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Patents Rights and Economic Growth: Empirical Evidence from Middle Income Countries

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Abstract
This study investigates the association between patents rights and economic growth, in case of selected middle income countries, using panel ARDL (auto regressive distributed lag) technique. Results under PMG and DFE estimator indicate that domestic patents contribute significantly to GDP of middle income only in short run, while MG estimator indicates that patents have no significant impact on economic growth both in short and long run.
Keywords—IPRs, Patents, Economic Growth, R&D.

1. INTRODUCTION

One of most important characteristic of a modern economy is that technological improvement is crucial for economic development. Modern technology not only improves factor`s productivity but also boost up the level of output. Among many other factors, one of the most important factor that encourages technology is intellectual property rights (IPRs). IPRs encourage investors and producers to explore new production techniques by providing them property rights over their inventions. The investors and innovators take decision of investment depending upon patents rights in order to earn higher profits from their invention and these inventions and modern production techniques in turn raise the growth rate of economy. Main objective of our research is to analyze impact of resident patents on economic growth, in lower and upper middle income countries (for time period 1993-2012). According to Park and Ginarte (1997), there exist indirect co-relation between patents and economic growth i.e. stronger patents rights enhance R&D and physical investment of an economy, which in turn boost economic growth.

The study is organized in following format; after brief introduction of study (section 1), section 2 consist of literature review. Furthermore, model specification and theoretical framework is discussed in section 3, while section 4 consists of results and discussion and section 5 comprises of concluding remarks of present study.

2. LITERATURE REVIEW

Previous literature demonstrates importance of IPRs in economic growth, and also gives detail about channels through which IPRs affect growth. Falvey and Foster (2006) and Kumar, 2003 specify that IPRs affect economic growth both directly (through encouraging domestic patents) and indirectly (through diffusion of technology from north). According to Jalles (2010) patents statistics contribute positively to economic growth through promoting novel ideas and innovations. Helpman (1991) states that although in past R&D data has been utilized frequently to determine innovation, but R&D data only measures innovations inputs. Moreover, time lag is also involved between R&D expenditures and output of these expenditures. So, IPRs statistics (particularly patents) is used as a proxy for innovations (Wang, 2013). Griliches(1990) examine that patents statistics is considered as measure of the output of modern technology, while R&D expenditures are input of new technology. Although, above literate indicate importance of patents toward innovation but on the other side, Furukawa (2010) and Minea and Hudson (2013) explore inverted U shape relationship between IPRs and innovation, and Furukawa (2010) states that IPRs encourage innovation in short run, while in long run IPRs lower innovation by depressing the learning by doing process. Schneider (2004) explore that IPRs encourage innovation only in developed country and indicate that dynamics of innovations and growth are different in developed and developing economies, and IPRs encourage innovation only in developed countries. Minea and Hudson (2013) explore that relation between IPRs and innovation depends upon initial level of IPRs and GDP per capita level of a particular country.

Even though, above literature indicate inverted U shaped relationship between patents and innovation, but on other side patents have also contribution in income of economies. Kim.*et al.,* 2009 indicate that patents statistics (resident and non-resident) contribute positively to factor productivity; Moreover, non-resident patents are more significant than resident patents. Park (1999); Yang (2006) and Iwaisako and Futagami (2011) end up with result that patents influence economic growth indirectly through encouraging factor accumulation, R&D and physical capital. The stronger patents rights uphold industrial growth through technical progress during time period 1981-85 and 1996-2000,whereas during year 1986-90 and 1991-95 through rapid factor accumulation (Hu and Png, 2009).Although, above literature elaborates that patents encourage economic growth, but patent protection is considered more significant in developed countries than in developing countries. Iwaisako (2013) states that height of patents protection depends upon ratio of public expenditures to output level of an economy. Lee *et al*. (2013) and Schneider (2005) argue developing countries are not equipped well to bear cost of patents at present phase of development. Thompson and Rushing (1996) conclude that patents protection add to economic growth after achieving a certain level of economic growth (Kumar, 2003). Ginarte and Park (1997) and Iwaisako and Futagami (2011) explore that size of research sector, R&D productivity and infrastructure are also important determinant of patents and growth relationship.

