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Institutions, innovation and Economic Growth: Theoretical and Empirical Analysis

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Abstract: This paper incorporates formal and informal institutions in Research and Development (R&D) sector of endogenous growth model. First, we establish a link between institutions and economic growth through innovation using a theoretical model. Then we test the model empirically using a sample of 72 developed and developing countries spanning 1984-2017. We employ two step system GMM technique to estimate the effect of institutions on economic growth tackling the endogeneity issue. The empirical results show a significantly positive effect of innovation and both formal and informal institutions on economic growth. Moreover, the effect of innovation on economic growth varies with formal institutions. There is also a presence of substitution between formal and informal institutions. The novel contribution of the paper is that countries with high level of happiness, friendship and gender participation experience higher per capita income. We employ gender participation as a proxy of informal institutions and found positive impact of gender participation on economic growth. The result shows that countries with greater gender participation also perform better in innovation field. Our results suggest some policy implications that is policy makers should focus on both formal and informal institutions as they promote growth through their impacts on innovation. Finally, policy makers should devise polices to increase the ratio of female to male in R&D sector which constitutes 29.3% of the world at present, as that would boost development of new product.

Keywords: Economic growth, Formal institutions, Informal institutions, R&D, Dynamic GMM

1. Introduction

Innovation is considered a primary driver of economic growth (Aghion & Howitt, 1992; Grossman & Helpman, 1990) However, the ability of an economic system to adapt and translate the innovative efforts into economic growth differs across regions and societies. It has been argued that institutions play a vital role in determining technological change and in the diffusion of existing knowledge (Acemoglu et al., 2005; Rose, 1999) Institutions are defined as the rules of game in society or humanly developed constraints that shape human interaction (North, 1990) Institutions can be both formal and informal. Formal institutions consist of constitution, law, rules, and regulations put in place by a government while informal institutions comprise norms, codes of conduct, conventions, traditions, religion and social trend. Empirical studies indicate that difference in economic performance between developed and underdeveloped countries are a function of variations in institutions (Acemoglu et al., 2005, 2012; Khan et al., 2017; Lien, 2018; North, 1990; Sattar & Mahmood, 2011; Stein, 2008; Tebaldi & Elmslie, 2013). Growth economists explain difference in per capita income in terms of difference path of factor accumulation. In these models, the disparity in factors accumulation is explained by divergence in savings rate (Cass, 1965; Solow, 1956), preferences (Koopmans, 1960) or exogenous technological changes (Solow, 1957). . Schumpeter (1934) argued that the variation in growth rate across countries is not due to technological differences; rather it is the diffusion of technology which is more important in the development of a country.

Endogenous growth models theorize technological change as endogenous to economic growth (Romer, 1990) but they do not see any role of institutions, focusing rather on conventional factors of production along with knowledge accumulation (North, 1990; (Acemoglu & Guerrieri, 2008; Silve & Plekhanov, 2015). These models consider markets and property rights institutions but variation in these institutions could not explain growth differential across nations (Acemoglu et al., 2005; Furubotn & Richter, 1993; Keefer & Knack, 1997). Studies by (Acemoglu et al., 2005; Glaeser et al., 2004; J. C. Hall et al., 2010; Rodrik et al., 2004), show that institutions matter for growth.

Another strand of literature examines the effect of formal institutions on economic development of a country through technological innovation (Keefer & Knack, 1997; Rodrik, 2000; Sattar & Mahmood, 2011) while ignoring the role of informal institutions. Not only formal institutions but also informal institutions are very important for economic growth (K. S. Chan et al., 2015; Hansen, 2013). According to North (1990), formal institutions are crystallization of informal institution and both co-evolve through social groups (both formal and informal), from household and villages to networks, firms, parties, and government. Recent studies find that informal institutions can improve the quality of formal institutions but cannot replace them (Cruz-García & Peiró-Palomino, 2019).

Informal institutions influence economic growth in multiple ways. Moral and ethical behaviors maximize welfare of nations which are embodied in informal institutions that determine the quality of formal institutions. Values and norms1 contain work ethic which results in cooperative behavior leading to increased work force productivity and hence overall economic growth. If workers cooperate by sharing their ideas, it would result in generation of new ideas and increase firms' innovation capabilities (Liu et al., 2017).Norms of cooperation can have a significant effect on the exchange of ideas and information and thus indirectly influence economic growth through the generation of new ideas and innovation (Lesser, 2000; Lucas Jr & Moll, 2011; Liu, Huang, Dou, & Zhao , 2017).

[1] Values refers to desirability of an act that influence human behaviors (Darity,2007)

The cooperative behavior also depends on gender diversity at workplace. Studies show that gender participation enhance cooperation at workplace. Literature indicate that recruiting and retaining women in scientific and technical field has produced significant progress in terms of innovation. This created new interest in designing policies to get more women in technology and innovation field in business. Women account a minority of world's researchers as less than one third (29.3) % of researcher employed across the world are women. However, recent research work shows that women can substantially contribute to innovative activities and can enhance knowledge outcome (Xie et al., 2020) and thus female remain the potential resources of innovation. Empirical studies conclude that gender diversity in working group promote creativity and innovation (Bond et al., 2001; Na & Shin, 2019; Xie et al., 2020) Studies shows that female are more cooperative than male and tend to friendly and agreeable with others (Karakowsky & Siegel, 1999; Nielsen et al., 2018). Thus, the presence of female at workplace creates cooperative environment which would increase sharing of ideas leading to development new product.

