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Innovation as a Driver of economic growth: An empirical Comparison between China and India

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Abstract

This study focuses on the relationship between patent application and economic development in two most important global economies China and India. We have used time series data and have applied ARDL bound testing approach for finding out a long run relationship. The outputs show that there must be a long run relationship between patent registration and economic development. We can conclude out of this those innovations (patent) might be a very vital factor for economic development in China and India. It has also helped us to draw some policies' recommendations.

Keywords: China, India, Economic growth, Patent application, ARDL, Bound test

Introduction

Intellectual property plays an important role in assessing and simulating creativity and inventions wit growing knowledge in the modern economy. It also has the potential to influence a country's GDP growth. The percentage increase in GDP is invariably determined by the patenting of new inventions. A patent is a legal right that grants applicants (or inventors) exclusive rights to their inventions for a set period of time (generally 20 years). As GDP and GDP per capita are two important parameters of macroeconomic performance of a country, some studies have examined and analysed the relationship between patents and the other ones. The goal of this paper is to conduct an empirical research on the relationship between number of patent registrations and economic growth. Schumpeter (1947), like other economists, emphasizes the importance of entrepreneurship and innovation in the process of economic growth. Schumpeter (op cit) demonstrated in "Theoretical Problems of Economic Growth" that scholars consider various factors that enhance economic growth: physical environment, social organization, institutions, technology, and so on. Creative response is important in the innovation process. In the economic sphere, creative response simply means combining existing productive resources in new ways or for new purposes, and because this function defines the economic type known as the entrepreneur, we can reformulate the preceding suggestions by saying that we should recognize the importance of, and systematically investigate, entrepreneurship as a factor of economic growth. Entrepreneurship with innovation significantly depends on patent registration to protect the innovation which eventually can be a good indicator of economic growth. Let us see what the study reveals after analysing the variables.

The remainder of the paper is structured as follows. Section II provides a synopsis of the literature. Section III discusses the paper's econometric methodology. Section V contains the empirical results of tests, and Section VI contains some conclusions

Literature Review

Patents exist to encourage inventive activity and to facilitate the incorporation of new technologies into the economy as a whole. One mechanism for technology diffusion in an economy is the patent system. Patent is the only recognized way to protect innovation and technology. Technology reaches on its peak if it ensures innovation. An innovation system is made up of individuals and organizations that invest time, energy, and resources in the creation of scientific and technical knowledge, both directly and indirectly (Katz, 2006). Technological change is now regarded as a major source of long-run productivity growth, and innovation is no longer regarded as an exogenous process (Josheski, Koteski 2011). Patents have grown in importance, particularly in the last two decades and innovations are protected by patent. The growth of patent has a positive relationship with growth of GDP. Gerguri (2010) have highlighted several core conditions that enable innovation and encourage economic growth: strong intellectual property standards and effective enforcement, vigorous competition and contestable markets, a strong and sustainable fundamental research and development infrastructure, encouraging information and technology communication developments, a strong emphasis on education at all levels, and so on. National patents provide insight into the extent to which a regional economy is developing and commercializing new-to-the-country technologies (Guan & Liu, 2005). National patents are divided into three categories: invention patents, utility patents, and design patents. Chen and Puttitanun, (2005) and Briggs (2007) who have investigated the question of whether the patent has any contribution to GDP using theoretical models and econometric analyses of multi-country data sets have identified a U-shaped relationship between GDP and the Ginarte-Park Index of patent rights. Maskus (2000) first openly acknowledged the U-shaped association using estimated coefficients for log GNP per capita and on the instrument-corrected Rapp-Rozek Patent Index in a cross-section regression. A study conducted by Sinha (2007) on Japan and South Korea on the relationship between patent and economic growth found a positive cointegration between the variables. She also found two way causality between GDP growth with growth of the number of patent. Roman Gurbiel (2002) from his study on technology and innovation based on EU countries concludes that in today's global economy, innovation and technology transfer are the primary drivers of economic growth. He discovered a strong relationship between the intensity of technology transfer and a country's ability to innovate. Recently Hasan & Tucci (2010) and Kim et al.(2012) By addressing some new questions, the research line was extended in an attempt to link innovation to economic growth. These researchers investigated the importance of both the quantity and quality of innovation in economic growth using global patent data from 58 countries. Furthermore, this study found that countries with higher quality patents have higher economic growth. On the side of the coin Fleisher et al. (2013), in line with Kim et al.(2012), have discovered that between 1992 and 2002, patent laws, including China's adoption of Trade Related Aspects of Intellectual Property Rights standards, had no direct effect on China's productivity. Some other researchers have also some orthodox statement instead of general findings of positive relationship between patent and economic growth. Briggs (2007) argues that The U-shaped relationship found in cross-section and panel regression estimates between GDP and patent strength is a misleading guide to the longitudinal experiences of the vast majority of countries in the Ginarte-Park data set. In the study Changtao Wang (2013) Patent and trademark statistics are used in the study conducted by Changtao Wang (2013) as innovation proxies to examine the long-run relationship between innovation and output in countries with a long-established intellectual property rights system. The findings suggest that innovation may no longer be a positive force in driving economic growth.

