Journal of Economic Integration jei
Vol.33 No.2, June, 2018, 1337~1362
http://dx.doi.org/10.11130/jei.2018.33.2.1337

Nonlinear Effects of Intellectual Property Rights on Technological Innovation

Selma Ezzeddine
Management and Economics, Sfax University, Sfax, Tunisia
M.Sami Hammami
Management and Economics, Sfax University, Sfax, Tunisia

Abstract

This study investigates the influence of intellectual property rights on innovation under the assumption that an optimal threshold has been reached beyond which the protection by the Institute of Pacific Relations, the non-governmental organization, is no longer working as an incentive for innovation. We estimate a threshold model applied to panel data on 10 emerging countries for 1985~2015. The results revealed a significant influence of the threshold of the intellectual property rights on innovation. In other words, the impact of protection by the Institute of Pacific Relations on innovation is significant, which implies a nonlinear relationship. It was also shown to play an indirect role by increasing the impact of human capital and economic development on innovation. These results have important implications for designing economic policy. In the emerging country, a minimum level of protection by the institute of pacific relations is needed to ensure an incentive encouraging technological innovation. Therefore, there is an inverse-U relationship between the intellectual property rights and innovation.

* **Corresponding Author: Selma Ezzeddine;** Faculty of Economics and Management of sfax; Unit of Research in Development Economics, Sfax University, Sfax, Tunisia, Tel: 0021629154522 Email: selnaezzeddine@gmail.com

Co-author:Sami Hammami; Faculty of Economics and Management of sfax; Unit of Research in Development Economics, Sfax University, Sfax, Tunisia, Tel: 0021629154522 Email: sami_hammami2005@yahoo.fr

 pISSN: 1225-651X eISSN: 1976-5525

JEL Classifications: O3, O34, O5
Keywords: Protection of Intellectual Property Rights, Technological Innovation, Panel Threshold Model, Emerging Countries

I. Introduction

This study examines the influence of intellectual property rights on innovation. Following the agreement on Trade Related Intellectual Property Rights (TRIPS), all the member countries of the World Trade Organization (WTO) are urged to establish high standards of Intellectual Property Rights (IPR). Certainly, protection of intellectual property rights is a major incentive to innovate. However, problems arise when the extent of protection is undetermined. Then, what is the optimal level of IPR strengthening beyond which any increase in protection shows negative effects on innovation?

These issues underscore the nonlinear nature of IPR's influence on innovation. In other words, it is possible that the IPR system has a different impact on the conditional innovation at some threshold. This study aims to emphasize a possible nonlinear relation between IPR and innovation. Therefore, an econometric approach that takes account of nonlinearity must be considered. In fact, Hansen's threshold regression approach (2000) can meet these requirements. A threshold model applied to panel data covering 10 emerging countries (India, Brazil, Russia, China, South Africa, Indonesia, Saudi Arabia, Turkey, Mexico, Nigeria) is estimated. This study contribute that the empirical the empirical analysis differs from the extant literature in several aspects. First, earlier empirical research on the relationship between IPR and innovation, including those of Dalkal and Lars Hendrik (1989), Lach (1995), Park and Ginarte (1997), Thompson and Rushing (1996, 1999) Maskus and McDaniel and Crosby (2000), focus on the developed countries or on a group of developed and developing countries. This analysis offers new evidence on the emerging countries. Second, in contrast to several studies, a nonlinear relationship between IPR protection and innovation is assumed. The rest of the paper is organized as follows. Section II presents the theoretical framework of the effect of IPR on innovation. Section III presents a literature review. Section IV focuses on the empirical study by specifying the model and the data. Finally, Section V concludes.

II. Background

According to the Arrow model (1962), an innovator's profit diminishes by competition when there is imitation. Thus, deferring imitation through patent protection offers a stimulus for firms to invest in Research and Development (R&D). However, greater protection does not always increase the motivation to innovate. Levin *et al.* (1987) note that, "*because technological progress is often an interactive and cumulative process, strong protection of intellectual property rights can slow down general progress*." The semiconductor industry is often cited as an example in which the rapid progress witnessed in the 1950s and 1960s was hindered by strong IPR protection. Recent studies suggested a nonmonotonic relationship between the level of IPR protection and innovation. Moreover, they suggested an inverted U-shape relationship between patent robustness and innovation. This relationship may evolve between the lifetime of the patent and the rate of innovation. Cadot and Lippman (1995), applying a theoretical model, identified the nature of the relationship between the rate of innovation activity λ and and the length l of the the exogenous delay between the introduction of a new product or process and its imitation. This delay is explained by the time required for competitors to ascertain the innovation's commercial success and to develop the new product through reverse engineering. The time required to acquire the equipment necessary for the production is also another explanation. Delay l, which represents the time at the end of which innovation is imitated, is therefore an important determinant of the λ rate of innovation activity. They concluded that when imitation times are longer, the presence of an imitator increases the motivation to innovate. In other words, an innovator will choose a higher level of innovation effort than a monopolist when faced by competition.