Most of the prominent growth economists consider flow of knowledge between individuals, firms and region to be the main sources of innovation ((Lucas Jr, 2009; Romer, 1986). Innovation is defined as process involving social interaction aimed at the generation of new ideas to solve production-related problems at workplace (Lin, 2007; Liu et al., 2017; Sáenz et al., 2009). It is no longer specific activities undertaken in a laboratory aimed at generating a technical solution to production-related problems and generating new product design. That is innovation is considered as a search process, problem-solving process, a sharing process and an interaction process (Kortum, 1997; Lucas Jr, 2009; Lucas Jr & Moll, 2014; Sáenz et al., 2009).This concept of innovation considers social interaction as an important factor of innovation. Social interaction is defined as spending free time with people whom a person like which can also facilitate knowledge sharing (Liu et al., 2017; Mehra et al., 2001). Sharing of knowledge between individuals is the result of personal initiative than a formal setting of organization and may occur in non-work settings. Mobility of skilled worker among firms is main channel of sharing of technical knowledge among innovative firms which is the main source of growth (Grossman & Helpman, 1991).

Companies acquire technology through their own research and development activities, reverse engineering and through informal exchange of information and ideas [2](Allen et al., 2007; Krugman & Obstfeld, 2009).Also, they view the later source of innovation to be more effective when the firms are in close proximity to each other (Jaffe et al., 1993; Keynes, 1924; Romer, 1986).Presently, with the development of new communication- enabling technologies such as Facebook, WhatsApp. Skype, Linked, and Twitter, have opened new venues of social interaction that are likely to have positive effects on generation of new ideas and proximity is not consider as source of innovation (Bailey et al., 2018; Bell & Zaheer, 2007).

Informal institutions promote cooperative behavior in society that ultimately results in development of society. The prevalence of these institutions at workplace helps workers to cooperate with other coworker in solving production related activities that may generate new ideas during team work. These institutions are different from formal institutions that restrict the sharing of knowledge without prior

[2] Informal exchange of information and ideas arise at the time of social interaction during lunch and breakfast times when they share their experiences.

approval of the owner. Intellectual property right in general and patent in particular is the main driver of innovation. New ideas are considered as a primary source of economic growth and incentives are needed to inventors to undertake risky and costly investment to generate new ideas. It is argued that strong formal institution protects the right of inventor which in result leads to an increase in generation of new ideas (Sharma & Kumar, 2018)

Growth model considers idea generation as much important as idea diffusion for economic development. This paper adds diffusion of innovation as essential element of economic growth. Broadly speaking, advanced research economies have been the source of innovation while developing countries have been adopting those innovations. Diffusion of product innovation usually takes place through patent selling, imitation through piracy or reverse engineering. Imitation could be due to weak institutional environments of imitating nations to stop piracy. It may also be due to complicity of policy makers or their strategic actions to copy and exploit foreign knowledge. In recent years, ICT has disrupted the diffusion system. A recent study finds that sci-hub – a website where researchers can download any piece of research – has not only made the existing stock of knowledge accessible to developing countries who otherwise could not afford expensive subscriptions but that downloads made through sci-hub are 1.72 times more likely to be cited than downloaded through other means (Correa et al., 2021). Diffusion could also be due to mobility of people between countries. Particularly, the effect of diaspora where large number of people from a developing country settle in an advanced research economy such as US for education, employment or business who develop strong networks with people and firms back home. Yet another important diffusion channel is the trade between countries. Research shows that, apart from economic gains from exchange of goods, trade is a channel to exchange ideas between firms and countries (Fuera & Oberfield, 2016). It is important to note that diffusion is not only happening between countries, but also within a society which can be between industries, firms and employees within a firm. The channels of diffusion within a country are through digital and physical communication system, informal institutions, and gender participation.

The world economy has experienced tremendous growth over the past century. But disparity in growth rates across countries invite the attention of economists to inquire the underlying causes embedded in the complex cultural, economic and political systems. This paper examines whether the variation in growth performance is explained by formal institutions, informal institution or both. In addition, the paper also investigates how institutions affect collective innovation and diffusion capabilities of organization and hence countries that ultimately economic performance of panel of sample countries.

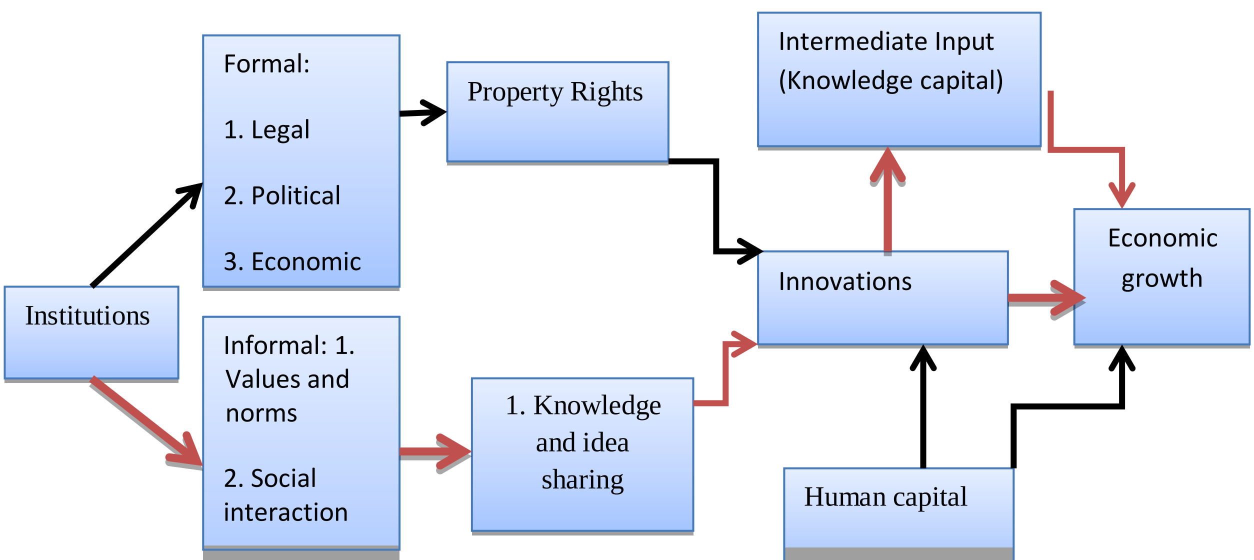
The paper is structured as follows: section 2 discusses background of the study, whereas, Data and Methodology is discussed in section 3 while results and discussion are shown in the section 4. Finally, section 5 concludes the article.

