Patenting Activity and Innovativeness in US and Japan: An Econometric Analysis

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Resumen

Este trabajo analiza los regímenes de propiedad intelectual en los Estados Unidos y Japón a través del número de patentes otorgadas durante el periodo 1940 a 2005 y 1965 a 2005, respectivamente. Haciendo uso de la base de datos generada por la Organización Mundial de la Propiedad Intelectual (OMPI), probamos la presencia de un cambio en el tiempo en el nivel o en la pendiente de la función tendencia de las series de patentes otorgadas. En la literatura sobre el tema se argumenta que la actividad patentadora en los Estados Unidos ha sido modificada como resultado de las nuevas regulaciones que se impusieron al régimen de propiedad intelectual en ese país durante los años ochenta. En el caso de Japón, se argumenta que las políticas a favor de una mayor actividad patentadora implementadas recientemente en ese país no han afectado significativamente las capacidades innovadoras de sus empresas. Los resultados obtenidos en este trabajo corroboran estos argumentos.

Palabras clave: propiedad intelectual, patentes, cambio estructural, Estados Unidos y Japón.

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Abstract

This paper analyzes intellectual property regimes in the United States and Japan by means of patents granted from 1940 to 2005 and 1965 to 2005, respectively. Making use of the database released by the World Intellectual Property Organization (WIPO), we search for presence of a one-time change in the level or in the slope of the trend function of patent granted series. It is argued that patenting activity in the United States was affected as a result of the new regulations affecting its intellectual property regime in the 1980s. In the case of Japan, it has been argued that impact of recent pro-patent polices on firms' innovative capabilities is not so clear. However, the results achieved in this research corroborate this principle.

Keywords: intellectual property, patents, structural change, United States and Japan.

Clasificación JEL: O34, O39, C22, O51, O53

Introduction

This paper analyzes innovative activity in the United States and Japan by means of the number of patents granted from 1940 to 2005 and 1965 to 2005, respectively. Making use of the patent database released by the World Intellectual Property Organization (WIPO), we search for presence of a one-time change in the level or in the slope of the trend function of the number of patents granted in these countries.

The new regulations implemented in the United States in the 1980s have influenced its intellectual property regime. Particularly, the passage of the Bayh-Dole Act in 1980 has affected university-industry technology transfer and patenting activity in this country. In the case of Japan, its current patent law was enacted in 1959 and revised several times, mainly for the purpose of international harmonization. Recently, the Japanese government has stressed the importance of pro-patent polices, aiming to strengthen intellectual property rights in order to stimulate business innovation and to regain international competitiveness (Motohashi 2003).

The question conducting this research is how the new regulations affecting intellectual property regimes in the United States and Japan have affected firms' innovative activity. In this sense, this research aims to get insight on how the pro-patent policies implemented in these countries resulted in strengthening competitiveness in their industries. Particularly, this paper analyzes the possibility to find a structural change in the number of patents granted to residents and non residents in the United States and Japan, resulting from the new realm characterizing intellectual property regimes in these countries. However, the possibility to find such changes confirm that firms' innovative activity in these countries has been modified. From the results achieved in this research, the trends characterizing patent data series in the United States confirms the existence of a structural change resulting from the new legislation implemented in the 1980s. In the case of Japan, results confirm no evidence that competitiveness has improved among its firms.

The paper is organized as follows. Section 2 presents a review of the literature on intellectual property, patent protection and innovative capacity. Section 3 contains a description of the model and econometric methods used in this research in order to test for presence of a one-time change in the level or in the slope of the trend function of patent granted series. Section 4 discuses the main results achieved in this research. Finally, Section 5 presents some conclusions.

Literature review

Nowadays, current intellectual property systems ought to face new challenges with the emergence of the knowledge-based economy. The tremendous changes observed in the patent systems over the past two decades have moved in the same direction (Encaoua et al. 2006): expanding and strengthening the protection of innovations. 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). The new realm implies that the value of patents may increase considerably for commercial purposes. In fact, the value of patents comes from the monopolistic right awarded to the patent holder by the patent system allowing a maximal length and scope, renewal and other

administrative costs over the patent lives, as well as enforcement and cost of enforcement of the patent rights (Deng 2007).

According to the economic literature, national patent applications are driven by several factors (Peeters and van Pottelsberghe de la Potterie 2006; De Rassenfosse and van Pottelsberghe de la Potterie 2007): (1) firm size; (2) market power; (3) technological opportunity; (4) research efforts; (5) 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 ones (Schumpeter 1942). 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).

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). 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). There are many factors influencing innovative capabilities in relation to the intellectual property strategy adopted by firms, 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).

