the contracts. The reason is that the contracts had to be read one by one and sometimes the specification of some variables was not explicitly made in a separate clause, but as part of another one. It is likely, therefore, that in some cases, some variables such as confidentiality or exclusivity might have been overlooked.

Table A.1 summarizes the number of observations of each contract clause. Two remarks have to be made about the quality of the data. First, the TE-30 form was filled out by each buyer individually. This creates a problem of misreporting, since the selection of one or several categories in the main object of the transaction was discretionarily made by each individual firm. On the other hand, the quantities reported as payments are estimates made by the firms based on future sales and they tend to be overestimated. The reason is that if the actual quantity was higher than the one reported at the time of filing, a new report had to be sent. For this reason, I expect an upward bias in this variable. However, in this paper I use categorical variables, i.e. whether the payments are fixed or output-based, and not the actual amounts reported.

Table 1a. Contract characteristics by industry

Industry	Total	Know-how %	Product technology %	Fixed Payments %	Variable Payments %	Average royalty rate %
Agriculture	11	45.5	100	27.3	90.1	10.24
Energy and water	2	50	0	50	50	12
Non-energ. minerals, chemicals	46	87	52.2	54.3	69.6	4.01
Metal transformation	67	64.2	58.2	59.7	62.9	4.23
Other manufacturing	32	50	56.2	28.1	87.5	4.59
Construction	8	50	62.5	62.5	62.5	2.12
Commerce, restaurants	19	42.1	47.4	52.6	68.4	5.88
Transport, communications	1	0	100	100	100	5
Finance, services to firms	23	39.1	26.1	65.2	34.8	6.5
Other services	4	75	0	75	25	3
Total	213	60.6	53.1	52.6	66.2	4.91

Table 1b. Firm characteristics by industry

Industry	Total	Unaffiliated %	Firms doing R&D %	Average sales (pta mn)
Agriculture	11	81.8	63.6	1568
Energy and water	2	50	50	440785
Non-energ. minerals, chemicals	46	69.6	69.6	15351
Metal transformation	67	70	70.1	22418
Other manufacturing	32	59.4	40.6	4439
Construction	8	50	12.5	10931
Commerce, restaurants	19	52.6	21.1	4881
Transport, communications	1	100	0	n.a.
Finance, services to firms	23	51.1	26.1	4558
Other services	4	50	75	1644
Total	213	65.3	53.5	18555

Table 2a. Scheduled payments. Full Sample

Year	FP only %	RP only %	FP+RP %	Total	Average royalty rate
First	33.33	47.42	19.25	213	4.91
Second	19.88	69.88	10.24	166	4.81
Third	12.50	82.35	5.15	136	4.67
Fourth	7.76	87.93	4.31	116	4.75
Fifth	7.34	88.07	4.59	109	4.72

Table 2b. Scheduled payments. Unaffiliated Subsample

Year	FP only %	RP only %	FP+RP %	Total	Average royalty rate
First	38.13	37.41	24.46	139	5.09
Second	23.81	62.86	13.33	105	4.92
Third	12.20	82.93	4.88	82	4.86
Fourth	7.04	88.73	4.23	71	4.92
Fifth	6.06	89.39	4.55	66	4.93

Table 2c. Scheduled payments. Affiliated Subsample

Year	FP only %	RP only %	FP+RP %	Total	Average royalty rate
First	24.32	66.22	9.46	74	4.65
Second	13.11	81.97	4.92	61	4.65
Third	12.96	81.48	5.56	54	4.36
Fourth	8.89	86.67	4.44	45	4.47
Fifth	9.30	86.05	4.65	43	4.39

Table 3. Probability of inclusion of certain contract clauses

	Dependent variable is an indicator of the transfer of:							
	patent		utility model		model and design		know-how	
	(i)		(ii)		(iii)		(iv)	
Affiliation	0.042		-0.012		-0.019		0.308	***
	0.067		0.012		0.067		0.07	
Product	0.28	***	-0.038	***	0.086		-0.105	
	0.061		0.027		0.068		0.081	
ln(sales)	0.064		0.01		-0.013		0.013	
	0.066		0.007		0.056		0.065	
ln(sales) squared	-0.003		-0.001		-0.000		-0.003	
	0.004		0.001		0.004		0.004	
European Union	0.002		-0.006		0.052		-0.067	
	0.063		0.009		0.064		0.079	
Same industry	-0.031		-0.013		0.037		0.137	*
	0.079		0.014		0.071		0.08	
Log-likelihood	-90.31		-23.392		-82.6		-103.73	
Pseudo-R2	0.175		0.219		0.136		0.177	
Sample size	190		190		172		190	

