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Institutions and Innovation: Evidence from Countries at Different Stages of Development

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This paper empirically analyses the impact of institutions, both formal and informal, on innovation performance of sampled countries at different stages of development. Data of 72 sampled countries on Research and Development Expenditures, numbers of article published, human capital, trade openness, internet users are collected from United Nations Educational, Scientific and Cultural Organisation (UNESCO), International Country Risk Guide (ICRG) and World Bank database. Formal and informal institutions indexes are constructed using data from Country Risk Guide and The World Value Survey (WVS). Fixed effect and System GMM technique are used to estimate the dynamic relationship between innovation performance and institutional indexes. The study finds positive significant effect of institutions on innovation in case of aggregate sample of developed and developing countries. However, the effects of formal institutions are more significant in case of sample of developed countries, while in developing countries informal institutions are found more effective than formal institutions in affecting innovation performance. The results also show that both formal and informal institutions are supplementary to each other in case of developing countries. Therefore, it is suggested that focus should be given to informal institutions. Moreover, collective initiatives be encourage in developing countries to have diverse ideas from different sectors of the countries. In addition, developing countries should initiate collaborative research projects with technologically advanced countries research and education institutions so as to learn from each other's ideas and experiences.

Keywords: Formal Institutions, Informal Institutions, Innovation

1. INTRODUCTION

Institutions are considered as main drivers of Innovation [Aghion and Howitt (1992); Grossman and Helpman (1990)]. However, in the knowledge-based economy, some of the features of each society influence the ability of an economic system to adapt and translate the innovative efforts into development of new ideas. Institutions are defined as the rules of the game in society. In other words, institutions are humanly developed constraints that shape human interaction [North (1990)]. It consists of both formal and informal institutions. The former means constitution, law, rules and regulation put in place by the government, while the latter means values, norms, honesty, and religiosity which promote cooperative behaviour in society that ultimately result in the

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development of society. Empirical studies indicate that differences in innovative performance of countries are due to diversity in institutions [Sattar and Mahmood (2011); Tebaldi (2013)] but studies undermine the role of informal institutions.

Informal institutions such as values and norms (proxies of informal institutions) contain work ethic which results in cooperative behaviour leading to sharing of knowledge and experience that ultimately generates new ideas and innovation [Lesser (2000); Lucas Jr and Moll (2011)]. Similarly, hierarchies often need new ideas and proposals for the introduction of new brands in the market and if workers cooperate by sharing their ideas, it would result in the introduction of innovative products in the market. This implies that norm of accepting hierarchies most likely encourage innovation within firms. Most of the prominent growth economists consider the flow of knowledge between individuals, firms and regions to be the main sources of innovation [Romer (1986); Lucas (2010)]. Innovation is defined as the generation of new ideas resulting from social interaction between workers, aimed at solving production related problems at workplace.

Studies on innovation recognised that differential in innovation performance among countries of the world is due to differences in research and development [Romer (1990); Grossman (1991)]. But the creation of new knowledge and ideas is not only the result of activities undertaken in laboratories aimed at solving technical production related problems or development of new product design by specific technical experts. It can also be generated when economic agents interact with one another in search of knowledge and ideas [Lucas Jr and Moll (2011)].

This paper analyses the impact of institutions, both formal and informal, on innovation performance of countries that are at different stages of development.[1] The current study is different in many respects from the existing studies. Tebaldi and Elmslie (2013) analysed the impact of formal institutions on innovation while ignoring informal institutions. Similarly, Sattar and Mahmmod (2010) studied the impact of intellectual property rights on innovation while missing informal institution's role in innovation. Lucas Jr and Moll (2011) highlighted the role of time spent in social interaction by focusing on how individuals allocate time optimally between the production of final goods and in search of knowledge activities. But they did not analyse the impact of informal institutions which promote cooperative environment in which workers interact with co-worker in search of knowledge and solution to problems related to production. This paper is different from Lucas in the sense that it examines the effect of institutions (as the institutions create an environment conducive to innovation) on generation of new ideas using technological change model. Romer (1990) developed Technological Change Model which states that new ideas are generated by researchers working in laboratories motivated by monopoly profit. Moreover, the model assumes that the cost of new ideas declines as the society accumulates more ideas represented by the number of new product. Further, the model assumes that the number of new ideas depends on the number of workers in Research and Development sectors. But the model ignores that ideas can be

[1]This paper tries to analyse the impact of institutions, both formal and informal institution on innovation performance of countries lying in different income groups. Following World Bank, countries are classified in different income groups such as low income countries, lower-middle income countries, middle income countries and high income countries group. Further low and lower-middle income countries are combined and named the group as developing countries while middle and high income countries constitute developed countries.

developed during social interactions among workers at the time when they face production related problems and share knowledge and experiences. This paper extends Romer (1990) model by incorporating the effect of informal and formal institutions on the generation of new ideas and innovation using sample of panel countries including developed and developing countries.

2. CONCEPTUAL FRAMEWORK

The basic theme of this paper is that within a firm, whenever workers face any problem related with production at workplace, they resort to getting help from their colleagues. If workers have social value or the worker has social links with other workers, they would be able to get help from their colleague in solving problems arising at the production point. Therefore when they discuss the problem encountered, they will find new methods (at least new for these workers) to solve the problems. As a result of sharing of knowledge, new intermediate input (new ideas, new method of production) would introduce which increase the efficiency of final goods production. Thus sharing of knowledge among workers within organisation would help in generation of new production process (new ideas and innovation) which would help in pushing upwards production frontier of the firm/industry and economy as whole. This logical relationship between institutions and innovation is shown in Figure 1.

