Innovative activity in NAFTA and EU countries:
an analysis of structural change in patent granted trends

Mario Gómez Aguirre*
José Carlos Rodríguez**

Abstract

This paper analyzes innovative activity in North America and European Union (EU) countries by means of the number of patents granted from 1965 to 2005. Making use of the database released by the World Intellectual Property Organization (WIPO), we search for presence of a structural change patent granted series. It is argued that patent activity in North America and EU countries has followed a different pathway, affecting firms' innovative capabilities and competitiveness. In North America, the new rules characterizing the United States' intellectual property regimen have influenced Canada's and Mexico's intellectual property regimes through North America Free Trade Agreement (NAFTA) and Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreements. In the EU region, the establishment of the European Patent Office (EPO) has allowed for multi-country patent rights, attracting high-quality patent applications and generating more valuable patents.

Keywords: Intellectual property, patents, innovative activity, structural change, NAFTA, European Union, TRIPS and EPO.

* Instituto de Investigaciones Económicas y Empresariales (Economic and Business Research Institute) Universidad Michoacana de San Nicolás de Hidalgo. gomez_ininee@hotmail.com
**Department of Management and Technology Université du Québec à Montréal and Instituto de Investigaciones Económicas y Empresariales (Economic and Business Research Institute) Universidad Michoacana de San Nicolás de Hidalgo. rodriguez_chavez.jose@courrier.uqam.ca

Este artículo analiza la actividad innovadora en los países de América del Norte y la Unión Europea a través del número de patentes otorgadas entre 1965 y 2005. Haciendo uso de la base de datos que genera la Organización Mundial de la Propiedad Intelectual (OMPI), probamos la presencia de un cambio estructural en las series de patentes otorgadas. Se argumenta que la actividad patentadora en los países de América del Norte y la Unión Europea han seguido diferentes trayectorias, afectando las capacidades innovadoras de las empresas y su competitividad. En América del Norte, las nuevas reglas que han caracterizado al régimen de propiedad intelectual en los Estados Unidos han influenciado los regímenes de propiedad intelectual en México y Canadá a través del Tratado de Libre Comercio de América del Norte (TLCAN) y de los Aspectos de los Derechos de Propiedad Intelectual Relacionados con el Comercio (ADPIC). En el área de la Unión Europea, el establecimiento de la Oficina Europea de Patentes (OEP) ha permitido patentar simultáneamente en varios países, generado patentes de mayor calidad y valor.

Palabras clave: propiedad intelectual, actividad innovadora, cambio estructural, TLCAN, Unión Europea, ADPIC y OEP.

Clasificación JEL: O34, O31, C22, O50, O52.

1. Introduction

This paper analyzes innovative activity in North America and European Union (EU) countries 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 a structural change in the number of patents granted in Canada, France, Germany, Mexico, Spain, the United Kingdom, and the United States. The possibility to find such a change suggests that firms' innovative activity in those countries has been modified affecting competition in markets.

On the one hand, the new regulations implemented in the United States in the 1980s and 1990s have influenced Canada's and Mexico's intellectual property

regimes through North America Free Trade Agreement (NAFTA) and Trade-Related Aspects of Intellectual Property Rights (TRIPS) (Scotchmer 2004). On the other hand, in the EU area, the establishment of the European Patent Office (EPO) in 1973 and the new tendencies observed in almost all countries after the pass of the Bayh-Dole Act in 1980 in relation to intellectual property matters have allowed for multi-country patent rights attracting high-quality patent applications and generating more valuable patents (Deng 2007).

The question conducting this research is how the new regulations affecting intellectual property regimes in world have influenced intellectual property in North America and European Union countries. Particularly, this paper aims to analyze the possibility to find structural changes in patent granted series in North America and EU countries resulting from the new realm characterizing intellectual property regimes in those countries. 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). In addition, in North America, NAFTA and TRIPS agreements have extended intellectual property rights beyond what is optimal, alienating intellectual property and patent protection in favor of the United States (Scotchmer 2004). On the other hand, in the EU region, the establishment of the EPO in 1973 has allowed for granting more valuable patents derived from the monopolistic rights awarded to patent holders (Deng 2007).

