Facultad de Ciencias Económicas y Empresariales
Universidad de Navarra

# Working Paper nº 11/04

## Contractual Implications of International Trade in Tacit Knowledge

Pedro Mendi

Facultad de Ciencias Económicas y Empresariales
Universidad de Navarra

# CONTRACTUAL IMPLICATIONS OF INTERNATIONAL TRADE IN TACIT KNOWLEDGE

Pedro Mendi

Working Paper No.11/04
May 2004
JEL No. O33, K12

ABSTRACT

This paper searches for evidence on the additional difficulty the parties have in contracting for the transfer of know-how relative to the transfer of patented technology. There is empirical evidence, drawn from a sample of contracts for the acquisition of technology by Spanish firms in 1991, that contracts scheduled to last shorter are less likely to include the transfer of know-how. It is also found that technical assistance is bundled together with the transfer of know-how, so as to mitigate opportunistic behavior on the seller's side.

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

## 1. Introduction

The transmission of tacit knowledge has some problems inherent to it not present in other types of technology. These problems stem from the fact that it is uncodified knowledge, which allows neither contracts being written contingent on technology characteristics nor legal protection of technology. This characteristic will be the origin of moral hazard problems on both sides, first described in Arrow (1962). Moral hazard problems are less acute in the case of codified, legally protected technology. On the one hand, codification implies that the relevant characteristics of the technology can be described, which allows the parties to write contracts contingent on them. On the other hand, legal protection against imitation dramatically limits potential moral hazard problems on the licensee's side.

These distinct features suggest that some characteristics of the agreement will have different effects on how likely an agreement for the transfer of know-how or a patent is. This paper explicitly analyzes the impact of contract duration on the probabilities of transferring know-how and a patent in a sample of technology-importing contracts signed by Spanish firms in 1991. The first finding of the paper is that, while contract duration, i.e. the number of years the parties agree the relationship to last at the time of signing the contract, has a positive effect on the probability of transmission of know-how, it has no effect on the probability of a patent being transferred.

Contract duration has not been the main focus of theoretical or empirical studies on contracts for the international transmission of technology. The temporal dimension of the agreement has been typically overlooked in the literature, focusing on difficulties to contract due to asymmetric information or the risk inherent to the transmission of the technology, but never considering the case of the relationship lasting for several periods. Thus, one of the contributions of this paper is to explicitly consider the effect of contract duration and to analyze when it will ease or make the transfer of

knowledge more difficult, depending on the kind of technology to be transacted. In this paper, contract duration is exogenously taken and determined how long will the technology be useful before its obsolescence.

The same sample is analyzed to search for evidence on the parties including the provision of technical assistance services to facilitate the transmission of tacit knowledge. Arora (1996) finds evidence of complementary inputs being bundled together with the transfer of know-how, arguing that they mitigate moral hazard on the licensor's side. The surprising result in this paper is that even patents are bundled together with know-how. This paper focuses specifically on the provision of technical assistance. In the presence of potential moral hazard problems on the licensor's side, technical assistance can be a safeguard against this opportunistic behavior. It can be regarded as commitment by the licensor to provide the licensee with the first-best level of technology, as long as providing technical assistance is costly to the seller of the technology. Thus, it will be tested whether the parties more likely include the provision of technical assistance services in the contract whenever know-how is to be transferred. The result obtained is that the transfer of know-how, but not of a patent, makes the provision of technical assistance more likely. An additional result from the empirical analysis is that technical assistance indeed helps in mitigating moral hazard problems on the seller's side.

The results obtained in the empirical analysis carried out in this paper suggest the existence of a selection effect in contracts for the transfer of technology. Contract duration affects the likelihood of know-how being transferred because longer contracts reduce the scope for moral hazard on both sides. This implies that if the relationship is scheduled to be short-lived, the temptation of the parties to breach the contract is greater than in the case of longer relationships. Foreseeing this, the parties may be unable to sign an agreement in the first place, and therefore, the observed distribution of contract duration in those contracts that include the transmission of know-how will be skewed to the right.

The organization of the paper is as follows. Section 2 discusses how contract duration may affect the transfer of know-how and why the parties may be interested in including technical assistance in the agreement. Section 3 describes the data, which will be analyzed in Section 4. Finally, Section 5 presents some conclusions.

