The Effects of Intellectual Property Protection on International Knowledge Contracting *

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Résumé

Le récent renforcement des systèmes de protection des droits de propriété intellectuelle (DPI) des pays en voie de développement, et en particulier de ceux à capacité technologique croissante, s'explique par leur volonté d'accroître les transferts technologiques intrants. Nous tentons dans cette étude d'évaluer empiriquement l'impact des DPI sur le commerce de connaissances désincorporées. Pour se faire, nous exploitons les recettes françaises en technologie au niveau industriel pour la période 1994-2000. Nous constatons que les DPI ont un impact positif sur les échanges internationaux en technologie. Néanmoins, nos résultats prouvent que cet impact diffère selon le niveau de revenu et la capacité technologique des pays d'accueil. Les effets des DPI semblent différer entre industries : une protection plus élevée de la propriété intellectuelle n'attire pas les contrats de connaissance désincorporés dans les industries intensives en R&D, contrairement aux industries à intensité moyenne. Finalement, nous rapportons des résultats sensiblement différents des enquêtes industrielles précédentes (Mansfield et alii, 1968 ; Levin et alii, 1987 ; Cohen et alii, 2000) quant à la sensibilité des industries aux brevets pour approprier l'innovation.

Mots Clés : Droits de Propriété Intellectuelle, Transfert International de Technologie, Protection des brevets.

Abstract

Developing countries, and particularly, those with a growing technological capacity, expect foreign technology transfers to increase when strengthening their intellectual property protection (IPR) rights. This paper evaluates empirically the impact of IPR on disembodied knowledge trade. It presents an exploration on Bilateral French Technology Receipts at the industry level for the period 1994-2000. Two main findings stem from our analysis. First, It is found that IPR affects positively international knowledge contracting. Nevertheless, our findings show that the impact of IPR protection differs according to countries' income level and technological capacity. Stronger IPR rights can deter technology contracting in developing economies. Second, the effects of IPR protection are found to differ across industries. Stronger protection is found to be irrelevant to attract knowledge contracting in R&D-intensive industries, contrarily to middle R&D-intensive industries. Lastly, our findings on industries' sensitivity to foreign IPR protection differ from the results reported by survey studies (Mansfield et alii, 1968; Levin et alii, 1987; Cohen et alii, 2000) concerning the relative importance of IPR protection across industries to appropriate innovation.

Key Words: Intellectual Property Rights, international technology transfer, patent protection.

JEL Classification: O34, K42, F14, O31

Introduction

Technology can be transferred across countries through many channels such as imports of capital goods (embodied technologies), direct investment, technology licensing and joint ventures. *A priori,* production modes involving a direct transfer of tacit knowledge towards third-local parties, such as patent licensing (or arms' length contracting, R&D assistance, R&D delocalization), are affected by the risk of knowledge dissipation in foreign markets (Glass and Saggi, 1998; Vishwasrao, 1994). The strength of intellectual property rights (hereafter IPR) constitutes consequently a major determinant for technology-exporting firms to appropriate additional returns to Research and Development in foreign markets (Glass and Saggi, 1998; Yang and Maskus, 2001b). Intellectual property protection by fostering technology transfer by foreign firms as well as innovation by local firms, should affect in turn, economic growth and welfare in the reforming country (Ginarte and Park, 1997; Gould and Grouben, 1996; Maskus, 2001).

The economic literature remains however largely inconclusive on the economic effects of strengthening IPR protection worldwide. Much controversy remains concerning the extent to which stronger IPR actually stimulate international technology transfer. Different theoretical arguments have supported both sides of the debate on IPR reform.

On the one hand, stronger IPR protection may stimulate further knowledge-based transactions by expanding market potential through the displacement of imitators (Maskus and Penubarti, 1995; Smith, 1999). IPR reduce transaction costs and costs related to contract enforcement between parties (the premium paid to employees to not defect is reduced) and increase proprietor's bargaining power (Yang and Maskus, 2001b). On the other hand, tighter IPR may reduce knowledge transfer obtained through imitation (Glass and Saggi, 2002; Helpman, 1993). Further, by reducing local imitation risk stronger IPR may induce a weaker local presence of innovators both through multinational activity and licensing, and increase exports as a serving-market mode (Glass and Saggi, 2002; Helpman, 1993). Lastly, knowledge-based transactions may also contract since the increased market power allows innovators to commercialize technologies at higher prices. Therefore, technology transfer through licensing might be reduced to the extent that there would be fewer new technologies available for commercialization.

In spite of its relevance however, the empirical evaluation of the impact of IPR on technology transfer, and particularly, on international technology contracting remains an understudied area.[2] Bringing empirical evidence on this matter is particularly urgent for developing countries as a considerable number of them have dramatically reformed their IPR regimes since the half 1980s.[3] The creation, notably, of the *Trade-Related Intellectual Property Rights Agreement* (TRIPs) at the Uruguay Round (1986-1994), raised a number of questions on the pertinence of harmonizing the standards of IPR worldwide and the resulting gains for the developing world in terms of innovation and technology transfer. Are stronger intellectual property rights an adequate strategy to stimulate knowledge transfer to developing nations? Moreover, is strengthening patent protection an efficient way to promote innovation in these regions? For developing countries, resolving these questions is essential in order to assess the implications in the process of technology catching-up and the design of complementary policies to IPR reforms (Primo Braga et al 2000; Siebeck et al 1990).

This study provides new evidence regarding the effects of patent protection on international knowledge transfer. It presents an empirical analysis on Bilateral French Technology Receipts at the industry level for the period 1994-2000. Technology receipts concern fees related to patent and trademark licensing, arm's length contracting, technical assistance and know-how alliances, as well as fees related to foreign R&D activities made by French firms. The data set is a cross section of 21 countries and 20 sectors. Our contribution is twofold. First, following theoretical predictions, our study presents evidence on a differentiated impact of IPR across countries. Countries' income level and technological capacity affect unambiguously the extent of technology contracting. Second, an examination of the effects of patent protection is conducted in an industry-basis. To the extent that imitation threat varies across sectors and consequently the sensitivity to tighter IPR protection (Cohen et al 2000; Levin et al 1987; Mansfield et al 1968), a differentiated impact of IPR on trade knowledge is identified across industries.

Our findings show that IPR does have a positive impact in average on international knowledge contracting. Nevertheless, our results cast some doubts about the efficacy of stronger patent

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[2] Contrarily, the question of spillovers related to disembodied knowledge embedded in international patents, has become recently an issue of intensive research (Guellec and Van Pottelsbergue 2001).
[3] For a survey of the literature concerning the economic effects of international harmonization of intellectual property rights, see Siebeck et al (1990) or Maskus (2000).

protection to enhance technology markets in developing countries, and particularly, in R&D intensive industries. IPR is found to deter technology contracting in emerging countries at small levels of reforms. At stronger level of IPR protection, technology contracting seems to react positively to IPR reforms. Furthermore, contrarily to common expectations stronger protection appears as irrelevant to attract knowledge contracting in R&D-intensive industries; although IPR is found to play a significant role in middle R&D-intensive industries. Lastly, in terms of knowledge transfer, our results differ from the conclusions offered by several survey studies on the relative importance of patents as appropriability means (Levin et al 1987). In terms of knowledge contracting, industries *à priori* sensitive to patents, do not necessarily answer to stronger foreign patent protection. The degree of response to foreign IPR will depend on industries' propensity to commercialize their intellectual assets. In other words, the effects of IPR should be conditioned by the use of IPR markets by firms (industries).

In conclusion, this work pointed out the limited role of foreign IPR protection to stimulate knowledge-based transactions overseas. In order to strengthen the incentives for knowledge contracting brought by the improved legal framework, complementary policies should be considered in alleviating other obstacles to the development of technology markets. The removal of barriers (institutional, economical, financial, etc.) both to innovation and technology markets should strengthen the receptivity of host countries to technology collaborations with foreigners.

The paper is organized as follows: Section 1 discusses the conceptual framework and reviews the empirical literature related to IPR and international economic transactions. Section 2 describes the data used in the study, the specification and methodology guiding our empirical analysis. Section 3 provides our empirical results. Section 4 concludes and discusses policy implications.