2. Background of the study

The basic theme of the study is that within firms, workers with different productivity levels interact with each other. When a problem arises during production process, these workers take assistance from others which result in solving the problem. As worker share their experience and ideas with other colleagues, resulting in increasing their productivity and hence growth. The main feature of the model is social or reciprocal character of intellectual activity. Informal institutions of trust, interpersonal exchange of information, norms and values, gender participation impact economic growth through their impacts on generation of new ideas. Values and norms contain work ethic which catalyze cooperative behavior that result in accelerating overall economic growth.

This paper intends to examine the effect of formal and informal institutions on economic growth through their effect on generation of new ideas. For this purpose, the study considers hypothetical economy where human capital, and intermediate inputs are causal factors of production. While both formal and informal institutions are supposed to effect economic growth through their effect on innovation. This is shown in figure 1.1.

Figure 1.1 shows that whenever worker faces any problem related with production at work place, they resort to get 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 aroused at production point. Therefore, when they discuss the problem aroused, they find new methods (at least new for these workers) to solve the problems. This increases productivity of workers at workplace involved in production process. As a result of sharing of knowledge, new intermediate input would introduce which increase the efficiency of final good production. Thus, sharing of knowledge among workers within organization would help in pushing upward production frontier of the firm/industry and economy as whole.



2.1 Extended Endogenous Technological Change Model

Taking into account endogenous technological growth model by Romer (1999), this study aims to explore the impact of institutions on economic growth. According to the model, there are three sectors in an economy. First sector produces a final good using human capital and aggregate intermediate input. The second sector produces intermediate goods using forgone consumption and knowledge developed in research and development sector. Finally, the third sector produces ideas and blueprint for the second sector using human capital, R&D, and already existing stock of knowledge. The model is further extended by other economists by incorporating formal institutions directly in the growth model (Acemoglu et al., 2005; d'Agostino & Scarlato, 2014)

This paper further extends the model by incorporating formal and informal institutions in knowledge production function (i.e., the third sector of the model) and tries to analyze the effect of institutions indirectly through innovation. Complete specification of the extended technological model is presented below.

2.2.1 Final Good Producing Sector

Consider a final good producing sector where a large number of firms produce a single homogenous good that would be sold in competitive market at a given price to consumers. The economy is postulated by a set of households who live for infinite periods. The number of households in each period is"N_t", growing at rate "n". Each household has a unit of time available. Our representative household spends a fraction "u_y"of their total available time in production of final good, a fraction "u_A" in R&D activities and a fraction "u_s" in social activities such as time spent with colleagues in discussing and solving problems aroused at workplace during production processes. The production function is assumed to be linearly homogenous. Moreover, capital is assumed to be disaggregated into the list of different types of producer durables available; i.e.$x(i,t)$, $for\ i = 1,2,3, \dots A(t)$[3]

Production function faced by our representative firm in the final output sector is

$$Y[t] = (u[t]_y H[t])^{\beta} \int_0^{A[t]} x(i,t)^{\alpha} \, \mathrm{di} \quad \text{.........(1)}$$

$$0 < \alpha < 1, 0 < \beta < 1 \ and \alpha + \beta = 1$$

Where"$H[t]$" is total number of working hours of skilled worker and "$u[t]_y H[t]$" denote working hours used in final production, $x(i,t)$ denote intermediate input used in the production of final good,"$A[t]$"denote number of ideas generated at period 't' at work place during discussion related to solution of problems aroused during production processes[4]. Final good is either used for consumption or investment in physical capital. That is, Physical capital production function is

$$K^{\bullet}[t] = K[t]^{\alpha} \left(u[t]_y A[t] H[t]\right)^{1-\alpha} - C$$

Final good producer maximizes his profit by solving the following profit maximization problem

[4] The new ideas generated are considered as intermediate input of production.

$$\max_{u[t]_y, x(i,t)} \pi = (u[t]_y H[t])^{\beta} \int_0^{A[t]} x(i,t)^{\alpha} \,\mathrm{di} - w_y u[t]_y H[t] - \int_0^{A(t)} p(i,t)[x(i,t)] * x(i,t)\,\mathrm{di} \quad \text{............(2)}$$

Where w_y denote wage paid to worker in the final good production and"$p(i,t)$" denote the price of intermediate input. Assuming price of final good to be unity, the first order conditions yield.

$$w_y = \frac{\beta A[t]\, x(i,t)^{\alpha}\, (\mathrm{H}[t]u_y[t])^{\beta}}{H_y[t]u_y[t]} \ldots\ldots\ldots\ldots(3)$$

$$p(i,t) = \alpha x(i,t)^{-1+\alpha}\big(H_y[t]u_y[t]\big)^{\beta} \ldots\ldots\ldots\ldots(4)$$

The first derivative of profit function of final producer with respect to labor time is marginal product of labor which state that firm hire labor/worker until his marginal product equal wage rate prevailing in the market. Since 0<β<1 which means that increase in labor supply in final good production have negative effect on wage. Whereas the effects of Knowledge have positive effect on Labor productivity. Equation () is the equilibrium market conditions of capital market which state that firm rent capital goods until the marginal product of each unit of capital equal the rental price $p(i,t)$.

