INNOVATIVE PERFORMANCE IN THE UNITED STATES: AN ANALYSIS OF MULTIPLE STRUCTURAL CHANGES

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Resumen

Este trabajo analiza la actividad innovadora en los Estados Unidos a través del número de patentes otorgadas en este país de 1965 a 2005. Haciendo uso de la base de datos generada por la Organización Mundial de la Propiedad Intelectual (OMPI), buscamos encontrar la presencia de uno o más cambios estructurales en las series de patentes otorgadas en este país. Igualmente argumentamos en este trabajo que la actividad patentadora en este país ha cambiado su tendencia después que fue aprobada la Ley Bayh-Dole en 1980, afectando las capacidades innovadoras de sus empresas, así como su competitividad.

1. Introduction

This paper analyzes innovative activity in the United States by means of the number of patents granted to residents and non residents from 1965 to 2005. Making use of the patent database released by the World Intellectual Property Organization (WIPO), we search for presence of one or more structural changes in patent granted series in this country. The possibility to find such changes suggest that firms' innovative activity in this country has been modified affecting competition in markets.

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The new regulations implemented in the United States in the 1980s and 1990s influenced its own intellectual property regime allowed for attracting high-quality patent applications and generating more valuable patents (Deng 2007). In the United States, the passage of the Bayh-Dole Act in 1980 has increased the interest in formal technology transfer and licensing (Jaffe and Lerner 2001; Mowery and Shane 2002), as well as developing equity financing mechanisms for supporting university R&D projects. By passing the Patent and Trademark Act of 1980, authorities in the United States attempted to institute a uniform patent policy to remove any restriction on licensing. However, the Patent and Trademark Act of 1980, as well as the Trademark Clarification Act of 1984, the Federal Technology Transfer Act of 1986, and the National Competitiveness Technology Transfer Act of 1989, allowed universities to hold their own patents drawn from federal research grants, supporting at the same time technology transfer activities in many universities and public research centers (Jaffe and Lerner 2001; Siegel et al. 2004). The problem analyzed in this research is thus how the new regulations implemented into the United States' intellectual property regime affected firms' innovation activity in this country. Particularly, this paper analyzes the possibility to find one or more structural changes in patent granted series in the United States resulting from the new realm characterizing its intellectual property regime. However, the possibility to find such changes may confirm that firms' innovative activity has been modified in favor of the science-based industries (Hall 2005). From the results achieved in this research, the trends characterizing patent data series in the United States confirm the existence of multiple structural breaks resulting from the new legislation implemented in terms of intellectual property in the 1980s and 1990s.

The paper is organized as follows. Section 2 presents a review of the literature on intellectual property, patent protection and innovative capabilities. Section 3 contains a description of the model and econometric methods applied in this research to test for presence of one or more structural changes in patent granted series in North America and European Union countries. Section 4 discuses the main results achieved in this research. Finally, Section 5 presents some conclusions.

2. Literature Review

Nowadays, with the emergence of the knowledge-based economy, current intellectual property systems ought to face new challenges. The tremendous changes observed in patent systems over the past two decades have moved into the same direction (Encaoua *et al.* 2006): expanding and strengthening the protection of innovations. However, since 1960s and 1970s, many other changes have been observed in relation to intellectual property regimes around the world. In this sense, the latest legal and administrative changes observed in the United States have affected its own intellectual property regime uncovering the need to adjust however other intellectual property regimes in the world.

The outcomes drawn from this new realm are that they opened up further opportunities to commercialize new knowledge through the use of patents and licenses (Jaffe and Lerner 2001; Siegel *et al.* 2004). Consequently, the value of patents may increase considerably due to the monopolistic right awarded to the patent holder by the patent system (Deng 2007). Nevertheless, national patent applications will continue to be driven by several factors (Peeters and van Pottelsberghe de la Potterie 2006; De Rassenfosse and van Pottelsberghe de la Potterie 2007):

- Firm size
- Market power
- Technological opportunity
- Research efforts
- Intellectual property strategies adopted by the firm

The effect of firm size on national patent applications derives from the Schumpeterian hypothesis suggesting that large firms are more innovative than small firms (Schumpeter 1942). In this sense, large firms benefit from economies of scale and scope, spillovers and access to financial markets for financing risky innovation projects (Cohen and Levin 1989). However, in some cases, small firms are more likely to patent to compensate for disadvantages in terms of market share and brand name (Brouwer and Kleinknecht 1999). On the other hand, the relation established between market power and patent applications also derives from Schumpeter's hypothesis in terms that firms with a higher market

power are more innovative than firms with weak market power (Schumpeter 1942). Even if this factor has also been controversial, there is evidence of a positive impact of firm's market power on its innovation activity (Duguet and Kabla 1998; Nielsen 2001).