However, the intensity of the effort of innovation is nonmonotonous with the duration of the entry. Increasing this delay beyond a threshold l_1 (> l_0) reduces the motivation to innovate, because for values of l higher than l_1, the longer delay relieves the innovator of the competitive pressure of imitation, which does not encourage the introduction of new product. Therefore, there is a non-monotonic relation between λ and l. Intermediate levels of imitation protection faced with imitation generate the highest volume of innovation activity. Horowitz and Lai (1996) consider the rate of innovation to be a product of the size of innovation and its frequency. The size of an innovation is a positive function of the lifetime of the patent, τ. If there is no imitation until the end of the patent expiry, the frequency of innovation is equal to l / τ. As a result, a long life of the patent has two opposite effects on the rate of innovation. It increases the size of the bonds, but helps them to occur less frequently. Hence, an increase of τ beyond a certain level has only incremental effects on the incentives to innovate. This relationship, which has an inverted U form, can also exist between the rate of innovation and the width of the patent (O'Donoghue and Zweimuller 2004). If an innovator has a patent on a quality property λ *, A width k means that all future innovations of quality $\lambda \in [\lambda^*, k \lambda *]$, for $k > l$, will infringe the patent holder's right. Increase in the k width has two contradictory effects on the motivations for conducting R&D. On the one hand, the patent holder enjoys strong marks and is more encouraged to engage in R&D activities. On the other hand, a new innovator has a weak position in negotiating with the existing patent holders at the beginning of the patent lifetime. Innovation covered by a new patent is likely to be based on existing patent rights, which are charged various license fees.

It is only at the end of the patent life, where the property rights of the competing inventions expire, that the new patent holder is in a strong negotiating position compared with the next generation of the patent holders. In this direction, the benefits of a patent are delayed. Therefore, a wider k increases the bargaining power of the current patent holders and reduces that of the new innovators, which reduces their incentives to engage in R&D.

In general, the benefit of R&D increases only if the benefits of a patent are not unduly delayed. Thus, R&D can have an inverted U relation with regard to the width (increase initially and decrease after *k* reaches a certain level). Shapiro (2000) states that the more robust the patent rights are, the stronger the incentive to file the patents will be. The more patents are granted, the more are the number of permissions that future innovators will seek to build on their own innovations. This increases the transaction costs of the licenses as well as the likelihood of blocking when the patent holders refuse to grant such authorizations to escape competition. These increasing transaction costs and blocking of patents will negatively affect R&D and innovation. Furukawa (2010) developed an endogenous growth model that explains the nature of the relationship between IPR protection and innovation. He showed that innovation and learning, as two growth engines, interact with each other to generate the inverted U-relation. In other words, while stronger IPR protection directly enhances the motivation to innovate, it discourages long-term innovation by eliminating the *learning by doing* process. He concludes that very strong or very weak IPR policies are likely to diminish innovation. Therefore, a moderate approach is preferable.

III. Literature Review

Several studies have analyzed the impact of the level of IPR protection on the level of innovation to determine whether IPR protection is a necessary condition for innovation and whether it is a linear or a nonlinear relationship.

A study of 50 countries was conducted by Varsakelis (2001) to analyze the factors that affect R&D activity. He found that patent protection is the most important factor affecting the intensity of the R&D. The result shows that a critical factor in the decision to invest in the R&D is the ability to create a monopoly advantage. It has critical impact on the design of economic policy, especially in the least developed countries. The government must adopt a strong patent protection framework to ensure the monopoly profits of the innovator. Lerner (2002) studied 177 patent reform events in 51 countries over a period of 150 years. The reforms include the enactment of patent laws, changes in the duration of the rights and fees, and limitations on the patent rights (e.g., compulsory licenses). On average, he found that the number of patents filed by residents before the reforms was not significantly different from that after the reforms.

Kanwar and Evenson (2003) investigated a sample of 29 countries over from 1981 to 1990. In the estimated equation, they introduced the IPR index and its squared term to test the hypothesis of a nonlinear relationship between IPR protection and innovation as measured by investment in the R&D. They also showed that IPR protection promotes technological change in monotonously since the coefficients relating to the IPR index and its square are positive. These results imply that the lack of a stimulating structure can be a significant factor that impedes technological change.

Chen and Puttitanun (2005) conducted a study of 64 Patent Examiner Data Systems (PEDs) from 1975 to 2000. They showed that innovations in the developing countries increase with increasing IPR protection.

Branstetter *et al.* (2006) examined the patent reforms in 12 PEDs between 1982 and 1999. They found that the reforms did not mention significant responses in the filing of patents by the residents. Kanwar (2007) used data from 44 developing and developed countries from 1981 to 2000. He found that the robustness of protection has a large positive influence on the R&D spending.

Qian (2007) assessed the influence on patent protection on innovations in the pharmaceutical sector in 26 countries from 1978 to 2002. He found there is an optimal level of IPR regulation beyond which innovation activities decline. In fact, the author concluded that a relationship in the form of an inverted U exists between the level of protection of IPR and innovation.