3. MODEL SPECIFICATION, THEORETICAL FRAMEWORK AND METHODOLOGY

Technological progress, innovations and knowledge are considered crucial for economic growth of any economy. Classical economists (including Adam Smith and others) demonstrated that productivity depend upon savings, population growth and technological development. Solow added technology to the production function equation, however, exogenously, while new growth theories take technological progress as endogenous e.g. Romer. P (2002), Grossman and Helpman (1991 a) introduced model of endogenous technical progress. Furthermore, knowledge has an important characteristic, that it is non-rival. But on other hand, according to Romer (1990) although knowledge is non-rival but its heterogeneity made it excludable. Knowledge is excludable if it is possible to prevent others from using it, for example, patent laws give exclusive rights to inventor over the use of their designs and discoveries. The main purpose of patents also is to encourage innovation rate and growth rate of an economy. By keeping in view above theoretical background, we will construct our model. In our study, technological progress, labor and capital all factors are combined, while technical progress and innovations have major contribution in growth process. Writing Cobb Douglas production function.

$$Y = AK^{\alpha}L^{\beta} \text{ ....3.1}$$

Y = Output
A = technology
K= Capital
α= marginal productivity of capital
L= Labor
β=marginal productivity of labor

In our model technology (*A)* is affected by total residence patent granted, IPRs encourage investors and innovators through providing exclusive rights to residence investor, which in turn affect economic growth. Writing "A" in form of equation

$$A = \omega_1(PR) + \omega_2(X) + e_t \text{............3.2}$$

In equation 3.2 *PR* refers to total no of residence patents granted, whereas *X* refers to vector other variable, those affect domestic innovation and technology i.e. human capital and research and development expenditures as % of GDP. Putting values of *X* in equation 3.2

$$A = \omega_1(PR) + \omega_2(HC) + \omega_3(R\&D) + e_t \text{............3.3}$$

Putting equation 3.3in equation 3.1, final estimable model can be written in following form.

$$Y = \lambda + \omega_1 log(PR) + \omega_2(HC) + \omega_3(R\&D) + e_t \text{.........3.4}$$

In equation 3.4*Y* refers to output growth and here GDP growth (annual %) is used to estimate output growth. *log(PR)* is log of total no of residence patents granted, *R&D* refers to research and development expenditure (% of GDP). Data GDP growth (annual %) and *R&D* was taken from World Bank, while data on patents was taken from statistics on WIPO (world intellectual property organization).*HC* is human capital index calculated as sum of enrollment at all education level (i.e. primary, secondary and tertiary enrollment) and this sum was divided by total labor force. Data on primary, secondary and tertiary school enrollment was taken from UNESCO (United Nations educational, scientific and cultural organization) statistics, while total labor force data was taken from World Bank.

3.1 Methodological framework

To estimate model of study, we used panel ARDL (autoregressive distributed lag) technique. Pesaran, Shin and Smith (1997, 1999) introduced PMG (pooled mean group), MG (mean group) and DFE (dynamic fixed effects) techniques, for estimation of panel ARDL, heterogeneous panel and non-stationary dynamic panel data[1].

[1]Dynamic panel data consist of larger no of cross sectional (N) & also larger no of time series observations (T). Dynamic panel data further assume heterogonous co-efficient for cross sections units or group.

MG technique assumes heterogonous coefficients both for short run and long run, while PMG which allow homogenous coefficients for long run but heterogonous coefficients for short run. Likewise, DFE assumes homogenous coefficients both in short and long run but estimates panel specific intercepts (Rafindadi and Yosuf, 2013).

Generally, ARDL is written as;

$$Y_t = \alpha_i + \gamma_i \; Y_{i,t-j} + \beta_i X_{i,t-j} + \varepsilon_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.5$$

Reparametring equation 3.5 in VECM format;

$$\Delta Y_{it} = \theta_i (Y_{i,t-1} - \beta_i X_{i,t-1}) + \sum_{j=1}^{p-1} \gamma_y^i \Delta Y_{i,t-j} + \sum_{j=0}^{q-1} \delta_y^i \Delta (X_i)_{t-j} + \mu_i + \varepsilon_{it} \ldots\ldots\ldots\ldots\ldots\ldots 3.6$$

In equation 3.6 θ represent error correction parameter or speed of adjustment in long run (existence of long run co-integration relation), while β_i refers to long run coefficients. Furthermore, γ and δ are short run coefficients.

