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Non-Linear Effects of Intellectual Property Rights on Innovation: Evidence from Developing Countries

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ABSTRACT: *This paper investigates the possibility of non linear effects of intellectual property rights (IPR) on innovation. It examines whether the impact of intellectual property rights on technological innovation is different for countries with different levels of GDP. Our methodological approach is based on estimating a threshold model applied to panel data on 43 developing countries for (1980-2009) period. The paper discovers a threshold level of economic development such that for countries whose economic development is below this level, tighter intellectual property rights have a negative impact on technological innovation, while for countries with economic development above this level, tighter intellectual property rights have a positive impact on technological innovation.*

KEYWORDS*: intellectual property rights, innovation, developing countries, economic development, threshold regression.*

I. INTRODUCTION

Technological innovation is crucial for economic growth. However, the industrial sector underinvests in research and development (R&D) because of problems associated with weak appropriability of innovation benefits. The protection of intellectual property rights (IPR) is a mechanism used to cope with these problems.
The patent, an exclusive right granted for an invention, affects innovation primarily through its effects on the rate of imitation. The model of [1] points that the profits of the innovator decline due to competition when imitation occurs. The protection of ideas through robust IPR prevents imitation. Therefore, it ensures return on investment. IPR system promotes the generation of new knowledge in this case. However, it is not clear that stronger protection always increases the motivation to innovate. Recent theoretical works suggest that IPR protection stimulates innovation only under certain conditions. Maskus (2005) points out that stronger IPRs need to be introduced into markets in which other competitive processes, such as firm entry, labour flexibility, distribution systems, and international trade, are already developed to a certain level. Otherwise the IPRs may have no effect or even be associated with negative effects on the economy. [3] noted that robust IPR are unlikely to promote R&D in developing countries due to several obstacles such as low level of human capital, lack of physical capital, poor institutions and economic uncertainty. [4] showed that the early stages of development that are associated with low levels of human capital are associated with great confidence to technological imitation. Whereas at later stages of development, skills allow the emergence of innovations. The objective of this study is to investigate the effect of intellectual property rights on innovation. It aims to highlight non linear effects in the relationship between IPR and innovation according to the initial level of economic development. This issue is becoming increasingly important especially in the context of developing countries. In fact, further to the Trade Related Intellectual Property Rights Agreement (TRIPS), all member countries of the WTO are required to achieve high standards of IPR.

Studies focusing on the link between IPR and innovation suffer from several limitations. For example, [5] and [6] considered a linear relationship between the two variables. Second, even if other studies deal with the problem of linearity, they did not allow a direct role of economic development level on innovation / IPR elasticity ([7] and [8]). [9] intended to illustrate the direct effect of economic development level on the link between IPR and innovation. They conducted a study for 64 developing countries covering (1975-2000) period. The authors found that the positive impact of IPRs on innovation increases with the level of economic development. However, the authors use a simple first-order polynomial interaction term (between IPR and the GDP level) to account for the nonlinear influence of GDP. This method is criticized for an ex-ante specification of the shape of the relation. To test whether the initial level of economic development exerts a nonlinear influence on the relationship IPR / innovation and to address the problems of previous studies, we will opt for model with threshold effects of [10]. Our methodological approach is based on estimating a threshold model applied to panel data on 43 developing countries for (1980-2009) period.

The remainder of this paper is organized as follows: Section 2 describes the methodology and presents the dataset. In section 3, we present the results followed by a conclusion in section 4.

II. METHODOLOGY

Sample description: This study includes 43 developing countries. These countries are members of World Trade Organisation (WTO). Appendix lists the names of these 43 countries.
The study uses data in the period of 1980-2009.

Data: We use the number of USPTO granted patents to developing countries as our measure of innovation, denoted by **PAT**. To measure protection degree of intellectual property rights (**IPR)**, we use the GP index, a commonly used measurement of intellectual property rights protection developed by [11]. They examined the patent laws of a comprehensive number of countries, considering five components of the laws: duration of protection, extent of coverage, membership in international patent agreements, provisions for loss of protection, and enforcement measures. The index scale ranges from 0 to 5, with higher numbers reflecting stronger levels of protection. Since it is a quinquennially index, we have collected the other variables in this study in every 5 years for the 1980–2009 period. To measure the level of economic development, we use per capita GDP, denoted by **GDP**. The data on PPP converted GDP per capita, at 2005 constant prices come from Penn World Table. Initial levels of economic development for (1980-2009) are GDP for initial year of each period. They are GDP for years 1980, 1985, 1990, 1995, 2000 and 2005. Three control variables are used in this study. To measure the education variable, **EDUC**, we use educational attainment for population aged 15 and over at the tertiary level. These ratios are collected from Barro and Lee database. We have data on measures of economic freedom, **EFREE**, from www.freetheworld.com. The freedom index ranges from 0 to 10, with a higher index indicating a higher level of economic freedom. Technology transfer from developed countries is measured by international trade volume as a percentage of GDP (**TRADE**) and Data for this variable are from Word Development Indicators. All variables are in natural log.
Summary statistics for the six variables are given in Table 1.