Fig. 1. Conceptual Framework

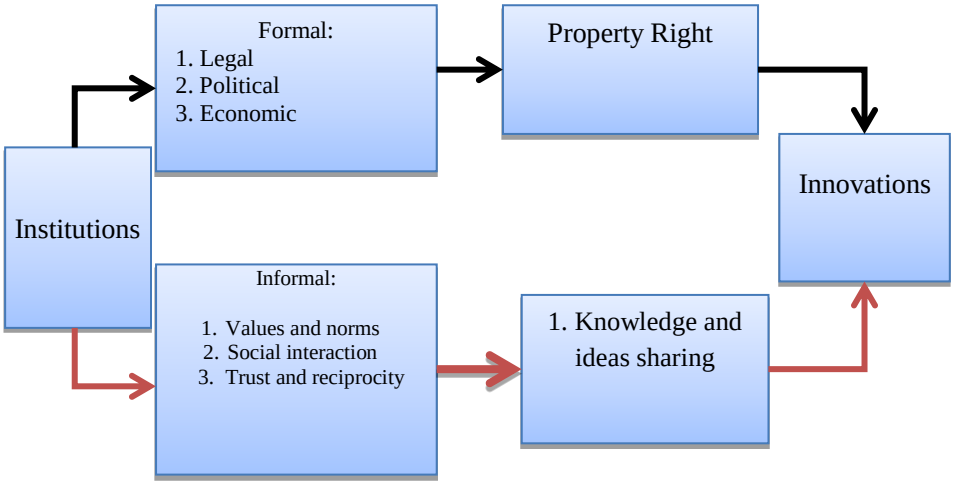

Figure 1 shows the channels through which formal institutions (here considered only intellectual property right) affect economic growth. In this paper, we follow Tebaldi (2008) who has shown theoretically that formal institutions have a positive effect on innovation. We have incorporated his idea in order to see whether formal institutions would be better in the presence of informal institutions or not?

3. DATA AND METHODOLOGY

The new growth theory suggests that generation of new ideas depends on persons engaged in research and development activities and the existence of a stock of knowledge [Romer (1990); Aghion and Howitt (1992)]. The skilled or educated workers also spend a fraction of available time on exchange of ideas, solving production and market related problems, and thus generate new ideas [Rupasinga, *et al.* (2006); Lucas (2008)].

Growth economists have used formal institutions explicitly as determinants of innovation, ignoring informal institutions, which are often considered more important than formal institutions. According to Arrow (1962), formal institutions are not sufficient to eliminate risk and uncertainty arising in business activities, particularly invention, as the moral factor limits their potential. Informal institutions create a cooperative working environment in which workers interact with other workers in search of information, knowledge and ideas that facilitate the creation of new ideas. To incorporate informal institutions, this paper assumes that individuals devote a fraction u_s of their time to social activities such as, helping other co-workers and exchanging ideas with other colleagues and workers. This non-market activity is described by social capital production, given below

$$\dot{S}[t] = P(u[t]_s H[t])^{\phi} S[t]^{\varphi} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

Where "*P*" is the productivity parameter of social capital, $u[t]_s\ H[t]$ is the time spent in discussing, helping and jointly solving production-related problems, which is only possible when the workers follow informal institutions. Equation (1) states that existing social capital (proxy of informal institutions) may have a positive effect on generation of current social capital.

Knowledge is the accumulation of ideas and ideas are produced by people/workers discussing production-related problems while working with machines or technology. This idea is incorporated in the knowledge production function by explicitly introducing the effect of informal institutions such as values and norms, trust, honesty and religiosity which are supposed to promote the culture of sharing of ideas and knowledge (improve existing social capital) among co-workers that would help in generation of new ideas. This paper also incorporates formal institutions as input in the production of ideas. Formal institutions such as intellectual property rights provide an incentive to undertake innovative activities as it restricts diffusion of knowledge without legal permission. The production function of new ideas is

$$\dot{A}[t] = \delta A[t]^{\psi} (u[t]_A H[t])^{\eta} S[t]^{\xi} T[t]^{\varsigma} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

Where ψ is spillover effect of existing stock of ideas, ξ indicates the effect of existing informal institutions in generation of new ideas, $u[t]_A\ H[t]=(1-u[t]_y - u[t]_s)\ H[t]$ time allocated to development of new idea and ς denote the effect of formal institutions. Here $u[t]_A\ H[t]$ are the total working hours which a worker spends in R&D sector, therefore the paper use Π_t in place of $u[t]_A\ H[t]$ for simplicity. Since the above equation is non-linear and cannot be estimated as it is. Therefore, rewriting Equation (2) in discrete form as

$$\Delta A_t = \delta A_{t-1}^{\psi} (\prod_{t-1})^{\eta} S^{\xi} T^{\zeta} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

Now taking logarithm of sides, we have

$$\textit{New ideas} = \ln(\Delta A_{i,t}) = \ln \delta + \psi \ln A_{i,t-1} + \eta \ln \Pi_{i,t-1} + \xi \ln S_i + \zeta \ln T_i + \nu_{i,t}$$

Rewriting the above equation,

$$\textit{New ideas} = \ln(\Delta A_{i,t}) = \beta_0 + \psi \ln A_{i,t-1} + \eta \ln \Pi_{i,t-1} + \xi \ln S_{i,t} + \zeta \ln T_{i,t} + \eta_i + \varepsilon_{i,t} \quad (4)$$

where subscript i = 1,2,3,… … … and t = 1,2,3,… … … represent country and time period respectively. Where $\eta_{i,t}$ unobservable country specific effect and $\varepsilon_{i,t}$ is white noise. $A_{i,t-1}$ is the initial stock of ideas across countries (initial value of Articles published in this case), $\Delta A_{i,t}$ denote the numbers of article published in country i during period t, $\Pi_{i,t-1}$ is the total time spent in R&D sectors (number of skilled labour force employed proxies with human capital), ln $S_{i,t}$ is logarithm of informal institutions measures and ln $T_{i,t}$ denoted logarithm of formal institutions measures.

Since the true measure of formal and informal institutions is unknown, standardised measures of these variables are used which are mostly cited in the literature. This paper uses indices of informal and formal institutions which may assume zero and negative values, in which case logarithmic transformation is not possible. Therefore, $\hat{T}$ (Formal institutions index) and $\hat{S}$ (Informal institution index) are used instead of ln $S_{i,t}$ and ln $T_{i,t}$. This paper adopts the aforementioned procedure parallel with Acemoglu, *et al.* (2001) and Hall and Jones (1990).