## 2. Technology Trade, Contract Duration and the Provision of Technical Assistance

Patented technology and know-how differ substantially in their tacitness. The former is codified knowledge, which allows for its description and delimitation of what is included and what is not included in the patent, and therefore, what is and what is not legally protected against imitation. Furthermore, the possibility of describing the object of a patent permits that contracts be written based on the characteristics of patented technology, since it is possible for third parties to verify these characteristics. By contrast, know-how is tacit, uncodified knowledge. This characteristic prevents the parties from writing contracts based on technology characteristics, which are non verifiable by third parties. This tacitness also impedes that know-how receive legal protection against imitation.

There is less room for potential moral hazard problems in the transfer of a patent than in the transfer o f know-how. In this type of transfers, the licensee may renege on payments, and the seller may provide a suboptimal type of technology, see for instance Choi (2001). If this threat is serious enough, in some cases the agreement might not be signed at all. In other cases, the parties will be forced to include safeguards in order to be able to sign the contract. This paper first inquires on whether contract duration can partially solve moral hazard problems and whether there is evidence of the parties including technical assistance as a way to ensure cooperation by the seller.

Contract duration is what the parties expect the relationship to last given their information at the time of signing the contract. This will not always be equal to actual contract duration, since some contracts may be terminated early. In this paper, contract duration is taken as an exogenous variable,

determined by product characteristics. The approach taken is of licensors selling different product and/or process technologies with different expected remaining useful lives. Once the remaining useful lives expire, these technologies become obsolete and therefore, worthless. These remaining useful lives will determine contract duration.

Incentives to deviate from honest behavior differ with contract duration. If the parties sign a short-term contract, they have a lower incentive to cooperate in the successful implementation of the technology than in the case of a longer relationship. The reason is that the opportunity cost of breaching the contract is greater the longer the remainder of the relationship. Of course, for this effect to be in place, there must be some way the non-deviant can punish the deviating firm. In the case of the licensee deviating by reneging on its payments due, the licensor can license another firm, thus reducing the original licensee's profits, a reduction that will be increasing in contract duration. Similarly, if the licensor does not provide the first-best technology to the licensee so as to save in costs, the opportunity cost to the licensor is the fact that it is receiving lower revenues. This opportunity cost is also increasing in contract duration.

Legal protection of technology is crucial in determining how profitable contract breaching is, and thus, to analyze whether contract duration will have any effect at all in the likelihood of observing specific types of technology being transferred. If legal protection of the technology is strong, for instance if the contract is for the right to use a patent for a given period of time, the temptation to cheat is reduced. In this case, contract duration should not be a factor in determining how likely to be signed these contracts are, and therefore, its effect on the likelihood of observing the transfer of a patented technology should be null.

By contrast, this same argument suggests that the likelihood of know-how being transferred should be non-decreasing in contract duration. For some short-term contracts, potential moral hazard on either side may impede that the parties actually sign the contract. The incentives to not behaving

opportunistically increase in contract duration, since the profit from continuous cooperation more likely exceed the instantaneous gain from deviation.

This double prediction is precisely what will be tested in the empirical section. Using data from contracts for the imports of technology by Spanish firms in 1991, it will be analyzed whether contract duration affects the likelihood of observing a patent and know-how. If moral hazard inherent to the transfer of know-how is an issue, then duration should positively affect the likelihood of know-how but should have no effect in the transfer of a patent. Notice that in this paper I do not claim that there exists a causality relationship between these variables. The positive correlation comes from a selection effect: in the case of know-how, if contract duration is short, some contracts may not be signed, which reduces the proportion of contracts where know-how is transferred.

Related to these problems, the provision of technical assistance can be used by the seller of the technology as a way to ensure that it will indeed supply the first-best level of technology. In some sense, it acts as a commitment device, if the provision of technical assistance is costly to the licensor. What will be analyzed empirically is whether the inclusion of a technical assistance clause in the contract occurs more frequently if know-how is to be transferred. Furthermore, it will be tested whether or not contract duration affects differently the likelihood of including know-how, depending on the inclusion of technical assistance in the original agreement.

Additionally, if the provision of technical assistance indeed solves the moral hazard problems on the seller's side, and moral hazard problems on the buyer's side are relatively less important, then duration should not affect the likelihood of transferring know-how in contracts where technical assistance is included. By contrast, in those contracts where technical assistance is not included, contract duration should still have a positive effect on the probability of transferring tacit knowledge. Evidence for this effect will also be searched for in the empirical section.

