WHY ORGANIZATIONS PATENT IN DIFFERENT TECHNOLOGICAL AREAS THAN THE COMPETITORS? A LONGITUDINAL ANALYSIS OF ENVIRONMENTAL PATENTS

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Nowadays, there is still a long debate about the advantages and disadvantages of allocating the firm's resources over a limited number of technological areas (exploitation) versus diversifying them over a greater variety of areas (exploration). Whereas this analysis is mostly based on the firm's internal resources and capacities, our work analyses the approach taken by an organization when it considers the strategic choices made by the competitors. In this regard, our work employs Transaction Cost Economics (TCE) to explain why an organization follows an strategy that differentiates it from the competitors, whether this approach is exploitative or explorative. Through a longitudinal analysis, our results show that the firm will invest in technological areas that are different from its competitors when its assets are highly specific, when the organization poses a greater knowledge about environmental issues, and even when it enjoys a greater bargaining power over competitors. In addition to this, our results show that such as strategy will lead to a greater economic performance. Our methodology is based on an analysis of 6,438 environmental patents issued from the period 2005-2009 by 53 multinational companies that belong to the Electrical Components & Equipment industry.

Keywords: Environmental innovations; environmental patents; Transaction Costs

¿POR QUÉ PATENTAR EN TECNOLOGÍAS DIFERENTES A TUS COMPETIDORES? UN ANÁLISIS LONGITUDINAL DE PATENTES MEDIOAMBIENTALES

A día de hoy todavía existen numerosos debates acerca de las ventajas e inconvenientes de que una empresa centre sus esfuerzos sobre un número limitado de áreas tecnológicas (explotación) frente a diversificarlos hacia una mayor variedad de áreas (exploración). Mientras que este análisis está basado en gran medida en los recursos y capacidades internos de la organización, nuestro trabajo analiza el comportamiento de dicha organización en función de las decisiones estratégicas que toman sus competidores. En este sentido, nuestro trabajo utiliza la Teoría de Costes de Transacción para explicar por qué una organización llevará a cabo una estrategia diferente a sus competidores, con independencia de si esta es finalmente explotadora o exploradora. Mediante un análisis longitudinal de patentes medioambientales, nuestros resultados muestran que una organización llevará a cabo inversiones en áreas tecnológicas diferentes a sus rivales cuando sus activos sean altamente específicos, cuando tenga un mayor conocimiento sobre temas medioambientales e incluso cuando tenga mayor poder de negociación que sus competidores. Asimismo, los resultados establecen que esta estrategia conducirá a un mayor desempeño económico. Para ello, utilizamos un análisis de 6,438 patentes medioambientales de 53 corporaciones multinacionales pertenecientes a la Industria de Componentes Eléctricos durante el período 2005-2009.

Palabras clave: Innovaciones medioambientales; patentes; Teoría de Costes de Transacción

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Agradecimientos: Los autores desean agradecer el apoyo financiero recibido para la elaboración de este trabajo del proyecto ECO2013-47009-P del Ministerio de Economía y Competitividad

1. Introduction

The increase of patenting protection due the so-called "pro-patent" era has shaped organization's competitive landscape in a non-trivial way. Whereas this pro-patent regime may be sometimes beneficial for the patent-holding company in terms of revenues and intellectual protection, an overprotective system may be detrimental for organizations, the industry innovativeness and social welfare in general (Shapiro, 2001). Lerner (1995) notes that in 1991 US firms spent over $1 billion in patent lawsuit, either enforcing or defending patents, what represents one-third of their yearly investments in basic research and development (R&D).

Industry innovativeness may decrease because a single innovation may contain thousands of patents owned by multiple organizations that can mutually exclude each other (Lin, 2011). Some scholars suggest organizations will reduce these transaction costs by expanding their bargaining power in that technological area, hence increasing the gross number of related patents, what will drive to a "patent portfolio race" (Hall and Ziedonis, 2001). Because organizations will patent in the same area, the industry will converge in technological terms.

However, this technological convergence may entail some relevant costs, such as assessing the value of the own patents used in the agreement, negotiating costs, monitoring costs for safeguarding a correct contract compliance, and other transaction costs aimed to avoid counterpart's opportunistic behavior (Williamson 1975, 2002).