On the other hand, it is argued that the firms' patenting behavior might correlate with the type of innovation strategy pursued, the perceive barriers to the innovation process (internal and external barriers, and 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, it is argued that patents are not always the most popular protection mechanism for manufacturing firms (Peeters and van Pottelsberghe de la Potterie 2006). Secrecy and lead time over competition may be actually preferred to protect innovations with highly risk when there are competitors inventing around or firms are obliged to disclosure critical information (Brouwer and Kleinknecht 1999; Levin et al. 1987; Cohen et al. 2000; Scotchmer and Green 1990).

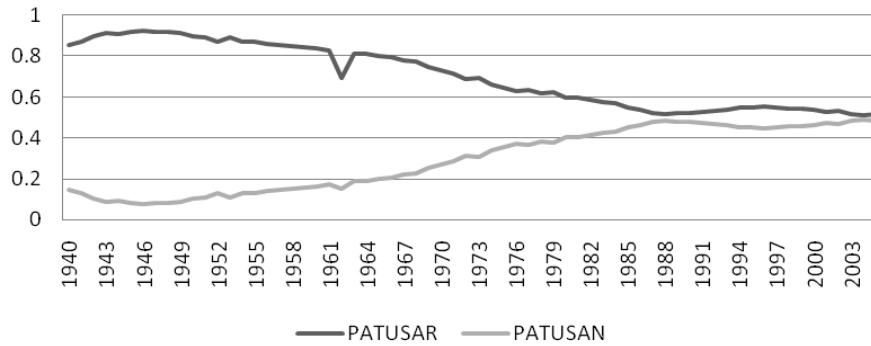
In this sense, firms that perceive higher ineffectiveness of the patent system and higher cost of patenting are therefore less willing to patent nationally. As a result, firms may evaluate patenting ineffectiveness, size of their domestic market, and the patenting cost associated to patenting nationally when defining their intellectual property strategy. In this context, the new realm characterizing intellectual property systems and policies in the world impose two types of obligations (Scotchmer 2004):

1. National treatment of foreign inventors;
2. Harmonized protection.

In the case of the United States, the new realm characterizing its intellectual property regimes has supported the idea that firms ought to stimulate their innovative capabilities to outweigh the increase in aggregate deadweight loss that arises when protection is extended across borders (Scotchmer 2004). Figure 1 shows how patents granted to residents and non residents in the United States have evolved from 1940 to 2005. Information in this figure suggests that the percentage of patents granted to residents considerably decreased in this country during 1970s and 1980s. Accordingly, the percentage of patents granted to non residents considerably increased during 1970s and 1980s.

Figure 1

Patents Granted to Residents and Non Residents in the United States (%)



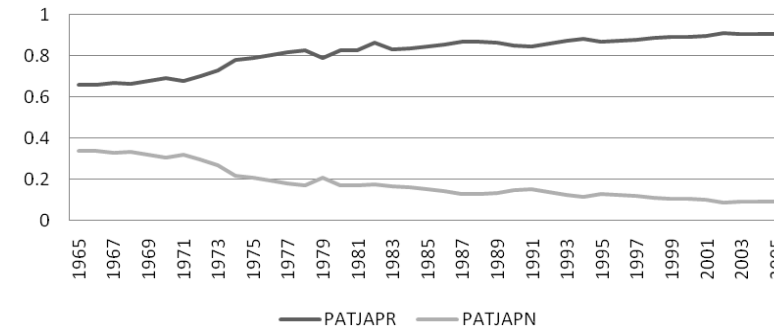
In this sense, it is expected that the new rules implanted in intellectual property regime in this country has affected the number of patents granted to residents and non residents.

> *Proposition 1. The new rules characterizing the intellectual property regime in the United States structurally affected, positively or negatively, patent granted function trends in this country.*

In the case of Japan, the Japanese government published the Strategic Framework for Intellectual Property Policy and Basic Law on Intellectual Property in 2003. However, other reforms implemented in the 1980s aimed to establish a patentable invention environment. The main goals followed by the new reforms on the Japanese intellectual property system were (Sakakibara and Branstetter 2001): (1) to change from a single-claim system to an "improved" multiclaim system; (2) a patent term restoration for pharmaceuticals; and (3) to revise the motives of the series of these reforms. The consequences of the new scheme were the significance of the multiclaim system in terms of its efficiency when granting new patents, the possibility to acquire more financial resources to fund R&D projects and develop new innovations, and to get a real expansion of Japanese intellectual property rights under these reforms. The objective was thus to enhance Japan's industrial

Figure 2

Patents Granted to Residents and Non Residents in Japan (%)



competitiveness by promoting the creation of new firms, as well as strengthening the protection and utilization of intellectual property (Motohashi 2003).