1. Intellectual Property Rights and Knowledge Transfer

The economic literature remains inconclusive about the effects of stronger IPR on knowledge transfer (either by foreign direct investment, trade or licensing). Nevertheless, there is some evidence suggesting that IPR protection constitutes a main determinant in technology transfer decisions by multinational firms (Maskus, 2001).

According to different survey studies (Lee and Mansfield, 1996; Mansfield, 1994), multinational firms report that intellectual property protection is *à priori*, a major condition when transferring knowledge assets cross borders through licensing to third parties.[4] Under a weak IPR regime the provision and sharing of tacit knowledge and intellectual assets with domestic firms becomes too risky when the threat of imitation posed by third firms (or partners) is strong (Markusen, 1998). As explained by Maskus (1998) and Yang and Maskus (2001b), in the presence of weak patents, problems of transacting information with licensing, such as the non-excludability property of new knowledge, informational asymmetry, imitation risk and transfer costs, could provide an internalization motive for foreign direct investment (Markusen, 1995; Pitkethly, 2001). In addition, the level of IPR influences firms' choice concerning the technologies' vintage to commercialize in the foreign markets.[5]

Nevertheless, the theoretical literature provides mixed conclusions on the effects of stronger IPR on technology-transfer (FDI, trade, licensing or joint-ventures). A group of studies in the line of partial equilibrium models has investigated the implications of extending IPR to southern countries on international production transfer, innovation and global welfare (Chin and Grossman, 1988; Deardorff, 1992; Helpman, 1993). By raising the costs of Southern imitation, stronger IPR in the South slows down this process of transfer of production to the South. The impact of IPR on other modes of technology transfer is however not clear: technology transfer through direct investment or licensing may increase or decrease.[6] Helpman (1993) concludes that a tighter IPR in the South may provoke a reduction of direct investment and an increase of imports which in turn would deter innovation and lower global welfare.[7] A similar pessimistic view is offered by Glass and Saggi (2002): the reallocation of production to the North (contraction of FDI) would provoke a scarcity of resources, reducing the resources available for innovation (R&D).[8] In conclusion, these models suggest that technology exporter countries (North) may gain from stronger protection IPR whereas developing countries will likely loss in the absence of innovation gains (Chin and Grossman, 1988,

[4] However, this finding depends on the industry or nature of the technology. In Mansfields' study (1994), U.S. firms in Chemicals and electronics industries appeared to place a greater emphasis on intellectual property protection, whereas firms in the metals and transportation industries were seen to be less reliant on it.

[5] Fosfuri (2000) shows that under weak IPR protection, the age of technologies is chosen strategically to prevent imitation.

[6] Furthermore, the impact of stronger IPR on knowledge transfer and global welfare in these models depend on the initial mode of technology transfer relating the North and South (Lai, 1998).

[7] Accordingly, a stronger IPR might lead to a two-folded inefficiency in the short run: an allocative inefficiency derived from monopoly pricing (rent transfer effect); and a productive inefficiency stemming from a reallocation of production from South to North (Helpman, 1993).

[8] In the opposite, Lai (1998) argues that stronger IPR could accelerate multinational activity and innovation in a context of technology transfer North-South through foreign direct investment (FDI) and weak local imitation.

Deardorff, 1992).[9] Helpman (1993) shows that welfare losses may arise due to monopoly pricing, a higher dependence of imports and loss of variety.

A more optimistic vision prevails about the impact of stronger IPR on licensing activity. By improving the legal framework for the enforcement of contracts (patent licensing, arm's length contracting, etc.) stronger IPR may reduce the costs of technology transfer, stimulating technology contracting in reforming countries. Stronger patent protection lowers the costs of enforcing contracts (i.e. monitoring, litigation costs, etc.) mitigating the costs of technology transfer (Caves et al 1983; Contractor, 1980).[10] Therefore the rent share accruing to the licensor rises with patent strength, raising the returns to licensing (Yang and Maskus, 2001a; 2001b). By modifying imitation costs and reducing consequently licensing costs, stricter IPR would increase the licensor's profit by two main effects: a higher economic return from licensing ("*the size effect"*) and a superior rent share ("*the distribution effect"*). In turn, a higher rent stemming from licensing increases the return to R&D and the incentives to innovate (assuming that southern firms do not innovate).[11] Furthermore, by reducing the relative transaction costs, i.e. fixed costs of reaching and enforcing licensing contracts, stronger patent rights may shift incentives toward licensing away from FDI or trade (Fosfuri, 2000; Maskus et al 2003; Vishwasrao, 1994).

Nevertheless, the economic gains previously mentioned should be confronted to the potential detrimental effects of stronger IPR (i.e. patent protection) on technology contracting. An increase in patent protection may have offsetting effects upon licensing propensity (Arora et al 2004). On the one hand, stronger patent protection increases the efficiency of licensing contracts, but on the other hand, also enhances the value of the innovation itself and thus, raises the opportunity cost of licensing. Patent effectiveness is likely to increase patent propensity, but may also decrease the share of patented innovations that are licensed (Arora and Ceccagnoli, 2004). Nonetheless, the impact of patent reinforcing on licensing behavior can be conditioned by the degree of firms'

[9] A different view is presented by Diwan and Rodrick (1995). He shows that welfare gains emanating from increased local innovation may arise in southern countries from strengthening IPR in the case of different demands between the North and the South.

[10] In a model of asymmetric information and imitation threat, Gallini and Wright (1990) show that licensors sacrifice rents in order to preclude imitation. Markusen (1998) show that a strengthening of protection reduces the premium that firms have to pay to their employees to deter them from disclosing their knowledge to rival firms.

[11] In addition, the rate of innovation is strengthened as more resources are available up in the North for innovation investment given the more efficient allocation of production in the two regions. A similar analysis is provided by Maskus et al (2003).

autonomy (e.g. production and commercialization capabilities) to bring innovation to the market (Arora et al 2001; Arora and Ceccagnoli, 2004). [12]

Stronger levels of IPR (e.g. stronger patent protection) might actually discourage knowledge diffusion (Machlup and Penrose, 1950). Stronger patents might reduce technology transfer through formal contracting because of the market-power effect can dominate the increase on economic-returns (e.g. through licensing) brought by the stronger protection. Stronger patents might deter the development of technology markets as well as industries' rate of innovation (Gallini, 1992; Gallini and Wright, 1990; Mergers and Nelson, 1995; Scotchmer, 1991): they make firms to incur in higher technology acquisition costs due to the increased market power of innovators and the amplified protection set over a larger rank of technologies (Bessen and Maskin, 1999; McCalman, 2001). Furthermore, stronger IPR could induce less R&D efforts by monopolistic firms leading to a lower rate of innovation and diffusion (Gallini, 1992).[13] Since stronger IPR protection reduces threats from potential rivals (who could imitate or invent around existing products), less incentive exists to upgrade existing intellectual property or to develop new varieties. To the extent that stronger IPR may slow down the pace of innovation, there would be fewer new technologies available for licensing.[14] It should also be noted that the effectiveness of patents to stimulate technology-contracting, may vary across industries and depends on the kind of innovation (industrial process and product innovation). As shown by several survey studies (Cohen et al., 1997; Cohen et al 2000; Levin et al., 1987; Mansfield, 1968), patent protection is not the only or even primary source of appropriating rents to innovation: first-mover advantages, secrecy and lead time constitute privileged strategies in an important number of industries.[15]

Lastly, technology licensing must also be considered in relation to alternative modes of technology transfer, such as exports, foreign direct investment (FDI) and joint ventures. Stronger IPR may increase or decrease licensing because stronger IPR may reduce or increase the other kinds of technology transfer activities. Reforms in intellectual property regimes may make one form of

[12] A higher autonomy might more likely lead to contractions of licensing intensity under stronger patents, whereas the existence of (local or foreign) firms endowed with superior capabilities (e.g. commercialization capabilities) might stimulate technology licensing.

[13] As explained by Takalo and Kammianen (2000) stronger patent protection could delay the commercialization of innovations as firms might find more profitable to keep exploiting current technologies.

[14] By increasing the costs of innovation and patents enforcement (imitation and inventing-around costs, litigation expenses, etc.), stronger patent rights might block incremental innovation, particularly in industries where innovation is mainly based on cumulative innovation (Scotchmer; 1991).