Based on this literature review, which assert a nonlinear relationship between IPRs and innovation, we assume that intellectual property rights' level of protection has a nonlinear effect on technological innovation taking the form of an inverted U-relation.

IV. Data and Methodology

A. Data source

This study analyzed a data set of 10 emerging countries (India, Brazil, Russia, China, South Africa, Indonesia, Saudi Arabia, Turkey, Mexico, Nigeria) from 1985 to 2015. The variables were divided into primary and control groups. The primary group considered innovation and intellectual property rights. With regard to innovation, there are two main methods of measurement: (i) the R&D expenditure and (ii) the number of patents. As the empirical study requires a large time-series dataset that includes the emerging countries, it uses the number of US patents per capita granted to the residents of a given country each year. To avoid a selection bias for US innovations, this study follows previous studies of Porter and Stern (2000) and excludes United States from the dataset. Thus, this study attempted to use the same data as those of previous studies to ensure a degree of comparability with regard to the choice and definition of the control variables. As regards the other primary variables, this study measured the IPR using the index developed by Ginarte and Park (1997) and updated by Park (2008b). Note that the IPR index is a constructed and not a “measured variable.” As mentioned earlier, it is based on Ginarte and Park’s approach, which is believed to be the best method to understand its subjective nature. The choice of the control variables is based on the existing literature. Using the Barro and Lee (2010) dataset, this study defines human capital as the percentage of the total enrollment among the school-aged population over 15 at the tertiary level (*EDUC*). In addition, openness is found to be a source of knowledge and technology transfers (Porter and Stern 2000); openness (*OPEN*) is defined as the total trade.

Table 1. Data source

Variables	Definition	Source
Dependent variable		
Innovation	Average number of US patents per capita granted to residents of a given country for each year *t*	United States Patent and Trademark (USPTO)
Independent variable		
Ginarte and Park index (IPR)	Level of IPR protection every 5 years	Ginarte and Park (1997), Park (2008b)
GDP per capita	The average annual GDP per capita	World Bank Development Indicators
Education	The percentage of the total school-age population of more than 15 at the tertiary level	Barro and Lee (2010)
OPEN	Total exports and imports as% of annual GDP	World Bank Development Indicators

(Note) IPR: Intellectual Property Rights

This study uses the Ginarte and Park (GP) index developed for each country. Using the coding system according to their national patent laws to cover all aspects of intellectual property rights, the GP index adopts five broad categories.

Table 2. Construction of the Ginarte–Park index

1	**Extent of Coverage**	Yes	No
	Patentability of Chemicals and Pharmaceuticals	1	0
	Patentability of Textiles, Paper and Metallurgy	1	0
	Physics and Electricity	1	0
	Mechanical Engineering, Lighting, Heating, Weapons	1	0
	Fixed Constructions	1	0
	Patentability of Food	1	0
	Patentability of Surgical products	1	0
	Patentability of Microorganism	1	0
2	**Membership in International Patents Agreements**		
	TRIPS Agreement	1	0
	Paris Convention	1	0
	Patent Cooperation Treaty (PCT)	1	0
3	**Provisions for the Loss of Protection**		
	Working Requirements	1	0
	Compulsory Licensing	1	0
	Revocation of Patents	1	0
4	**Enforcement Mechanisms**		
	Preliminary Injunction	1	0
	Contributory Infringement	1	0
	Burden-of-Proof Reversal	1	0
5	**Duration of Protection**	Value	
	Application-based Standard		
	$x \geq 20$ years	1	
	$0 \geq x < 20$	$x / 20$	
	Grant-based Standard		
	$x' \geq 17$ years	1	
	$0 \geq x' < 17$	$x' < 17$	

(Note) PCT: Patent Cooperation Treaty
(Source) See Ginarte and Park (1997) for explanations of the categories and features.

http://dx.doi.org/10.11130/jei.2018.33.2.1337

B. Methodology of Panel Threshold Model

This study explains the technological innovation by the level of protection of IPR and other control variables. To account for the nonlinear effect of the IPR innovation system, it uses a Panel Threshold Regression (PTR) model developed by Hansen (1999).

The Hansen (1999) threshold model consists of estimating the following relation:

$$Y_{i,t} = \alpha_i + \beta_1\ X_{i,t},tI(D_{i,t}+\gamma) + \beta_2 X_{i,t} I(\mathrm{D}_{i,t} > \gamma\ )\varepsilon_{i,t} \tag{1}$$

The average number of US patents per capita (*innovation*) was chosen as the dependent variable. The threshold variable (*Di, t*) is GP index of IPRs, which is the key variable used to verify whether a threshold effect of IPR on innovation exists.

Γ refers to a threshold parameter, (I) is an indicator function that takes value 1 if the value of the intellectual property rights (*Di, t*) is below a specified threshold value, and 1 otherwise.