By, keeping in view above methodological framework, we will construct our model in ARDL format. Writing equation in 3.4 VECM format;

$$d(Y_t) = \lambda + \Sigma\beta_i d(Y_{t-i}) + \Sigma\omega_{1i} d(log(PR_{t-i}) + \Sigma\omega_{2i} d(R\&D_{t-i}) + \Sigma\omega_{3i} d(HC_{t-i}) + \varphi\{\theta_o(Y_{t-1}) + \theta_1 log(PR_{t-1}) + \theta_2(R\&D_{t-1}) + \theta_3(HC_{t-1})\} + e_{it}$$

…………3.7

4. Results and discussion

To check order of integration, panel unit root test ((Levin, Lin and Chu Test (test with common unit root process)) was applied.

4.1 Unit root test

Results of unit root test are given in Table 4.1. P-values are reported in parentheses, t-statistics are above parentheses' values. Results indicate that Y, *PR* (Resident patents), *HC* (human capital) are stationary at level, as p-value is less than 0.05 and t-statistics is negative. R&D is stationary at 1st difference. As, our three variables are of I (0) while other one is of I (0), so panel ARDL technique will applicable here.

Table 4.1 Levin, Lin and Chu Test

Variables	Level	1st difference	Integration order
Y	-2.22897 (0.0129)*	-	**I(0)**
PR	-1.72016 (0.0427)*	-	**I(0)**
HC	-2.72190 (0.00032)*	-	**I(0)**
R&D	-	-10.6976 (0.0000)*	**I(1)**

P values are in parentheses, t values above parentheses values (* significant at 5%)

4.2 Lag length selection

After formulation of ARDL equation, lag length is selected and for selection of lag AIC and SC criteria is used. In our model, optimal lag length is 1, because SC value is lesser at lag 1, as shown in table 4.2. So, Schwarz-Bayesian criterion (SBC) is used to choose optimal number of lags for ECM.

Table 4.2 Lag length selection

Lags	AIC	SC	HQ
0	5.364713	5.504336	5.419327
1	-1.835780	-1.137665*	-1.562709*
2	-1.858445*	-0.601838	-1.366917

* Indicate significant at 5% level

4.3 Panel ARDL

We can estimate equation 3.7 using pooled mean group, mean group and dynamic fixed effects approach. Results of panel ARDL are reported in table 4.3.

Table 4.3 Panel ARDL

Variable	PMG		MG		DFE	
	Coefficient	t-Statistic Prob.	Coefficient	t-Statistic Prob.	Coefficient	t-Statistic Prob.
	Short Run Model					
EC	-0.7493835	-5.81 (0.000*)	-0.845858	-5.41 (0.000)*	-0.8311817	-7.95 (0.000)*
Constant	2.468413	3.75 (0.000*)	-8.128034	-1.67 (0.095)**	3.995341	1.58 (0.114)**
D1.PR	2.149403	1.60 (0.111**)	2.911401	0.94 (0.348)	2.759189	1.57 (0.116)**
D1. HC	-11.00606	-0.95 (0.344)	-47.01985	-1.12 (0.265)	-11.77028	-1.21 (0.228)
D1.RD	-14.85445	-1.54 (0.123)	7.069232	0.55 (0.580)	-5.534527	-1.45 (0.148)
Long Run Model						
L.Pr	0.6832272	0.44 (0.657)	-0.2144806	-0.06 (0.949)	0.0139875	0.01 (0.994)
L.Hc	5.396084	1.24 (0.216)	82.29688	1.34 (0.181)	4.154942	0.73 (0.468)
L.Rd	-1.513409	-0.60 (0.549)	-53.25844	-1.11 (0.267)	-0.7223408	-0.24 (0.811)

* indicate Significant at 5% level, ** indicate significant at 10% level

4.3.1 Pooled Mean Group (PMG)

Table 4.3 (column 2 and 3) demonstrates results of PMG estimator. Upper part of table 4.3 depicts short run model. Results indicate that in short run only *PR*(resident patents) contributes significantly to income of middle at 10% level of significant and one percentage increase in patents leads to 2.14% increment in income of middle income countries. Furthermore, *HC* (human capital) and *RD* (research and development expenditure) are insignificant in short run, and have negative coefficient in case of middle income countries.

Furthermore, for sake of adjustment parameter (restricted ECM equation) is calculated. Results are reported in table 4.3. E(-1) is error correction term or adjustment parameter. Results indicate that co-efficient of EC (adjustment parameter) is negative (negative sign indicate convergence) and 75% of disequilibrium is corrected in one time period.