2.2.2 Intermediate Good Sectors

This study assumes that there is large number of firms producing different varieties of intermediate capital goods. Each firm$i$, buy the patent (design) or blueprint from an R&D producer to produce the intermediate capital good and become the only producer of that variety of good. Each firm rent capital at rate r_k and using the idea developed in R&D sector transform one unit of raw material into one unit of intermediate input. Therefore, each firm determines the optimal quantity of the intermediate capital good to sell to final good producer to maximize his profit. The profit maximization problem for intermediate good firm is

$$\max_{x(i,t)} \pi = p(i,t)[x(i,t))] * x(i,t) - r_k x(i,t) \ldots\ldots\ldots\ldots(5)$$

Taking First order conditions with respect to $x(i,t)$ and solving, we have

$$r_k = p(i,t)[x(i,t)] + x(i,t) * p(i,t)'[x(i,t)] = 0 \ldots\ldots\ldots\ldots(6)$$

Taking derivative of equation (6) with respect to time and substituting the resulting expression and equation (6) in profit function, we have the resultant expression

$$\text{profit} = \frac{(1-\alpha)}{\alpha} r_k x(i,t) \ldots\ldots\ldots\ldots(7)$$

2.2.3 The Research and Development Sector

The new growth theory suggests that generation of new ideas depend on individual engagement in research and development activities and the existence of enormous amount of knowledge (Aghion & Howitt, 1992; Romer, 1990).The skilled or educated labor also spend a fraction of available time on exchanging ideas, solving production and market related problems, and thus generating new ideas (Lucas Jr, 2009; Rupasingha et al., 2000).Ideas are non-rival which leads to increasing return to scale (Jones, 2019).

Growth economists used formal institutions explicitly as determinant of economic growth ignoring informal institutions which are as important as formal institutions. According to (Arrow, 2015) formal institutions are not sufficient to eliminate risk and uncertainty due to moral hazard and adverse selection arising in business activities particularly those related to radical innovation, as the moral factor limit their potential. Informal institutions are also equated with interaction of worker in search of information, knowledge and ideas that facilitate the creation of new ideas (Jones, 2019; Lucas Jr, 2009; Lucas Jr & Moll, 2014; Sáenz et al., 2009). To incorporate informal institutions, we assume that individuals devote a fraction u_s of their time to social activities such as helping co-workers and exchanging ideas with other colleagues and workers. This non-market activity is described by social capital production that promote informal institutions, given below.

$$\dot{S}[t] = P(u[t]_s \, \mathrm{H}[t])^{\phi} S[t]^{\varphi} \text{...}(8)$$

Where "P" 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 have trust on each other. Equation (8) states that existing social capital may have positive effect on generation of current social capital. In addition, we assume that social capital has no direct effects on final good production.

Knowledge is the accumulation of ideas and ideas are produced by people/workers discussing production related problems while working with machines or technology. Each worker gain from the knowledge and expertise of co-workers which in turn stimulate development of new ideas (Lucas Jr, 2009).We incorporate this social dimension in to knowledge production function by explicitly introducing the effect of informal institutions on new idea generation. Formal institutions, such as intellectual property rights on the other hand, restrict diffusion of knowledge and increase reward to an inventor (J. Chan, 2011; Gans & Stern, 2010).The production function of new ideas is

$$\dot{A}[t] = \delta A[t]^{\psi} (u[t]_A H[t])^{\eta} \, \mathrm{S}[t]^{\xi} T[t]^{\varsigma} \text{..}(9)$$

Where ψ is spillover effect of existing stock of ideas, ξ indicate the effect of existing stock of 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.

Each R&D firm maximizes its profit by selling ideas or design to intermediate capital good producer at price$P_A[t]$,getting revenue of,$P_A[t]\dot{A}[t]$and paying wage bill of $W_A[t]u[t]_A H[t]$to workers engaged in research and innovative activities. From profit maximization problem of R&D firm ,we have

$$w_A[t] = \frac{S[t]^{\xi} T[t]^{\varsigma} \delta \mathrm{A}[t]^{\psi} \eta P_A[t] (H[t]u[t]_A)^{\eta}}{H[t]u[t]_A} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots . (10)$$

The above expression states that wage of worker is negatively related to the time spent on R&D activities i.e., labor supply of researchers while positively related to price of patents (ideas). The main idea behind the expression is that workers practicing social values and norms would be rewarded more in innovative activities and is consistent with predictions of previous studies (Deming, 2017; Weinberger, 2014). Equation (15) also implies that countries where institutions are stronger, their workers would be paid more than countries with weaker institutions.

Households Behavior

Assume that there is large number of identical households, and each household maximizes his/her utility function subject to budget constraints. We use CRRA utility function and assume that our representative household is the ultimate owner of all capital and shareholder of final good firms, intermediate goods, and R&D firms. The optimization problem of the household is thus [5]

$$\max_{C,u[t]_y,u[t]_A,u[t]_s} \int_0^\infty \frac{C[t]^{1-\theta}-1}{1-\theta} e^{-\rho t} dt$$

Subject to

$$K^{\bullet}[t] = K[t]^{\alpha}\left(u[t]_y A[t] H[t]\right)^{1-\alpha} - C$$

$$S^{\bullet}[t] = P(u[t]_s H[t])^{\sigma} S[t]^{\phi}$$

$$A^{\bullet}[t] = BA[t]^{\psi}(u[t]_A H[t])^{\eta}\, S[t]^{\xi} T[t]^{\varsigma} \text{..........................(11)}$$