Methodology

Here we have used the mixed stationarity of our variables that allows the application of ARDL bounds testing approach that has been developed by Pesaran et al (2001). The basic issue of ARDL model is that it can be used irrespective of the order of stationarity of the variables, though there is an exception for I(2) variables. We can specify the ARDL model can be specified in the following way (Pesaran et al op cit):

$$\Delta GDP_t = \alpha_0 + \alpha_1 GDP_{t-1} + \alpha_2 Patent_{t-1} + \sum_{i=1}^{n} \varphi_i \Delta GDP_{t-i} + + \sum_{i=1}^{n} \pi_i \Delta Patent_{t-i} + \mu_t$$

Where Δ is the differenced operator, α1; α2 are the long run estimates, φ_i, π_i ,i are short-run estimates, and μ_t is residual term in time t.

The ARDL may choose its appropriate lag length in automatic way. The appropriate calculation of the F-statistic relies on the proper lag order selection of the series integrated in the model. The asymptotic critical values produced by Pesaran et al. (op cit) are compared with the F-statistic to find the co integration. The condition for co integration is that the F-statistics be greater than the upper critical values—otherwise means absence of cointegration. If cointegration is recognized, then we go on to error correction model (ECM) following Pesaran et al. with the short-run dynamics symbolized as:

$$\Delta GDP_t = \alpha_1 + \sum_{i=1}^{n} \varphi_i \Delta GDP_{t-i} + + \sum_{i=1}^{n} \pi_i \Delta Patent_{t-i} + \gamma ecm_{t-1} + \mu_t$$

The short-run coefficients are as well φ_i, π_i; ,i, while γ is the speed of adjustment coefficient to equilibrium.

Empirical Analysis

Before estimating Auto Regressive Distributed Lag model, we need to check for stationarity of the variables via Augmented Dickey-Fuller Test and Philips-Perron Test for being sure that none of the variables is integrated of second order. Because bound testing procedure gets broken down (Pesaran et al op cit). The output of unit root tests namely ADF and PP Test has been presented in Table 1 and 2. The results show that the variables are stationary in level and first difference that means I(0), I(1) or both. The level of significance is 5%. The interesting matter is that the most macroeconomic variables have the propensities of being stationary at level that means I(0), if not it usually gets stationary at first difference, I(1). That's why ARDL method usually does not need pre-testing for the unit root. Moreover, this method considers enough lags of the variables that serve as a proper instrument to remove the endogeneity issue (Bahmani-Oskooee & Hajilee, 2010). Pesaran et al. (2001) describe this instrument as an approach of general method, because it provides very flexible choice for the dynamic lag structure and also allow for short run feedbacks.

The long run and short run test results presented in Table 3, Table 4 show that F value is 3.532259 For China, 9.543696 For India. For India there must be a co-integration relationship at 5% level of significance as the F value lie above upper bound critical value at 5%. For China, it's inconclusive at 10% level of significance. Though for the presence of co-integration relationship, the co-efficient of ECM term should be statistically significant. Apart from that it must lie between -1 to 0. It will help to check and test the speed of adjustment back to equilibrium after a shock occurs (Banerjee et al., 1998). The ECM terms presented in Tables 5 and 6 prove that there must be long-run relationship between dependent and explanatory variables as the ECM terms are statistically significant.