This policy aims to encourage innovation through proactive action plans for stimulating effective use of intellectual property and covering a wide range of topics, such as patenting by universities and public research institutions, and the revision of regulations on staff inventions within business. Therefore, the new propositions derived from this legislation aims to promote the creation, dissemination, and effective exploitation of intellectual property to contribute to the development of new industries (Motohashi 2003). Japan's patent system has thus undergone various changes since 1959. The major changes in Japanese patent system fall into the following four categories (Motohashi 2003): (1) extension of patent protection to new spheres; (2) extension of patent protection across technology fields; (3) strengthening of patent rights; and (4) modification of the way the patent system operates.

These changes have implied the introduction of microbiology patents, revision of the system of multiple claims, increasing in damage claim amounts, and the introduction of electronic patent application submission. These changes largely stem for international requirements, such as harmonization with

international agreements (Paris Convention and TRIPS). However, the major changes to Japan's patent system were introduced in the 1980s and 1990s, aiming to strengthening the protection of patent rights through pro-patent policies in fields such as information technologies and biotechnology. The result was a new relationship between these revisions in business and patenting activity in this country. Figure 2 shows how patents granted to residents and non residents in Japan have evolved from 1965 to 2005. Information in this figure suggests that the percentage of patents granted to residents in this country increased during 1980s. Accordingly, the percentage of patents granted to non residents decreased during 1980s.

> *Proposition 2. The new rules characterizing the intellectual property regime in Japan structurally affected, positively or negatively, patent granted function trends in this country.*

These propositions are econometrically tested for the existence of unit root (Perron 1997) and structural change (Vogelsang 1997) using patent granted series realized by the WIPO. The objective is thus to evaluate the importance of the new rules characterizing intellectual property regimes in the United States and Japan to innovative improvements among firms in these countries.

Model and methods

From an empirical perspective, Hall (2005) already analyzed the possibility to find a structural change in patent application series in the United Sates during the period 1967-1997. However, this study uses patent application data to test for structural breaks resulting from regulatory changes implemented to the intellectual property regime in this country. However, the results achieved in this study are centered on the science-based industries, revealing a very significant structural change between 1983 and 1984 concentrated in the electrical sector including electric machinery, electronics, instruments, computers, and communication equipment. In the case of Japan, it is expected that the reforms of the 1980s, as

well as the Strategic Framework for Intellectual Property Policy and Basic Law on Intellectual Property of 2003 allowed a more patentable environment among Japanese firms and universities.

There are three different types of models to test on the existence of unit root in a series:

1. The Crash Model;
2. The Changing Growth Model;
3. The Mixed Model.

The Crash Model allows testing the existence of structural change in the intercept of a series. The Changing Growth Model allows determining structural change in the slope. Finally, the Mixed Model allows determining the change in the intercept and slope. The Mixed Model is however more appropriate to analyze structural change in series with trend such as patent granted series (Sen 2003).

In turn, the three models can be estimated using two alternative approaches:

1. The Additive Outlier (AO) approach;
2. The Innovative Outlier (IO) approach.

The AO approach offers the possibility to estimate instantaneously changes in the trend function. On the other hand, the OI approach estimates these changes gradually. However, the OI approach is more adequate to estimate the type of data used in this research, given that intellectual property regimes react gradually (Perron 1989). Therefore, the Mixed Model contains regressions in the following terms (Perron 1997):

$$\Delta y_t = \mu + \theta DU_t + \beta t + \gamma DT_t + \delta D(T_b)_t + \alpha y_{t-1} + \sum_{j=1}^{k} c_j \Delta y_{t-j} + e_t$$

The period in which the change in the parameters trend function occurs is referred as the break time (T_B). y_t is the variable to be analyzed, in this case patent data. Break dummy variables take the following values: DU = 1 if $t > T_B$, and 0

otherwise; $DT_t = t - T_B$ if $t > T_B$, and 0 otherwise. This equation was estimated sequentially for $T_B = 2, \ldots, T-1$, where T is the number of observations after adjusting for the observations lost resulting from a first-differencing process that incorporates a lag length k.

The parameters θ and γ are measures of changes in the intercept and the slope, respectively. The null hypothesis of unit root was tested against the alternative hypothesis of a stationary process around a trend with structural change in the trend function occurring into an unknown time period. The null hypothesis of unit root was rejected if the t-statistics for α was greater (in absolute value) than its critical value.

The appropriate number of lags was determined for estimating an AR(k) process using the maximum value of k (Ng and Perron 1995). If the latest lag was significant, then the selection of k was k_{max} (k = 5). 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.