[15] For instance, to appropriate returns from product innovation lead time is the main appropriation strategy in basic-chemicals, cosmetics, computers, semi-conductors, automobile and aero-spatial (Yale Survey).

technology transfer more attractive than another and thus induce substitutions among the different modes of transfer. However, some studies suggest that the economic return effect on rent share and R&D on patent licensing might be more significant than the ones generated on alternative production modes (Yang and Maskus, 2001a; Maskus et al 2003).[16]

The contribution of empirical works evaluating the relationship between IPR in southern countries and technology transfer remains also inconclusive. In fact, most of studies have particularly focused on the role of stronger IPR on trade (embodied knowledge) and FDI (Maskus, 2000; 2001). Regarding the impact on trade, Maskus and Penubarti (1995) show that weak protection of IPR may reduce expected levels of trade. Further, IPR seems to play a role to stimulate economic transactions in larger income countries, whereas for small countries the effect might be non-significant (Ferrantino, 1993; Maskus and Penubarti, 1995). Maskus and Penubarti (1995) and Primo Braga and Fink (2000), show that the impact of IPR on trade may varies significantly across industries. Exports in patent-sensitive or high-R&D intensive sectors may be in fact not correlated to the strength of foreign patent protection. Smith (1999) finds also similar results.

Concerning FDI and licensing, conclusions are less clear-cut. Studies on FDI suggest however, a negative although weak relationship between a lax patent regime and the volume of American or European Direct Investment, particularly in R&D-intensive sectors (Lee and Mansfield, 1996; Maskus, 1998).[17] In the opposite, Kumar (1996) shows that the intensity in R&D by foreign affiliates and the extent of R&D collaboration, appear both insensitive to patent protection in developing economies. Regarding licensing, the few empirical studies available offer also mixed results. Using cross-sectional data on the ratio U.S. receipts of unaffiliated royalties and licensing fees, Contractor (1980) finds that the patent intensity of a nation (defined as patents in force) attracts licensing volumes. In a similar study, Ferrantino (1993) shows that the adhesion of the countries to the convention of Paris (in combination with long duration of the patents), seems to have stimulated receipts and royalties volumes from licensing coming from the United States. More recent works have shown that the effect of stronger IPR on international licensing depends on the imitative capabilities of host countries. Smith (2001) has found that in countries where

[16] Relative to other entry modes, the cost of FDI and licensing relative to imports decreases as IPR protection increases, allowing a better exploitation of production costs differentials. Firms might shift towards licensing at stronger levels of patent protection as the risks of defection are reduced further and differential production costs are not largely dissimilar (Fosfuri, 2000; Viswharao, 1999).

[17] Lee and Mansfield (1996) report a negative effect of lax IPR regimes on different forms of direct investment.

imitative capabilities are high (low), stronger patent rights may stimulate (deter) licensing to unaffiliated foreign firms. In a panel of 26 technology recipient countries covering three time periods (1985, 1990, and 1995), Yang and Maskus (2001a) find a positive significant effect on receipts of royalties and licensing fees from unaffiliated sources. A positive effect is also found on receipts of fees from unaffiliated sources relative to exports.[18] On the other hand, a number of other studies cast doubts on the link between patent strength and the extent or form of international technology licensing. Smith (2001) finds similarly that US firms are more likely to export or directly manufacture rather than license technology in countries with weak patent regimes. Fosfuri (2004) similarly does not find that patent protection significantly affects the extent or composition of technology flow (as joint-venture, direct investment or licensing) in the chemical sector.

2. An Exploration on French Technology Receipts

This study evaluates empirically whether national differences in IPR affect the extent of technology contracting cross borders. For this purpose, we explore data on international technology services as a measure of disembodied knowledge contracting. We present an empirical exploration on Bilateral French Technology Receipts at the industry level over a set of 21 countries destinations, 20 sectors (NACE transformed to ISIC 2 digit level, Rev. 3), over a period of six years (1994-2000). Data is from the *Report on International Technology Transfers* (*Rapport sur les Transferts Techniques Internationaux*) published by the National Institute of Intellectual Property (INPI). Our dependant variable represents the total of receipts related to technology services and contracting (flows) received by French firms. It includes the following aggregates reported in an industry basis (total affiliated and non-affiliated firms): *i)* Royalties and licensing fees concerning patent licensing of technologies; *ii)* Trademarks licensing fees and technical assistance; *iii)* Engineering and know-how services provided by French firms; *iv)* R&D services cross-borders and R&D expenditures overseas by French affiliates.

Table (1) displays the distribution of total receipts in technology contracting by technology services (as reported in current euros). As noted, patent licensing (product and industrial processes), followed by technical assistance stand as the two main technology services exported by

[18] Applying the elasticity found (5.3) to changes in patent rights and using existing fees for 1995, Maskus (2001) found that licensing activity could significantly increase in some countries. For instance, large responses were reported for Korea, Mexico, Brazil, and Indonesia.

French Firms. Patents and patent licensing represent the main growing receipt in the French Technology Balance of Payments (20.4% of total technology receipts in 1993, 35.5% in 2000), followed by technical assistance (31.3% in 1986 and 40% in 2000).

====TAB 1===

Looking at the distribution of technology receipts by destination (tab. 2), some distinguishing features of French technology contracting can be noticed. While European Union (EU) and OECD countries remain the two main zones of French contracting overseas (in 2000, 40.5% of technology receipts came from EU, and 50%, from OECD-countries others than EU, INPI), contracting with southern countries shows differentiated trends. Overall, the rest of the world countries accounted for 6.4% of technology receipts in 2000 (1.8% OPEP countries, 1.2% Eastern Europe).

====TAB 2====

====TAB 3====

The largest amount of receipts in this group comes from Mexico, South Africa and Brazil. Indeed, these countries, and particularly, Brazil and Mexico (EU countries like Ireland, Portugal etc.) showed an increasing share in technology receipts flows over the period 1994-2000 under study (tab. 2). On the other hand, countries like India, Singapore and China reduced their contribution relative to other countries.[19] Different factors can explain these cross-country differences in knowledge contracting by French Firms (absorption capacity, infrastructure, market potential regulatory framework on FDI, licensing and trade, etc.).

National differences in terms of patent protection, as a measure of IPR protection, are reported in table (3). The protection offered may differ along several dimensions. IPR laws across countries differ with respect to coverage (according to the nature of innovation, product and process innovations; novelty criteria, etc.), and particularly, respect to coverage protection in certain

[19] Our data under study concerns only technology receipts disaggregated at the industry level for a representative group of countries. Our study evaluates in this perspective, the incidences of national differences in IPR to attract technology contracting mainly in a cross-sectional dimension. Time dimension is taking into account with two changes of the IPR index. We acknowledge that having more refined data at the contract or firm level on royalties and licensing fees would provide a richer analysis on firms' strategies to foreign IPR.

technological areas (such as pharmaceuticals, chemicals and food products, e.g. India, Brazil, etc.).[20] IPR laws differs also with respect to the duration of protection (20 years according to TRIPs), the date of patent life begins (application, grant date, publication)[21], and particularly, in terms of enforcement procedures (i.e. preliminary injunctions, the burden of proof, etc.).

Our testing explanatory variable indicating the strength of IPR protection by country is the Ginarte and Park Index (1997), a common measurement of patent protection developed by Juan Cinarte and Walter G. Park (1997). The index of strength of IPR ranges from 0 to 5, with higher numbers reflecting stronger levels of protection and is reported each five year since 1965. It incorporates five aspects of patent laws: extent of coverage, membership in international patent agreements, provisions for loss of protection, enforcement mechanisms, and duration of protection. The relative superiority of this index relative to alternative measures (Rapp and Rozeck, 1990; Sherwood, 1997) relies in its greater variability across countries and time, since it describes more in detail the IPR standards than the one used by Rapp and Rozeck (1990) and Sherwood (1997).[22]

===TAB 4===

Finally, remarkable differences in the intensity of technology contracting cross borders exist also across industries (tab. 4). Only 5 sectors represent 77% of the total receipts in technology services exported by French Firms overseas: Software and Computer Materials, Pharmaceuticals (23%), Fine-Chemicals (14%), tires and rubber industries, and Engineering and Technical Studies (6%). As suggested by number of studies, R&D intensive industries have been found to participate more fiercely in international markets (Amable and Verspagen, 1995).[23] Finally, as noted previously, the propensity to rely on IPR, i.e. patent, trademark, etc. and other means to appropriate the returns to R&D (first mover advantage, secret, etc.), differs largely across sectors (Mansfield, 1968; Levin et

[20] Regarding patent protection on product innovation in pharmaceuticals, South Korea passed new legislation in 1987, Indonesia, Bulgaria and Chili in 1991, Thailand, Taiwan, Rumanian, Russia and Ukraine in 1992, Turkey in 1991, Brazil in 1996, etc. (Siebeck et al. 1990).