Table 1: Unit Root Tests (PP)

UNIT ROOT TEST TABLE (PP)					
At Level					
		GDP_CN	GDP_IN	PATENT_CN_GROWTH	PATENT_IN_GROWTH
With Constant	t-Statistic	-2.9822	-5.0642	-4.3109	-5.2821
	Prob.	0.047	0.0002	0.0018	0.0001
		**	***	***	***
With Constant & Trend	t-Statistic	-2.9938	-11.6974	-4.0538	-5.5499
	Prob.	0.149	0	0.0164	0.0004
		n0	***	**	***
Without Constant & Trend	t-Statistic	-1.2307	-0.9788	-2.1322	-2.6171
	Prob.	0.196	0.2866	0.0336	0.0105
		n0	n0	**	**
At First Difference					
		d(GDP_CN)	d(GDP_IN)	d(PATENT_CN_GROWTH)	d(PATENT_IN_GROWTH)
With Constant	t-Statistic	-8.0411	-21.1871	-10.0224	-22.5046
	Prob.	0	0.0001	0	0.0001
		***	***	***	***
With Constant & Trend	t-Statistic	-9.2204	-21.1174	-11.3524	-24.6609
	Prob.	0	0	0	0
		***	***	***	***
Without Constant & Trend	t-Statistic	-8.1132	-19.8285	-10.2223	-17.6062
	Prob.	0	0	0	0
		***	***	***	***

Table 2: Unit Root Tests (ADF)

Table A1.2: UNIT ROOT TEST TABLE (ADF)					
At Level					
		GDP_CN	GDP_IN	PATENT_CN_GROWTH	PATENT_IN_GROWTH
With Constant	t-Statistic	-2.9454	-5.0947	-4.2949	-5.2821
	Prob.	0.0509	0.0002	0.0019	0.0001
		*	***	***	***
With Constant & Trend	t-Statistic	-2.963	-5.5283	-4.0337	-5.5499
	Prob.	0.1573	0.0004	0.0172	0.0004
		n0	***	**	***
Without Constant & Trend	t-Statistic	-1.1847	-1.0542	-1.4073	-0.7789
	Prob.	0.211	0.2574	0.1453	0.3705
		n0	n0	n0	n0
At First Difference					

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		d(GDP_CN)	d(GDP_IN)	d(PATENT_CN_GROWTH)	d(PATENT_IN_GROWTH)
With Constant	t-Statistic	-5.1795	-5.783	-8.5209	-7.5953
	Prob.	0.0002	0	0	0
		***	***	***	***
With Constant & Trend	t-Statistic	-5.0955	-5.6883	-8.5818	-7.4561
	Prob.	0.0013	0.0003	0	0
		***	***	***	***
Without Constant & Trend	t-Statistic	-5.2738	-5.8657	-6.4852	-7.6848
	Prob.	0	0	0	0
		***	***	***	***

Notes: (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1%. and (no) Not Significant
*MacKinnon (1996) one-sided p-values.

Table 3: ARDL Long Run Form, Short Run Form and Bound Test – India

ARDL Long Run Form and Bounds Test				
Dependent Variable: D(GDP_IN)				
Selected Model: ARDL(1, 3)				
Case 2: Restricted Constant and No Trend				
Conditional Error Correction Regression				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.481391	1.342056	4.084322	0.0004
GDP_IN(-1)*	-1.0299	0.192785	-5.34222	0
PATENT_IN_GROWTH(-1)	12.04175	8.442113	1.42639	0.1661
D(PATENT_IN_GROWTH)	-2.61656	4.131114	-0.63338	0.5322
D(PATENT_IN_GROWTH(-1))	-9.66409	5.84826	-1.65247	0.1109
D(PATENT_IN_GROWTH(-2))	-4.929	4.158983	-1.18515	0.2471

* p-value incompatible with t-Bounds distribution.