$u[t]_y + u[t]_A + u[t]_s = 1$ Time resource constraint

And initial conditions are

$K[0] = K_0,\qquad A[0] = A_0, S[0] = S_{0,}\qquad T[0] = T_0$

Transversality conditions can be stated as

$$\text{Limit}[\lambda_1[t]K[t] = 0, t \to \infty]$$

$$\text{Limit}[\lambda_2[t]A[t] = 0, t \to \infty]$$

$$\text{Limit}[\lambda_3[t]S[t] = 0, t{-}{>}\, \infty]$$

Formulating Hamiltonian we have,

[5] Complete solution of the model is given in appendix :Mathematical Model derivation

$$J = \frac{e^{-\rho t}(-1 + C[t]^{1-\sigma})}{1-\sigma} + \lambda_1[t]\left(A[t]^{1-\alpha}K[t]^{\alpha}\left((1 - u_A[t] - u_S[t])H[t]\right)^{1-\alpha} - C[t]\right)$$
$$+ \lambda_2[t]BT[t]^{\zeta}A[t]^{\Omega}S[t]^{\psi}\left(H[t]\left(1 - u_S[t] - u_y[t]\right)\right)^{\eta}$$
$$+ \lambda_3[t]PS[t]^{\phi}[t]\left(H[t]\left(1 - u_A[t] - u_y[t]\right)\right)^{\epsilon} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (12)$$

Where C, $u[t]_y, u[t]_A, u[t]_s$ are choice variable K, S, A are the state variables, $\lambda_1[t], \lambda_2[t], \lambda_3[t]$ are co-state variables.

Steady State Solution

Level variables grow at constant rate at steady state, while per capita variable growth at rate of zero. Expressing variables in per capita form as $\hat{k}[t] = \frac{K[t]}{A[t]H[t]}, \hat{c}[t] = \frac{C[t]}{A[t]H[t]}, \hat{y}[t] = \frac{Y[t]}{A[t]H[t]}$, the steady state conditions are $\frac{\hat{k}'[t]}{\hat{k}[t]} = 0, = \frac{\hat{c}'[t]}{c[t]} = 0, \frac{u_y'[t]}{u_y[t]} = 0, \frac{u_A'[t]}{u_A[t]} = 0, \frac{u_s'[t]}{u_s[t]} = 0$

At a steady state growth of capital, growth of consumption and growth rate of output all are equal to each other. At steady state, production function is

$y[t] = k[t]^{\alpha} \mathrm{A}[t]^{1-\alpha}$..(13)

Where $y[t]$ is per capita GDP and $\mathrm{A}[t]$ indicate numbers of ideas (new technologies),$k[t]$ indicate per capita Physical capital. Using the steady state level of per capital physical capital and expressing technology knowledge production function as $A_{it} = A_0 e^{g_A t + T_{it} + S_{it}}$ [6]following Mankiw et al., (1992), Campos & Nugent, (1998) Campos and Campos & Nugent, (1998) and (Islam, 1995) the steady state output per capita is obtained as

$$y[t] = A_0 e^{g_A t + T_{it} + S_{it}} \left[\frac{\alpha}{\rho - \sigma(g_A + g_H)}\right]^{\frac{\alpha}{1-\alpha}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (14)$$

Equation (14) describes that at steady state output per capita dependents upon the innovation, formal institutions, informal institutions and human capital (time used in final good production by workers) where the effect of informal institutions is indirect through innovation. However, the effect of formal institutions can have direct effect on economic growth and is explicitly incorporated in production function.

[6] See Islam, N; 1993, Growth Empirics: A panel data Approach. *The Quarterly Journal of Economics*, 110(4), 1127-1170.

3. Methods

In this section, we discuss an empirical methodology of extended technological growth model. Taking logarithm of equation (38), including appropriate error term, country and time specific effect term and matrix of control variables$X$, the resulting extended technological growth model is given below[7]:

$$ln\, y_{it} = \beta_0 + \beta_1 T_{it} + \beta_2 S_{it} + \beta_3\, ln\, g_A + \beta_4\, ln\, g_H + \theta X + \eta_i + \gamma_t + \varepsilon_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots..(15)$$

Where the right-hand side indicate log of per capita GDP,T_{it} denote informal institutions index, S_{it}represent informal institutions index, shows "g_A" innovation (patent granted as percent per inhabitant) and "g_H"denote growth of researchers/worker/skilled labor proxies with human capital. This paper constructed property right index taking average of corruption index, law and order and investment index following (S. G. Hall & Ahmad, 2014). Similarly, informal institutions index is constructed from happiness index and friendship index by taking their average. This paper uses gender participation as proxy of informal institutions which is not used before in institutions literature. It is hypothesized that Workplace where there is greater participation by female labor, is expected to be more cooperative as female tend to friendly and agreeable with others (Karakowsky & Siegel, 1999)(Myaskovsky et al., 2005)(Xie et al., 2020). Thus, the presence of female at workplace improves cooperation among group members which would increase sharing of ideas leading to development new product (Xie et al., 2020). Growth literature shows that poor countries grow at higher rate than rich countries. To examine the convergence hypothesis, we also include initial level of per capital income in regression model and the resulting model become dynamic model as is given below.

$$ln\, y_{it} = \beta_0 + \beta_1 T_{it} + \beta_2 S_{it} + \beta_3\, ln\, g_A + \beta_4\, ln\, g_H + \beta_5\, n\, y_{it-1} + \theta X + \eta_i + \gamma_t + \varepsilon_{it} \ldots\ldots\ldots\ldots..(16)$$

Institutions and growth literature show that institutions cause economic growth (Acemoglu et al., 2005; North, 1990), therefore institutions index is expected to have positive effect on economic growth (Aghion & Howitt, 1992; Romer, 1990; Sattar & Mahmood, 2011; Tebaldi & Mohan, 2010).