Once it was determined which variables had unit root, they were tested for structural change using the SuperWald test [2] to estimate the breaking time period. The equation used for testing the breaking time period was stated as follows:

$$y_t = \mu + \theta DU_t + \beta t + \gamma DT_t + \sum_{j=1}^{k} c_j y_{t-j} + e_t$$

Table 1

Variables Definition

Variable	Definition
PATJAPR	Ratio of resident patents to total patents granted in Canada
PATJAPN	Ratio of non resident patents to total patents granted in Canada
PATUSAR	Ratio of resident patents to total patents granted in the United States
PATUSAN	Ratio of non resident patents to total patents granted in the United States

This equation was estimated sequentially for each breaking time period, excluding 1% of data at the beginning and the end of the period ($0.01T < T_B < 0.99T$), where T was the number of observations. The structural change was determined endogenously through $SupF_t$ as maximum value over all possible breaks of two times the F standard statistics for testing $\theta = \gamma = 0$. The null hypothesis tests non structural change against the alternative hypothesis of structural change. The null hypothesis is rejected if the $SupF_t$ is greater than its corresponding critical value. Table 1 shows the variables used in these model:

We use the patent database released by the WIPO office as indicators of innovative activity among firms in North America and EU countries during the period of 1965 to 2005.

Results

The null hypothesis of non structural change is thus rejected against the alternative hypothesis of break point in the patent series. Therefore, the null hypothesis of non structural change is rejected if the $SupF_t$ is greater than its corresponding critical value.

Table 2 shows the results of the sequential test of unit root in the case of the series of patents granted to residents and non residents as percentage in the

Table 2

Sequential Test of Unit Root

Variable	Break Year	Dickey-Fuller t-Statistic	k	Level of Significance**
PATCJAPR	1978	-6.39	5	1%
PATJAPN	1972	-6.26	0	1%
PATUSAR	1992	-4.420	1	
PATUSAN	1990	-5.315	1	10%

* PRMEX and PNMEX only include data for the period 1963-2005.

** The critical values for stationary variables at 1%, 5% and 10% of the Dickey-Fuller t-Statistics are -6.32, -5.59 and -5.29, respectively (Perron 1997, p. 363).

United States and Japan. The results suggest that PATUSAN, PATJAPR, and PATJAPN are stationary at a level of significance of 10%, 1%, and 1%, respectively.

In the United States, the Bayh-Dole Act (1980), as well as many other changes implemented during 1980s and 1990s, influenced patenting activity in this country, and thus innovative activity among firms. However, a structural break is observed in PATUSAN in 1988 (Table 3). This result confirms the idea that the new realm characterizing the intellectual property regime in the United States positively influenced the desire of foreign inventors for patenting in that market as a mechanism to ensure economic rents and to establish entry barriers. Nevertheless, the structural break observed in PATUSAR is not statistically significant.

In the case of Japan, PATJAPR and PATJAPN are both statistically significant at a level of significance of 1%. These results confirm the existence of a structural break in both series in 1973 (Table 3). These results also suggest that the new regulations implemented in Japan in the 1980s did not deeply affect its innovative activity among firms. These results are in accordance with the evidence found in other papers in terms that there is not conclusive evidence supporting the idea of a strong increase in patenting activity resulting from the new scheme characterizing Japanese intellectual property regime (Motohashi 2003; Sakakibara and Branstetter 2001).

Table 3

Sequential Test of Structural Change

Variable	Break Year	$SupF_t$	k	Level of Significance**
PATJAPR	1973	23.24	4	1%
PATJAPN	1973	36.52	1	1%
PATUSAR	1988	20.71	2	
PATUSAN	1988	51.78	2	1%

* PRMEX and PNMEX only include data for the period 1963-2005.

** The critical values for stationary variables at 1%, 5% and 10% of the Dickey-Fuller t-Statistics are -6.32, -5.59 and -5.29, respectively (Perron 1997, p. 363).

Finally, further research should be developed at a level of industry for these countries to get insight on where patenting activity is concentrated. This approach would allow knowing whether the growth in patenting and innovative activities in the United Sates and Japan can be explained from the fact that R&D is more "fertile" in some industries or, alternatively, firms' patent strategy in these countries has presently changed (Cohen et al. 2000; Hall 2005).

Conclusions

This paper analyzes innovative activity in the United States and Japan by means of the number of patents granted to residents and non residents in these countries. The objective is to get insight on the possibility to find structural changes in patent granted series resulting from the new realm characterizing intellectual property regimes in the world. The results confirm the existence of a structural break in the number of patents granted to non residents in 1988 in the United States. However, this result confirms the idea that foreign inventors are disposal to patent in this country as a mechanism to ensure economic rents and establish entry barriers. In the case of Japan, the results achieved in this research confirm that there is not conclusive evidence supporting the idea of a strong increase in patenting activity resulting from the new scheme characterizing Japanese intellectual property regime.

However, further research should be done to get insight on what industrial sectors patenting activity is concentrated. Such an approach would allow knowing whether the growth in patenting and innovative activities can be explained as a result of a more "fertile" hypothesis, or alternatively from firms' patent strategy changes hypothesis. However, the intensity and direction of these changes is rather different for each country in these regions.

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