Levels Equation					
Case 2: Restricted Constant and No Trend					
Variable		Coefficient	Std. Error	t-Statistic	Prob.
PATENT_IN_GROWTH		11.69212	7.94799	1.471079	0.1537
C		5.322242	0.840873	6.329423	0
EC = GDP_IN - (11.6921*PATENT_IN_GROWTH + 5.3222)					
F-Bounds Test	Null Hypothesis: No levels relationship				
Test Statistic	Value	Signif.	I(0)		I(1)
			Asymptotic: n=1000		
F-statistic	9.543696	10%	3.02		3.51

k	1	5%	3.62	4.16
		2.50%	4.18	4.79
		1%	4.94	5.58
Actual Sample Size	31		Finite Sample: n=35	
		10%	3.223	3.757
		5%	3.957	4.53
		1%	5.763	6.48
			Finite Sample: n=30	
		10%	3.303	3.797
		5%	4.09	4.663
		1%	6.027	6.76

Table 4: ARDL Long Run Form, Short Run Form and Bound Test – China

ARDL Long Run Form and Bounds Test				
Dependent Variable: D(GDP_CN)				
Selected Model: ARDL(4, 1)				
Case 2: Restricted Constant and No Trend				
Conditional Error Correction Regression				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.001648	1.983862	2.0171	0.0555
GDP_CN(-1)*	-0.51952	0.190562	-2.72626	0.012
PATENT_CN_GROWTH(-1)	4.270561	2.715155	1.572861	0.1294
D(GDP_CN(-1))	0.686521	0.200794	3.41903	0.0023
D(GDP_CN(-2))	-0.19259	0.183745	-1.04813	0.3055
D(GDP_CN(-3))	0.387609	0.162053	2.391866	0.0253
D(PATENT_CN_GROWTH)	1.195058	2.17095	0.550477	0.5873

* p-value incompatible with t-Bounds distribution.

Levels Equation				
Case 2: Restricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
PATENT_CN_GROWTH	8.220159	6.191875	1.327572	0.1973
C	7.702544	1.475325	5.220915	0
EC = GDP_CN - (8.2202*PATENT_CN_GROWTH + 7.7025)				

F-Bounds Test	Null Hypothesis: No levels relationship			
Test Statistic	Value	Signif.	I(0)	I(1)

			Asymptotic: n=1000	
F-statistic	3.532259	10%	3.02	3.51
k	1	5%	3.62	4.16
		2.50%	4.18	4.79
		1%	4.94	5.58
Actual Sample Size	30		Finite Sample: n=30	
		10%	3.303	3.797
		5%	4.09	4.663
		1%	6.027	6.76

Table 5: ARDL Error Correction Regression - India

Dependent Variable: D(GDP_IN)				
Selected Model: ARDL(1, 3)				
Case 2: Restricted Constant and No Trend				
ECM Regression				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(PATENT_IN_GROWTH)	-2.616561	3.458605	-0.756537	0.4564
D(PATENT_IN_GROWTH(-1))	-9.664094	4.240806	-2.278834	0.0315
D(PATENT_IN_GROWTH(-2))	-4.929003	3.612912	-1.364274	0.1846
CointEq(-1)*	-1.029903	0.18521	-5.560717	0
R-squared	0.564707	Mean dependent var		0.082827
Adjusted R-squared	0.516342	S.D. dependent var		2.690061
S.E. of regression	1.870818	Akaike info criterion		4.210543
Sum squared resid	94.49893	Schwarz criterion		4.395573
Log likelihood	-61.26341	Hannan-Quinn criter.		4.270858
Durbin-Watson stat	1.674919			

* p-value incompatible with t-Bounds distribution.

Table 6 : ARDL Error Correction Regression - China

Dependent Variable: D(GDP_CN)				
Selected Model: ARDL(4, 1)				
ECM Regression				
Case 2: Restricted Constant and No Trend				
ECM Regression				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GDP_CN(-1))	0.686521	0.1815	3.782474	0.001
D(GDP_CN(-2))	-0.192589	0.175259	-1.098882	0.2832

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D(GDP_CN(-3))	0.387609	0.153101	2.531719	0.0186
D(PATENT_CN_GROWTH)	1.195058	1.857629	0.643325	0.5264
CointEq(-1)*	-0.519523	0.153078	-3.393853	0.0025
R-squared	0.573265	Mean dependent var		-0.149094
Adjusted R-squared	0.504987	S.D. dependent var		2.238253
S.E. of regression	1.574771	Akaike info criterion		3.897109
Sum squared resid	61.9976	Schwarz criterion		4.130642
Log likelihood	-53.45663	Hannan-Quinn criter.		3.971818
Durbin-Watson stat	2.154108			

* p-value incompatible with t-Bounds distribution.