Conversely, if an organization decides to technologically diverge from the industry it may not only reduce the costs associated with multiple-owned innovations (Ziedonis, 2004) but it may also generate temporary monopoly rents that could lead to superior performance gains (Patel and Ward, 2011). Following this line of reasoning we consider that organizations will reduce transaction costs by technologically diverging from their competitors, what will result in a positive effect on performance. Although one may think that technological divergence is an approach more frequently taken by small enterprises, as they may have not enough bargaining power for settling agreements, we believe that technologically converging may cause so high transaction costs that even large corporations will opt for technologically diverge.

We analyze environmental patents in the Electrical Components & Equipment industry for two main reasons. First, since scholars have used complex industries for justifying the proliferation of patent portfolio races (e.g. Hall and Ziedonis, 2001; Joshi and Nerkar, 2011; Lerner, 1995), we base our analysis in the same kind of industry to propose a completely different approach, what reinforces our theoretical insights. Second, we focus on environmental patented innovations because they are experiencing a notorious increase due to their growing importance at multiple levels (national, international, and organizational) (Nameroff et al., 2004). In fact, while environmental patents initially grew by approximately 20% yearly after the adoption of Kyoto protocol in 1997, they are recently growing by more than 30% and are expected to keep growing because of national and supranational environmental goals, such as 20% target for renewables by 2020 (EPO, 2010).

Our work makes two primary contributions. First, while agreeing that the current pro-patent era has prompted a strategic use of patented innovations, we step aside from advocators of patent portfolio races (e.g. Hall and Ziedonis, 2001; Joshi and Nerkar, 2011; Lerner, 1995) because we believe this strategy may drive to an increase of transaction costs, contrary to intended. Consequently, instead of investing in the same areas as competitors, organizations may increase their performance by investing in unrelated areas. Second, this work is one of the few studies that empirically test the relationship between a cost minimization strategy and firm performance, hence answering the call made in David and Han's (2004) extensive literature review of Transaction cost economic (TCE), who noted that "some key variables have received very little scrutiny (e.g. performance)" (David and Han, (2004:54).

2. Transaction Cost Economics

TCE argues that transactions (i.e., exchange of goods or services) have a cost for the parties involved, thus each party will choose an organizational form (hierarchy, market or an hybrid of both) that minimize these costs (Williamson, 1975). Transactions are costly because individuals have bounded rationality and may behave opportunistically (Williamson, 2002). Bounded rationality assumes that "human agents behavior is intendedly rational, but only limitedly so" (Williamson, 2002:174). Consequently, individuals' cognitive limits along with a system of imperfect information make them unable to picture all possible future contingences, what hinders the decision making process. Opportunism, defined as "self-interest seeking with guile" (Williamson, 1975:6), may cause one party to intentionally take advantage of a transaction that unavoidably does not consider all contingences.

We employ a TCE perspective to explain why patenting has shifted from the traditional point of view of "ensuring the freedom to design and manufacture" (Hall and Ziedonis 2001:107) to become a strategic weapon organizations may use in their competitive landscape. Although some scholars argue firms may safeguard from competitors' opportunistic behavior by entailing portfolio races, we believe that strategy not only does not only reduce transaction costs but escalate them. When a given company increase the number of patents in a technological domain so competitors do, as they strike for maintaining their bargaining position to safeguard from unpredictable scenarios. Additionally, this strategy may create an attraction effect (Arrow, 1971; Clarkson and Toh's 2010; Lieberman and Montgomery, 1988) among companies that were not initially interested in that technology, hence increasing the hazard of opportunistic behavior because there are more players in the game.

This approach will lead to a technological convergence among a greater number of companies, what may aggravate the aforementioned anti-commons tragedy because the company's bargaining power may be diluted (Lin, 2011), the cost of negotiating different contracts with different competitors may arise to a point that may be prohibitively expensive (Grindley and Teece, 1997), and the uncertainty of unintentionally infringe competitors' patents is higher (Rivette and Klein, 2000). Additionally, some companies may hide patented innovations on purpose and wait until other firm has already developed a product so they can claim for compensation and thus appropriate of the product's quasi-rents (Rivette and Klein, 2000).