In relation to technological opportunities, this variable is defined as the extent to which an industry relies on science-based research (Levin et al. 1987). In consequence, firms in high technology opportunity sectors are found to patent more than other firms (Brouwer and Kleinknecht 1999). In the same way, the relation established between research efforts and patent applications goes from R&D to patents as a process that affects firms' innovative performance. In this sense, the relationship between R&D and patents can be seen as a virtuous cycle that in turn requires further development costs in order to reach the market (Peeters and van Pottelsberghe de la Potterie 2006).

Finally, in relation to the intellectual property strategy adopted by firms, there are many factors that influence their innovative capabilities, such as the relative importance of basic and applied research in total R&D, the product or process orientation of innovation efforts, the extent to which R&D is jointly performed with other institutions, and the limitations and inefficiencies of the patent system (Peeters and van Pottelsberghe de la Potterie 2006).

It is argued that the firms' patenting behavior may correlate with the type of innovation strategy pursued, the perceive barriers to the innovation process (internal, external, risk and cost-related barriers), as well as the limitations of the patent system they recognize (Peeters and van Pottelsberghe de la Potterie 2006). However, firms that perceive higher ineffectiveness of the patent system and higher cost of patenting are therefore less willing to patent nationally. As a result, firms may evaluate patenting ineffectiveness, size of their domestic market, and the patenting cost associated to patenting nationally when defining their intellectual property strategy.

However, the new realm characterizing intellectual property systems and policies in the world has imposed two types of obligations (Scotchmer 2004):

· National treatment to foreign inventors

· Harmonized protection

In the case of North America countries, for example, these obligations have been acquired through the North America Free Trade Agreement (NAFTA) and Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreements. In Canada and Mexico, for example, patenting activity is characterized to be idiosyncratic, responding to firms' specific needs to successfully compete in the marketplace. In fact, many firms in these countries are now more willing to patent in the United States as a mechanism to ensuring economic rents and establishing market barriers. In this sense, the TRIPS agreement has extended intellectual property rights beyond what is optimal as trade negotiations have been captured by the United States (Scotchmer 2004; Hall 2001; Lanjouw and Cockburn 2001). On the other hand, in the case of European countries, the European Patent Convention of 1973 has allowed for higher quality in the patent applications generating more valuable patents (De Rassenfosse and van Pottelsberghe de la Potterie 2007). In this sense, European patents obtained through the European Patent Office are more valuable than those obtained nationally, facilitating to patent holders to invest more resources in finding new commercialization strategies to better exploit their patented ideas (Deng 2007).

3. Model and Methods

This study analyzes the possibility to find one or more structural breaks in the series of patents granted to residents and non residents in the United States. This possibility results from the regulatory changes implemented into the intellectual property regimes in this country in the 1980s and 1990s. In so doing, we used patent data information released by WIPO. The model used in this research to testing for multiple structural breaks in the series of patents granted to residents and non residents was specified following a linear regression model with m breaks ($m+1$ regimes) where all coefficients are subject to change:

$$y_t = z'_t\delta_j + u_t \quad (t = T_{j-1}+1,...,T_j) \tag{1}$$

for $j = 1,...m+1$, T_0 and $T_{m+1}=T$

In this case, y_t is the observed dependent variable, $z_t(qx1)$ is a covariance vector, δ_j ($j = 1,...,m+1$) is the corresponding coefficients vector, and u_t is a disturbance term. The parameter m indicates the number of breaks. The break points $(T_1,...,T_m)$ are explicitly treated as unknown. The estimation methods used in this research is based on the least square principles proposed by Bai and Perron (1998). For each m-partition $(T_1,...,T_m)$, denoted as $\{T_j\}$, the associated least squared estimated of δ_j is obtained by minimizing the sum of the squared residuals $\sum_{i=1}^{m+1}\sum_{t=T_{i-1}+1}^{T_i}[y_t - z'_t\delta_t]^2$ constrained to $\delta_i \neq \delta_{i+1}$ $(1 \leq i \leq m)$. Let $\hat{\delta}[\{T_j\}]$ to be the resulting estimations. Substituting it into the objective function and denoting the resulting sum of squared residuals as $S_T(\hat{T}_1,...,\hat{T}_m)$, the estimated break points $(\hat{T}_1,...,\hat{T}_m)$ are such that