## 3. The Data

The dataset is taken from the records of the Spanish Ministry of Industry. All Spanish firms that imported technology were required, up to 1992, to report the terms of the technology purchase. The importer of the technology 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. This type of control is no longer allowed by the European Union, and thus filing was terminated in 1992.

The Spanish firm had to describe in this form some features of the technology being purchased or licensed. First, it declared whether that technology could be classified as a product and/or a process technology. The Spanish firm also report whether or not the agreement included a transfer of a patent, a utility model (a minor invention also legally protected), know-how, an industrial design or software. In some cases, the contract includes the transfer of several of these technology types. Out these types of technology, know-how is the only one that constitutes tacit knowledge, since the rest of them are codified and receive some legal protection against imitation, whereas legal protection is strongest in the case of a patent. In the same form, the Spanish firm also reported whether the contract was a licensing contract, where only the right to use a given technology was purchased, or it was an actual sale, where the Spanish firm acquired ownership of the technology. In the empirical analysis, all the variables constructed using these items will be dichotomous, since what is observed is the Spanish firm reporting whether or not the contract includes the transfer of these technological characteristics.

Regarding the Spanish firm, in addition to the industry of its main activity, it reported 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 exporter of 50% or more in the importer's equity or if both firms have a common parent. The Spanish firm also reported whether it performed R&D, although there was no information on the percentage of sales devoted to this activity. Regarding the seller's characteristics, both its industry and country appear on the form. The form also contains a buyer's estimate of scheduled payments to be made during the first five years of the contract, distinguishing between fixed and variable payments. If the relationship was scheduled to last longer than five years, the buyer was not required to provide an estimate of payments. The impact of some characteristics of the transferred technology on payment schemes has been analyzed in Mendi (2003).

Whenever the contract is filed together with the form, more variables are observable, by inspection of the contract clauses. In particular, the contracts refer to the duration of the agreement, which is the number of years the parties expect the relationship to last at the time of signing the contract. Thus, for those observations where the contract was filed together with the form, the duration variable just takes the value specified in the contract. For some cases in which only the form was filed, duration can be inferred by observing when scheduled payments stopped. In these cases, duration is the last year for which positive payments were reported. There are, therefore, some observations for which duration is neither observable nor inferred; they are agreements with duration longer than five years, since they schedule payments for the five years the seller was report, but it is not possible to infer the exact extent of the relationship.

Out of the 5168 forms filed in 1991, the sample used in this paper includes 212 observations. The final sample of 212 observations contains transfers that explicitly mentioning the transfer of a

patent, a utility model, an industrial design, know-how, or software (not for resale[1]). Thus, contracts where the technological content is less clear, for instance those where the buyer is just a software retailer have been explicitly excluded from the final sample. This has left out of the final sample 109 observations that were initially included.

Concerning the sampling process, the Spanish Ministry of Industry followed no systematic criterion in the 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 suggests 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 two weeks to copy the contents of the forms manually.

Table 1 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, according to Spanish classification of industries (CNAE-74).

[Insert Tables 1a and 1b here]

As it can be seen in Table 1a, 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 than half of the contracts in Services or Agriculture include the transmission of this type of technology. By contrast, the proportion of contracts that include the transfer of a patent is highest in Agriculture, and in the rest of the industry groups, it is below one third. This stresses the fact

[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

that patented technology, which has received significant attention in the Economics literature, represents a relatively small part of the international market for technology. This result also holds when total payments in transfers including a patent and not including one are considered.

The provision of technical assistance services is more frequent in Metal Transformation and Services, and rarely observed in Agriculture and Other Manufacturing and Construction. On the other hand, process technologies are prevalent in Services, and no contract in Agriculture fall into this category. In this paper, a given technology is considered to be of a process type if the Spanish firm classifies it as a process but not product technology. All the variables that appear in Table 1a are dichotomous.