3. Hypotheses

3.1 Asset specificity of patents.

In a patent context, asset specificity may occur when an organization needs access to other firms' patents to develop and commercialize a product, for which it will have to pay a royalty.

Licensing royalties may be both an important source of revenues for some companies and a notorious cost for others. For example, during the year 2006 the Asian company Creative Technology received $100 million from Apple Computers for using patents related with music player technologies, what represented the 90% of Creative's profit (Noguchi, 2006). On the other hand, in 2005 Microsoft earned $100 million while paid $1 billion for royalties (Ricadela, 2006). In this paper we consider licenses as a cost because even when licenses may sometimes be very lucrative, focusing only on this way of business may be detrimental for the long run profitability (and even survival) of the organization, as they are less profitable than product development and commercialization, as well as they erode firm's ability to continue innovating.

When the licensee uses a technology that is widely based on a specific knowledge (i.e. a high specific asset) it becomes bilateral dependent to it, what may foster licensor's opportunistic behavior. Because licenses are not valid everlastingly, when it comes to renegotiating the contract it appears a contracting hazard so that the licensor may appropriate the quasi-rents generated by the licensee by significantly increasing royalty fees (Grindley and Teece, 1997).

The cost of licensing fees may notably increase when, for developing a specific technology, an organization needs a number of patents held by multiple companies, which may be the case of complex industries such as electronic, electrical equipment, semiconductors, computers, instruments, transportation, and machinery (Grindley and Teece, 1997).

In this situation the organization has to identify all possible patent infringements and negotiate licensing contracts individually, what will increase transaction costs (Williamson 1985) to a point at which might be unaffordable (Grindley and Teece, 1997). Even when the final cost is not prohibitive the multiple negotiations will cause an increase of total cost of licensing as well as a delay of the development of the technology due to the time employed on bargaining with all patent-holding companies (e.g. Grindley and Teece, 1997; Lin, 2011).

According to TCE, under this circumstance an organization may prefer to develop its own technology when possible (Williamson 1985), or at least generate a knowledge that although in its first stages of development may be related to the patented technology, the resulting knowledge is unrelated to it. In other words, when there is a high asset specificity an organization may opt for diverging technologically from its competitors. Consequently, we hypothesize the following:

H1: There is a positive relationship between asset specificity and technological divergence.

3.2 Uncertainty of patenting.

Whereas in hypothesis 1 we mention that identifying all patent owners entails a searching cost, now we go one step further and consider the situation in which the organization cannot identify the owner because he *intentionally* hides information related to the patent, as in the case of "minefield" patents (Rivette and Klein, 2000). In this case, patent owners behave opportunistically because they present “incomplete or distorted disclosure of information, especially to calculated efforts to mislead, distort, disguise, obfuscate or otherwise confuse” (Williamson, 1985:47).

Minefield patents are so called because they explode when a competing firm has commercialized a product that is based in an already patented technology (Rivette and Klein, 2000). A company may launch a product without knowing some of its components are based on a protected technology (Shapiro, 2001), hence when the company that owns the patent claim for the invention the former has no other choice but paying for it, as the product is already in the market. In complex industries such as our sample (i.e. the "Electrical Components & Equipment" sector) there is a high degree of uncertainty so that it becomes very easy to unintentionally infringe on patent rights, thus "potentially exposing [the infringer] to billions of dollars of liability and/or an injunction forcing [it] to cease production of key products" (Shapiro, 2001). For example, when Intel started commercializing its first generation of 64-bit microprocessors in 1998 it was issued by a small company, S3, that had bought relevant patents from a failed start-up company (Ziedonis, 2004). Yet only "after developing the architecture and tailoring its fabrication facilities to produce the new chip [by Intel]" (Ziedonis, 2004:806), S3 filed a lawsuit, forcing Intel to settle an agreement as it was too late to change and doing so will delay the product sales.

We believe that these opportunistic organizations, i.e. those that issue minefield patents for quasi-rent appropriation, have a tendency to patent in technological areas where there are more companies because by doing so they have more chances of charging for their inventions. Therefore, an organization that aims to avoid the uncertainty of unintentionally infringing patents will invest in areas less used by its competitors. In other words, that firm will technologically diverge.