This methodology aids in dividing the study sample into two regimes based on whether the threshold variable is above or below the estimated threshold. The two regimes are distinguished by different regression slopes, *β1* and *β2*. Therefore, the regression equation for a single threshold can be written in two equations:

$$Y_{it} = \alpha_i + \beta_1 X_{i,t} + \varepsilon_{i,t} \qquad if \quad D_{it} \leq \gamma \tag{2}$$

$$Y_{it} = \alpha_i + \beta_2 X_{i,t} + \varepsilon_{i,t} \qquad if \quad D_{it} > \gamma \tag{3}$$

where the first represents the speed below the threshold and the second the speed above the threshold.

Equation (1) in the first step is estimated using Ordinary Least Square(OLS) to identify the threshold. The sum of square error S_1 is calculated next for all the possible values of the threshold variable.

$$S_1(\gamma)=\varepsilon(\gamma)'\varepsilon(\gamma)$$

In the second step, the threshold parameter is obtained by minimizing S_1, such that

$$\gamma = argminS_1(\gamma)$$

On estimating the endogenous threshold, it is essential to check whether its effect is statistically significant. The null hypothesis of this test is presented as follows:

$$\text{H0} : \beta 1 = \beta 2$$
$$F_1 = (S_0\text{-}S_1\ (\gamma))\ /\ \sigma^2$$

S_0 and S_1 are the sum of the square errors under the null and alternative hypotheses. Since the threshold value is not identified in H0, the asymptotic distribution of F is not standard. As a solution, Hansen (1999) proposed a bootstrap method to simulate the p-value for F_1 statistics.

Thus, the threshold model in this study that of Hansen (1999), which consists in estimating the following relation:

$$Innov_{i,t} = \alpha_i + \beta_1 X_t, tI(D_{i,t}<\gamma) + \beta_2 X_{i,t}1(D_{i,t} >\gamma) + \varepsilon_{i,t}$$

The dependent variable $Y_{it:}$ is the average number of US patents issued to the per capita residents (innovation).

D_{it} is the threshold variable of country i at date t, which measures the index

http://dx.doi.org/10.11130/jei.2018.33.2.1337

of the protection of the IPR developed by Park and Ginarte (1997). This index is between 0 and 5, where a high index reflects a higher level of protection, as explained earlier, and how to build it. γ is the threshold value (DPI value); (I) is an indicator function, which takes value 1 if the condition in parentheses is respected and 0 if not.

X represents a vector of the control variables, such as education, trade openness, FDI / GDP, and GDP per capita.

For empirical analysis, our study uses a descriptive analysis that clarifies and describes the data characteristics and measurements of the sample.

V. Empirical Results

Table 3 indicates a summary statistics. It presents information on the average level of the standard deviation, the minimum and maximum of the variables of research for all the countries of the sample. While the average number of US patents issued is high (550.4317), that of the other countries reached its maximum (18040).

Table 3. Descriptive statistics

Variables	Mean	Standard Deviation	Minimum	Maximum
Innovation	550.4317	1905.245	1	18040
IPR	2.837714	1.287642	0	4.76
GDP per capita	4590.14	3832.471	335.3974	16972.32
Education	22.34906	18.87479	2.47547	78.98195
Open	54.31334	25.22903	3.964631	102.3765

(Note)IPR: Intellectual Property Rights
GDP: Gross Domestic Product

The index of the IPR protection is on average equal to 2.83% in the emerging countries. A high margin of dispersion indicates the variations and fluctuations of this index from one country to another. The maximum percentage of the protection of innovations is equal to 4.76% in some emerging countries, while that of the other countries is zero. Finally, one can see that the explanatory variables of this model show many variations.

Table 4. Correlations

	Innovation	*IPR*	*GDP per capita*	*Education*	*Open*
Innovation	1				
IPR	0.3470*(0.003)	1			
GDP per capita	−0.0939(0.104)	0.1663(0.168)	1		
Education	0.0711(0.219)	0.3690*(0.001)	0.3866*(0.000)	1	
Open	−0.0144(0.804)	0.3791*(0.001)	0.3031*(0.000)	0.3279*(0.000)	1

(Note)IPR: Intellectual Property Rights
GDP: Gross Domestic Product

Multicollinearity can falsely identify the estimation of the regression coefficients at low fluctuations of the data which make it unstable and difficult to interpret(Bourbonnais 2009). Therefore, the correlations matrix is further elucidated. Pearson's correlation matrix shows a strong correlation between the *Education* variable and *IPR*, which implies the importance of higher education in the valuation of R&D. It helps to transform scientific knowledge into commercial outputs and to protect them through IPR. Similarly, the correlation between the percentage of higher education and the *GDP per capita* variable is strong and significant at 1%. Thus, it is argued that education is a fundamental vector for the creation and stimulation of economic growth.