Table 1b summarizes information on other variables also employed in the empirical analysis. Unaffiliated transfers are prevalent in all industries, with Agriculture having the highest percentage, over 80%. This variable is also dichotomous, taking the value zero if unaffiliated, and one if the transfer is made between affiliated parties. The transfer of ownership is rarely observed in these contracts, less than 10% overall, implying that most contracts are indeed licensing contracts. Ownership is transferred about 15% of the times in Energy, Minerals, and Chemicals and in Metal Transformation, whereas in the rest of the industries it is rarely transmitted. Duration, measured in years, is also highest in Agriculture, and in the neighborhood of five years in the case of the remaining industries, except for Services, which presents shorter contracts on average. Finally, there is a high degree of heterogeneity across industries in the buyer's sales, measured in millions of Spanish pesetas with the average firm in Energy, Minerals and Chemicals being 15 times as big as the average firm in Agriculture. In the empirical analysis, the logarithm of this variable will be used.

---

sample.

## 4. Empirical evidence

This section analyzes up to what extent the transfer of know-how is eased by some contract characteristics, and how the transmission of tacit knowledge is likely to be bundled together with technical assistance services, in order to mitigate moral hazard problems on the seller's side.

*Transfer of know-how and contract clauses*

Table 2 presents estimated marginal effects in different Probit specifications where the dependent variables are indicators of the transfer of patented technology and of know-how. What will be estimated are specifications like the following one:

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

and the observed dichotomous variable is $Patent_i = 1(V_i > 0)$ or $KnowHow_i = 1(V_i > 0)$, i.e. whether patented technology or know-how has been included in the transfer. In columns (i) and (ii) of Table 2, the dependent variable is an indicator of the transfer of a patent, whereas in columns (iii) and (iv), it is an indicator of know-how being transferred. The regressors include four industry dummies, one for each industrial group except for Agriculture (*Ind* variables). *Link* is a dummy that takes the value 1 if the transfer is affiliated, and zero otherwise. *Duration* is contract duration in years. *SameInd* is a dummy that equals one if both parties to the contract are classified into the same industry. The ln*impts* variable is the logarithm of the percentage of total Spanish imports that came from the seller's country of origin. It is a measure of asymmetric information both on the buyer and the seller's side, since a lower value of this variable suggests less commercial ties between Spain and the seller's country, and thus less information about the conditions of the Spanish market and less information about the seller itself. Finally, ln*sales* is the logarithm of sales of the Spanish firm in the year prior to the signing of the contract, which had to be reported in the form.

The comparison of estimated coefficients in columns (i) and (ii) with those in columns (iii) and (iv) sheds light on whether the transmission of tacit knowledge presents more difficulties than the transfer of codified, protected knowledge. Column (i) reports estimated marginal effects of different contract clauses on the transfer of patented technology using both affiliated and unaffiliated transfers. None of the coefficients is statistically significant, except for that on process technology, which is negative. Thus, neither affiliation nor contract duration seem to affect the probability of patented technology being transferred, suggesting that the legal protection that a patent receives indeed mitigates possible moral hazard problems on both sides. The sample size is only 165 observations because the duration variable is not observed in all cases, as it was discussed in the previous section, and because there are some missing data in the sales variable, since some firms did not report anything in this item in the forms filed to the Ministry.

Column (ii) carries out the same analysis, but using unaffiliated transfers only, thus dropping the affiliation variable from the set of regressors. For this type of transfers, moral hazard problems are potentially more acute, and therefore, if contract duration or asymmetric information have any influence at all in the successful transmission of technology, the effect of these variables should be stronger in this subsample. However, the coefficients of contract duration and the logarithm of imports remain statistically insignificant, like in the previous case. Size effects are positive, suggesting that larger firms are the ones purchasing patented technology, but the effect is not statistically significant.

Columns (iii) and (iv) report estimated marginal effects in similar specifications as those in columns (i) and (ii), but where the dependent variable is an indicator of the transfer of know-how. Now affiliation seems to play an important role in the likelihood of tacit knowledge being transferred: the effect is positive and statistically significant, making the transfer of know-how about 25% more likely if the two parties are affiliated. On the other hand, neither contract duration nor the logarithm of imports

have a statistically significant effect on the probability of the transfer of know-how if the full sample of contracts is used.

The interesting result that appears in column (iv) is that contract duration has a positive effect, statistically significant at the 1% level, and much greater in absolute value than that in column (iii). Within unaffiliated transfers, contract duration does not affect the likelihood of a patent being transferred, but the shorter the contract, the less likely it is that the parties agree on the transfer of know-how. This is consistent with the difficulties the parties have in contracting for the transfer of tacit knowledge: moral hazard problems on both sides are more acute the shorter the expected duration of the relationship. When the parties agree on transferring a technology with longer useful life, the temptation to misbehave is lower, because the opportunity cost of doing so increases, and thus, it is more likely that the agreement be actually signed. This shows up in the data as the positive effect of contract duration on the probability of transfer of tacit knowledge.