Including matrix of control variables $X_{i,t}$ and rewriting the fixed effect panel regression equation of innovation as

$$\textit{New Ideas} = \ln(\Delta A_{i,t}) = \beta_0 + \psi \ln A_{i,t-1} + \eta \ln \Pi_{i,t-1} + \xi \hat{S} + \zeta \hat{T} + \theta X + \eta_i + \varepsilon_{i,t} \quad (5)$$

The coefficient of informal institutions is expected to have a positive sign as informal institutions are conducive to sharing of knowledge and experience that result in the creation of new ideas. In a working environment where workers are paid according to their contribution (if the worker reap full benefits of their innovative activities), the workers would put more effort to generate new ideas, so the expected sign of formal institutions is positive. Similarly, time spent in research and development sector proxies with the number of researchers, skilled workers employed (human capital) also expected to have a positive sign. So far the effect of existing stock of ideas and knowledge is considered; it can be positive (already accumulated stock of ideas helps in the generation new ideas) or negative (development of new knowledge becomes difficult in the presence of already accumulated knowledge). Literature shows that research and development expenditures have a positive effect on innovation [Romer (1990); Acs and Audretsch (2005)]. Therefore research and development expenditure is included as input into innovation/knowledge production function with the expected positive sign.

Traditional growth regressions carry problems of endogeneity, measurement error and omitted variable bias [Acemoglue (2001)]. In this case, the problem of endogeneity may arise due to the reason that institution variables both formal and informal are correlated with explanatory such as human capital and the stock of knowledge, initial

level of institutions. Moreover, institutions change with time, so they are contemporarily correlated with other variables of the model. In the presence of these problems, OLS estimates are biased because of the unobserved relation between omitted variables and the explanatory of the regression equation.

In growth literature, Two Step Least Square method (2SLS) is often used to address the problems of endogeneity and error of measurement which require finding of appropriate instrument for endogenous variables. In this paper, formal and informal institutions are endogenous as they depend on others factors such as earlier institution, ethnicity, religiosity, colonisation and existence of norm and values in society. In addition, dynamic growth and innovation model given in Equation (4) also carries problem of endogeneity as the lagged value of dependent variable is correlated with the residual [Nickell (1981)]. To tackle the problem of endogeneity, system GMM is used to estimate dynamic model of innovation given in Equation (5).

This paper uses a panel data set of 72 countries over the period of 1980-2014. The selection of sample is based on data availability and prevalence of difference in informal institutions, formal institutions and the difference in innovation performance of the sample countries. The overall sample has been divided according to different stages of development i.e. the sample is divided into Low income, lower middle income, upper middle income and high income level following World Bank classification. Further low income countries and lower middle income countries are combined into a separate group called developing countries while the last two are combined to frame group of developed countries.

The literature on innovation shows patents granted as an indicator of innovation [Schmookler (1966); Griliches (1979); Griliches (1984); Romer (2002)] but the problem with the patents granted is that every new idea is not necessarily granted a patent. Moreover, the process of registering patent is cumbersome which results in failure of registering ideas [Jaffe and Trajtenberg (2002)]. Also, all the patents are not of the same quality. Therefore, in this paper, the number of articles published is used as an indicator of innovation following Castellacci and Natera (2011). Articles published is used as dependent variable in different specifications of the innovation model. As discussed above, innovation depends on R&D Expenditure; already accumulated stock of knowledge, formal and informal institutions and control variables such as Religion, Settler mortality, Ethnic diversity, corruption and income inequality.

This study uses data on institutional variables collected from the International Country Risk Guide (ICRG) which is widely used in growth and institutional related studies. Literature shows that researchers have used all components of the index or taken a few components or even a single component best suited to the objectives of their study. Knack and Keefer (1995) used a composite index of institutional quality by using five indicators which are (i) Rule of law; (ii) Corruption in government; (iii) Bureaucratic quality; (iv) Risk of expropriation of assets by the government; and (v) Repudiation of contract by the government. Rodrik (2000) uses only bureaucratic quality, Mauro (1995) employs only corruption and Sala-i-Martin (1997) uses only the rule of law, and so on. Papaioannou (2009) developed an institutional quality index by simply taking the sum of all the twelve indicators included in the ICRG dataset. This paper developed Formal institutions index by taking simple average of six indicators of institutions including (i) Government Stability; (ii) Investment Profile; (iii)

Control over Corruption; (iv) Law and Order; (v) Democratic Accountability; and (vi) Bureaucracy Quality [Papaionnou (2009)].

The literature on informal institutions shows various proxies of informal institutions such as social capital, generalised trust [Narayan and Pritchett (1999); Krishna and Uphoff (1999)], Crime rates, Gini index and corruption index as a measure of informal institutions. To measure informal institutions, researchers have used either single measure [Putnam (1993); Grootaert (1999); Narayan and Pritchett (1999); Krishna and Uphoff (1999)] or take few measures together [Rose (1999); Brehm and Rahn (1997); Doh and Acs (2010)]. As the above measures of informal institutions are likely to be correlated; therefore the present paper constructs informal institutions index by taking a simple average of trust variable, happiness index and friendship index taken from CANA database [Castellacci and Natera (2011)]. The data on the aforementioned variables is collected from World Bank, World value Survey, Country Risk Guide and CANA database [Castellacci and Natera (2011)]. Detail of Variables and data sources are given in Appendix 1.

4. RESULTS AND DISCUSSION

Fixed effect estimation results show that lag articles published (innovation indicator) shows a positive effect on innovation thereby supporting the RD growth model prediction that past discoveries help in present discoveries [Romer (1990)]. The coefficient of RD expenditure also shows a positive significant effect on innovation which implies that innovation and research and development expenditure are positively related (see Tables 1, 3, and 6).

The result of fixed effect methods shows a positive significant effect of both formal and informal institutions on innovation performance of both developed and developing countries (see Tables 3 and 6). The coefficient interaction shows a positive significant effect on innovation but becomes insignificant when time effects are introduced (see Table 3). The coefficient of internet users shows significant positive effect on innovation which implies that development of information technology increased the size of the market, strengthened formal institutions in protecting copy right and made sharing of knowledge accessible. However, the coefficient of internet users is positively insignificant in case of developing countries (see Tables 3 and 5).