http://dx.doi.org/10.11130/jei.2018.33.2.1337

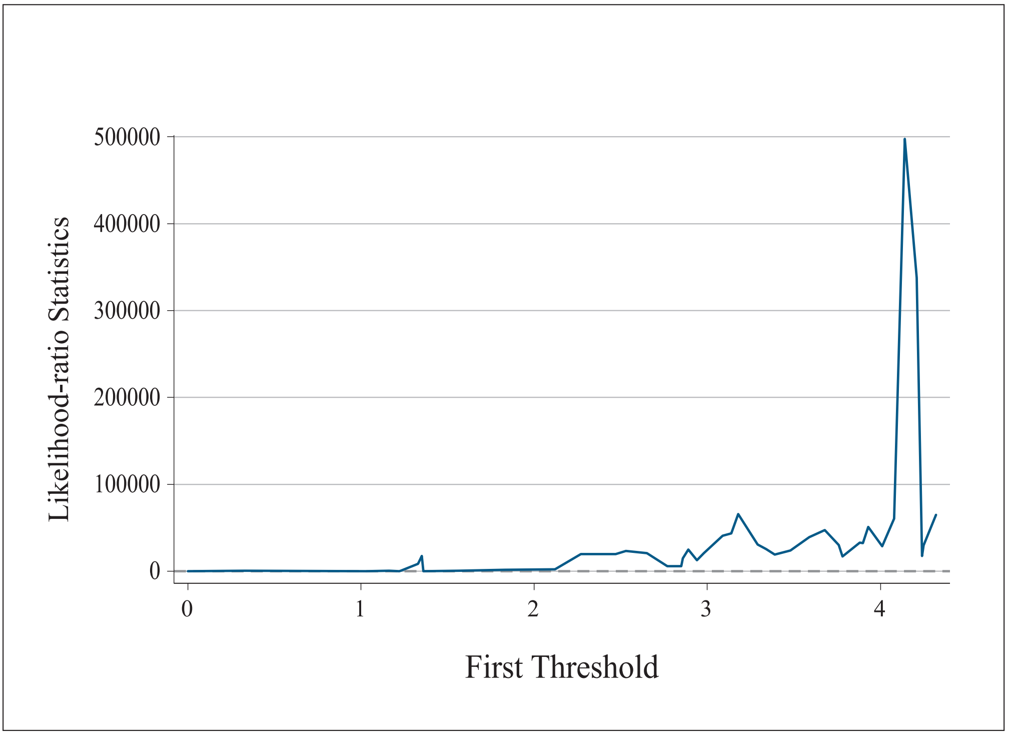
Table 5. Tests for threshold effects

Single threshold effect test	
Threshold value	1.2200
F_1	114.44
p-value	0.000
Critical value of *F* 10%,5%,1%	(11.4233;13.3379;15.7027)
Double threshold effect test	
Threshold value	1.2200;1.5600
F_2	−6.86
p-value	0.1780
Critical value of *F* 10%, 5%, 1%	(2.9988;14.6031;34.7669)
Triple threshold effect test	
Threshold value	1.0300;1.2200;1.5600
F_3	−66.03
p-value	0.4760
Critical value of *F* 10%, 5%, 1%	(0.000;0.000;5.0935)

(Note) *p*-value: probability value

Table 5 presents the test statistics F_1, F_2, and F_3, along with their bootstrap *p*-values. It is found that the tests for a double-threshold F_2 and a triple-threshold F_3 are insignificant with a bootstrap *p*-value of 0.178 and 0.74, respectively. Only the test for a single-threshold F_1 is significant with a bootstrap *p*-value of 0.000. Thus, the study concludes that IPR have only one threshold effect on innovation in a country. The point estimate of the threshold (γˆ1) is 1.2200 and the asymptotic confidence interval is [1.1600; 1.2300]. Figure 1 shows more information on the threshold estimate from plot of the concentrated likelihood ratio function LR1 (γ).

Figure 1. Plot of first threshold



(Note) LR Statistics: Likelihood-ratio test
(Source) STATA

Figures 1 indicates the estimates of the thresholds of the likelihood ratio function. Point estimates are the values from which the likelihood ratio reaches the 0 axis, which is seen in the end of left part. Therefore, the likelihood ratio is below the dotted line.

Table 6. Estimation of the Panel Threshold Regression model

Dependent variable : The average number of patent				
Independent variable	Regime1 (*DPI≤ 1.2200*)		Regime 2 (*DPI>1.2200*)	
	Coefficient	*T*-Statistics	Coefficient	*T*-Statistics
Intellectual Property Rights	1.1930	0.000 ***	1.8103	0.000 ***
GDP per capita	0.0300	0.000 ***	0.0007	1
Education	0.0040	0.0046 ***	0.0022	0.0277 **
Open	0.0111	0.317	−0.0060	0.774
Confidence Interval	[1.1600, 1.2300]			
F_1 statistic bootstrap value	0.000			

This study assumes that there is a threshold effect of the IPR index on innovation. It is important to determine if this threshold effect is statistically significant. The null and the alternative hypotheses can be represented as follows:

$$\begin{cases} H0 : \delta = \theta \\ H1 : \delta \neq \theta \end{cases}$$

When the null hypothesis is accepted, coefficient $\delta = \theta$; therefore, the threshold effect does not exist. When the alternative hypothesis is retained, coefficient $\delta \neq \theta$; hence, there is a threshold effect of the IPR index on innovation.