On the other hand, if the parties belong to the same industry, it is about 25% more likely that they agree on the transfer of know-how. This result did not appear in the case of transfers of patents, where the effect was statistically insignificant, even in the unaffiliated subsample. By its very nature, tacit knowledge requires the buyer to be familiar with the procedures that know-how applies to, in a lesser degree than in the case of a patent, where a description of it is available.

Now the analysis focuses on the provision of technical assistance. Arora (1996) links the transmission of technical assistance to the transfer of know-how in order to mitigate moral hazard problems on the seller's side. Thus, if these problems are important in order to determine the successful transfer of the technology, there should be a positive relationship between the transfer of know-how and the likelihood of the inclusion of technical assistance services in the contract. Table 3 reports estimated marginal effects in a Probit specification where the dependent variable is a dummy variable that takes the value one if the provision of technical assistance is included in the original

agreement, and zero otherwise, and the regressors those included in equation (1) plus indicators of the transfer of know-how and of patented knowledge. Again, the analysis is carried out first using the full sample of contracts and then using unaffiliated transfers only.

Column (i) reports estimated marginal effects using the full sample of contracts. It can be the transfer of know-how increases and the transfer of a patent decreases the probability of the provision of technical assistance services, with both effects being statistically significant. Moreover, the effect of the transfer of know-how is greater in absolute value if only unaffiliated transfers are used, see column (ii), which is again consistent with moral hazard problems being more acute in this type of transfers. The effect of duration is positive and statistically significant in column (i), but it is smaller in absolute value and loses statistical significance in column (ii). The statistically insignificant effect of duration in the unaffiliated subsample is consistent with the provision of technical assistance being driven chiefly by the type of technology to be transferred, not merely by contract duration only, which was found to influence the transfer of know-how.

The marginal effect of the logarithm of imports variable is negative and statistically significant both in columns (i) and (ii). This suggests that asymmetric information on both sides worsens moral hazard problems, and this becomes an additional reason to include technical assistance in the contract. Finally, both in columns (i) and (ii), the effect of the Spanish firm's size, measured by the logarithm of its sales, is positive and statistically significant. This is consistent with, other things equal, larger firms demanding more complex technologies on average, independently of how tacit these technologies are, which require technical assistance from the seller after the contract is signed.

Finally, Table 4 presents results of regressions that inquire into whether technical assistance is actually bundled together with know-how in order to mitigate moral hazard problems on the seller's side, as suggested in Arora (1996). For that purpose, it will be analyzed if technical assistance removes the effect of duration on the likelihood of transferring patented technology and know-how, within

unaffiliated transfers. The evidence suggests that technical assistance actually helps in the transmission of know-how, but not if a patent is to be transferred.

First, column (i) in Table 4 presents estimated marginal effects of a Probit specification where the dependent variable is an indicator of the transfer of a patent, and the regressors are the same as in the case of equation (1), except for the absence of the affiliation variable, since only the unaffiliated subsample will be used, and of industry dummies, because of the low number of observations due to the additional splitting of the sample into contracts which include technical assistance and contracts which do not include it. In column (i) only observations where the contract does not stipulate the provision of technical assistance are used, and no effect is statistically significant, except for that of the technology being of a process type. On the other hand, column (ii) uses observations where the technical assistance services are provided by the licensor. In this case, duration has a positive marginal effect, and becomes statistically significant at the 10% level. If moral hazard on the seller's side was a major factor driving the likelihood of patented technology being transferred and technical assistance helps mitigating this problem, then the effect of duration should have been positive if no technical assistance services are provided, and null if technical assistance is provided.