The positive significant effect of informal institutions on innovation implies that innovations increase at the workplace where social values prevail i.e. where norm of cooperation, respect, trust and mutual help prevails. This empirical conclusion supports the hypothesis that researchers/worker in cooperative environment would be more productive. The significant positive coefficient of interaction term of institutions indicates that informal institutions support formal institutions in effecting innovative performance of sample countries. It also implies that informal institutions such as respect, honesty and religiosity restrict people from violation of property rights leading.to increase in generation of new ideas. The empirical results concerning formal institutions effect on innovation also support the hypothesis that formal institutions protect copy rights of inventor and so it will be helpful in generation of new ideas and knowledge.

Endogenous technological change model [Romer 1990)] indicates that research and development expenditures are positively related with development of new ideas and

technology. The claim of Romer (1990) is re-examined in various specifications and the results show that expenditures on R&D as percentage of GDP has a positive and

Table 1

Table 1

Impact of Institutions on Innovation Using Fixed Effect Method: Dependent Variable is Article Published (Overall Sample of Countries)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Article(-1)	0.770***	0.705***	0.763***	0.734***	0.705***	0.668***	0.566***	0.721***	0.702***	0.728***	0.704***	0.699***	0.697***	0.579***
	(0.013)	(0.014)	(0.013)	(0.014)	(0.015)	(0.015)	(0.017)	(0.015)	(0.016)	(0.014)	(0.016)	(0.016)	(0.016)	(0.017)
Formal Institutions	0.076***							0.300						
	(0.014)							(0.016)						
Informal Institutions		6.034***							5.416***					
		(0.333)							(0.347)					
Interaction			0.053***							0.017*				
			(0.008)							(0.009)				
RD Expenditure				0.186***	0.179***	0.136***	0.079***				0.164***	0.166***	0.139***	0.069***
				(0.017)	(0.017)	(0.017)	(0.023)				(0.017)	(0.017)	(0.017)	(0.023)
Trade Openness					0.222***	0.108***	0.111**					0.138***	0.147***	0.096*
					(0.039)	(0.040)	(0.051)					(0.044)	(0.043)	(0.052)
Human Capital						0.122***	0.144***						0.153***	0.100***
						(0.013)	(0.017)						(0.018)	(0.021)
Internet User							0.003							0.024***
							(0.005)							(0.009)
Constant	0.541***	-8.053***	0.597***	1.216***	1.487***	0.540***	0.758***	1.072***	-7.106***	1.069***	1.099***	1.514***	0.103	0.890***
	(0.078)	(0.510)	(0.074)	(0.060)	(0.076)	(0.124)	(0.165)	(0.117)	(0.540)	(0.107)	(0.083)	(0.093)	(0.188)	(0.213)
Observations	2,039	1,857	1,618	2,193	2,193	2,193	1,539	2,039	1,857	1,618	2,193	2,193	2,193	1,539
R-squared	0.655	0.637	0.719	0.614	0.620	0.636	0.604	0.692	0.659	0.753	0.634	0.635	0.648	0.630
Number of c_no	70	60	57	68	68	68	68	70	60	57	68	68	68	68

Note: Dependent variable is Number of Articles published). Lagged Article (Articles Published (–1)) and other are treated as regressors. Period dummies are included but not reported. Standard errors in parentheses and asterisk denote respectively *** p<0.01, ** p<0.05, * p<0.1.

Table 2

Impact of Institutions on Innovation Using System GMM: Dependent Variable is Article Published (Overall Sample of Countries)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
RD Expenditures	0.110***	0.0700***	0.106***	0.0545***	0.0846***	0.0928***	0.0552***	0.0711***	0.0530***	0.0523***
	(0.0253)	(0.0197)	(0.037)	(0.0148)	(0.0233)	(0.0176)	(0.0144)	(0.0161)	(0.0138)	(0.0143)
Articles Published(–1)	0.917***	0.910***	0.907***	0.871***	0.869***	0.871***	0.876***	0.875***	0.859***	0.873***
	(0.0159)	(0.0191)	(0.023)	(0.0173)	(0.0242)	(0.0163)	(0.0182)	(0.0182)	(0.0191)	(0.0185)
Informal Institution Index	**0.272*** **		**0.922***							
	(0.0521)		(0.515)							
Formal Institution Index		**0.0811*** **	**0.287** **							
		(0.0172)	(0.141)							
Human Capital				0.0736***	0.0653***	0.0608***	0.0696***	0.0651***	0.0790***	0.0545***
				(0.0103)	(0.0138)	(0.00876)	(0.0109)	(0.00967)	(0.0110)	(0.00939)
Interaction Term			**–1.226**							
			(0.785)							
Trade Openness				0.0717*						
				(0.0380)						
Internet User					0.00521					
					(0.00763)					
Gini Index						0.00214**				
						(0.000877)				
Ethnic Fractionalisation							–0.109*			
							(0.0632)			
Muslims								0.000983**		
								(0.000449)		
Catholic									-0.00122***	
									(0.000385)	
Other Religions										0.177**
										(0.0762)
Observations	590	852	473	936	603	590	936	936	936	936
Number of c_no	34	41	43	47	43	34	47	47	47	47
AR(1) p-value	0.000	0.000	152.000	0.000	0.002	0.007	0.000	0.000	0.000	0.000
AR(2) p-value	0.518	0.511	0.000	0.524	0.745	0.718	0.546	0.724	0.534	0.734
Sargen p-value	1.000	0.922	0.711	0.677	0.434	0.0076	1.0000	0.789	0.976	0.789

Note: All specifications include time dummies. AR(1) and AR(2) are test of the 1st and 2nd order autocorrelation in the residual of difference equation respectively. Sargen P-value test over-identification of exogenous variable. Robust standard error are in parentheses *, **, *** denote significance at 10 percent, 5 percent, 1 percent level respectively.