As we mentioned earlier, uncertainty is an attribute that becomes relevant in the presence of asset specificity (Williamson, 1985) because when assets are generic the organization may avoid transaction costs related with uncertainty by changing the transacting party. Consequently, we hypothesize that in the presence of asset specificity, high levels of uncertainty strengthen the relationship between asset specificity and technological divergence.

H2: When asset is specific, uncertainty has a positive effect on the relationship between asset specificity and technological divergence.

3.3 Size and technological divergence.

A number of scholars argue that organizations may reduce transaction costs by increasing their bargaining power (e.g. Joshi and Nerkar, 2011; Hall and Ziedonis, 2001; Hegde, Mowery and Graham, 2009). For instance, Hedge, Mowery and Graham's (2009) analysis of a dozen of US industries showed that in "complex" industries such as electronics and semiconductors and Joshi and Nerkar's 2011 study of patent pools in the optical disc industry showed that firms increase patenting for increasing their bargaining power against competitors.

However, it appears that these likely advantages are only valid for large corporations, as they may have higher bargaining power. Blind, Cremers and Mueller (2009)recognize that organizations with little bargaining power may suffer from notorious transaction costs because they will have to pay more for entailing in cross-licenses at the same time that competitors can appropriate from their developments. According to this line of reasoning, large corporations will patent in areas related to their competitors, i.e. they will technologically converge.

Nevertheless, we consider that even if an organization has to pay little or zero for joining the cross-licensing it may not be very interested in innovating in that technological area because all developments it achieves can be used by any other part of the agreement (Joshi and Nerkar, 2011), hence disappearing the extracting of monopoly rents, a central issue of patenting (e.g. Patel and Ward, 2011).

Consequently, we consider that even large corporations may fear the transaction costs entailed in cross-licenses or any other mechanism of sharing their knowledge with competitors, hence they will prefer to technological diverge.

H3: There is a positive relationship between firm size and technological divergence.

3.4 Technological divergence and firm performance.

Since patenting on areas where competitors are present may entail relevant transaction costs for the company, such as costly litigation procedures, delays in product development, risk of infringing protection rights without being aware -e.g. minefield patents-, payment of exacerbated licensing costs, share of new developments -e.g. cross-licensing and patent pools-, etc. organizations that technologically diverge from their competitors may avoid these costs, what may result in a positive effect on performance.

Additionally, when organizations diverge they not only avoid transaction costs associated with multiple-owned innovations but they can also create market leadership and extract temporary monopoly rents (Patel and Ward, 2011), sometimes extending them by patenting related knowledge. Organizations may issue related and overlapped patents with the purpose of building a fence against current and potential competitors (e.g. Blind et al., 2009; Lin, 2011). Competitors may try overcome this fence by inventing around it, but such as approach becomes a hard task when the firm holds key patents (Lin, 2011) and even when they achieve the development of similar technologies the patent-holding may suit competitors through the so-called "doctrine of equivalents", as sufficiently equivalent knowledge are considered a major cause of infringement (Clarkson and Toh, 2010). As Blind et al., (2009:428) states "patents are also an instrument for securing one's own future technological space against competitors or for restricting competitors' future technological opportunities".

Even if in the long run competitors develop relevant patents in the firm's technological domain, investments initially made by the firm help to maintain a leadership in terms of reputation and market share (Spencer, 2003), reduce production costs and increase the speed of creating new related products thanks to an early learning curve (Lieberman and Montgomery, 1988), and may place the firm in a privileged position for bargaining cross-licenses. Consequently, we hypothesize the following:

H4: There is a positive relationship between technological divergence and firm performance.

4. Method

4.1 Sampling and data collection

We used patent data from the European Patent Office (EPO) Global Patent Index (GPI). We filtered all patents using the EPO's European Classification System (ECLA), which is divided into eight sections (A-H), each of which is subdivided into classes, sub-classes, groups, and sub-groups. EPO has adapted these ECLA codes to differentiate and sort environmental patents, resulting in dozens of subgroups that include over 17,000 patents to date (EPO, 2010). Because the same application can be published several times, we selected only one document per application, i.e. the family representative[1.]