Lower part of table 4.3 (column 2 and 3) depicts long run model. Results indicate that in long run none of variable has significant effects on income of middle income countries. Resident patents (*PR*) have no contribution towards growth of middle income countries, the reason is that developing countries are not prepared well to achieve benefits from patents at their present stage of development, according to Thompson and Rushing (1996) patents protections contribute to economic growth after achieving a certain level of economic growth (kumar, 2003). Moreover, due to weak infrastructure, market structure, economic policies of developing economies regarding residence patents and inefficient R&D sector, patents don't contribute to growth. In long run, coefficient of research and development expenditures (*RD*) is negative because of inefficient research and development sector in developing countries; results are persistence with Birdsall and Rhee (1993). Moreover, human capital (*HC*) is also insignificant and results are persistence with (Mayer, 2001) and Benhabib and

Spiegel (1994)[1]), means contribution of education sector towards income is not significant in middle income countries, for the reason that in middle income economies, education sector is not so active, so education has no contribution towards income in middle income countries.

4.3.2 Mean Group (MG)

Table 4.3 (column 4 and 5) reports results of mean group estimator. Above part of table 4.4 depicts short run dynamics. In short run, none of variable contributes significantly to income of middle income countries, as given in table 4.4. Coefficient of *PR* is insignificant in case of MG contrary to PMG technique. Moreover, *RD* is insignificant with positive coefficient opposing to PMG while coefficient of *HC* is also insignificant with negative coefficient.

Lower part of table 4.3 (column 4 and 5) depicts long run model. Results indicate that in long run, *PR* (resident patents) contributes negatively towards income of middle income countries, contrary to PMG approach. Furthermore, human capital has insignificant impacts on income of middle income countries. Reason of insignificant results is that in middle income economies, education sector is not so active, so education has no contribution towards income in middle income countries[2] and results are persistence with Hanushek (2013). Moreover, *RD* (research and development expenditures) has negative impact on growth of middle income countries.

Adjustment parameter is negative and shows convergence, means 84% of disequilibrium is corrected in one time period.

4.3.3 Dynamic fixed Effects (DFE)

Table 4.3 (column 5 and 6) demonstrates results regarding DFE estimator. Upper part of table 4.3 (column 5 and 6) depict short run model while lower part of table demonstrate long run model. Results of DFE estimator are similar to PMG estimator and none of variable contributes significantly to economic growth in long run. Additionally, in short run only PR is significant at 5% level, while *RD* and *HC* have no contribution in growth of middle income countries. In long run, although coefficients of resident patents and human capital have positive sign but it have no significant contribution in income of middle income countries. Furthermore, coefficient of *HC* is negative in both short and long run. Results demonstrate that speed of adjustment is -0.083 means 83% of disequilibrium is corrected in one time period.

Hausman Test

Table 4.6 indicates results of houseman test for comparison of PMG, MG and DFE estimators. Results demonstrate that PMG is efficient estimator than MG and DFE. As, in both cases null hypothesis of efficient PMG estimator is accepted.

TABLE 4.6 HAUSMAN TEST

	Null Hypothesis	Prob>chi	chi	Results
Hausman test	PMG is efficient estimation than MG under null Hypothesis	0.8766	0.62	PMG is efficient estimator.
	MG is efficient estimation than DFE under null Hypothesis	0.5900	1.92	MG is efficient estimator.
	PMG is efficient estimation than DFE under null Hypothesis	0.89	0.8272	PMG is efficient estimator.

4.4 Research and Development expenditures

Result of R&D are negative because in developing countries research and development expenditures contribute to economic after achieving certain level of growth. Furthermore, GDP and initial level of research and development expenditures also affect R&D and its positive consequences (Birdsalland, 1993).

[1]Benhabib and Spiegel (1994) conclude that one reason of negative sign is that in developing countries started with low level of initial human capital stock. And countries those start with efficient initial human capital stock, smaller improvement in their education lead to larger improvement in human capital stock. Furthermore, Benhabib and Spiegel (1994) recommend using human capital in level rather than in growth to obtain significant outcomes.

[2] According to Hanushek (2013) "*Cognitive skills of the population*" have more importance than school attainment of particular country. Hanushek (2013) demonstrates that "*Cognitive skills*" have major role in earning of any individual and especially in growth of economy and policy makers should focus on school quality and its improvement.

Birdsalland (1993) explore that R&D expenditures depend upon initial stock of R&D and GDP of country because countries having higher level of GDP contain lower marginal productivity of physical investment (MPPI). Lower MPPI encourages these countries to invest in R&D sector in order to "*lighten the diminishing marginal productivity of physical capital*". Birdsalland (1993) investigate reason for the positive effects of initial stock of R&D on current level of R&D is that "*productivity of R&D capital is not diminishing i.e., there are constant or increasing returns to R&D investment.* Birdsalland (1993) further stated that "*This is consistent with the view that huge fixed costs are involved in R&D investment"*.