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 this country. In Canada and Mexico, evidence support the idea that firms are more willing to patent in the United States as a mechanism to ensure economic rents and to establish market barriers to potential competitors. In this sense, it has been argued that Canadian and Mexican firms ought to stimulate their own innovative capabilities to successfully compete in the marketplace in order to outweigh the increase in aggregate deadweight loss that arises when protection is extended across borders (Scotchmer 2004). In contrast, in the case of the EU countries, the establishment of the EPO has allowed for a higher degree of innovativeness among European firms (Deng 2007).

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 structural change in the number of patents granted series. Section 4 discuses the main results achieved in this research. Finally, Section 5 presents some conclusions.

2. 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, Guellec and Martínez 2006): expanding and strengthening the protection of innovations. In the United States, the latest legal and administrative changes have affected its own intellectual property regime and practices, uncovering the need to adjust intellectual property regimes in North America, as well as in many other countries in the world. In addition, in the Europe, several countries signed the European Patent Convention under which the EPO was founded beginning to provide a uniform patent examination and granting procedures since 1978 (Deng 2007).

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, Waldman, Atwater and Link 2004). The new realm implies therefore that the value of patents may increase considerably (Deng 2007). 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, Klerovick, Nelson and Winter 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).

Finally, in the intellectual property strategy adopted by firms, there are many factors influencing 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).

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, Klerovick, Nelson and Winter 1987; Cohen, Nelson and Walsh 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 Canada, Mexico and the United States, these obligations have been acquired through the NAFTA and TRIPS agreements. However, Canada's and Mexico's patent activity has followed a different pathway than that followed in the United States. In the case of Canada and Mexico, patent activity and practices are characterized to be idiosyncratic, responding to firms' specific needs to successfully compete in the marketplace. In fact, the new realm characterizing intellectual property regimes in North America supports the idea that many Canadian and Mexican firms are willing to patent in the United States as a mechanism to ensure economic rents and to establish market barriers. In addition, it has been argued that the TRIPS agreement has extended intellectual property

rights beyond what is optimal since trade negotiations are captured by industry (Scotchmer 2004; Hall 2001; Lanjouw and Cockburn 2001). These facts suggest that Canadian and Mexican firms ought to stimulate their own innovative capabilities to outweigh the increase in aggregate deadweight loss that arises when protection is extended across borders (Scotchmer 2004).

> *Hypothesis 1. The new rules characterizing the intellectual property regime in the United States structurally affected, positively or negatively, patent granted function trends in North America countries.*

In the case of the EU countries, it is expected that the transfer of priority patent filings to EPO reflects higher quality in the patent applications and thus generating more valuable patents (De Rassenfosse and van Pottelsberghe de la Potterie 2007). In 1973, several European countries signed the European Patent Convention. The new regime has provided a uniform patent examination and procedures for applicants within the EPO since 1978. European patents obtained through the EPO are more valuable than those obtained nationally (Deng 2007). Actually, the uniform examination and granting procedures at the EPO eliminates the inter-country differences in the patentability standards and the scope of protection awarded to the patent holders (Deng 2007). These tendencies facilitate to patent holders to invest more resources in finding new commercialization strategies to better exploit their patented ideas (Deng 2007). The result is that the learning process of the EPO patents is found to be much longer than that of the national patents before the 1980s.

> *Hypothesis 2. The establishment of the EPO structurally affected, positively or negatively, patent granted function trends in EU countries.*

The hypotheses stated above were econometrically tested for the existence of unit root (Perron 1997) and structural change (Vogelsang 1997) using patent granted series realized by the WIPO.

3. 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 the United States in the 1980s. 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.

From a different perspective, the study developed in this paper analyzes the possibility to find structural changes in intellectual property regimes in North America and EU countries, resulting from the regulatory changes implemented to the intellectual property regime in the United States in 1980s, the adoption of the TRIPS agreement under the Uruguay Round, and the establishment of the EPO in 1973. Furthermore, the study developed in this paper makes use of the patent data released by the WIPO office in terms of the number of the patents granted to residents, non residents, as well as the number of total patents granted in Canada, France, Germany, Mexico, Spain, the United Kingdom, and the United States to test for presence of unit root (Perron 1997) and structural change (Vogelsang 1997) in patent granted series.