Table 6 shows that the threshold effect is significant at 1% (p-value = 0.0000). The threshold divides the observations into two regimes. The existence of nonlinear effects is confirmed by a positive and highly significant coefficient of the threshold variable.

The threshold value of the DPI index (γ) is equal to 1.22% When the IPR index is less than or equal to 1.22%, the IPR coefficient is positive (1.1930) and significant. The same results can be applied to the second regime, so it can be said that IPR positively affects technological innovation in case of both lower and upper threshold. From the moment that δ and θ are both significant, the influence of IPR protection on innovation is significant regardless of the level of protection below or above the threshold.

The study results corroborate those found by Kanwar (2007), Kanwar and Evenson (2003), and Chen and Puttitanun (2005). The GDP per capita is significant in the first regime, but not in the second. Therefore, it is also an important indicator in the process of innovation. The percentage of higher education is significant in the first threshold (0.0046), while it has a positive and significant effect on the second threshold. However, trade openness is negative for the second regime and not significant in both regimes. Higher education is highly significant and positively impacts technological innovation as a second variable influencing the protection of innovation; therefore, the highest levels of education encourage innovation.

The effect of the control variables of our model is similar to that found in the related studies. Jaunotte (2005), Park (1997), and Ortega and Derman (2010) showed that the interactions between the stock of the human capital and IPRs determine the overall balance of the R&D effort, and IPR tends to increase the effect of education on innovation.

These results examine that, to stimulate innovation in the emerging countries, a combination of a high level of IPR protection with the human capital factor (% of higher education) is required. This is not effective when the country has a low level of IPR protection. However, the gain in innovation would be considerably higher as the GDP per capita increases. In this case, the high level of GDP per capita is considered as an incentive for the protection of innovation (Lerner 2009 and Qian 2007).

However, several studies have found that to explain the effect of IPR on innovation, it is necessary to concentrate exclusively on the level of economic development. Allred and Park (2007), Chen and Puttitanum (2005), Ginarte and Park (1997), and Schneider (2005) also emphasized the existence of a second variable, which shows that IPRs have a fundamental impact on innovation. In fact, there is a "*U inverse*" relationship between the optimal strength of the intellectual property regime and innovation.

This relationship might vary because of other important factors such as the level of economic development and the level of education, as stated by Stiglitz (2008): "*IPRs should be considered as part of an instrument portfolio. Therefore, we need to strengthen the other elements of this portfolio and know our intellectual property regime to increase its benefits and reduce its costs, which means that the increase the economy efficiency is very likely to increase the pace of innovation*."

Trade openness not only enables a greater potential market but it is also a possible source of knowledge transfer, which implies increased competition (Eaton and Kortum 1996), which in turn may reduce the incentive to innovate. Protection of innovations helps renew the design and the role of IPRs in innovation for public authorities in the emerging countries. While IPR protection does not play a direct role as an incentive for innovation in the emerging countries, this factor should not be ignores, but it must occupy a central place in the policy of promoting innovation due to the importance of the human capital for research and development as well as for economic development.

VI. Conclusion

In this study, we have shown that the strengthening of IPR has a complex effect on innovation, in terms of both signs and magnitude, which reflects higher levels of both education and high per capita GDP.

These indicators are encouraging factors and IPRs for protection of technological innovation. The importance of the IPR system, however, appears in association with the education factor. The main result supports that of Ortega and Lederman (2010), which states that the interactions between the stock of the human capital and IPRs determine the overall balances of R&D effort, and the IPRs tend to increase the effect of education on innovation.

From innovation perspective, countries should shift their IPRs to the point where innovation is maximized. On the other hand, countries with relatively high levels of IPRs should support an economic policy of preserving IPRs because they stimulate innovation. These results have important theoretical and practical implications. First, the significant presence of the threshold effect calls into question the relevance of any econometric specification presupposing a linear relationship between IPR protection and innovation.

Second, IPRs are one of the essential elements required to promote innovation and growth. Therefore, to realize its full potential, IPRs need to be supported by other country-specific characteristics, including sound economic management, an institutional environment, and regulatory and judicial reforms. IPR regimes have been strengthened when countries have become important producers of innovation and new technologies. The studies reviewed and the findings of the study indicate that strengthening IPRs could lead to more international economic activity, but that these effects would be contingent on country-specific conditions.

However, global policy tends not to move toward a progressive strengthening position for all but for a single minimum standard. Considering the *optimal* level of IPRs, it must be recognized that IPR policies can have other impacts on the economy and social well-being than on innovation policies. In the long run, it is also necessary to be aware that innovation can have on different economic indicators. Consequently, we are no longer confronted with a unique and optimal level of IPRs for each country. Therefore, stronger IPRs may have both positive and negative effects on the economy, but the net effect depends on economic and political institutions and, more importantly, on the ability to engage and disseminate the achievements of R&D.

Received 18 January 2018, Revised 31 March 2018, Accepted 30 April 2018

http://dx.doi.org/10.11130/jei.2018.33.2.1337

References

Ginarte, J. C., & Park, W. G. "Determinants of patent rights: A cross-national study". *Research policy*, 26 (3), (1997): 283-301.