4.2 Measures

Dependent variables

For the first regression (hypothesis H1, H2 and H3) we used the "technological divergence" measure as dependent variable, whereas for the second regression (hypothesis H4) we used Tobin's Q. Following previous studies based on patent data (Clarkson and Toh, 2010) we use a 3-digit patent classification code to delimitate the different technological domains.

Because organizations may invest in different technological domains, we consider the organization totally converges when it invests in the same technological domains and in the same proportion as the sector. Conversely, investments in other domains or in different proportion will lead to a technological divergence.

In line with previous studies (Hayashi, 1982) we employed Tobin's Q for assessing market-based firm performance. We used a one-year lagged Tobin's Q to avoid reverse causality and because the positive/negative effects of innovations on performance may not be immediate (Pakes and Griliches, 1984)

Independent Variables

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[1] According to the GPI user manual, the same application can be filed in different countries and thus can be published by several authorities. These publications have similar content and, together, form a simple patent family. When filtering one representative per family, we assure that the same patent does not appear several times.

For measuring asset specificity we employ R&D intensity (i.e. the ratio between R&D expenditures and sales) and the number of technological domains.

Because our sample contains worldwide companies we assessed organizational uncertainty by using country's "uncertainty avoidance", a behavioral dimension based on research conducted in more than seventy countries over a forty-year span (Hofstede, 2010). This variable "expresses the degree to which the members of a society feel uncomfortable with uncertainty and ambiguity" (The Hofstede Centre, 2013).

We consider firm's bargaining power depends on both firm size, measured by the natural log of net sales, and the size of its patent portfolio, i.e. the number of patents it possesses because "a large patent portfolio enhances the bargaining power of a company" (Blindt et al., 2009: 429).

5. Results

We employed the statistic program STATA 12 to test our hypothesis. Descriptive statistics and correlations for the first and second regression are displayed in Table 1 and Table 3 respectively. We took Hausman test, which endorsed the use of fixed effect in both regressions. Fixed effect models are preferred over random effects models because the formers provide a more reliable estimation of the regression parameters as they eliminate the unobservable variables in conventional OLS regression estimates (Ernst, 2001). We used robust standard errors to avoid the problems of serial correlation and heteroscedasticity.

The relationship between the two measures of asset specificity and firm's technological divergence appears to be significant and positive, as predicted in hypothesis 1. It is interesting to note that the "number of ECLA codes" measure we implement in our sample has a similar level of significance that a widely-used measure of asset specificity such as the coefficient between R&D and sales (e.g. Coff, 2003; Delios and Henisz, 2000)

Our results show that when firms posse specific assets they become more aware to the potential transaction costs derived from counterparts' opportunistic behavior (Grindley and Teece, 1997). Because producing all patents related to a specific technological domain is nowadays virtually impossible (Grindley and Teece, 1997; Hall and Ziedonis, 2001; Joshi and Nerkar, 2011; Lerner, 1995), firms try to minimize risks related to competitors' rent appropriation and hold-up behaviors by investing in less overcrowded areas.

With respect to the hypothesis H2 we found evidence of a positive relationship between firm size and firm's technological divergence when considering overall organizational size, but not when patent portfolio size is taken into account. Whether it seems that larger corporations have greater bargaining power due to their higher levels of resources, when it comes to patent portfolio size firms with more patents do not enjoy a better negotiating position. Probably, the fact that some large companies decide to technologically diverge from their competitors make them unable to have valuable (in terms of relatedness) patents to entail in negotiations.

Table 1. Descriptive statistics and correlations

	Mean	S.D.	1	2	3	4	5	6	7	8
1. Technological Divergence	0.13	0.11	-							
2. Age	63.85	39.59	-0.18*	-						
3. Size (Ln Sales)	14.65	2.08	-0.08	0.32***	-					
4. Number of patents	19.21	32.37	-0.03	0.23**	0.32***	-				
5. Asset specificity (RD/Sale)	0.050	0.040	-0.04	-0.02	-0.23**	-0.10	-			
6. Asset specificity (scope)	5.84	4.54	-0.12	0.29***	0.47***	0.83***	-0.12	-		
7. Uncertainty	74.91	21.70	-0.30***	-0.05	0.00	0.09	-0.15†	0.07	-	
8. Asset specificity (RD/Sale) x Uncertainty	-0.36	1.62	0.29***	0.11	0.16*	-0.02	-0.12	-0.00	-0.74***	-
9. Asset specificity (scope) x Uncertainty	9.57	113.46	-0.21**	0.03	0.16*	0.38***	0.06	0.38***	0.19*	-0.23**