Table 3

Impact of Institutions on Innovation Using Fixed Effect Method: Dependent Variable is Article Published (Developed Countries)

	Country Specific Effect						Time Specific Fixed Effect					
	(1)	(2)	(3)	(4)	(5)	(6)	(1)	(2)	(3)	(4)	(5)	(6)
Article(–1)	0.754***	0.682***	0.763***	0.661***	0.626***	0.387***	0.688***	0.664***	0.703***	0.657***	0.658***	0.393***
	(0.013)	(0.016)	(0.013)	(0.016)	(0.016)	(0.018)	(0.015)	(0.019)	(0.015)	(0.017)	(0.017)	(0.018)
Formal Institutions	0.051***						-0.010					
	(0.011)						(0.012)					
Informal Institutions		6.128***						5.398***				
		(0.325)						(0.341)				
Interaction			0.037***						0.003			
			(0.007)						(0.008)			
RD Expenditure				0.208***	0.166***	0.143***				0.184***	0.158***	0.135***
				(0.018)	(0.019)	(0.024)				(0.018)	(0.019)	(0.024)
Trade Openness				0.261***	0.162***	0.202***				0.201***	0.206***	0.164***
				(0.039)	(0.040)	(0.042)				(0.044)	(0.043)	(0.043)
Human Capital					0.096***	0.110***					0.106***	0.062***
					(0.012)	(0.013)					(0.016)	(0.016)
Internet User						0.011***						0.047***
						(0.004)						(0.007)
Constant	0.855***	-8.061***	0.808***	1.798***	1.056***	2.019***	1.493***	-6.885***	1.395***	1.603***	0.819***	2.065***
	(0.071)	(0.499)	(0.071)	(0.084)	(0.124)	(0.144)	(0.102)	(0.538)	(0.104)	(0.095)	(0.150)	(0.178)
Observations	1,652	1,584	1,416	1,799	1,799	1,273	1,652	1,584	1,416	1,799	1,799	1,273
R-squared	0.705	0.627	0.751	0.641	0.654	0.593	0.744	0.652	0.788	0.665	0.673	0.626
Number of c_no	56	48	48	55	55	55	56	48	48	55	55	55

Note: Dependent variable is Articles published. Lagged Articles Published (–1) and other are treated as regressors. Period dummies are included but not reported. Standard errors in parentheses and asterisk denote respectively *** p<0.01, ** p<0.05, * p<0.1.

Table 4

Impact Institutions on Innovation using SYS-GMM (Developed Countries): Dependent Variable is Article Published

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
RD Expenditures	0.0833***	0.0387**	0.126***	0.0489***	0.0512**	0.114***	0.0510***	0.0591***	0.0440***	0.0422***
	(0.0242)	(0.0163)	(0.0163)	(0.0134)	(0.0224)	(0.0205)	(0.0141)	(0.0149)	(0.0137)	(0.0136)
Articles Published(-1)	0.931***	0.951***	0.896***	0.904***	0.936***	0.869***	0.905***	0.901***	0.896***	0.891***
	(0.0157)	(0.0161)	(0.0109)	(0.0155)	(0.0207)	(0.0169)	(0.0158)	(0.0160)	(0.0167)	(0.0169)
Informal Institution Index	**0.228*** **									
	(0.0519)									
Formal Institution Index		**0.0464*** **								
		(0.0144)								
Human Capital				0.0528***	0.0339***	0.0630***	0.0515***	0.0521***	0.0572***	0.0446***
				(0.00888)	(0.0113)	(0.00906)	(0.00913)	(0.00856)	(0.00954)	(0.00821)
Interaction Term			**-0.0539**							
			(0.0482)							
Openness				0.0281						
				(0.0222)						
Internet User					0.00128					
					(0.00592)					
Gini Index						0.00206**				
						(0.000860)				
Ethnic Fractionalisation							0.0225			
							(0.0541)			
Muslims								0.000588		
								(0.000397)		
Catholic									-0.00064**	
									(0.000326)	
Other Religions										0.190***
										(0.0596)
Observations	514	610	673	673	438	514	673	673	673	673
Number of c_no	29	31	37	37	33	29	37	37	37	37
AR(1) p-value	0.000	0.000	0.001	0.000	0.002	0.007	0.000	0.000	0.000	0.000
AR(2) p-value	0.518	0.511	0.543	0.524	0.745	0.718	0.546	0.724	0.534	0.734
Sargan p-value	1.0000	0.922	0.441	.677	0.434	0.0076	1.0000	0.789	0.976	0.789

Note: All specifications include time dummies. AR(1) and AR(2) are test of the 1st and 2nd order autocorrelation in the residual of difference equation respectively. Sargan P-value test over identification of exogenous variable. Robust standard errors are in parentheses *, **, *** denote significance at 10 percent,5 percent,1 percent level respectively.

Table 5

Impact of Institutions on Innovation Using Fixed Effect Method: Dependent Variable is Article Published (Developing Countries)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Article Published(1)	0.786***	0.749***	0.760***	0.784***	0.768***	0.718***	0.666***	0.666***	0.775***	0.714***	0.711***	0.713***	0.719***	0.644***
	(0.033)	(0.034)	(0.042)	(0.034)	(0.037)	(0.035)	(0.039)	(0.042)	(0.038)	(0.052)	(0.041)	(0.042)	(0.041)	(0.045)
Formal Institutions	0.151***							0.034						
	(0.048)							(0.070)						
Informal Institution		5.915***							4.519***					
		(1.319)							(1.349)					
Interaction			0.128***							0.116**				
			(0.037)							(0.052)				
RD Expenditure				0.157***	0.156***	0.110***	0.036				0.083**	0.083**	0.070*	0.020
				(0.040)	(0.040)	(0.039)	(0.054)				(0.041)	(0.041)	(0.040)	(0.053)
Trade Openness					0.126							-0.034		
					(0.108)							(0.114)		
Human Capital						0.238***	0.295***						0.282***	0.240**
						(0.042)	(0.067)						(0.072)	(0.099)
Internet User							0.002							-0.068
							(0.018)							(0.044)
Constant	–0.231	–8.131***	–0.333	0.759***	0.905***	–0.711**	–1.510***	0.799*	–7.205***	1.196**	–0.156	0.306	–1.152**	0.019
	(0.192)	(1.935)	(0.208)	(0.104)	(0.163)	(0.279)	(0.562)	(0.418)	(1.985)	(0.503)	(0.238)	(0.275)	(0.582)	(0.772)
Observations	387	273	202	394	394	394	266	387	273	202	394	394	394	266
R-squared	0.621	0.662	0.679	0.596	0.597	0.627	0.664	0.708	0.746	0.802	0.677	0.677	0.691	0.723
Number of c_no	14	12	9	13	13	13	13	14	12	9	13	13	13	13