[21] For instance, some countries measure patent life from the patent application filing date (Nigeria, Jordan, Thailand), while other measure if from the grant date (Pakistan, Mexico, Portugal Canada, Iceland, USA).

[22] The difference between this indicator and the Rapp and Rozeck index (1990) is that Ginarte and Park use a more comprehensive set of criteria to build a score that weights a subset of conditions such as the availability of different IPR (patents, trademarks, utility models, etc.), the coverage by technology area (pharmaceuticals, chemicals, etc.), the duration of protection, membership in international patent agreements, provisions for loss of protection and very important, it considers if the country has or not enforcement measures.

[23] Previous works have identified significant differences across industries in the way firms' exploit knowledge assets cross-borders (Vishwashrao, 1994; Markusen, 1995; Fosfuri, 1999).

al., 1987; Cohen et al., 1997; Cohen et al 2000): pharmaceuticals, chemicals, software and computing industries being the sectors wherein patents are considered as the principal mean to appropriate returns to R&D; followed by the instruments industry, the radio, television and communication equipment industries.

3. An Empirical Model

To explore the impact of the strength IPR protection on knowledge flows we apply a reduced econometric equation of technology transfer inspired from the theoretical works by Glass and Saggi (1998) and Yang and Maskus (2001a). It relates technology trade to several countries' factor endowments, notably in technology and labor resources, market size and openness and patent protection (Baltagi, 2001; Smith, 2001). This form expresses the technology flows as follows:

$$Y_{it} = GDPC_{it}^{\beta 0} LAB_{it}^{\beta 1} IPR_{it-5}^{\beta 2} HS_{it}^{\beta 3} OP_{it}^{\beta 4} \qquad (2)$$

where Y_{it} is the flow of receipts in technology services from knowledge-recipient country i at the industry level received by France as the technology exporter country. $GDPC_{it}$ is the gross domestic product per capita, LAB_{it} represents labor endowment relative to countries' population; IPR_{it} is the level of patent protection of the host country i at time t (Ginarte and Park, 1997).[24] HS_{it} is a proxy for human capital (the average number of years of formal schooling equal or over the age 15). As measure of a countries' market openness *(OP)* we use the ratio of total trade (exports + imports) relative to GDP. Monetary values are in constant USD 1995. In order to control for countries' technological capacity we include the total number of patents applied (*PAT*) by the country i in period t, at the USPTO (United States Patent Office).

The empirical specification is derived by taking natural logs of Eq. (1).

$$\begin{aligned} ln(Y_{it}) &= \beta_0 \, ln\,(GDPC_{it}) + \beta_1 \, ln(LAB_{it}) + \beta_2 \, ln\,(IPR_i) + \beta_3 \, ln\,(HS_{it}) + \beta_4 \, ln\,(OP_{it}) \\ &\quad + \beta_4 \, ln\,(PAT_{it}) + \beta_5 \,(IPR_{it} {*} D) + u_{it} \qquad (3) \end{aligned}$$

[24] In order to avoid multicollinearity between the IPR protection index and economic development variables, we use the Ginarte and Park index, 5 year period lagged. That is, for 1994-1996 flows we use the 1990 G&P index, and for 1997-2000, we use the 1995 G&P index, respectively.

$$where\ \ u_{it} = \mu_i + \delta_t + \varepsilon_{it}$$

To control for non-observed multiple heterogeneity, we include three different elements in the composite error term. μ_i are unobservable time invariant individuals-specific effects (country/sectors), δ_t are time-specific effects, and ε_{it} is the measurement error. The interaction IPR*D represents interactions between the IPR index and dummy variables corresponding to different group of countries according to industries' technological intensity and countries' technology capacity (W, S), to be explained in the following section.

We implement a cross-sectional times series analysis, by taking industry (or country) as a panel unit of analysis over the period of 1994-2000. Dispersion of zero flows is important in our data: almost 48% of the observations on the dependent variable are zeros. Coefficients from the conventional Ordinary Least Squares regressions (OLS) or traditional panel estimation would be biased and inconsistent since they do not account for the difference between limit (zero) observations and non limit (continuous) observations. A solution to deal with censored data is to employ a Tobit Model. Assuming that the disturbance term has a normal-distribution; Tobit combines probability estimation with regression analysis (Maddala, 1983; Greene, 2000).[25] By modeling as a Tobit regression (type II), it is assumed that Y_{it} is observed for all countries' flows, but Y_{it}* is only observed (censored versions of Y_{it}) if Y_{it}*>0. By adding (+1) the value of one to the dependent variable observation we can implement the log transformation of the technology transfer flow. Tobit estimation is expressed:

$$\begin{aligned} &Observed: \quad Y_{it} = Y_{it}*+1 \quad \text{if } Y_{it}*+1>1; \quad \text{where} \quad Y_{it}* = X_{it}'\beta + \mu_i + \delta_t + \varepsilon_{it} \\ &\qquad\qquad\quad\ Y_{it} = 1 \qquad\qquad \text{if } Y_{it}*+1 \le 1; \end{aligned}$$

for i=1, ….., n (industry units);, t=1,….., 6. The random (industry) effects, μ_i are iid $N(0,\sigma^2)$ and ε_{it} are iid $N(0,\sigma_\varepsilon^{\,2})$ independently of μ_i.

3.1 Expected Signs

The strength of IPR or foreign patent rights might have ambiguous effects. It can have a positive impact when stronger protection expands the product space over which the exporting innovating

[25] The main assumption is that data is censored to zero; zero reported flows are effectively observable and they are not due to decisions of individual firms.

firm enjoys monopoly power. As discussed previously, by modifying imitation costs and reducing consequently licensing costs, stricter IPR would increase the licensor's profit by two main effects: a higher economic return from licensing (*the size effect*) and a higher rent share (*the distribution effect*, Yang and Maskus, 2001b). In addition, IPR should expand technology markets particularly in countries strengthening their IPR regimes which have a significant technological capacity (Smith, 1999; 2001). On the other hand, IPR protection may deter knowledge commercialization, "*the market power effect"*, when the reduction of contracting due to increased monopoly pricing overcomes the market expansion effect brought by the IPR reforms.[26]

We define 3 sets of variables to assess IPR interactions. The first two sets of dummies class host countries' according to their technical capacity. We code the country whether it has a strong or weak technical capacity according to their R&D intensity (R&D expenditures relative to GDP, UNESCO), above or below 0.5%, as in Smith (1999, 2001) and Mayer and Pfister (2001). By interacting this proxy for technical capacity with the level of IPR (column 1, table 5), we distinguish four groups of countries; strong patent protection with strong technical capacity, strong patent protection with weak technical capacity, weak patent protection with strong technical capacity and weak patent protection with weak technical capacity *(SS*IPR, WS*IPR, WW*IPR).* A second criterion for classing technical capacity (relative to the mean) relies on countries' high technology exports. In order to take into account the absorptive capacity of host countries, we class countries according to the percentage of exports in high-technology products related to total manufacture exports (World Bank, Development Indicators).[27] The interaction of these dummies with IPR index allows us to evaluate the imitation threat from the host countries, and consequently, the importance of IPR protection while considering their technological capacity. Following Smith (2001), we expect that imitating countries and countries with intermediate and high technological capabilities strengthening their intellectual property rights will attract larger volumes of technology services, rather than countries with low levels of technical skills and strong patent regimes.