† $p < 0.1$; * $p < 0.05$; ** $p < 0.01$; *** $p<0.001$

The moderating effect of environmental uncertainty on the relationship between technological divergence and asset specificity (hypothesis 3) is confirmed in our results for the RD to Sales coefficient. Our results showed a positive relation between asset specificity and technological divergence when firm is adverse to environmental uncertainty. This relationship is stronger when both asset specificity and aversion to environmental uncertainty increase. Regarding firm age, we did not find any significant influence on firm's technological divergence.

Regarding to our second regression (hypothesis H4), descriptive statistics and correlations are displayed in Table 3, and results are displayed in Table 4. Whereas in the hypotheses H1, H2 and H3 we relate the existence of transaction costs with an strategic approach (i.e. technological divergence) that is aimed to reduce them, in the hypothesis H4 we test if this strategy has a positive effect on firm performance. Our results confirm the predicted positive relationship between firm's technological divergence and one-year Tobin's Q, what indicates that reducing transacting costs positively influences firm market-based performance.

Table 2. Result of the regression analysis

	Model 1	Model 2	Model 3	Model 4	Model 5
Age	-.002(.0045)	-.001(.0045)	-.004(.0044)	-.006(.0044)	-.004(.0043)
Size (Ln Sales)	.19(.021)	.0258(.019)	.042(.018)*	.061(.019)**	.042(.018)*
Number of patents		-.001(.000)*	.000(.00)	.000(.000)	.000(.000)
Asset specificity (RD/Sale)			.833(.266)**	1.054(.28)***	.833(.268)**
Asset specificity (scope)			-.038(.003)*	-.007(.003)**	-.007(.003)*
Uncertainty				.000	.000
Asset specificity (RD/Sale) x Uncertainty				.0126(.007)†	
Asset specificity (scope) x Uncertainty					-.000(.000)
R^2 (ΔR^2)	.0928 (-)	.1115 (.0187)	.1953 (.0838)	.2122(.0169)	.1954(-.0168)

Dependent variable: firm's technological divergence.
Robust standard errors are in parenthesis.
†*p* < 0.100; * *p* < 0.050; ** *p* < 0.010; ***p<0.001

These results indicate that, while avoiding transaction cost may be less plausible nowadays, minimizing their impact has a positive impact on firm performance. Therefore, our results suggest firms should invest in areas less overcrowded in order to minimize risk of competitor's opportunistic behavior.

Table 3. Descriptive statistics and correlations

	Mean	S.D.	1	2	3	4	5
1. Tobin Q	1.01	0.52	-				
2. Age	60.24	37.42	-0.09	-			
3. Size (Ln Sales)	14.44	2.28	-0.12†	0.39***	-		
4. Number of patents	31.59	60.04	-0.18*	0.07	0.39***	-	
5. Number of technological domains (centered)	37.72	225.79	-0.19**	0.06	0.38***	0.99***	-
6. Technological divergence	0.16	0.10	0.13†	-0.14†	-0.29***	-0.16*	-0.18*

† $p < 0.1000$; * $p < 0.0500$; ** $p < 0.0100$; ***p<0.0010

Table 4. Result of the regression analysis

	Model 1	Model 2
Age	-.053 (.029)	-.044 (.028)
Size (Ln Sales)	-.024 (.20)	-.049 (.191)
Number of patents	-.003 (.007)	-.004 (.006)
Number of technological domains (centered)	.000 (.002)	.001 (.002)
Technological divergence		1.12 (.427)*
R^2 (ΔR^2)	.3791 (-)	.4089 (.0298)

Dependent variable: one-year lagged Tobin's Q.
Robust standard errors are in parenthesis.
†p < 0.100; * p < 0.050; ** p < 0.010; ***p<0.001

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