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 (Sen 2003), such as patent granted series.

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. 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 is 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 is rejected if the t-statistic for α was greater (in absolute value) than its critical value. Ng and Perron (1995) suggest that the appropriate number of lags is determined by estimating an AR(k) process using the maximum value of k. If the last lag included in the above equation is significant, then the choice of k is k_{max}. If

the lag is not significant, then k is reduced by one. This process continued until the last lag becomes significant or k = 0. In this case, 5 is taken as the maximum value of k and the significance of the lags is 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:

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

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 is tested 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:

Table 1

Variables Definition	
Variable	Definition
PATCANR	Ratio of resident patents to total patents granted in Canada
PATCANN	Ratio of non resident patents to total patents granted in Canada
PATFRAR	Ratio of resident patents to total patents granted in France
PATFRAN	Ratio of non resident patents to total patents granted in France
PATGERR	Ratio of resident patents to total patents granted in Germany
PATGERN	Ratio of non resident patents to total patents granted in Germany
PATMEXR	Ratio of resident patents to total patents granted in Mexico
PATMEXN	Ratio of non resident patents to total patents granted in Mexico
PATSPAR	Ratio of resident patents to total patents granted Spain
PATSPAN	Ratio of non resident patents to total patents granted Spain
PATKINR	Ratio of resident patents to total patents granted in the United Kingdom
PATKINN	Ratio of non resident patents to total patents granted in the United Kingdom
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

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.

4. Results

The Vogelsang (1997) test, which will be used to determinate the existance of structural breaks, are valid whether or not a unit root is present in patents series, however, the critical values are different for stationary variables and variables with unit root. Therefore, the unit root test must be applied to the series in advanced.

In the case of NAFTA countries, results suggest that PATMEXR, PATUSAR and PATUSAN series are stationary and the remaing have unit root (Table 2). In the case of EU countries PATFRAN, PATGERR, PATGERN and PATSPAR are stationary (Table 4) and the remaing have unit root.

In the United States, patent series confirms the existence of statistical significance structural breaks, resulting from the reforms implemented in this country in 1980s (see Table 3). However, the Bayh-Dole Act (1980), as well as many other changes implemented in the patent system influenced firms' innovative activity in this country. However, in the case of the United States, a structural break is observed in PATUSAN in 1988. This result confirms the idea that the

Table 2

North America Countries Sequential Test of Unit Root				
Variable	Break Year	Dickey-Fuller t-Statistic	k	Level of Significance**
PATCANR	1975	-4.645	0	
PATCANN	1975	-4.646	0	
PATMEXR*	1987	-7.038	1	1%
PATMEXN*	1983	-13.860	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 statistical significance critical values at 1%(-6.32), 5%(-5.59) and 10%(-5.29) levels (Perron 1997, p. 363).

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.

In the case of Canada and Mexico, the results achieved in this research suggest that the major statistical significant changes observed in patents granted to residents and non residents follow a different path behavior. In Canada, a structural break is observed in PATCANR and PATCANN in 2001 (see Table 3). These results suggest that the new regulations affecting the intellectual property regime in the United States only influenced indirectly firms' innovative performance in Canada. However, the science and technology policy implemented in this country in the 1990s aims to make Canadian economy more competitive shortly in the following years, resulting therefore in an improvement of the degree of innovative capacity among Canadian firms. In this case, it is important to say that an significant quantity of R&D expenditure would be performed by universities in order to develop related science-based industries.

Table 3

North America Countries Sequential Test of Structural Change				
Variable	Break Year	$SupF_t$	k	Level of Significance**
PATCANR	2001	23.69	4	10%
PATCANN	2001	23.32	4	10%
PATMEXR*	1971	16.43	3	5%
PATMEXN*	1982	31.01	3	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% significance levels are 19.90, 15.44 and 13.62, respectively, and the critical values of unit root at 1%, 5% and 10% significance levels, respectively, are 30.44, 25.27 and 22.60 (Vogelsang 1997, pp. 824-825).