A last set of dummies classing industries according to their R&D intensity is included. A differentiated impact of IPR on high, middle or low technology intensive sectors should be

[26] As reported empirically by McCalman (2001), patent harmonization can lead to significant increases in technology payments to exporter countries (namely, to the USA), ceteris paribus. The developing countries are found to be the major contributors (jointly with Canada, Great Britain and Japan).
[27] We believe that this indicator as a good proxy of absorption capacity, since it can reflect not only local technological skills but also countries' integration to international technology markets.

expected (Fosfuri, 2000; Bessen and Maskin, 1999). Industries less knowledge-intensive are assumed to be less affected by the level of foreign IPR. We follow the criteria hold by the OECD (OECD Science and Technology, 2001; Hatzichronoglou, 1997).[28] Accordingly, manufacturing industries are classified in three different categories of technological intensity: high technology (HT), medium-technology industries (MT) (grouping medium-high technology and medium-low technology) and low technology (LT). Finally, industries are classed according to their sensitivity to IPR protection, namely, patent protection. We follow the classification followed by Mayer and Pfister (2001) for the French Industry. This distinction is made essentially in terms of patent protection.[29] Separated regressions for these two groups of industries are implemented.

3.2. Explanatory Variables

Several control variables are considered in our model of disembodied technology trade. As a measure of market demand we introduce GDP per capita *(GDPC)* as a regressor (World Bank, Development Indicators, 2001). It indicates the level of economic development and should have *à-priori* a positive impact on the extent of French technology services. A higher market demand should be translated into higher consumers' demand for high-quality and technologies (Yang and Maskus, 2001a). Furthermore, IPR might be a necessary but not a sufficient condition to attract technology services. IPR might be valuable also when a market for technology consumption exists, but also when technical conditions for knowledge transfer are present (Helpman, 1993). Hence we incorporate as a measure of absorption capacity *(HS)*, the human capital variable by Barro-Lee (2000) data on the average number of years of formal schooling of the population equal to or over age 15. A country with greater human capital more educated people will demand more knowledge

[28] High-technology industries include (ISIC. 3): Aerospace, Office and computing equipment; Drugs and medicines, Radio, TV and communication equipment. Medium Technology groups the two classes distinguished by OECD: Medium-high-technology industries (Scientific instruments, Motor vehicles, Electrical machines excl. communications equip., Chemicals excl. drugs, Other transport, and Non-electrical machinery) and Medium-low-technology industries (Rubber and plastic products, Shipbuilding and repairing, Other manufacturing, Non-ferrous metals, Non-metallic mineral products, Metal products, Petroleum refineries and products, Ferrous metals). Low-technology industries are: Paper, products and printing; Textiles, apparel and leather; Food, beverages and tobacco and Wood products and furniture.

[29] Patent sensitivity classification is made according to the patent propensity: percentage of innovation that are patented in the French industries (Mayer and Pfister, 2001). The patent-sensitive industries are: electronic and electric equipment, the car industry, chemicals, fine chemicals and drugs and cosmetics, precisions and medical instruments, transport equipment, electronic and electric components. Patent insensitive sectors are: mechanical equipment, rubber and plastic products, mineral products, wood and paper and metal products.

services to complement its production needs and its local effort (Braga and Willmore, 1991; Lee, 1996).[30]

Two more refined measures of technological capacity are evaluated: R&D (UNESCO) and the number of patents *(PAT)* applied to the United States Patent Office (World Bank, Development Indicators, 2001). Research and development expenditure relative to GNP *(R&D)* reflects the percentage of resources by private and public institutions consecrated to innovative activity.[31] The sign of R&D intensity and patenting by recipient countries on technology services is expected to be positive. Although the two indicators are valuable measures of countries' innovation capacity, they indicate different stages of the innovation process: R&D is mainly an innovation input and patents, a measure of innovation output. They should therefore be interpreted with caution, taking into account the different timing they represent.[32] They are expected to show a positive impact on technology transfer in the sense that a technical capacity (an imitative capacity) facilitates knowledge absorption, and constitutes an opportunity for technology contracting, i.e. production alliances. On the other hand, more technologically autonomous countries could be less reliant on external knowledge assistance (Cohen and Levinthal, 1989).

We include an openness index *(OP)* defined as the sum of exports and imports divided by the nominal GDP. Trade orientation of a country is assumed to play a determinant role in determining its propensity to innovate and consequently, its propensity to participate in technology markets. More open countries are better inserted in the world economy and more likely to attract economic transactions and enjoy an easier access to international technology markets (Maskus, 2001). In addition, embodied trade is frequently accompanied by arms' length contracting, technical assistance, etc. According to empirical studies, the net effect is however indeterminate.[33] Finally, we include countries' labor *(LAB)* as an additional control variable. Differences in labor resource endowments across technology recipient countries might have a positive (negative) impact when

[30] A negative sign would indicate substitution of local technological effort (Lee, 1996).
[31] Although the explanatory power of R&D relative to GNP could be rather limited since for a small period of time such ratio does not change radically, the cross-country differences remain important, particularly between emerging and developed countries.
[32] Patents applied to USPTO as indicators of innovative output are a good measure of countries' technology dynamism (PAT). Taking this variable 4 years lagged allow us to reduce a potential problem of multicollinearity between these innovative indicators and patent protection.
[33] For FDI and R&D location, Kumar (1996) and Maskus (1998) concludes to a positive impact, Mayer and Pfister (2001) found a positive impact on French multinational location. Nevertheless, for USA, Yang and Maskus (2001) found that countries' openness seems not to play a determinant role on USA receipts on royalties and licensing fees receipts cross borders.

technology licensing is conducted under a reducing-production costs perspective (Glass and Saggi, 1998), or alternatively (negative), when it deters technology contracting by representing a weak-capital intensive market for production (World Bank, Development Indicators, 2001).

4. Estimation Results

Table 5 displays the results of the random-effects Tobit model using industry-individual random estimation.[34] As observations for the period 1994-2000 are pooled, year dummies allow for time specific effects.[35] The use of a censored estimation procedure was necessary to account for zero cells in the data set (Tobin, 1958). Lastly, the Wald tests and the log- likelihood statistic at the bottom of the table justifies the model specification as we include more explanatory variables.

The model (1) shows the basic equation without taking into account the effects of the strength of IPR. In the following columns (columns 2 and 3), we include the level of intellectual property rights (IPR) along other contracting determinants of technology transfers. According to the model in column (2), the coefficient on IPR is positive and significantly. The average impact of IPR protection is reported in column (2). Consisting with some theoretical studies (Yang and Maskus, 2000; Maskus et al 2003), the strength of protection of intellectual assets, i.e. patent protection, affects positively the extent of knowledge contracting cross borders by French Industries. As Tobit-coefficients cannot be interpreted as ordinary regression coefficients, multiplying the coefficients with the fraction reported in the last row (% censured data) of the table ensure a proper discussion of the estimated results. Although, significant at 1%, the coefficient of IPR indicates that a one unit increase of the level of IPR protection, spurs technology transfer (1.284*0.512) by 0.657 percent. Evaluated at the mean, one unit increase of IPR protection stimulates a volume of 1 309 047 (95 dollars PPP) in technology-services.[36] Likewise, an increase of 1% of the GDP per capita (5.42*0.512) should promote a 2,47% increase of receipts in technology-contracting. The estimated coefficients are significant to 1%. A similar strong effect is reported for French exports

[34] The percentage of residuals' variation ρ (0.49), from the industry-individual effects model is found to be larger and more significant than the one conceived by the model reposing on country-random individual effects (0.12).

[35] The log-likelihood test on the panel tobit (industry random effect) versus the pooled tobit model (Ho: whether the random effect is different from zero) is rejected at 1% confidence level. In the model in column (1), table 5, the corresponding test is: $\chi 2(01)=$ 178.43, with a Prob>=$\chi 2$= 0.000

[36] For interpretation purposes, the share of the coefficients from the Tobit model, for which the transactions are higher than zero, is 0,512 (1-0,488). That is, more than 50% of the total variation of technology-receipts (resulting from the variations of the independent variables), is generated by marginal variations in the intensity of the transactions carried out, while less than 40%, is generated by the variations of the probability of having a transaction.

(embodied knowledge), a higher intensity of French trade in final products stimulates a higher trade in disembodied knowledge towards these countries. Countries' technological capability measured by patenting at the USPTO (PAT does not show to have a determining role in technology-contracting.