Note: Dependent variable is Number of Articles published. Lagged Articles and other are treated as regressors. Period dummies are included but not reported. Standard errors are in parentheses and asterisk denote respectively *** p<0.01, ** p<0.05, * p<0.1

Table 6

Impact of Institutions on Innovation Using System GMM: Dependent Variable is Article Published (Developing Countries)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
RD Expenditures	0.108***	0.0725**	0.130***	0.0470*	0.0660*	0.116***	0.0433*	0.0557**	0.0394	0.0451*
	(0.0370)	(0.0295)	(0.0405)	(0.0256)	(0.0395)	(0.0411)	(0.0253)	(0.0259)	(0.0253)	(0.0260)
Articles Published(-1)	0.825***	0.836***	0.890***	0.842***	0.783***	0.815***	0.850***	0.826***	0.839***	0.849***
	(0.0456)	(0.0369)	(0.0374)	(0.0340)	(0.0425)	(0.0501)	(0.0322)	(0.0341)	(0.0332)	(0.0327)
Informal Institution	0.320***									
	(0.0870)									
Formal Institutions		**0.109*** **								
		(0.0259)								
Human Capital				0.0587***	0.0562**	0.0286	0.0689***	0.0665***	0.0741***	0.0579***
				(0.0156)	(0.0252)	(0.0387)	(0.0188)	(0.0152)	(0.0177)	(0.0185)
Interaction Term			**1.482*** **							
			(0.486)							
Openness				–0.0489						
				(0.0594)						
Internet User					0.0368*					
					(0.0194)					
Gini Index						0.0115				
						(0.00716)				
Ethnic Fractionalisation							0.0917			
							(0.149)			
Muslims Dummy								0.00212**		
								(0.00106)		
catholic Dummy									–0.00119	
									(0.000893)	
Other religion Dummy										0.104
										(0.287)
Observations	76	242	263	263	165	76	263	263	263	263
Number of c_no	5	10	10	10	10	5	10	10	10	10
AR(1) pvalue	0.000	0.000	0.001	0.000	0.002	0.007	0.000	0.000	0.000	0.000
AR(2) pvalue	0.518	0.511	0.543	0.524	0.745	0.718	0.546	0.724	0.534	0.734
Sargan p-value	1.000	0.922	0.441	.677	0.434	0.0076	1.0000	0.789	0.976	0.789

Note: All specifications include time dummies. AR(1) and AR(2) are test of the 1st and 2nd order autocorrelation in the residual of difference equation respectively. Sargan P-value test over-identification of exogenous variable. Robust standard errors are in parentheses *, **, *** denote significance at 10 percent, 5 percent, 1 percent level respectively.

a significant effect in all the specifications. Moreover, the Romer model also states that the number of researcher (skilled labour or human capital) also has a positive effect on new product variety development or new ideas development. In all specifications the coefficients of human capital show a positive and significant effect on innovation supporting Romer (1990).

Trade openness indicators show positive significant effect on innovation in case of developed countries' sample which confirms Grossman and Helpman (1990) conclusion. The positive effect of trade openness indicator implies that trade liberalisation can be used as mechanism of diffusion of technology in the world. In contrast to the developed countries, trade liberalisation shows positive insignificant effect on innovation and become negative insignificant when time effect is considered.

The study also used system GMM to check the robustness of estimation result. The estimation result of system GMM shows a positive significant coefficient of past research work which implies that past innovations have a significant positive effect on current innovations. In base line specification, RD expenditures and past innovations show a positive significant effects on current innovations supporting RD growth models [Romer (1990); Hall and Jone (1991)].

The coefficient of informal institutions is positive significant in all specifications. The positive significant effect of informal institutions on innovation implies that innovations increase at workplace where social values prevail. The coefficient of formal institutions is positive significant which means that strong formal institutions create an incentive to innovate more (see Tables 2, 4, and 6).

The empirical results concerning formal institutions' effect on innovation also support our theoretical intuitions i.e. formal institutions protect copyright of researchers and so the existence of strong formal institutions helps in generation of new ideas and knowledge. This is the same result which full sample of countries shows. In contrast to developing countries, the coefficient of the interaction term is negative insignificant, which implies that formal institutions are complementary to informal institutions. The last result hints at capitalist nature of developed countries where informal networking is lacking. This result support Putnam (1990) finding that due to individualistic nature of people living in the developed countries, they lack social networking. Whereas the coefficient of interaction term is positive significant in case of developing countries which implies that social values in the form of informal institution support formal institutions in affecting innovative performance of the sampled countries. This hints at an interesting point that in order to increase innovative activities, developing countries should seek collaboration with developed countries in order to increase the stock of new ideas in those countries.

The study considers the effect of formal and informal institution and examines the individual effect of internet users on the generation of new ideas. The study of the individual result of internet user shows insignificant positive effects of intent user on innovation. RD growth model [Romer (1990)] states that the number of researcher (skilled labour or human capital) also has a positive effect on development of new product varieties or generating new ideas. In all specifications the coefficients of human capital show positive and significant effects on innovation.

The study also includes religions dummies and the results shows positive effect of Muslim dummy. Other religion dummy also shows significant positive (0.190***) effect on innovation while catholic dummy shows negative significant (–0.000640***) effect on innovation performance of developed countries (see Table 4). The result for developing countries shows that Muslims are more cooperative in sharing of knowledge as compared to other religions (see Table 6). The study also includes ethnicity as a dummy variable and the result shows positive insignificant effect on innovation. This shows that workers in workplace with heterogeneous workers would be able to create more ideas due to diversity in their specialisation. The coefficient of Gini index is positive which means that income inequality has a positive effect on innovation. This implies that workplace where each worker is paid to his/her contribution would experience an increase in innovative ideas (see Tables 4 and 6).