Columns (iii) and (iv) do the same exercise but now the dependent variable is the indicator of the transmission of know-how. Now the difference between the estimated marginal effects of duration in columns (iii) and (iv) suggest that technical assistance is associated to the existence of moral hazard problems on the seller's side. If no technical assistance is provided, the effect of duration is relatively large, increasing the likelihood of know-how being transferred by 7.7% per year of duration of the contract, and statistically significant at the 1% level. By contrast, in the subsample of unaffiliated transfers where technical assistance is provided, the effect of duration is much smaller in absolute value, and loses its statistical significance. Thus, in contracts that stipulate the provision of technical assistance, contract duration is less relevant in determining the likelihood of signing the contract,

suggesting that the very presence of technical assistance is a partial solution to moral hazard on the seller's side. It is interesting to stress the asymmetry of this result comparing transfers of codified technology with tacit knowledge: technical assistance only helps in the case of tacit knowledge, which again suggests that moral hazard problems on the seller's side indeed affect the likelihood of signing the contract.

Additionally, the transmission of technical assistance also makes the effect of the same industry variable less important, although it remains positive and statistically significant. In some sense, technical assistance substitutes for lack of knowledge about the usual procedure in a different industry. The effect of the logarithm of imports variable is positive, statistically significant, and it is not influenced by the transmission of technical assistance: know-how tends to be acquired from countries with closer commercial ties with Spain regardless to the efforts made by the parties to reduce moral hazard on the seller's side. This again is consistent with asymmetric information on variables other than technology characteristics worsening moral hazard problems on both sides.

Finally, the provision of technical assistance dramatically changes the effect of the technological importer's size, switching from it being positive and statistically significant at the 5% level to negative and statistically significant at the 1% level. A candidate explanation is that when no technical assistance is provided, mostly larger firms acquire tacit knowledge because they can more easily bear the loss from possible moral hazard on the seller's side, and thus, the likelihood of the contract actually being signed is smaller if the buyer is of a smaller size. On the other hand, if technical assistance is provided, then there is less room for opportunistic behavior on the seller's side, and thus, the true distribution of buyers' sizes appears, with smaller firms more likely acquiring tacit knowledge.

## 5. Conclusions

This paper analyzes whether contract duration has any effect on the probability of tacit knowledge being traded across national borders, and whether there is evidence on the parties to the transaction using technical assistance as a way to mitigate potential moral hazard problems on the seller's side, and thus ease the transfer process and increase the likelihood of the parties actually reaching an agreement. The empirical evidence is drawn from a sample of contracts for the acquisition of technology by Spanish firms from foreign sources in 1991.

The empirical analysis shows evidence that contract duration influences positively the probability of transferring tacit knowledge, but has no effect if patented knowledge is to be transferred. The difference between the two effects lies in the legal protection that a patent receives, which is not in place if tacit knowledge is to be transferred, a potential source of moral hazard problems on the buyer's side, and in the fact that tacit knowledge is uncodified, which may create moral hazard problems on the seller's side. If the parties agree on signing a long-term contract, then moral hazard problems are less acute because the opportunity cost of misbehavior is higher. Since the legal protection and codification of a patent reduce the temptation to cheat, duration has no effect in this type of transfers, but the transfer of know-how, lacking these two features, is sensitive to duration, which changes the parties' incentives to breach the contract.

The positive effect of contract duration on the likelihood of transferring know-how is through an increase in the likelihood of the parties actually signing the contract if duration is long. If know-how is to be transferred and the expected duration of the technology is short, then the potential moral hazard problems on both sides may be so acute that the parties are not able to reach a successful agreement.

The paper also investigates whether the parties include the provision of technical assistance as a way to solve moral hazard problems on the seller's side. Technical assistance is a commitment by the

licensor to provide the licensee with the first-best level of technology, if contracting upon technological characteristics is impossible. The evidence found in the paper can be interpreted as supporting the claim that these services are indeed used by the parties for this purpose: technical assistance is associated with the transfer of know-how, but not of a patent. Furthermore, the provision of technical assistance services makes the effect of contract duration in the likelihood of transferring know-how be zero.

The results obtained in this paper suggest that the legal protection offered by the patent system in Spain in 1991 was sufficient to ensure that two unaffiliated parties interested in transferring ownership or the right to use a patent were not refrained by potential moral hazard problems. By contrast, the transfer of know-how was much more difficult because of its lack of legal protection and its tacitness. Technical assistance services are introduced as a partial solution to this problem, but whenever this service was not provided, the probability of transferring know-how depended on factors such as contract duration, which determined how acute moral hazard problems were to be. Moreover, it was precisely smaller firms the most likely to forgo the possibility of acquiring tacit knowledge. This fact can be used as an argument for the introduction of a system of legal protection of know-how, which was absent in Spain at the time the contracts analyzed were written.