The model in column (3) includes a non-linear term for IPR. The negative significant sign on the square term of IPR suggest that the strength of intellectual property rights promotes knowledge contracting at small increases of protection, whereas at stronger levels of protection it deters technology contracting.[37] Thus, at very strong levels of IPR protection perverse effects arise: technology contracting may be reduced because technologies are commercialized at higher prices (monopoly power).[38] It would also mean that at very strict levels of IPR protection, innovating firms' are not longer encourage to license or commercialize their knowledge through contracting, they might prefer alternative modes of commercializing intellectual assets (exports or IDE).

===TAB 5===

The column 3-4 display estimates on the sample of industrialized countries, whereas the columns 5-6 present estimations for some developing economies. Concerning the industrialized countries' sample, the coefficients on IPR and its square term (column 4) display a similar impact as in the whole sample. Small increases of IPR promote technology contracting from France towards its OECD partners. Nevertheless, stronger levels of protection appears to discourage knowledge contracting, and consequently, to deter the development of technology markets.

Regarding the developing countries' sample, an inversed relationship is reported: whereas without including the square term, IPR is found to be not significant for stimulating technology contracting toward these regions, a reversed effect appears when including the non-linear term. Small increases of IPR protection deter knowledge contracting (the monopoly power effect might dominate immediately economic-returns, the "market size" and "distributional" effects related to contracting). Nonetheless, at higher levels of IPR, technology contracting answers positively to

[37] These results are consistent with previous empirical works, notably by Maskus (1998), Yang and Maskus (2001a) and Mayer and Pfister (2001) on license and FDI flows: production and knowledge transfers respond in a non-linear fashion to increases in patent strength.

[38] Our data does not allow us to disentangle an increase on royalties or licensing fees, the contraction might imply either a change of prices, or either a reduction of contracts.

IPR reforms. Such result implies an important aspect of IPR laws. First, modest strengthening of IPR laws in developing economies might not be meaningful enough to raise efficiency-gains in contracting, to stimulate the development of technology markets. Hence, foreign IPR proprietary might take profit of small changes to increase prices or shift towards IDE or trade. Larger changes in IPR regimes, accompanied in particular by significant enforcement mechanisms (a more efficient judiciary system, a decrease of corruption and bureaucratic procedures), can be more credible to attract technology-contracting. Lastly, a positive reaction to stronger levels of protection should also be dependent of countries' technological-capacity for knowledge commercialization. Overall, our findings suggest that the main determinants of technology services receipts are the level of market demand, GDP per capita, followed by labor and our proxy of human capital (HS). Market openness (OP) is negative and highly significant only in the baseline model.

===TAB 6===

Table 6 displays estimates on the technology transfer model including dummies on groups of countries according to their technological level, interacted with the IPR index (*WS, SW, WW* and *SS*). Column (1) displays estimates firstly *S*IPR* and *W*IPR*. Accordingly, stronger IPR protection stimulates (disembodied) technology flows towards countries showing significant technological abilities. Estimates in column (2) confirm and refine this finding: a stronger IPR protection enhances technology contracting only in countries possessing strong technical capacity *(SS*IPR),* relative to the rest of countries' groups. Stronger IPR and a strong technical base attract larger knowledge flows. This result is consistent with Smith (1999) and Yang and Maskus (2001). Nevertheless, the coefficient of the dummies concerning countries with weak technical-capacity countries and strong IPR regimes (*WS*IPR*) is negative. Market-power effect of IPR dominates over the market-expansion effects in countries lacking technological infrastructure. In addition, countries with strong technical capacity and weak IPR represent actually an imitation threat for technology services commercialization.

Column (3) in Table 6 reports estimates of the IPR impact across groups of industries (high technology, middle low and low technology intensive industries). Interactions with the IPR index are evaluated. Not surprisingly, estimates show that for middle high tech intensive sectors (*MHT*IPR*), IPR stimulate further technology transactions. Nevertheless, the impact of IPR in high-tech industries (*HT*IPR*) is not significant. Knowledge contracting in high tech industries (instruments, optical medical telecommunications industries, etc.) depend more upon other factors than IPR to enhance technology markets. Certainly imitation (and reverse engineering) is not feasible given the high complexity of technologies and the technology infrastructure required for production. A high R&D investment and a sophisticated technological capacity in the technology-recipient market might be conditional factors for such exchanges (Cohen and Levinthal, 1986). These findings echoes the results reported by Primo Braga and Fink (2000) on international trade.[39] On the other hand, the interaction terms of IPR protection with middle low and low high tech intensive sectors (*MLT*IPR* and *LT*IPR*) shows negative and significant signs suggesting that tighter IPR deter knowledge contracting by French firms in these industries. Perverse effects of IPR emerge: stronger IPR protection allows innovating firms to charge higher (monopoly) prices, reducing consequently demand and knowledge-services in these industries.

Industry Regressions

Table 7 presents results distinguishing industries according to their sensitivity to IPR protection, namely to patent protection. We differentiate between *à priori* high IPR sensitive sectors and less IPR sensitive sectors. Separated regressions are conducted for each group of industries.

According to estimates reported in column (2), stronger foreign IPR protection seems not to influence the extent of technology or knowledge contracting by French firms in patent-sensitive industries. Furthermore, estimates on column (2) report an absence of non-linearity either. In the opposite, estimation conducted on the less-patent sensitive group of industries, suggest that the strengthening of IPR promotes technology contracting at small increases of protection, whereas larger changes (stronger levels of IPR protection) provokes a contraction. Hence our results differ from the conclusions offered by well-known survey studies on the relative importance of patents as appropriability means (Levin et al 1987). In terms of knowledge contracting, industries *à priori* sensitive to patents, are not influenced by stronger foreign patent protection. A possible explanation of such result is that the degree of response to foreign IPR should depend on industries' propensity to commercialize their intellectual assets. In other words, the effects of IPR should be conditioned by the effective use of IPR markets by firms (industries).

[39] They found that IPR protection have a significant negative impact on the probability that countries trade in high technology industries (they found however, a positive relationship between IPR protection and total trade flows).

===TAB 7===

Finally, we conduct Tobit (or OLS) regressions in an industry-basis (Table 8 and 9) in order to identify more adequately the effects of IPR across industries. Table 8 displays estimations for some IPR sensitive industries, whereas table 9 reports results for IPR less sensitive sectors. These findings seem to be consistent with the previous result on pooled data by the nature of industry (IPR sensitive and IPR less sensitive industries). In the group of IPR sensitive industries, only three industries react to the strength of foreign IPR protection. The chemicals and the office, accounting and computers industry answers positively to countries' IPR protection: a better appropriation of returns to innovation, stimulate IPR owners to commercialize their intellectual assets through technology contracting. In the opposite, stronger IPR appears to deter knowledge trade in the Radio, T.V. and Communications Equipment industry. Contrarily to expectations, pharmaceuticals, medical and precision instruments industry or the coke, petroleum and fuel industries are found to be indifferent to the strength of IPR protection. Weak protection of intellectual assets does not necessarily deter knowledge transactions in industries such as Motor Vehicles and Transport Equipment or the Coke, petroleum and Fuel Production Industries, since a set of different technical and production abilities are needed for successful imitation.

===TABLE 8===

===TABLE 9===

In the less sensitive IPR industries, estimates show also a differentiated impact across sectors. IPR seems to play a significant positive role on technology contracting services in Agriculture, Fishing and Forestry; the basic and fabricated metal products as well as in the machinery and materials industry. Nevertheless, the level of IPR protection affects negatively the extent of technology flows in the textiles, wearing apparel and leather industries, the paper and printing industries, and the rubber and plastic products industries, although the latter the coefficient is not significant. Hence market-power effects might dominate in these industries. IPR owners contract their extent of knowledge contracting by increasing prices (or shifting toward other modes of production, FDI or trade).