$$(\hat{T}_1,...,\hat{T}_m) = \arg\min_{T_1,...,T_m} S_T(T_1,...,T_m), \tag{2}$$

Where the minimization is taken over all partitions $(T_1,...,T_m)$, such that $T_i - T_{i-1} \geq q$. Thus, the break point estimators are global minimizes of the objective function. Finally, the regression parameter estimates are the associated least-squares at the estimated m -partition $\{T_j\}$, i.e. $\hat{\delta} = \hat{\delta}[\{T_j\}]$.

In this research, $AR(k)$ models were applied for each variable. The appropriate number of lags was determined using Ng and Perron methods, and estimating an $AR(k)$ process using the maximum value k_{max} (Ng and Perron 1995). If the latest lag was not significant, then the selection of k was reduced by one. This process continued until the latest lag was significant or $k = 0$. In this case, 5 was taken as the maximum value of k and the significance of the lags was evaluated using the critical value of 10% of the normal standard distribution. To determine the number of structural breaks, the Bayesian Information Criterion (BIC) was used (Yao 1988). The number of estimated structural breaks $\hat{m}$ was determine by minimizing the above-mentioned information criterion give a fixed upper bound for m, $M=4$.

TABLE 1. VARIABLES DEFINITION

Variable	Definition
PATUSAR	Rate of growth in patents granted to residents in the United States
PATUSAN	Rate of growth in patents granted to non residents in the United States

In this research, the patent database released by the WIPO office was used as an indicator of innovative activity among firms in the United States during the period of 1965 to 2005. Table 1 shows the definition of the variables used in this model to estimate one or more structural breaks in the series of patents granted to residents and non residents in the United Sates. Thus, the patent generated series to estimate this model were computed as the growth rate of the absolute value of the number of patents.

4. Results

The model estimated in this research was computed making use of Rats 6.0. From a general perspective, the results suggest that the main changes observed in the intellectual property regimes in the United States in the1980s and 1990s influenced patenting activity in this country as a response to the changes observed in its science and technology policy. The new intellectual property regime in this country however reacted in searching to support firms' innovative activity and competitiveness.

TABLE 2. BREAKING YEARS IN PATENT GRANTED SERIES IN THE UNITED STATES

Patents Granted to Residents			Patents Granted to Non Residents		
Variable	Breaking Years	BIC	Variable	Breaking Years	BIC
PATUSAR	1978	-4.56154	PATUSAN	1972	-4.22843
	1980			1978	
	1983			1980	
	1998			2003	

In this sense, patent series confirms the existence of structural breaks resulting from the reforms implemented in the United States in the 1980s and 1990s (Table 2). It would be expected however that these reforms might influence intellectual property regimes in other countries.

In the United States, structural breaks were observed in 1978, 1980, 1983 and 1998 in the case of patents granted to residents, and in 1972, 1978, 1980 and 2003 in the case of patents granted to non residents. These results may confirm the idea that the new realm characterizing the intellectual property regime in the United States positively influenced innovative activity among residents in this country, as well as the desire of foreign inventors to patenting in this market as a mechanism to ensure economic rents and to establishing entry barriers.

5. Conclusions

This paper analyzed structural breaks in the series of patents granted to residents and non residents in the United States. The purpose was to get insight on such changes resulting from the new realm characterizing intellectual property regimes affected innovative activity, as well as competitiveness in this country. It was suggested that such changes may come from the new dispositions adopted into the United Sates' intellectual property regime derived from the TRIPS agreement. The results confirm the existence of structural breaks in the number of patent granted to residents and non residents in the United States mainly in the 1980s and 1990s. However, the intensity and direction of these changes would be rather different for each breaking year.

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