Traditional growth regressions carry problems of endogeneity, measurement error and omitted variable bias (Acemoglu, 2001). In our case, the problem of endogeneity may arise due to the reason that institutional variables both formal and informal are correlated with explanatory such as human capital and the stock of knowledge. 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 (2 SLS) is often used to address the problem of endogeneity and error of measurement which require finding of appropriate instrument for endogenous variables. In our case, formal and informal institutions are endogenous as they depend on others factors such earlier institution, ethnicity, religiosity, colonization and existence of norm and values in society. In addition, dynamic growth model also carry problem of endogeneity as the lagged value of dependent

[7] Following Acemoglu et al. (2001), Hall and Jones (1990) and Tebaldi (2008), we use formal and informal institutions index without taking their logarithm.

variable is correlated with residual. The latter problems can be solved by applying first difference GMM estimator (Arellano & Bond, 1991)

Nevertheless, Blundell & Bond, (1998) show that this "differenced GMM" estimator may be subject to a large downward finite-sample bias, especially when the number of time period is small. They showed that when the explanatory variables are persistent over time (like institutions in this case), lagged levels of the dependent variable are weak instruments in first differences. In these cases, severe problems of identification can lead to bias and could result in a poorly performing differenced estimator. To obtain a linear GMM estimator better suited to estimate autoregressive models with persistent panel data, they impose the stationary restrictions on initial condition which further requires means of the lagged dependent variable to be constant. This estimator with an additional moment condition is commonly known as the "system GMM" estimator. In other words, Blundell and Bond (1998) instruments level with differences whereas (Arellano & Bond, 1991) instruments differences with levels. In view of the merits of System GMM estimators, we use system GMM for estimation of extended technological change model.

This paper uses a panel data set of 72 countries over the period of 1984-2017. The selection of sample is based on data availability and prevalence of difference in informal institution and formal institutions performance and gender diversity of the sample countries.

In this paper, GDP per capita is used as dependent variable in different specification of the model. As discussed in methodological section, growth of a country depends on formal institutions, informal institution, and already available stock of knowledge and control variables such as Settler mortality, Ethnic diversity, and corruption. The data on the aforementioned variables are collected from World Bank, World value Survey, Country Risk Guide. Detail of data sources are given in appendix 1.

4. Results and Discussions

Table 01 shows pairwise correlation among the variable of the study. The table shows that there is strong correlation between GDPPC, informal institutions, protection of property right index, and gender participation index. Correlation between patent granted and GDPPC is positive. The results also show negative correlation between population growth and per capital GDP. In addition, we found a negative correlation between internet use and gross fixed capital formation, population growth and protection of property right, internet use and population growth. The correlation coefficient of gender participation index and internet user is positive, implying that female participation in job market improved with internet availability. Internet use save time by working online and hence increase labor force participation (Billari et al., 2019). The table also shows negative correlation between population growth and internet user which implies that with increase use in internet, population growth decreases. This may be due to awareness about health issues in society that discourage increase in birth ratio.

First, we check robustness of results of panel data for estimation of growth model using pooled OLS, fixed effect model and System GMM (one step and two step) and difference GMM (one step and two step). The objective of this practice is to examine which technique is better to employ.

Caselli et al., (1996) pointed out that dynamic GMM perform better than any other models because it is capable to handle unobservable heterogeneity of cross sections, omitted variable bias, endogeneity issue and measurement error. Using the robustness check, we examine which estimation method gives most suitable results. In the presence of persistence series, difference GMM may be subject to weak instruments bias (Blundell & Bond, 1998) while in this case system GMM performs better as it reduces small sample bias (Caselli et al., 1996).

Table 02 shows pooled OLS, fixed effect, one-step and two-step system and difference GMM estimation results. The table shows that two-step GMM result are more efficient, and the variables have expected sign. Moreover, system GMM results show significant positive effect of institutions on economic growth. As far as patents are concerned, it has significant positive effect on economic growth using system difference GMM methods. All the models accept AR (1) test but reject AR (2) test which means that there is no serial correlation at level. Hansen over identification test is, however, better for both estimations as it is unable to reject the null hypothesis – that instrument used in the estimations are exogenous as a group. Nevertheless, the Hansen p-value indicates that the test is weakened by high instrument count. Most important finding is that the estimated coefficient of lagged dependent variable using OLS is greater than the estimated coefficient using GMM while the coefficient using twostep GMM is greater than the estimated coefficient using fixed effect i.e. OLS estimate>twostep system GMM estimate >fixed effect estimate (1.264***>1.182***>1.159***).Although the coefficient of lagged dependent variable using one step system GMM is better but the instrument test indicate that the instruments are not exogenous.(Nickell, 1981) and (Bond et al., 2001) argue that in such situations, the system GMM perform better than the other two. In short, two conclusions can be drawn. First, country fixed effect is present in the penal data as the result of fixed effect, OLS and system GMM confirm to the prediction of (Nickell, 1981) and Bond et al., (2001)Second, difference GMM suffer measurement problem as it overestimates the coefficient for lagged dependent variable. On the basis of this information, system GMM would perform better than difference GMM since it produces better result and so we use twostep system GMM.

System-GMM uses lag dependent variables to introduce dynamic in the model. The inclusion of a lagged dependent variable allows for path dependency in the model and works as a partial adjustment mechanism. Lagged level of per capita GDP is taken to test the hypothesis of convergence to a long run steady state. Using two step GMM, lag GDPPC is used as predetermined variable. The result of correlation matrix shows that previous GDPPC is perfectly correlated with current GDPPC, therefore we use two lags of GDPPC capita in first model. As there is strong correlation between gross capital formation and property right protection, therefore the paper also used lag of GFCF. In theoretical model, innovation is shown as function of past innovation, formal and informal institutions (See Eq (13)) and correlation matrix also shows strong correlation between patent and property right index; therefore, patent is taken as endogenous variable. When patent is added to GMM style instrument, property right index become significant. Population growth, formal and informal institutions, education expenditures are taken as exogenous variable of the model. To check endogeneity, the study uses second lag of dependent variable as instrument following Blundell & Bond, (1998) as well as of other regressor used in estimation of growth model. The paper used two step GMM, since the efficiency gain from one steps GMM is smaller. (Bond et al., 2001)

Column (7) and Column (8) shows that informal institutions index and Patents are highly positively correlated with property right index, therefore including both variables will create multicollinearity problem. Therefore, informal institutions index is separately included, treating patent as endogenous variable and education expenditure (as percent of GDP), lag of GFCF and population growth as exogenous instrument.