5. CONCLUSION

This paper has attempted to shed further light on the impact of national differences in intellectual property rights on international knowledge contracting. It has pointed out the limited role of foreign patent protection to stimulate the transactions in technology. The empirical contribution of this paper has been twofold. First, this study has shown that strengthening patent protection might have a differentiated impact across countries. According to our results, stronger patent rights might not be enough to stimulate technology contracting in developing economies. Second, to the extent that imitation threat varies across sectors, a differentiated impact of IPR on trade knowledge has been identified across industries. Nevertheless, our findings show that the strength of IPR may have a positive impact on international knowledge contracting.

IPR protection is found to be negligible to explain knowledge contracting in the high technology industries, although it is for middle high tech industries. Hence stronger protection is not sufficient to attract knowledge contracting in R&D intensive industries, whereas it might facilitate technology transfer in more mature industries. Finally, our results across industries differ from the findings reported by several survey studies about the relative importance of patents as appropriability mean (Levin et al 1987). In terms of knowledge contracting, industries *à priori* sensitive to patents, do not necessarily react to stronger foreign patent protection. In particular, the degree of response to the international reinforcement of patents will depend largely on industries' propensity to tie external contracts in knowledge (exploitation of intellectual assets).

Some country-policy suggestions arise from this empirical evaluation. Stronger protection of intellectual assets might not be enough to attract technology alliances and patent licensing with foreign firms. At this respect, the removal of barriers (institutional economical limited access to finance, etc.) both to innovation and technology markets should strengthen the incentives to technology contracting. For instance, the adequate supply of engineering and management skills increases the countries' absorption capacity, decreasing technology transfer costs. Finally, the alleviation of other market imperfections (e.g. regulation of FDI and technology transfer, antitrust and competition policies, etc.) should strengthen receptivity of host countries to technology collaborations with foreigners.

APPENDIX

Tab. 1
Distribution of French Receipts in Technology

Year	Royalties and Licensing Fees	Trademarks	Know-How and Software	Engineering Consulting	Technical Assistance
1993	27,1%	21,4%	16,4%	10,8%	24,3%
1994	30,9%	22,5%	15,4%	7,6%	23,6%
1995	34,5%	21,3%	15,9%	8,9%	19,5%
1996	32,1%	20,3%	15,9%	9,6%	22,1%
1997	29,0%	21,7%	15,7%	9,1%	24,4%
1998	31,5%	19,3%	16,2%	9,2%	23,8%
1999	28,2%	18,1%	16,1%	7,9%	29,7%
2000	31,6%	17,8%	15,0%	9,4%	26,3%

Source : *Rapports sur les Transferts Technique Internationaux* , INPI.

Tab. 2
French Technology Receipts Allocation by Partner Country

Country	1994	2000	Country	1994	2000
AUT	1,3%	1,5%	IRL	0,4%	1,2%
BEL	3,5%	2,8%	ITA	11,5%	7,8%
BRA	0,3%	0,8%	JPN	12,1%	7,9%
CHE	11,2%	6,2%	MEX	1,1%	1,7%
CHN	1,0%	0,6%	MYS	0,2%	0,1%
DNK	1,2%	1,2%	NLD	4,3%	3,5%
ESP	7,6%	5,6%	PRT	1,1%	1,8%
FIN	0,3%	0,6%	SGP	0,3%	0,1%
GBR	8,2%	11,5%	SWE	1,3%	1,3%
GRC	0,4%	0,3%	USA	32,2%	43,3%
IND	0,7%	0,2%			

Source : *Rapports sur les Transferts Technique Internationaux* , INPI.

Tab. 3
Index of Intellectual Property Protection

Country	Index 1990	Index 1995	Country	Index 1990	Index 1995
AUT	3,32	3,86	IRL	2,99	2,99
BEL	3,9	3,9	ITA	4,04	4,19
BRA	1,84	3,05	JPN	3,94	3,94
CHE	3,8	3,8	MEX	1,63	2,52
DNK	3,9	3,71	MYS	2,37	2,84
ESP	3,61	4,04	NLD	4,23	4,24
FIN	2,95	4,19	PRT	1,97	2,98
GBR	3,57	3,57	SGP	2,57	3,91
GRC	2,32	2,32	SWE	3,9	4,24
IND	1,47	1,17	USA	4,52	4,86

Source: *Ginarte and Park (1997)*

Tab. 4
French Technology Receipts Allocation by Industry (ISIC. 3)

IPR (patent) Less Sensitive Sectors	1994	2000
Agriculture, hunting and forestry	0,43%	0,09%
Mining and quarrying	0,00%	0,00%
Food products and beverages and tobacco	5,37%	4,61%
Man. of textiles, wearing app., leather, harness and footwear	7,46%	1,63%
Rubber and plastics products	7,15%	8,90%
Paper and paper products, publishing, printing	0,31%	0,07%
Coke, refined petroleum products and nuclear fuel	2,31%	0,54%
Furniture, manufacturing n.e.c.	0,02%	0,03%
Manufacture of other non-metallic mineral products	1,36%	1,55%
Manufacture of basic metals, fabricated metal products	1,10%	0,67%
Motor vehicles, trailers and semi-trailers	3,33%	1,88%
Building and repairing of ships and boats	0,76%	0,31%
IPR (patent) Sensitive Sectors		
Chemicals and chemical products (except pharmaceuticals, etc.)	3,19%	3,53%
Pharmaceuticals, medicinal chemicals and botanical products	12,22%	25,84%
Manufacture of machinery and equipment n.e.c.	1,69%	4,14%
Electrical machinery and apparatus n.e.c.	1,72%	0,47%
Manufacture of medical, precision and optical instruments	3,98%	2,33%
Manufacture of office, accounting and computing machinery	28,57%	22,07%
Radio, television and communication equipment	0,81%	0,26%
Others		
Construction	0,34%	0,10%
Technical studies, services	4,81%	5,83%

Source : *Rapports sur les Transferts Technique Internationaux* , INPI.

Tab. 5

Bilateral Technology-Services Receipts by French Firms

		Whole Sample		Industrialized Economies[a]		Developing Economies[b]	
		1	2	3	4	5	6
GDPC	5.829	5.424	4.958	3.794	3.825	6.126	5.730
	(0,477)***	(0.657)***	(0.687)***	(1.441)***	(1.436)***	(1.539)***	(1.533)***
LAB	3,512	4.401	4.702	4.365	4.763	3.194	1.994
	(0,323)***	(0.413)***	(0.433)***	(0.571)***	(0.586)***	(0.849)***	(0.943)**
HS	-2,095	-1.350	-0.479	-1.413	0.814	-3.563	-3.796
	(0,658)**	(0.794)*	(0.870)	(1.035)	(1.228)	(2.739)	(2.737)
OP	-0,328	1.688	1.885	2.048	3.147	2.065	1.256
	(0,5367)***	(0.536)***	(0.544)***	(0.819)**	(0.885)***	(1.094)*	(1.135)
EXF	3,859	3,859	3,258	5,23	4,876	2,23	2,876
	(0,316)***	(0,316)***	(0,387)***	(0,543)***	(0,438)**	(0,543)***	(0,438)**
PAT_{t-3}	0,043	-0.514	-0.583	-0.160	-0.107	0.365	0.555
	(0.184)	(0.184)*	(0.187)*	(0.458)*	(0.460)*	(0.386)	(0.387)
IPR		1.284	6.952	0.872	19.316	0.868	-9.548
		(0.522)*	(2.370)**	(0.744)*	(5.626)***	(1.254)	(3.871)**
IPR^2			-0.888		-2.632		1.826
			(0.363)*		(0.795)***		(0.641)***
Obs.	2324	2324	2324	1428	1428	896	896
Groups (industries)	28	28	28	28	28	28	28
Country Dummies	YES	YES	YES	YES	YES	YES	YES
Year Dummies	YES	YES	YES	YES	YES	YES	YES
ρ	0,42	0,42	0,49	0,45	0,41	0,46	0,44
Wald Test Joint Sig.	492,82	450.94***	589.30***	617.74***	629.72***	213.70***	202.61***
Log-Likelihood	-4711,83	-4904.47	-4891.82	-3078.55	-3072.95	-1769.51	-1775.08
% Censored	48,88%	48,88%	48,88%	45,87%	45,87%	53,68%	53,68%

a: Belgium, Denmark, Spain, Italy, Ireland, Greece, Portugal, USA, Netherlands, Great Britain, Sweden, Finland and Japan.

b: Mexico, Malaysia, Chine, India, Singapor, Argentina, Brazil.