Table 1: Summary statistics

	Mean	Median	Stand. Dev	Minimum	Maximum
PAT	6.08	0.8	0.98	0	150.2
IPR	2.1	1.92	0.05	0.2	4.275
GDP	4262.55	3557.9	183.25	323.26	12472.58
EDUC	6.85	5.8	0.33	0.1	27.2
EFREE	5.72	5.79	0.06	2.3	7.66
TRADE	72.09	60.4	2.44	12.87	226.87

Panel Threshold Model

According to [10], we construct the single threshold model as follows:

$$Y_{it} = \alpha_i + \beta X + \delta c_{it} * I(d_{it} \leq \gamma) + \theta c_{it} * I(d_{it} > \gamma) + \varepsilon_{it} \quad (1)$$

Y_{it} represents dependant variable (PAT), c_{it} is intellectual property rights (GP index), d_{it} is the threshold variable: the initial level of economic development (GDP); and γ is the estimated threshold value. X is a vector of four variables: GDP, EDUC, EFREE, TRADE. α_i: the fixed effect which represents the heterogeneity of companies under different operating conditions. I(.) is an indicator function. The error term ε_{it} is independent and identically distributed with zero mean and finite variance o^2. The subscript i stands for the cross-sections (i = 1, 2,…43) and t indexes time (t = 1, 2,…6).
Specification (1) highlights two regimes: one regime for which the variable d_{it} is less than or equal to the threshold γ and a second regime for which the variable d_{it} is greater than the threshold γ. Our equation (1) can be rewritten as follows:

$$\begin{cases} Yit = \alpha_i + \beta X + \delta d_{it} & \text{if } d_{it} \leq \gamma \quad (2) \\ Yit = \alpha_i + \beta X + \theta d_{it} & \text{if } d_{it} > \gamma \quad (3) \end{cases}$$

To estimate this model, we first eliminate the individual effect α_i using the within transformation estimation techniques in the traditional fixed effect model of panel data. By using the ordinary least squares and minimizing the concentrated sum of squares of errors, $S_1(\gamma)$, we can obtain the estimators of our threshold value and the residual variance, $\hat{\gamma}$ and $\hat{o}^2$, respectively.
The second step will consist in testing the null hypothesis of linearity, H0: $\delta = \theta$ which can be based on the likelihood ratio test: $F_1 = (S_0 - S_1(\hat{\gamma}))/ \hat{o}^2$
Where S_0 is the sum of squared errors under H0 and S_1 the sum of squared residuals under H1.
However, as the asymptotic distribution of F_1 is non standard, we use the procedure of bootstrap to construct the critical values and p-value.

Upon the existence of threshold effect, H0: $\delta = \theta$, we should test for the asymptotic distribution of threshold estimate, H_0: $\gamma = \gamma_0$, and adopt the likelihood ratio test: $LR_1(\gamma) = (S_1(\gamma) - S_1(\hat{\gamma}))/\hat{\sigma}^2$ with the asymptotic confidence intervals: $c(\alpha) = -2\log(1-\sqrt{1-\alpha})$.

III. EMPIRICAL RESULTS

Table 2 presents the test statistics F1, F2, and F3, along with their bootstrap p-values. We find that the tests for a double threshold F2 and a triple threshold F3 are insignificant with a bootstrap p-value of 0.31 and 0.85, respectively. Only the test for a single threshold F1 is significant with a bootstrap p-value of 0.09. Thus, we conclude that intellectual property rights have only one threshold effect on country innovation. The point estimate of the threshold ($\hat{\gamma}_1$) is 1112.5 PPP and his asymptotic confidence interval is [688.7; 1283.39]. More information can be learned about the threshold estimate from plot of the concentrated likelihood ratio function $LR_1(\gamma)$ in Figure 1.