4.4.1 Dependent variable Y (GDP growth)

Table 4.7 demonstrates association between research and development expenditures (*RD*) and *GDP* growth. Variable *RD* (research and development expenditures) affects *GDP* negatively at level, as coefficients of *RD* is negative. While, *RD* contributes positively to *GDP* at 1^{st} and 2^{nd} difference as coefficient of *RD* (research and development expenditures) is positive at 1st and 2^{nd} lag of *RD*. So, inverted U shaped relationship exists between *GDP* and research and development expenditures.

Table 4.7 Relationship between Y (GDP growth) and research and development expenditures (RD)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.116603	0.626911	4.971368	0.0000*
RD	-2.767767	4.454477	-0.621345	0.5360
RD(-1)	5.935178	4.493589	1.320810	0.1901
RD(-2)	1.781359	4.880922	0.364964	0.7160
R-squared	0.257120			

* Significant at 5% level

4.7.2 Dependent variable RD

As, discussed above *RD* is affect by previous level, so we compute association between *RD* and lag value of *RD*. *RD* is positively affected by its previous lags both lags are significant at 5% level as given in table 4.8.

Table 4.8 Relationship between RD and lag value of RD

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.013965	0.015014	0.930148	0.3549
RD(-1)	0.480634	0.095088	5.054626	0.0000*
RD(-2)	0.570839	0.100274	5.692788	0.0000*
R-squared	0.963217			

* Indicate coefficients are significant at 5% level

4.5 DIAGNOSTIC TEST

Diagnostic test are reported in table 4.9. Distributions are not normally distributed, as Jarque-Bera test reject null hypothesis of normal distributions. While, for serial independent residuals LM test is employed and error term are not correlated as shown in table 4.9. Moreover, variance of error term is not persistence because we reject null hypothesis of persistent variance of error term. For sake of dynamic stability of UECM, inverse roots are constructed (graphs are reported in appendix; fig A1 and A2). Before differencing (fig A1), inverse roots demonstrate instability. So, we constructed inverse root again after differencing. After differencing (fig A2) inverse roots exhibits stability as none of root lay on x-axis.

Table 4.9 Diagnostic tests

Diagnostic Tests	Test	Stats			Results
Normality Test	Jarque-Bera	1270.434 (0.0000)*			Not normal
Serial Correlation Test	LM-Stat	Lags	LM-Stat	Prob	No serial correlation
		1	9.734944	0.8801	
Standard Error	SE	3.362678			3.362%
Auto corelation	DW-statistics	1.412590			Not exists

* Significant at 5% level

5. Conclusion and policy recommendations

In this study, we analyzed impact of domestic patents on economic growth using panel ARDL, in case of middle income countries for time period 1993-2012. Results revealed that domestic patents affect GDP of middle income countries positively only in short run according to PMG and DFE estimator. While, MG estimator reveals insignificant results both in short and long run. This reveals that present development stage of country and active R&D sector also play important role to obtain encouraging consequences of domestic patents. So, developing countries can obtain benefits from patents through adequate R&D facilities, providing incentives for investors, building adequate infrastructure and encouraging domestic patents. As, IPRs contribute to GDP after a certain phase of development, so WTO can resolve this issue through allowing flexibilities for developing country regarding IPRs implementations. Moreover, proper information regarding patents laws and implementation should be provided to investors through regular publication in order to encourage patents holder in developing countries.

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APPENDIX

Innovation equation

Fig A1: Before differentiating

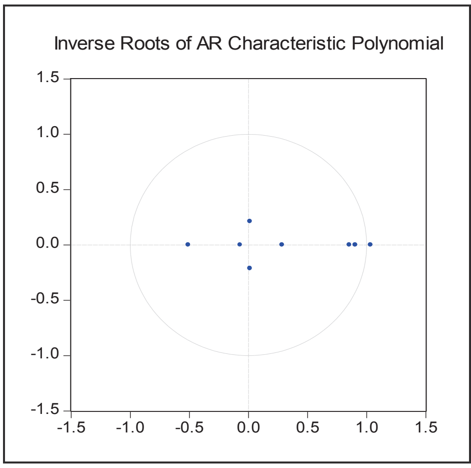

Fig A2: After differentiating