Lerner, "J. L'impact empirique des droits de propriété intellectuelle sur l'innovation: puzzles et indices". *The American Economic Review*, 99 (2), (2009) : 343-348.

Qian, "Y. Les lois nationales sur les brevets stimulent-elles l'innovation nationale dans un environnement de brevets mondial? Une analyse transnationale de la protection des brevets pharmaceutiques, 1978-2002". *The Review of Economics and Statistics*, 89 (3), (2007) : 436-453.

Allred, BB, & Park, WG. "Droits de brevet et activité innovante: éléments de preuve provenant de données nationales et de niveau d'entreprise". *Journal of International Business Studies*, 38 (6), (2007): 878-900.

Schneider, P. H. "International trade, economic growth and intellectual property rights: A panel data study of developed and developing countries". *Journal of Development Economics*, 78 (2), (2005): 529-547.

Eaton, J., & Kortum, S. "Measuring technology diffusion and the international sources of growth". *Eastern Economic Journal*, 22 (4), (1996): 401-410.

Aboites, J and Cimoli, M. "Intellectual property rights and national innovation systems –some lessons from the Mexican experience", *Revue d'Economie Industrielle,* 99, (2002): 215-232.

Aghion, P and Howitt, P. "A model of growth through creative destruction", *Econometrica,* 60, (1992): 223-351.

Arrow, K. "Economic walfare and the allocation of resources for invention", p 609-626, In "The rate and direction of inventive activity: economic and social factors", Universities- National Bureau (eds) UMI. (1962)

Arrow, KJ. “The economic implications of learning by doing”, *The Review of Economic studies*, 29 (3), (1962): 155-173.

Bresnahan, T and Trajtenberg, M., “General purpose technologies: “engines of growth?”, *Jounal of Econometrics,* 65, (1995): 83-108.

Castellacci, F. “Evolutionary and new growth theories. Are they converging?”, *Jounal of Economic Surveys,* 21 (30), (2007): 585-627.

Chaminade, C and Edquist, C. “Rationales for public policy intervention from a systems of innovation approach: the case of VINNOVA”, *CIRCLE Electronic Working Paper Series,* n°2006/04. (2006)

Chen, Y and Puttitanum, T. “Intellectual property rights and innovation in developing countries”, *Journal of Development Economics,* (78) (2005): 474-493.

Chin, JC and Grossman, GM. “Intellectual Property Rights and North-South” In: Jones, R.W., Krueger,A. (eds), The political economy of international trade: essays in Honor Robert F. Baldwin; Blackwell, Cambridge, MA. (1990)

Crosby, M. “Patents, innovation and growth”, *Economic Record,* (76), (2000): 255-262.

Dcolalikar, A. and Lars-Hendrik, R. “Patenting by manufacturing firms in India: its production and impact”, *Journal of Industrial Economics,* (37), (1989): 303-314.

Deardorff, AV. “Welfare Effects of Global Patent Protection”, *Economica,* 59 (233), (1992): 35-51.

Diwan, I and Rodrik, D. “Patents, appropriate technology, and north-south trade”, *Journal of International Economics,* 30 (1-2), (1991): 27-47.

Forero-Pineda, C. “The impact of stronger intellectual property rights on science and technology in developing countries”, *Research Policy,* 35, (2006): 808-824.

Gilbert, R and Newbery, DMG. "Preemptive Patenting and the Persistence of monopoly”, *The American Economic Review,* 72, (1982): 514-526.

Grossman, GM and Helpman, E. “Comparative advantages and long run growth”, *American Economic Review,* 80, (1990): 796-815.

Grossman, GM and Helpman, E. “Quality ladders in the theory of growth”, *Review of Economic Studies,* 58, (1991): 86-91.

Hansen, B.E. “Sample splitting and threshold estimation”, *Econometrica*, 68, 3, (2000): 575-603.

Hauknes, J and Nordgren, L. “Economic rationales of government involvement in innovation and the supply of innovation-related services”, *STEP Report*. (1999)

Hu, MC and Mathews, JA. “National innovative capacity in East Asia”, *Research Policy,* 34, (2005):1322-1349.

Kanwar, S and Evenson, RE. “Does intellectual property protection spur technological change?”, *Oxford Economic Papers,* 55 (2), (2003): 235-264.

Kanwar, S. “Business enterprise R&D, technological change, and intellectual property protection”, *Economics Letters,* 96, (2007): 120-126.

Lach, S. “Patents and productivity growth at the industry level: a first look”, *Economics Letters,* 49, (1995): 101-108.

Langinier, C and Moschini, G. “The economics of patents: an oveview”. *In “intellectual property rights and patenting in animal breeding and genetics” edited by Scott Newman and Max Rothschild.* (2002)

Langlois, RN and Robertson, PL. “Stop crying over spilt knowledge: a critical look at the theory of spillovers and technical change", *Economics Working Papers*, n°1996/06. (1996)

Levin, RC., Klevorick, AK., Nelson, RR. and Winter, SG. "Appropriating the returns from industrial research and development", *Brookings Papers on Economic Activity,* 87, (1987): 783-831.