In the case of Mexico, a structural break is observed in PATMEXR and PATMEXN in 1971 and 1982, respectively (see Table 3). These results suggest two explanations in terms of inventors' activity in this country. On the one hand, it is expected that local inventors in Mexico has been influenced by the adherence of this country to the Paris Convention at the beginning of the 1970s. On the

other hand, the new realm characterizing intellectual property regimes in the world, along with the new patenting conditions in the United States in the 1980s, affected foreign firms' innovative activity in Mexico in 1982.

Table 4

European Union (EU) Countries Sequential Test of Unit Root				
Variable	Break Year	Dickey-Fuller t-Statistic	k	Level of Significance*
PATFRAR	1984	-4.887	0	
PATFRAN	1985	-3.813	1	5%
PATGERR	1985	-5.700	1	5%
PATGERN	1985	-5.700	1	1%
PATSPAR	1987	-8.537	4	1%
PATSPAN	1987	-7.670	3	
PATKINR	1982	-3.126	0	
PATKINN	1983	-4.514	4	

* The statistical significance values of stationary variables at 1%, 5% and 10% are 19.90, 15.44 and 13.62, respectively, and the statistical significance values of variables with unit root at 1%, 5% and 10%, respectively, are 30.44, 25.27 and 22.60 (Vogelsang 1997, pp. 824-825).

In the case of the EU countries, France, Germany and the United Kingdom show not to have statistically significant results (see Table 5). Nevertheless, all variables show to be characterized by structural breaks in the 1980s. In the case of France, however, PATFRAR shows a structural break in 1985 at a level of significance of 1%. In the case of Spain, both variables, PATSPAR and PARSPAN, show structural breaks in 1987 and 1988, respectively, at a level of significance of 1%. These results suggest that the new tendencies observed in relation to intellectual property regimes in the world since the 1980s, along with the establishment of the EPO in 1973, have influenced innovative activity in these countries.

Finally, further research should be developed at a level of industry for each of these countries to get insight on where patenting activity is concentrated. This approach would allow us to know whether the growth in patenting and innovative activities in North America and EU countries 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, Nelson and Walsh 2000; Hall 2005).

Table 5

European Union (EU) Countries Sequential Test of Structural Change				
Variable	Break Year	SupF$_t$	k	Level of Significance*
PATFRAR	1985	58.845	0	1%
PATFRAN	1985	12.644	1	
PATGERR	1984	6.960	1	
PATGERN	1984	6.960	1	
PATSPAR	1987	26.438	4	1%
PATSPAN	1988	91.240	4	1%
PATKINR	1984	22.461	3	
PATKINN	1986	19.544	4	

* The statistical significance values of stationary variables at 1%, 5% and 10% are19.90, 15.44 and 13.62, and the statistical significance values of variables with unit root at 1%, 5% and 10%, respectively, are 30.44, 25.27 and 22.60 (Vogelsang 1997, pp. 824-825).

5. Conclusions

This paper analyzes innovative activity by means of the number of patents granted to residents and non residents in North America and EU countries. The purpose 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. In the case of the North America countries, we suggest that such changes may come from the new dispositions adopted by the intellectual property regime in the United Sates and the TRIPS agreement. In case of the EU countries, such changes derived from the new realm characterizing intellectual property practices in these countries, along with the establishment of the EPO in 1973.

The results confirm the existence of structural breaks for almost all countries in the 1980s and the beginning of the 1990s. These results also suggest that the new features characterizing intellectual property regimes in the world, the TRIPS agreement, and the establishment of the EPO have influenced innovative activity in North America and Europe. However, the intensity and direction of these changes is rather different for each country in these regions.

Further research, however, should be done to get insight on what industrial sectors patenting activity is concentrated. Such an approach would allow us to

know whether the growth in patenting and innovative activities can be explained as a result of a more "fertile" hypothesis, or alternatively from a firms' patent strategy changes hypothesis.