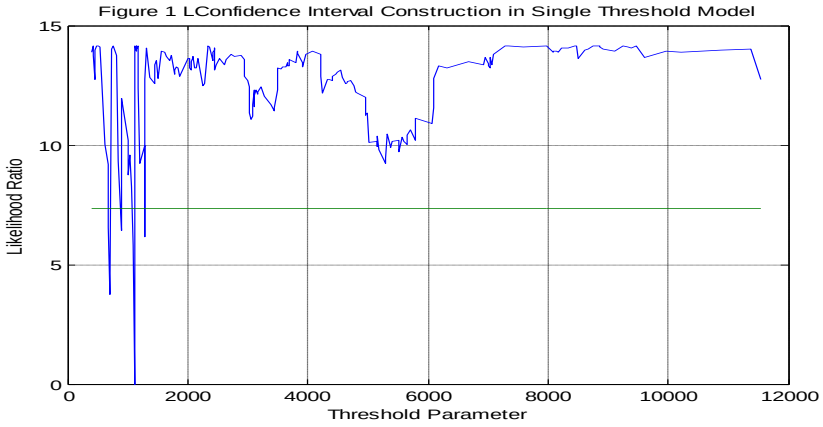

Table 2: Tests for threshold effects

Single threshold effect test	
Threshold value	1112.5
F1	14.14
P-value	0.09
(Critical value of F 10%, 5%, 1%)	(13.6; 17.6; 25.8)
Double threshold effect test	
Threshold values	707.09; 1112.5
F2	8.36
P-value	0.31
(Critical value of F 10%, 5%, 1%)	(11.7; 13.1; 16.5)
Triple threshold effect test	
Threshold values	707.09; 1112.5; 5283.99
F3	3.29
P-value	0.85
(Critical value of F 10%, 5%, 1%)	(8.8; 10.3; 13.2)

Table 3 : Estimation of coefficients

	Coefficient	OLS SE	T(OLS)	White SE	T(White)
GDP	1.11	0.32	3.46***	0.30	3.7***
EDUC	0.29	0.13	2.23**	0.1	2.9***
EFREE	-0.15	0.26	-0.57	0.19	-0.78
TRADE	0.06	0.08	0.75	0.07	0.85
IPR I(GDP <= 112.5)	-2.2	0.86	-2.55**	0.66	-3.33***
IPR I(GDP > 1112.5)	0.48	0.17	2.82***	0.13	3.69***

As table 3 shows, IPR protection affects significantly the level of innovation. However, this impact is different depending on the regime. In the first regime, where the initial level of economic development is less than or equal to the threshold value (1112.5 PPP), the effect of the GP index is negative and significant at 1%. In the second regime where countries are characterized by a high level of economic development, the effect is positive and significant at 1%. In the first class, when the index of patent rights increases by a point, the number of

patents granted by the USPTO decreases by 220 percentage points. On the other hand, in the second regime the increase of the GP index by a point generates an increase in the number of patents by 48 percentage points. Thus, we find that only countries with a high initial economic development can benefit in terms of innovation from the increase in the level of protection of patent rights. As expected, our results confirm the nonlinear relationship between the protection degree of intellectual property rights and the level of technological innovation. They are consistent with those of [9]. These results highlight the disadvantages of TRIPS for some developing countries. These countries will increase the level of IPR protection only under pressure from the developed countries that seek international harmonization of IPR standards. To ensure the growth, these countries should imitate new technologies developed in advanced countries. So the increase in IPR standards will make costly imitation and adaptation of foreign technology to their national needs. For the control variables, the GDP per capita and the education level have a positive and significant impact on innovation, others are not significant.We find that the marginal effect of GDP per capita is positive and significant. In fact, patents are increasing with log GDP (1.11). This result is consistent with that found by [12] and [13].The coefficient for EDUC is positive (0.29) and significant. This result highlights the importance of the stock of human capital for innovation. In contrast to these findings, the impact of the economic freedom index is not significant. This implies that the institutional environment in developing countries is unfavourable to innovative activity. The impact of TRADE is not significant. An explanation for this is that the degree of trade openness is not enough to promote innovation in developing countries. The result may also be explained by the fact that the imported and exported goods are out of date, they are not new technologies that can provide a learning support to innovate.

IV. CONCLUSION

The initial level of economic development seems to influence the size of the marginal effect of IPR on a country's technological innovation. We find that an economic development threshold exists below which IPR have a strong negative impact on innovation and above which IPR have a marginally significant positive impact on innovation. The results imply that the introduction of a robust system of IPR does not always give the expected positive result. The IPR system plays its role of promoting innovation only in countries that already have a high initial level of economic development. For the poorest countries, they must keep a low level of protection of IPR to encourage companies to imitate foreign technologies. The conclusion of this study is that some developing countries members of the WTO are threatened by the provisions of the TRIPS agreement. The present study has important implications. First, the significant presence of threshold effects call into question the relevance of any econometric specification assuming a linear relationship between IPR protection and innovation. Second, and to summarize our results, we can say that "one size fits all" is not valid. In other words, there is no unique model for all countries to stimulate innovation. We showed in this study that economies which differ by their initial level of economic development may not converge and thus be on different paths of innovation.

V. APPENDIX

Developing countries included in the data set : Argentina, Bangladesh, Benin, Bolivia, Cameroon, Chile, Colombia, Congo, Costa Rica, Dominican Republic, Ecuador, Egypt, El Salvador, Fiji, Gabon, Ghana, Guatemala, Guyana, Honduras, Indonesia, Jamaica, Jordon, Kenya, Malawi, Malaysia, Mauritius, Mexico, Morocco, Nicaragua, Pakistan, Panama, Paraguay, Peru, Philippines, Senegal, Sri Lanka, Thailand, Tunisia, Turkey, Uganda, Uruguay, Venezuela, Zimbabwe.

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