The long run estimates have been presented in Table 3 and 4. It shows that the coefficient of patent growth Rate is insignificant for China and India. Here the statistical insignificance might have happened because of the assumption of symmetric effect in linear A.R.D.L.

The residual statistics and stability tests' outputs have been showed in the Tables 7-8 and Figs 1-6. They prove that the models are stable, free from serial correlation and rid of heteroskedasticity.

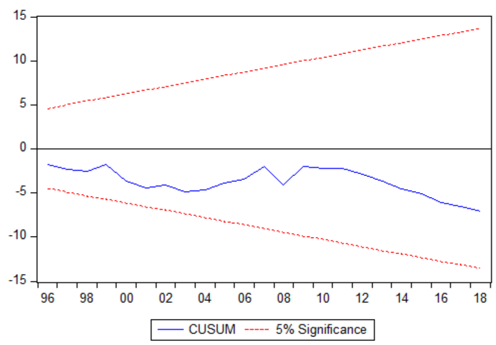

Fig 1: CUSUM-CHINA

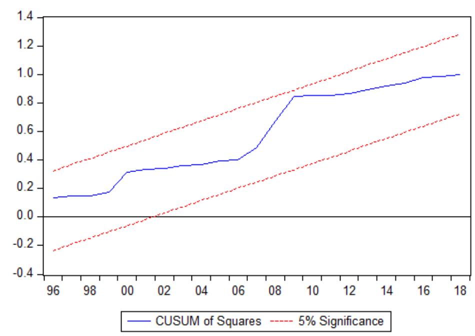

Fig 2: CUSUMSQ-CHINA

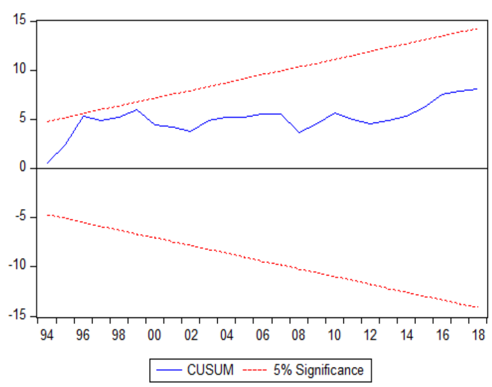

Fig 3: CUSUM-INDIA

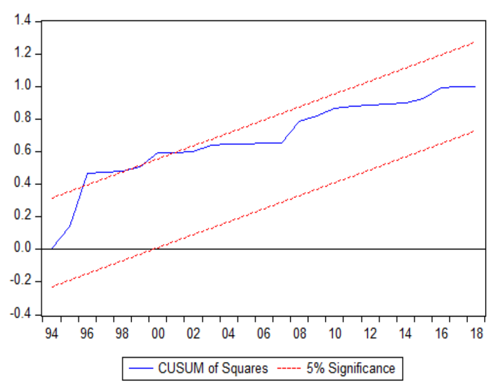

Fig 4: CUSUMSQ-INDIA

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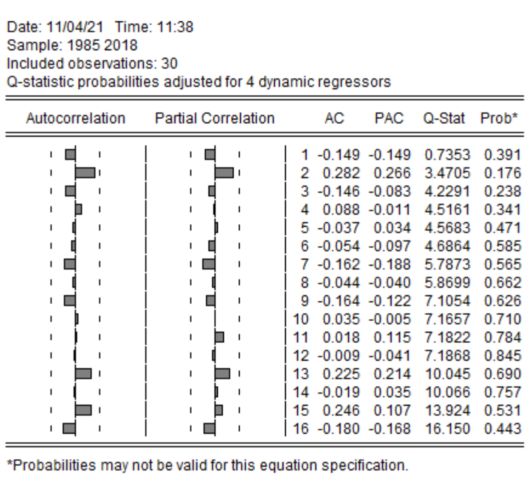
Table 7: Breusch-Godfrey Serial Correlation LM Test

India				
F-statistic	1.47118	Prob. F(2,23)		0.2505
Obs*R-squared	3.515993	Prob. Chi-Square(2)		0.1724
China				
F-statistic	1.806485	Prob. F(3,20)		0.1785
Obs*R-squared	6.396033	Prob. Chi-Square(3)		0.0939