References

Arundel, A. 2001. The relative effectiveness of patents and secrecy for appropriation. *Research Policy*: 30: 611-624.

Brouwer, E., and A. Kleinknecht. 1999. Innovative output and a firm propensity to patent: An exploration of CIS micro data. *Research Policy* 28: 615-624.

Cohen, W. M., and R. C. Levin. 1989. Empirical studies of innovation and market structure. In: Schmalensee, R., and R. D. Willing (eds.) *Handbook of Industrial Organization*. North-Holland: Amsterdam.

Cohen, W. M., R. R. Nelson, and J. P. Walsh. 2000. Protecting their intellectual assets: Appropriability conditions and why US manufacturing firms patent (or not). NBER Working Paper Series No. 7552.

De Rassenfosse, G., and B. van Pottelsberghe de la Potterie. 2007. Per un pugno di dollari: A first look at the price elasticity of patents. *Oxford Review of Economic Policy* 23: 588-604.

Deng, Y. 2007. The effects of patent regime changes: A case study of the European patent office. *International Journal of Industrial Organization* 25: 121-138.

Duguet, E., I. and Kabla. 1998. Appropriation strategy and the motivations to use the patent system: An econometric analysis at the firm level in French manufacturing. *Annales d'économie et statistique* 49: 289-327.

Encaoua, D., D. Guellec, and C. Martínez. 2006. Patent systems for encouraging innovation: Lessons from economic analysis. *Research Policy* 35: 1423-1440.

Hall, B. H. 2001. The global nature of intellectual property: Discussion. Discussion Paper, Industry Canada.

Hall, B. H. 2005. Exploring the Patent Explosion. *Journal of Technology Transfer* 30: 35-48.

Hall, B. H. 2007. Patents and patent policy. *Oxford Review of Economic Policy* 23: 568-587.

Jaffe, A. B., and J. Lerner. 2001. Reinventing public R&D: Patent policy and the commercialization of national laboratory technologies. *The RAND Journal of Economics* 32: 167-198.

Lanjouw, J. O., and I. M. Cockburn. 2001. New pills for poor people? Evidence after GATT. *World Development* 29: 265-289.

Levin, R. C., A. K. Klerovick, R. R. Nelson, and S. G. Winter. 1987. Appropriating the returns from industrial research and development. *Brookings Papers on Economic Activity* 3: 783-831.

Ng, S., and P. Perron. 1995. Unit root tests in ARMA models with data dependent methods for the selection of the truncation lag. *Journal of the American Statistical Association* 90: 268-281.

Nielsen, A. O. 2001. Patenting, R&D and market structure: Manufacturing firms in Denmark, *Technology Forecast and Social Change* 66: 47-58.

Peeters, C., and B. van Pottelsberghe de la Potterie. 2006. Innovation strategy and the patenting behavior of firms. *Journal of Evolutionary Economics* 16: 109-135.

Perron, P. 1989. The great crash, the oil price shock, and the unit root hypothesis. *Econometrica* 57: 1361-1401.

Perron, P. 1997. Further evidence on breaking trend functions in macroeconomics variables. *Journal of Econometrics* 80: 355-385.

Schumpeter, J. A. 1942. *Capitalism, Socialism and Democracy*. Harper: New York.

Scotchmer, S. 2004. The political economy of intellectual property treaties. *The Journal of Law, Economics & Organization* 20: 415-437.

Scotchmer, S., and J. Green. 1990. Novelty and disclosure in patent law. *The RAND Journal of Economics* 21: 131-146.

Sen, A. 2003. On unit-root test when the alternative is a trend-break stationary process. *Journal of Business and Economic Statistics* 21: 11-30.

Siegel, D. S., D. A. Waldman, L. E. Atwater, and A. N. Link. 2004. Toward a model of the effective transfer of scientific knowledge from academicians to practitioners: Qualitative evidence from the commercialization of university technologies. *Journal of Engineering and Technology Management* 21: 115-142.

Vogelsang, T. 1997. Wald-type tests for detecting breaks in the trend function of a dynamic time series. *Econometric Theory* 13: 818-849.