All regressions include industry dummies.
Standard errors reported below the estimated coefficient.
* indicates statistically significant at the 90% level (two-tailed test).
** indicates statistically significant at the 95% level (two-tailed test).
*** indicates statistically significant at the 99% level (two-tailed test).

Table 4. Probit regression of likelihood of variable payments

	Dependent variables: indicator of the presence of output-based payments in the first year							
	full sample		unaffiliated subsample		affiliated subsample		unaffiliated, duration>1 yr	
	(i)		(ii)		(iii)		(iv)	
Patent	0.056		0.05		-0.022		0.151	**
	0.086		0.122		0.115		0.059	
Know-how	0.123		0.044		0.358	**	0.092	
	0.103		0.127		0.172		0.094	
Affiliation	0.117							
	0.088							
Product	0.366	***	0.389	***	0.312	***	0.257	***
	0.083		0.103		0.132		0.083	
Duration=1 year	-0.646	***	-0.638	***	-0.721	***		
	0.094		0.107		0.196			
European Union	-0.095		-0.088		-0.068		-0.165	**
	0.084		0.117		0.07		0.074	
ln(sales)	0.188	**	0.212	***	0.152		0.114	**
	0.061		0.074		0.116		0.074	
ln(sales) squared	-0.015	***	-0.018	***	-0.01		-0.01	***
	0.004		0.005		0.008		0.004	
Log-likelihood	-67.4		-46.864		-18.357		-31.178	
Pseudo-R2	0.438		0.447		0.446		0.403	
Sample size	190		128		62		98	

All regressions include industry dummies.
Standard errors reported below the estimated coefficient.
* indicates statistically significant at the 90% level (two-tailed test).
** indicates statistically significant at the 95% level (two-tailed test).
*** indicates statistically significant at the 99% level (two-tailed test).

Table 5. Royalty rate and selected contract clauses

	Full sample, selection eq.		Full sample, regression eq.		Unaffiliated, selection eq.		Unaffiliated, regression eq.	
	(i)		(ii)		(iii)		(iv)	
Patent	0.298		0.035		0.38		-0.136	
	0.306		0.14		0.361		0.201	
Know-how	0.482	*	-0.002		0.439		-0.106	
	0.272		0.186		0.307		0.244	
Affiliation	0.56	**						
	0.272							
Product	1.046	***			0.946	***		
	0.237				0.269			
Duration=1 year	-2.654	***			-2.266	***		
	0.461				0.489			
ln(sales)	-0.079	*	-0.115	***	-0.077		-0.087	**
	0.057		0.036		0.06		0.043	
European Union	-0.861	***			-0.767	***		
	0.275				0.291			
Constant	1.05	*	2.25	***	0.99	*	2.086	***
	0.551		0.331		0.581		0.364	
Log likelihood	-200.388				-138.534			
Sample size	190				128			

All regressions include industry dummies.
Standard errors reported below the estimated coefficient.
* indicates statistically significant at the 90% level (two-tailed test).
** indicates statistically significant at the 95% level (two-tailed test).
*** indicates statistically significant at the 99% level (two-tailed test).

Table A.2. Number of observations by contract clause

Clause	Times	Clause	Times	Clause	Times
Patents	58	**Technical assist.**	171	**Exclusivity**	141
Util. Models	11	**R&D abroad**	8	**Confidentiality**	145
Know-how	129	**R&D parent**	5	**Improvements**	81
Software	40	**Ownership**	40	**No competition**	28
Trademarks	48	**Right to use**	210	**Sublicensing**	111
Models, designs	45	**Right to sell**	116	**Input tying**	33
Franchise	9	**Product**	141	**Defense**	46
Engineering	51	**Process**	225	**Minimum royalty**	37
Databases	28	**Territoriality**	148	**Total contracts**	319