Finally, the results obtained in this paper suggest that models that analyze contracts for the transfer of technology should explicitly consider its temporal dimension. To the best of my knowledge, all papers in this field consider instantaneous transfers of technology and analyze how moral hazard, asymmetric information, or risk-sharing influence scheduled payments or the inclusion of certain contract clauses. The fact that contracts differ in their durations has been overlooked in the literature, and in my opinion, deserves more attention.

# References


Anand, B., and T. Khanna. 2000. The Structure of Licensing Contracts. *Journal of Industrial Economics*. 48(1):103-135.

Anton, J., and D. Yao. 1994. Expropriation and inventions: appropriable rents in the absence of property rights. *American Economic Review*. 84(1):190-209.

Anton, J., and D. Yao. 2002. The sale of ideas: strategic disclosure, property rights, and incomplete contracts. *Review of Economic Studies*. 69(3):513:532.

Arora, A. 1992. The transfer of technological know-how to developing countries: technology licensing, tacit knowledge, and the acquisition of technological capability. PhD dissertation. Stanford University.

Arora, A. 1996. Contracting for tacit knowledge: the provision of technical services in technology licensing contracts. *Journal of Development Economics*. 50:233-257.

Arrow, K.J. 1962. Economic Welfare and the Allocation of Resources for Invention. In National Bureau of Economic Research, *The Rate and Direction of Inventive Activity*. Princeton, NJ: Princeton University Press.

Arrow, K. J. 1969. Classificatory Notes on the Production and Transmission of Technological Knowledge. *American Economic Review*. 59(2):29-35.

Caves, R., H. Crookell, and P. Killing. 1983. The imperfect market for technology licenses. *Oxford Bulletin of Economics and Statistics*. 45(3):249-268.

Choi, J. P. 2001. Technology transfer with moral hazard. *International Journal of Industrial Organization*. 19:249-266.

Contractor, F. J. 1981. *International technology licensing*. Lexington, MA: Lexington Books.

Kamien, M. 1992. Patent licensing. in Aumann, R., and S. Hart, Eds. *Handbook of Game Theory, vol. 1*. Amsterdam: Elsevier.

King, J. T. 2003. The sale of unprotected inventions under alternative models of contracting behavior. *International Journal of Industrial Organization*. 21:57-77.

Klein, B. 1996. Why hold-ups occur: The self-enforcing range of contractual relationships. *Economic Inquiry*. 34(3):444-463.

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

Mendi, P. 2003. The Structure of Payments in Technology Transfer Contracts: Evidence from Spain. University of Navarra Working Paper #05/03.

Ministerio de Industria, Comercio y Turismo. 1992. *Manual para la Transferencia de Tecnología*. Madrid, Spain: Secretaría de Estado de Industria, Ministerio de Industria, Comercio y Turismo.

Pérez-Rodríguez, S. 1996. Metodología para el estudio de los procesos de transferencia de tecnología: aplicación al caso español. PhD dissertation. UNED, ETSII.

**Table 1a. Contract and firm characteristics by industry**

| Industry | Total Obs. | Know-how % | Patented technology % | Technical assistance % | Process technology % |
|---|---|---|---|---|---|
| **Agriculture (0)** | 11 | 45.5 | 45.5 | 27.3 | 0 |
| **Energy, Minerals, Chemicals (1-2)** | 48 | 85.4 | 31.3 | 50 | 50 |
| **Metal Transformation (3)** | 67 | 64.2 | 29.9 | 56.7 | 41.8 |
| **Other Manufacturing, Construction (4-5)** | 40 | 50 | 25 | 30 | 42.5 |
| **Services (6-9)** | 46 | 43.5 | 15.2 | 54.3 | 67.4 |
| **Total** | 212 | 60.8 | 26.9 | 48.1 | 47.2 |

**Table 1b. Contract and firm characteristics by industry**

| Industry | Unaffiliated % | Ownership % | Duration years | Average sales (pta mn) |
|---|---|---|---|---|
| **Agriculture (0)** | 81.8 | 0 | 7.6 | 1568 |
| **Energy, Minerals, Chemicals (1-2)** | 68.7 | 16.7 | 4.7 | 24266 |
| **Metal Transformation (3)** | 71.1 | 13.4 | 4.6 | 21414 |
| **Other Manufacturing, Construction (4-5)** | 57.5 | 2.5 | 5.5 | 5284 |
| **Services (6-9)** | 58.7 | 4.4 | 3.3 | 17217 |
| **Total** | 65.6 | 9.4 | 4.6 | 17120 |