Table 8: Heteroskedasticity Test: Breusch-Pagan-Godfrey

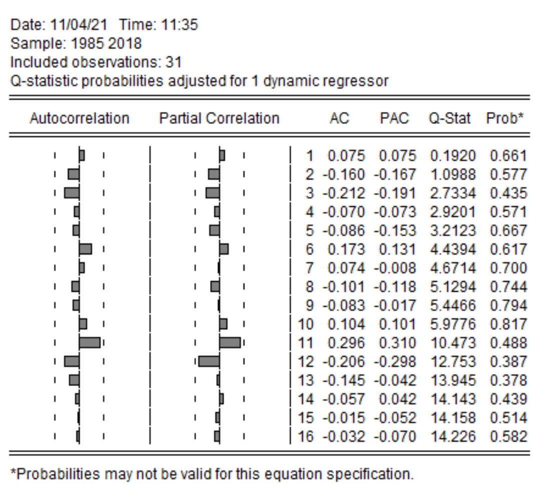
China				
F-statistic	1.393118	Prob. F(6,23)		0.2595
Obs*R-squared	7.996544	Prob. Chi-Square(6)		0.2384
Scaled explained SS	6.335017	Prob. Chi-Square(6)		0.3867
India				
F-statistic	0.776438	Prob. F(5,25)		0.5759
Obs*R-squared	4.166856	Prob. Chi-Square(5)		0.5257
Scaled explained SS	4.909492	Prob. Chi-Square(5)		0.427


Date: 11/04/21 Time: 11:38
Sample: 1985 2018
Included observations: 30
Q-statistic probabilities adjusted for 4 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.149	-0.149	0.7353	0.391
		2	0.282	0.266	3.4705	0.176
		3	-0.146	-0.083	4.2291	0.238
		4	0.088	-0.011	4.5161	0.341
		5	-0.037	0.034	4.5683	0.471
		6	-0.054	-0.097	4.6864	0.585
		7	-0.162	-0.188	5.7873	0.565
		8	-0.044	-0.040	5.8699	0.662
		9	-0.164	-0.122	7.1054	0.626
		10	0.035	-0.005	7.1657	0.710
		11	0.018	0.115	7.1822	0.784
		12	-0.009	-0.041	7.1868	0.845
		13	0.225	0.214	10.045	0.690
		14	-0.019	0.035	10.066	0.757
		15	0.246	0.107	13.924	0.531
		16	-0.180	-0.168	16.150	0.443

*Probabilities may not be valid for this equation specification.

Fig 5: correlogram-CHINA


Date: 11/04/21 Time: 11:35
Sample: 1985 2018
Included observations: 31
Q-statistic probabilities adjusted for 1 dynamic regressor

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	0.075	0.075	0.1920	0.661
		2	-0.160	-0.167	1.0988	0.577
		3	-0.212	-0.191	2.7334	0.435
		4	-0.070	-0.073	2.9201	0.571
		5	-0.086	-0.153	3.2123	0.667
		6	0.173	0.131	4.4394	0.617
		7	0.074	-0.008	4.6714	0.700
		8	-0.101	-0.118	5.1294	0.744
		9	-0.083	-0.017	5.4466	0.794
		10	0.104	0.101	5.9776	0.817
		11	0.296	0.310	10.473	0.488
		12	-0.206	-0.298	12.753	0.387
		13	-0.145	-0.042	13.945	0.378
		14	-0.057	0.042	14.143	0.439
		15	-0.015	-0.052	14.158	0.514
		16	-0.032	-0.070	14.226	0.582

*Probabilities may not be valid for this equation specification.

Fig 6: correlogram-INDIA

Conclusion

Though this paper explores the relationship between patent application and economic growth, there has been some limitation of this paper. This paper has used only different models and estimation techniques on patent application and growth. For further research we should put light on the R&D and its multiple types and its expenditures. We should also classify sector wise expenditures as well to find out sectors' specific innovation and their roles for economic growth. The government should be more effective for promoting and fostering innovation within the economy. On the contrary, just counting higher number of patent applications could not classify between ordinary patents and higher quality of patents. Moreover, an economy should not lower its standards by granting more patents. Government should charge subsidize amount of fess to register patents. For higher level of innovation activities, government should provide motivational measures to foster the environment of innovations.

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