Lin, C., Lin, P. and Song, F. "Property rights protection and corporate R&D: evidence from China", *Journal of Development Economics,* 93, (2010): 49-62.

Lo, S. "Strengthening intellectual property rights: experience from the 1986 Taiwanese patent reforms", *International Journal of Industrial Organization,* (2011): 1-13.

Lucas, R. "On the mechanics of economic development", *Journal of Monetary Economics*, 22, (1988) : 3-42.

Malerba, F. "Sectoral systems of innovation and production", *Research Policy*, 31 (2), (2002): 247-264.

Maskus, KE and Penubarti, M., "How trade related are intellectual property rights?", *Journal of International Economis,* 39, (1995): 227-248.

Maskus, KE. "The economics of intellectual property rights and globalization: dancing the dual distortion. In Maskus, K.E. (eds), *Intellectual property rights in the global economy*. Institute for International Economics. Washington, DC, 296. (2000)

Maskus, KF and McDaniel, C. "Impacts of the Japanese patent system on productivity growth", *Japan and the World Economiy,* 11, (1999): 557-574.

Metcalfe, JS and Georghiou, L. "Equilibrium and evolutionary foundations of technology policy", CRIC discussion paper, n°3. (1998)

Metcalfe, S and Ramlogan, R. "Innovation systems and the competitive process in developing economies", *The Quarterly Review of Economics and Finance,* 48, (2008): 433-446.

Moschini, G. "Intellectual property rights and the world trade Organization: retrospect and prospects", in Anania, G Bohman, M Carter C., and McCalla, A, eds, agricultural policy reform and the WTO: where are we heading? Edward Elgar Publishing. (2004)

Park, WG. "International patent protection: 1960-2005", *Research Policy,* 37, (2008): 761-766.

Park, WG. and Ginarte, JC. "Intellectual property rights and economic growth", *Contemporary Economic Policy,* 15, (1997): 51-61.

Primo Braga, C., Fink, C. and Paz Sepulveda, C. "Intellectual property rights and economic development", *World Bank Discussion Paper,* 412. (2000)

Romer, P. "Increasing returns and long run growth", *Journal of Political Economy*, 94, (1986): 1002-1037.

Romer, P. "Endogenous technological change", *Journal of Political Economy*, 98, (1990):71-102.

Schneider, PH. "International trade, economic growth and intellectual property rights: a panel data study of developed and developing countries", *Journal of Development Economics,* 78, (2005): 529-547.

Schulz, M and Jobe, L. "Codification and tacitness as knowledge management strategies an empirical exploration", *Journal of High Technology Management Research,* 12, (2001): 139-165.

Segerstrom, PS. "Innovation, imitation and economic growth", *Econometrics and Economic Theory Paper,* n° 8818. (1990)

Silverberg, G and Verspagen, B. "Learning, innovation and economic growth: a long run model of industrial dynamics", *Industrial and Corporate Change,* 3, (1994 a): 199-223.

Taylor, MS. "TRIPS, trade and technology transfer", The Canadian *Journal* *of Economics,* 26 (3), (1993): 625-637.

Taylor, MS. "Trips, trade and growth", *International Economic Review,* 35 (2), (1994): 361-381.

Thompson, MA and Rushing, F. "An empirical analysis of the impact of patent protection on economic growth and extension", *Journal of Economic Development,* 24, (1999): 67-76.

Varsakelis, N. "The impact of patent protection, economy openness and national culture on R&D investment: a cross country empirical investigation", *Research Policy,* volume 30, (2001): 1059-1068.

Winter, S. "Schumpeterian competition in alternative technological regimes", *Journal of Economic Behavior and Organization*, (5), (1984): 137-158.

Woolthuis, RK., Lankhuizen, M. and Gilsing, V., "A system failure framework for innovation policy design", *Technovation,* 25, 6 (2005)

Lundvall, B. Å. Systèmes-analyse nationaux d' innovation concept et outil de développement. *Industrie et de l' innovation*, 14 (1), (2007): 95-119.

Akiyama, T., & Furukawa, Y. Intellectual property rights and appropriability of innovation. *Economics Letters*, 103(3), (2009)

Furukawa, Y. Intellectual property protection and innovation: An inverted -U relationship. *Economics Letters*, 109(2), (2010)

Branstetter, L., Fisman, R., & Foley, F. Do stronger intellectual property rights increase international technology transfer? Empirical evidence from U.S. firm-level data. *Quarterly Journal of Economics*, 121(1), (2006): 321-349.

Chen, Y., & Puttitanun, T. Intellectual property rights and innovation in developing countries. *Journal of Development Economics*, 78(2), (2005): 474-493.

Falvey, R., Foster, N., & Green away, D. Intellectual property rights and economic growth. *Review of Development Economics*, 10(4), (2006): 700-719.

Yang, G and Maskus, KE. “Intellectual property rights, licensing, and innovation in an endogenous product - cycle model”, *Journal of International Economics*, 53, (2001): 169-187.