**Table 2. Probability of transfer of patented and tacit knowledge**

| | Patented technology | | | | Know-how | | | |
|---|---|---|---|---|---|---|---|---|
| | Full sample | | Unaffiliated subsample | | Full sample | | Unaffiliated subsample | |
| | (i) | | (ii) | | (iii) | | (iv) | |
| **Affiliation** | 0.037 | | | | 0.267 | *** | | |
| | 0.073 | | | | 0.077 | | | |
| **Process** | -0.253 | *** | -0.166 | * | 0.155 | * | 0.212 | * |
| | 0.067 | | 0.084 | | 0.087 | | 0.119 | |
| **Duration** | -0.008 | | 0.003 | | 0.011 | | 0.047 | *** |
| | 0.01 | | 0.012 | | 0.012 | | 0.018 | |
| **Same industry** | -0.037 | | -0.026 | | 0.14 | | 0.244 | ** |
| | 0.074 | | 0.087 | | 0.093 | | 0.115 | |
| **ln(imports)** | -0.014 | | 0.003 | | 0.026 | | 0.052 | |
| | 0.033 | | 0.037 | | 0.04 | | 0.05 | |
| **ln(sales)** | 0.012 | | 0.012 | | -0.025 | | -0.019 | |
| | 0.015 | | 0.017 | | 0.019 | | 0.024 | |
| **Log-likelihood** | -76.664 | | -53.487 | | -89.644 | | -60.692 | |
| **Sample size** | 165 | | 113 | | 165 | | 113 | |

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 3. Probability of provision of technical assistance**

| | Full Sample (i) | | Unaffiliated Subsample (ii) | |
|---|---|---|---|---|
| **Patent** | -0.262 | ** | -0.188 | |
| | 0.102 | | 0.127 | |
| **Know-How** | 0.281 | *** | 0.332 | *** |
| | 0.096 | | 0.115 | |
| **Affiliation** | 0.102 | | | |
| | 0.099 | | | |
| **Process** | 0.108 | | -0.069 | |
| | 0.095 | | 0.116 | |
| **Duration** | 0.029 | ** | 0.014 | |
| | 0.014 | | 0.017 | |
| **Same industry** | 0.077 | | -0.748 | |
| | 0.095 | | 0.115 | |
| **ln(imports)** | -0.08 | ** | -0.081 | * |
| | 0.044 | | 0.491 | |
| **ln(sales)** | 0.04 | ** | 0.037 | * |
| | 0.02 | | 0.022 | |
| **Log-likelihood** | -92.025 | | -64.107 | |
| **Sample size** | 165 | | 113 | |

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. Technical assistance as a safeguard against opportunistic behavior**

| | Patented technology | | | | Know-how | | | |
|---|---|---|---|---|---|---|---|---|
| | No technical assistance | | Technical assistance | | No technical assistance | | Technical assistance | |
| | (i) | | (ii) | | (iii) | | (iv) | |
| **Process** | -0.278 | ** | -0.031 | | 0.36 | ** | -0.113 | |
| | 0.12 | | 0.099 | | 0.141 | | 0.167 | |
| **Duration** | 0.001 | | 0.022 | * | 0.077 | *** | 0.024 | |
| | 0.019 | | 0.012 | | 0.027 | | 0.022 | |
| **Same industry** | -0.001 | | 0.038 | | 0.418 | *** | 0.281 | * |
| | 0.126 | | 0.096 | | 0.127 | | 0.165 | |
| **ln(imports)** | -0.007 | | 0.022 | | 0.134 | * | 0.135 | * |
| | 0.056 | | 0.044 | | 0.072 | | 0.067 | |
| **ln(sales)** | 0.027 | | 0.022 | | 0.078 | ** | -0.086 | *** |
| | 0.025 | | 0.019 | | 0.035 | | 0.032 | |
| **Log-likelihood** | -32.913 | | -17.688 | | -31.631 | | -23.042 | |
| **Sample size** | 61 | | 52 | | 61 | | 52 | |

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).