The overall conclusion is that informal institutions, formal institutions, human capital, Research and development expenditure, Internet usage, and trade liberalisation have a positive effect on innovation. Muslim dummy and other religion dummy shows positive effect on innovation while catholic dummy shows negative effect on innovation.

7. CONCLUSIONS AND POLICY RECOMMENDATIONS

This paper has attempted to analyse the effects of institutions, both formal and informal, on innovations in aggregate and disaggregate sample of countries. The assumption is that not only formal institutions, such as intellectual property right but informal institutions such as values, norms, traditions and religiosity affect innovation performance of sampled countries. Fixed effect method and system GMM are used for empirical analysis. Religion dummies are used as instrument of informal institutions.

Empirical results of fixed effect method show that the research and development expenditures, stock of knowledge, human capital, and informal institutions and formal institution show significant positive effect on innovation in case of the full sample and the samples of developed countries and developing countries. However formal institutions are more effective in developed countries and informal institutions in developing countries. In contrast to institutions of developed countries, in developing countries institutions are found supplementary to each other. Muslims are found to have a significant positive effect on innovation in developing countries while other religion dummy is found to have positive significant effect on innovation in case of developed countries.

Based on the results, it is suggested that attention may focus on informal institutions as these would strengthen formal institutions in developing countries. As formal institutions are found to be more effective in the developed countries, informal institutions need to be strengthened in developing countries in order to improve their innovative performance. In developing countries, organisation need to provide an environment in which workers could freely meet and share ideas with co-workers. The study concludes that collective work encourages innovation; therefore, governments of less developed countries should foster innovation activities in collaboration with industries, organisations and institutions of developed countries. To accelerate innovative activities, there is a need to encourage sharing of knowledge through better internet facilities, improved access to libraries and databases, and establishment of research infrastructure.

This paper can be extended by taking micro level study at organisation level to highlight the importance of institutions and its impact on innovation. Also this paper can be extended by taking individual measures of formal and informal institutions to examine its effect on innovation.

Appendix 1

List of Variables

Income Group	LowIncome-1, Lower middle Income-2 Upper Income-3 HighIncom-4	Data Sources
Region	Region1, Region 2, Region 3, Region 4, Region 5, Region 6, Region 7	WDI
GDP Per Capita	GDP per capita (current US$)	WDI
Article	Scientific and technical journal articles. Number of scientific and engineering articles published in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences, per million people	World Bank; National Science Foundation, UNESCO
RD Expenditures	R&D expenditures as a percentage of GDP	OECD
Openness	Openness Indicator. (Import + Export)/GDP	UNCTAD
Human Capital	Mean years of schooling. Average number of years of school completed in population over 14	Barro and Lee (2001); World Bank
Education Expenditures	Public Expenditure on Education. Current and capital public expenditure on education	UNESCO
Internet User	Internet users per 1000 people. People with access to the worldwide web network divided by the total amount of population.	World Bank
Corruption Index	Corruption Perception Index. Transparency International Index, ranging from 0 (High Corruption) to 10 (Low Corruption)	Transparency International
Gini	Gini Index	United Nations
Family Important	Family important in life. Index ranging from 3 (very important) to 0 (not import	World Values Survey
Trust	Most people can be trusted. Percentage of respondents who "agree" with this stat	World Values Survey
Happiness	Feeling of Happiness. Index ranging from 3 (very happy) to 0 (not happy).	World Values Survey
School Friendship	Friends important in life. Index ranging from 3 (very important) to 0 (not important)	World Values Survey
Informal Institutions Index	Informal institutions Index is the average value of Trust, Happiness and School Friendship variables	Author own calculation
Government Stability	A measure of both of the government's ability to carry out its declared program(s), and its ability to stay in office. The risk rating assigned is the sum of three subcomponents: Government Unity, Legislative Strength, and Popular Support	ICRG
Socio-economic Conditions	A measure of the socioeconomic pressures at work in society that could constrain government action or fuel social dissatisfaction. The risk rating assigned is the sum of three subcomponents: Unemployment, Consumer Confidence, and Poverty	ICRG
Investment Profile	A measure of the factors affecting the risk to investment that are not covered by other political, economic and financial risk components. The risk rating assigned is the sum of three subcomponents: Contract Viability/Expropriation, Profits Repatriation, and Payment Delays	ICRG
Corruption	A measure of corruption within the political system that is threat to foreign investment by distorting the economic and financial environment, reducing the efficacy of government and business by enabling people to assume position of power through patronage rather than ability, and introducing inherent instability into the political process	ICRG
Law and Order	Two measures comprising one risk component. Each sub-component equals half of the total. The "law" sub-component assesses the strength and impartiality of the legal system, and the "order" sub-component assesses popular observance of the law	ICRG

Continued—

Appendix Table I—(*Continued*)