Table 03 shows a positive impact of institution on economic growth in all specifications, implying that institutions are growth enhancing. Different specifications show that institutions have a positive significant effect on economic growth at 1 percent level, 5 percent and 10 percent level of significance result. The results support the arguments put forth by North (1991), leading figure of institutional school.(North, 1990) argues that institutions increase productivity of the factor inputs by improving the incentive structure. According to Acemoglu *et al.* (2008) good institutions enhance the ability of a country to use modern technologies which in turn increase economic growth. The result given in table No.03 also shows significant impact of informal institutions on per capita GDP of sample countries. Column (7) of table No.1 shows that formal and informal institution are positively correlated, therefore, we introduce interaction of both formal and informal institutions to know whether they are supplementary or complementary to each in their effect on per capita GDP. Including trade to GDP (%) as additional exogenous instrument variable, the interaction effect of formal and informal institutions become significant which implies that countries where formal institutions are weak, their informal institutions exert strong positive effects on economic growth.

From column (7) of correlation matrix, it is clear that there exists positive correlation between property right protection and gender participation index. Therefore, we take interaction of the variables and column (6) in table 03 shows that gender participation weakens formal institution effect on economic growth. The reason behind the role of gender participation is that in workplace where female participation is greater, in that workplace dense social networking exist, which result in diffusion of ideas. This feature of gender participation hinders effectiveness of formal institutions i.e., protection of property become less effective in protecting patent. Sci hub is one of the websites, where researchers can easily download journals articles without subscription. Similarly, scholars get copy of registered software without actual payment. We used gender participation as proxy of informal institution and the result shows that both coefficient of informal institutions and gender participation have same positive affect on per capita income when taken separately in regression model. This result is novel contribution as it finds a mechanism through which informal institutions change and their ultimate effect on per capita income (Waylen, 2017). The main contribution of the paper is to find the mechanism through which formal and informal institutions cause economic growth. In theoretical model, we showed that informal institutions boost generation of new ideas which are used in production of intermediate input that ultimately produce final goods. This theoretical underpins is tested empirically and table No.03 shows that patented granted (innovation indicator) has significant impact on per capita income. This finding support (Romer, 1990) Endogenous technological growth model predication as well as Aghion & Howitt, (1992).

The study examined the effect of innovation in absence of formal and informal institutions in specification (1) and the estimated results shows significant positive effect of innovation on economic growth. It is hypothesized that institutions effect economic growth through innovation and therefore to test the hypothesis, formal and informal institutions index are included in steady state production function. Specification (2,3 and 4) shows that with the incorporation of formal institutions index, the coefficient of innovation indicator become insignificance i.e. that is innovation indicator decrease from 0.005***to

0.004.The individual effect of formal and institutions are positive significant which implies that formal institutions and informal institutions (also gender participation) have also direct effects on economic growth. Correlation matrix shows that there is significant positive correlation between formal and informal institutions, therefore we include interaction term in specification (5) and the coefficient of interaction shows that informal institutions are complementary to formal institutions supporting (North, 1990). This hints to an important proposition that countries where formal institution are weak, people resort to informal institutions in their daily life. The study can also conclude from this result that countries where higher is the ratio of female participation and friendship exist in workplace, their formal institutions would be not too effective in affecting per capita income.

Endogenous growth models suggest that output and ratio of physical capital to GDP tend to move together (Barro & Sala-i-Martin, 1992).Table 03 shows significant positive impact of physical capital on economic growth in all specification at 1% level of significance. Most of the coefficients are significant at 1 percent while some of the coefficients are at 5%level of significance. The results also show that population growth has negative impact on economic growth which supports the prediction of endogenous growth theories which state that with increase in population growth, steady state economic growth rate declines.

Overall conclusion is that institutions and innovation have positive effect on economic growth of the world. Most interesting conclusion is that informal institutions are more effective in effecting growth where formal institutions are weak. The study also finds that countries with higher ratio of female to male in labor force also experience higher per capita income.

5. Conclusion

The paper concludes that institutions both formal and informal institutions have significant positive effect on economic growth. The results support the arguments put forth by North, (1990) argues that institutions increase productivity of the factor inputs by improving the incentive structure. According to Acemoglu & Guerrieri, (2008), good institution enhances the ability of a country to use modern technologies which in turn increase economic growth. The individual effect of formal institutions, informal institutions and gender participation (Proxy of informal institutions) are positive significant. The interaction of formal and informal institutions shows that both institutions are complementary, implying, people in weak formal institutions countries resort to informal institutions in their daily life. Empirical results also show significant positive impact of Physical capital and negative effect of population growth on economic growth which supports growth theories. Patent granted (to resident and non-resident) shows positive significant effect on per capita income which support theories of innovation and growth. The main contribution of the paper is identification of mechanism through which informal knowledge sharing affect economic growth of countries. Moreover, the study explored a new measure of informal institutions (gender participation) which is main determinant of economic growth

This study suggests that countries where formal institutions are weak, policy maker should focus to increase ratio of female to male in organization in R&D sector, should develop networking within country across different organization, institutions and industries. Also, allocation should be made to provide ICT infrastructures in countries especially in of face Covid-19 to easily access workplace across the globe. Also, ICT infrastructures should be made available where formal institutions are weak as ICT would replace formal institutions.

The present paper has also some limitations. The study employee macro data to analysis the impact of institutions on economic growth through generation of ideas in organization which require micro analysis because of unavailability of organizational level data of enterprises across the global. Also, organizational level studies should be conduct using some survey, interview and structured questionnaire to know why female are more cooperative than men in sharing ideas and knowledge at workplace.