* significant at 10%; ** significant at 5%; *** significant at 1%.

Tab. 6

Bilateral Technology-Services Receipts by French Firms

	1	2	3
GDPC	4.608	3.543	3.009
	(0.524)***	(0.510)***	(0.542)***
LAB	3.624	2.886	2.303
	(0.343)***	(0.366)***	(0.354)***
HS	3.296	3.494	1.566
	(0.741)***	(0.737)***	(0.796)**
OP	2.543	0.198	-0.620
	(0.536)***	(0.543)	(0.576)
EXF	2.876	2.730	1.809
	(0.438)*	(0.678)***	(0.637)*
PAT_{t-3}	0.526	0.270	0.153
	(0.152)***	(0.137)**	(0.143)
*S*IPR*	2.632		
	(0.409)***		
*W*IPR*	-0.490		
	(0.368)		
*SS*IPR*		1.309	
		(0.424)***	
*WS*IPR*		-2.202	
		(0.406)***	
*SW*IPR*		-1.493	
		(0.560)***	
*WW*IPR*		-2.181	
		(0.506)	
*HT*IPR*			0.025
			(0.246)
*MHT*IPR*			1.543
			(0.180)***
*MLT*IPR*			-1.060
			(0.198)***
*LT*IPR*			-1.001
			(0,195)***
Obs.	2324	2324	2324
Groups	28	28	28
Country Dummies	YES	YES	YES
Year Dummies	YES	YES	YES
ρ	0.45	0.44	0.42
Wald Test Joint Sig.	678.39	637.95	775.35
Log-Likelihood	-4429.5057	-4422.5294	-4398.508
% Censored	48,88%	48,88%	48,88%

* significant at 10%; ** significant at 5%; *** significant at 1%.

Tab. 7

Bilateral Techhology Receipts by French Firms - Industry Regressions

	IPR Sensitive Industries		IPR Less Sensitive Industries	
	1	2	3	4
GDPC	2.557	5.301	1.504	3.242
	(0.892)***	(6.32)***	(0.618)**	(0.38)***
LAB	1.546	3.088	1.805	1.837
	(0.25)***	(0.27)***	(0.399)***	(0.74)***
HS	1.138	0.560	2.681	1.564
	(1.349)	(0.46)	(0.782)***	(0.65)*
OP	0.391	-0.578	-2.861	0.667
	(0.892)	(0.71)	(0.650)***	(0.98)
EXF	3.730	2.916	1.574	1.045
	(0.184)***	(0.438)***	(0.237)***	(0.637)**
PAT	0.139	0.395	0.013	-0.292
	(0.182)**	(2.06)**	(0.169)	(1.52)
IPR		2.323		5.728
		(0.05)		(1.55)**
IPR^2		-0.548		-1.172
		(0.57)		(1.39)***
Constant	-5.279	-9.362	-3.604	-7.511
	(13.754)***	(6.19)***	(12.986)**	(4.63)***
Obs.	913	913	1411	1411
Groups	12	12	18	18
Log-Likelihood	-2358.89	-2190.06	-2656.23	-2186.40
Country Dummies	YES	YES	YES	YES
Year Dummies	YES	YES	YES	YES
ρ	0.46	0.46	0.53	0.53
% Données Censurées	32,09%	32,09%	59,74%	59,74%

* significant at 10%; ** significant at 5%; *** significant at 1%.

Tab. 8

Industries less sensitive to IPR (patent protection)

	Agriculture, Fishing, Forestry	Mining & Quarrying	Food, beverage & Tobacco	Textiles, wearing apparel, leather	Paper & Printing	Other materials (pottery, etc.)	Basic & Fabricated Metal Prd.	Machinery and Materials	Rubber & Plastic Products
GDPC	-0.697	0.788	0.989	4.772	-3.007	1.754	-0.236	0.199	-3.117
	(0.787)	(0.437)*	(0.523)*	(0.636)***	(0.673)***	(1.035)*	(0.445)	(0.477)	(0.686)***
LAB	0.346	-0.329	1.152	1.262	0.127	2.111	0.373	0.597	-0.250
	(0.480)	(0.198)*	(0.262)***	(0.434)***	(0.000)	(0.723)***	(0.271)	(0.360)*	(0.561)
HS	-1.414	-2.016	-1.380	-2.645	6.252	-2.744	-0.840	-0.398	5.177
	(0.554)**	(0.855)**	(0.476)***	(0.296)***	(1.039)***	(0.694)***	(0.522)	(0.548)	(0.785)***
OP	1.026	-0.814	0.847	1.182	2.706	2.254	0.341	-0.749	0.810
	(0.775)	(0.349)**	(0.469)*	(0.859)	(0.813)***	(1.300)*	(0.344)	(0.482)	(0.804)
IPR	1.547	0.375	0.119	-1.613	-5.149	0.466	0.876	1.012	-0.149
	(0.504)***	(0.300)	(0.298)	(0.611)***	(1.635)***	(0.794)	(0.434)**	(0.454)**	(0.593)
Observ.	140	140	140	140	140	140	140	140	140
Wald $\chi 2$	53,54***	0.82***	102,95***	135,39***	105,28***	94,93***	39,09***	140,53***	121,59***
% Censored	64,71%	45,00%	32,08%	79,29%	32,08%	81,43%	39,29%	38,57%	66,43%

* significant at 10%; ** significant at 5%; *** significant at 1%.

Tab. 9

Industries Sensitives to IPR (patent protection)

	Chemicals	Pharmaceuticals	Machinery & equipment	Radio, TV and Com. Equip.	Medical, precision & opt. instr.	Office, account. & computer mach.	Other transport equipment	Motor Vehicles, etc.	Coke, Petroleum & Fuel Prd.
GDPC	0.458	1.422	0.551	1.700	1.696	-0.551	0.421	-0.145	0.151
	(0.352)	(0.492)***	(0.411)	(0.478)***	(0.607)***	(0.756)	(0.895)	(0.567)	(0.384)
LAB	0.413	1.388	0.524	1.599	1.478	-0.511	-0.754	-0.550	1.068
	(0.194)**	(0.224)***	(0.298)*	(0.421)***	(0.337)***	(0.321)	(0.228)***	(0.471)	(0.308)***
HS	0.630	-0.571	0.632	1.668	-0.197	0.774	-0.717	1.201	0.945
	(0.462)	(0.538)	(0.570)	(0.638)***	(0.661)	(0.554)	(0.837)	(0.466)***	(0.574)*
OP	-0.704	0.775	0.812	1.939	1.284	-0.520	-2.694	-1.102	0.668
	(0.330)**	(0.485)	(0.507)	(0.563)***	(0.734)*	(0.554)	(0.387)***	(0.918)	(0.436)
IPR	0.722	0.499	0.125	-2.428	-0.058	2.186	0.603	0.335	-0.437
	(0.368)**	(0.451)	(0.404)	(0.585)***	(0.504)	(0.516)***	(0.585)	(0.490)	(0.369)
Obs.	140	140	140	140	140	140	140	140	140
Wald $\chi 2$	208,42***	235,77***	103,26***	70,08***	76,38***	77,18***	400,97**	53,55***	88,10***
% Censored	9,29%	20,71%	40,00%	58,57%	32,08%	17,86%	50,00%	50,00%	25,71%

* significant at 10%; ** significant at 5%; *** significant at 1%.

Tab. 10
Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Receipts in Technology (total)	2464	3065326	1.48e+07	0	3.68e+08
GDP per Capita	2464	21416.34	12959.3	400.55	45630
Exports in High Technology (% Manuf. Trade)	2464	18.78264	13.90258	4.0266	61
Labour	2464	8.21e+07	1.84e+08	1467300	7.50e+08
Market Openess (Trade % GDP)	2352	.6965768	.4036713	.1721317	1.839983
R&D (% GDP)	1932	1.678261	.8399257	.31	3.78
IPR (Ginarte and Park Index)	2324	3.333567	.8992348	1.17	4.86
Patents by Domestic (USPTO)	2464	26314.43	76639.21	14	361090
Av. No. Years of Formal Schooling (>=15 years)	2464	2.941091	1.176487	.905	5.048

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