Ethnic Tensions	A measure of the degree of tension attributable to racial, national, or language divisions. Lower ratings (higher risk) are given to countries where tensions are high because opposing groups are intolerant and unwilling to compromise	ICRG
Democratic Accountability	A measure of, not just whether there are free and fair election, but how responsive government is to its people. The less responsive it is, the more likely it will fall. Even democratically elected government can delude themselves into thinking they know what is best for the people, regardless of clear indication to the contrary from the people	ICRG
Bureaucracy Quality	Institutional strength and quality of the bureaucracy is a shock absorber that tends to minimise revisions of policy when governments change. In low-risk countries, the bureaucracy is somewhat autonomous from political pressure	ICRG
Formal Institution Index	Informal institutions index is the average value of i) Government Stability ii) Investment Profile iii) Control over Corruption iv) Law and Order v) Democratic Accountability and vi) Bureaucracy Quality	Author own calculation
Settler Mortality	Log of the mortality rate faced by European settlers at the time of colonisation	The Quality of Government Institute, http://www.qog.pol.gu.se
Ethnic Fractionalisation	The variables reflect the probability that two randomly selected people from a given country will not share a certain characteristic, the higher the number the less probability of the two sharing that characteristic	The Quality of Government Institute, http://www.qog.pol.gu.se
Linguistic Fractionalisation	Reflects probability that two randomly selected people from a given country will not belong to the same linguistic group. The higher the number, the more fractionalised society	The Quality of Government Institute, http://www.qog.pol.gu.se
Religious fractionalisation	Reflects probability that two randomly selected people from a given country will not belong to the same religious group. The higher the number, the more fractionalised society	The Quality of Government Institute, http://www.qog.pol.gu.se
Colonial	This is a tenfold classification of the former colonial ruler of the country. 0=never,1= Dutch,2= Spanish,(3) Italian,(4) US,(5) British,(6) French, (7) Portuguese (8) Belgian (9) British-French (10) Australian	The Quality of Government Institute, http://www.qog.pol.gu.se
Catholics	Catholics as percentage of population in 1980	The Quality of Government Institute, http://www.qog.pol.gu.se
Muslims	Muslims as percentage of population in 1980	The Quality of Government Institute, http://www.qog.pol.gu.se
Other Religion:	Other Denomination	The Quality of Government Institute, http://www.qog.pol.gu.se
Population Density	Population density (people per sq. km of land area)	WDI
Population Growth	Population growth (annual %)	WDI
Death Rate	Death rate, crude (per 1,000 people)	World Bank
Distance	Distance to frontier score (0=lowest performance to 100=frontier)	World Bank
Droughts		World Bank

Appendix 2

Names of Countries, Regions and Groups

Country No.	Country Name	Regions	Income Group
1	Algeria	Middle East and North Africa	Upper Middle income
2	Argentina	Latin America and Caribbean	Upper Middle income
3	Armenia	Europe and Central Asia	lower middle income
4	Australia	East Asia and Pacific	High-income OECD
5	Austria	Europe and Central Asia	High-income OECD
6	Azerbaijan	Europe and Central Asia	Upper Middle income
7	Bangladesh	South Asia	Low Income
8	Belgium	Europe and Central Asia	High-income OECD
9	Bolivia	Latin America and Caribbean	lower middle income
10	Botswana	Sub-Saharan Africa	Upper Middle income
11	Brazil	Latin America and Caribbean	Upper Middle income
12	Bulgaria	Europe and Central Asia	Upper Middle income
13	Canada	North America	High-income OECD
14	Chile	Latin America and Caribbean	High-income OECD
15	China	East Asia and Pacific	Upper Middle income
16	Colombia	Latin America and Caribbean	Upper Middle income
17	Costa Rica	Latin America and Caribbean	Upper Middle income
18	Croatia	Europe and Central Asia	High Income non-OECD
19	Czech Republic	Europe and Central Asia	High-income OECD
20	Denmark	Europe and Central Asia	High-income OECD
21	Dominican Republic	Middle East and North Africa	Upper Middle income
22	Ecuador	Latin America and Caribbean	Upper Middle income
23	Egypt	Middle East and North Africa	lower middle income
24	El Salvador	Latin America and Caribbean	lower middle income
25	Finland	Europe and Central Asia	High-income OECD
26	France	Europe and Central Asia	High-income OECD
27	Georgia	Europe and Central Asia	lower middle income
28	Germany	Europe and Central Asia	High-income OECD
29	Greece	Europe and Central Asia	High-income OECD
30	Honduras	Latin America and Caribbean	lower middle income
31	Hungary	Europe and Central Asia	Upper Middle income
32	India	South Asia	lower middle income
33	Indonesia	East Asia and Pacific	lower middle income
34	Iran	Middle East and North Africa	Upper Middle income
35	Ireland	Europe and Central Asia	High-income OECD
36	Israel	Middle East and North Africa	High-income OECD
37	Italy	Europe and Central Asia	High-income OECD
38	Jamaica	Latin America and Caribbean	Upper Middle income
39	Japan	East Asia and Pacific	High-income OECD
40	Malaysia	East Asia and Pacific	Upper Middle income
41	Mauritius	Sub-Saharan Africa	Upper Middle income
42	Mexico	Latin America and Caribbean	Upper Middle income
43	Moldova	Europe and Central Asia	lower middle income
44	Netherlands	Europe and Central Asia	High-income OECD
45	New Zealand	East Asia and Pacific	High-income OECD
46	Nicaragua	Latin America and Caribbean	lower middle income
47	Norway	Europe and Central Asia	High-income OECD
48	Pakistan	South Asia	lower middle income
49	Panama	Latin America and Caribbean	Upper Middle income
50	Paraguay	Latin America and Caribbean	lower middle income
51	Peru	Latin America and Caribbean	Upper Middle income
52	Poland	Europe and Central Asia	High-income OECD
53	Portugal	Europe and Central Asia	High-income OECD
54	Romania	Europe and Central Asia	Upper Middle income
55	Russia	Europe and Central Asia	High Income non-OECD
56	Singapore	East Asia and Pacific	High Income non-OECD
57	Slovakia	Europe and Central Asia	High-income OECD
58	Slovenia	Europe and Central Asia	High-income OECD
59	South Africa	Europe and Central Asia	Upper Middle income
60	Spain	Europe and Central Asia	High-income OECD
61	Sri Lanka	South Asia	lower middle income
62	Sweden	Europe and Central Asia	High-income OECD
63	Switzerland	Europe and Central Asia	High-income OECD
64	Thailand	East Asia and Pacific	Upper Middle income
65	Trinidad and Tobago	Latin America and Caribbean	High Income non-OECD
66	Tunisia	Middle East and North Africa	Upper Middle income
67	Turkey	Europe and Central Asia	Upper Middle income
68	Ukraine	Europe and Central Asia	lower middle income
69	United Kingdom	Europe and Central Asia	High-income OECD
70	United States	North America	High-income OECD
71	Uruguay	Latin America and Caribbean	High Income non-OECD
72	Venezuela	Latin America and Caribbean	Upper Middle income

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