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Table 1: Matrix of correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	11)	12)
(1) GDPPC	1.000											
(2) GDPPC (1)	1.000	1.000										
(3) GDPPC (2)	**0.999**	1.000	1.000									
(4) Gross Fixed Capital Formation	0.063	0.058	0.050	1.000								
(5) Gross Fixed Capital Formation (1)	0.047	0.047	0.041	**0.922**	1.000							
(6) Gross Fixed Capital Formation (2)	0.046	0.048	0.047	0.829	0.927	1.000						
(7) Property Right	**0.779**	**0.77**	**0.776**	0.19	0.155	0.13	1.00					

		8		4		2	0					
(8) Informal Institution Index	**0.591**	**0.590**	**0.589**	0.047	0.030	0.030	**0.505**	1.000				
(9) Patented Granted	**0.925**	**0.925**	**0.925**	-0.024	-0.029	-0.020	**0.765**	**0.586**	1.000			
(10) Internet Use	0.328	0.327	0.327	-0.005	-0.025	-0.039	0.407	0.225	0.251	1.000		
(11) Population Growth	-0.406	-0.405	-0.405	0.139	0.131	0.116	**-0.257**	-0.074	-0.399	**-0.081**	1.000	
(12) Gender Participation Index	**0.500**	**0.498**	0.496	**-0.090**	-0.080	-0.069	0.423	0.329	**0.541**	**0.299**	-0.336	1.000

Table 2: Robustness Test of Extended Technological Change Model

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Pooled OLS	Fixed Effect	One Step Sys GMM	Two Step Sys GMM	one Step diff GMM	twostep diff GMM
GDPPC(1)	1.264***	1.159***	1.194***	1.182***	1.193***	1.190***
GDPPC (2)	-0.271***	-0.179***	-0.215***	-0.214***	-0.201**	-0.203***
Gross Fixed Capital Formation	0.152***	0.171***	0.162***	0.159***	0.171***	0.165***
Gross Fixed Capital Formation (1)	-0.163***	-0.174***	-0.165***	-0.172***	-0.178***	-0.171***
Gross Fixed Capital Formation (2)	0.022**	0.012	0.016	0.028	0.015	0.014
Property Right	-0.014*	0.010	0.012	0.028***	0.014	0.005
Informal Institutions Index	-0.028	0.048	0.049	0.093***	0.046	0.009
Property Right# Informal Institutions Index	0.006*	-0.003	-0.003	-0.009**	-0.006	-0.002
Gender Participation Index	0.010***	0.006	0.015***	0.016***	-0.006	-0.005
Patented Granted	0.000	-0.002	0.002	0.004**	0.002	0.006
Population Growth	-0.003***	-0.005***	-0.006***	-0.007***	-0.005***	-0.005***
Constant	0.070	0.011				

Observations	1,189	1,189	1,189	1,189	1,135	1,135
R-squared	1.000	0.987				
No. of instruments			29.000	29.000	27.000	27.000
Hansen p-value			0.547	0.547	0.402	0.402
Number of C_No		54	54	54	53	53
AR1 p-value			0.000	0.000	0.000	0.000
AR2 p-value			0.044	0.083	0.040	0.048
Sargan p-value			0.103	0.103	0.077	0.077

Note: Dependent variable is **GDP per Capita** while **GDP per capital( ) denote lagged GDPPC and** is used as initial income. Standard errors are not reported to free space. All estimations include time dummies .AR(1) and AR(2) tests 1st order and 2nd order autocorrelation in the residual of differenced equations. Hansen P value is used for testing over identification of exogenous variables. ***, **,* denote significance levels at 1%,5% and 10% respectively.

Table 3: Institutions, innovation and Economic Growth Using Two Steps System GMM: Dependent Variable is GDP Per Capita

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
GDPPC (1)	1.177***	1.180***	1.119***	1.180***	1.139***	1.181***	1.079***
GDPPC (2)	-0.189**	-0.204***	-0.149*	-0.208***	-0.176***	-0.210***	-0.165**
Gross Fixed Capital Formation	0.149***	0.200***	0.192***	0.178***	0.152***	0.165***	0.177***
Gross Fixed Capital Formation (1)	-0.112***	-0.179***	-0.170***	-0.172***	-0.147***	-0.174***	-0.146***
Gross Fixed Capital Formation (2)	0.025**	0.037	0.037	0.034	0.013	0.027	0.006
Population Growth	-0.003**	-0.004***	-0.007***	-0.007***	-0.008***	-0.006***	-0.007***
Patent granted	0.005***	0.006*	0.004	0.004**	0.004**	0.005***	0.008***
Gender Participation Index		0.035**	0.032***	0.020***	0.018***	0.062***	0.024**
Property Right			0.006*		0.037***	0.046***	0.051***
Informal Institutions Index				0.058***	0.110***		
Property Right #Informal Institutions Index					-0.012**		

Gender Participation Index# Property Right						-0.009***	
GDPPC (3)							0.043
Trade							0.070***
Trade# Property Right							-0.011***
Observations	1,438	1,189	1,189	1,189	1,189	1,189	1,163
Number of C_No	55	54	54	54	54	54	54
No. of instruments	11.000	10.000	26.000	27.000	29.000	28.000	29.000
AR1 p-value	0.000	0.001	0.001	0.000	0.000	0.000	0.000
AR2 p-value	0.201	0.089	0.046	0.100	0.033	0.051	0.108
Sargan p-value	0.646	0.400	0.190	0.051	0.095	0.211	0.328
Hansen p-value	0.599	0.494	0.150	0.294	0.558	0.672	0.736

Note: Dependent variable is **GDP per Capita** while **GDPPC(1) denote lagged GDPPC and** is used as initial income. Standard errors are not reported to spare space .All estimations include time dummies .AR(1) and AR(2) tests 1st order and 2nd order autocorrelation in the residual of differenced equations. Hansen P value is used for testing over identification of exogenous variables. . *, **, and *** display the significance levels at 10%, 5%, and 1%, respectively.