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Determinants of Innovation in Developing Countries: A Panel Generalized Method of Moments Analysis

(Penentu-Penentu Inovasi di Negara-Negara Sedang Membangun: Kaedah Analisis Panel Momen Teritlak)

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ABSTRACT

This study aims to examine empirically the determinants of innovation in developing countries by using 52 selected countries with data spanning from 2000 to 2010. Innovation, defined as a process that attempts to try out new or improved products and processes. In order to achieve this phase, past studies have emphasized the determinants of innovation as human capital, patent, trademark, regulation, stock market, and trade openness. A systematic empirical study based on the Generalized Method of Moments (GMM) which has been taken to estimate all these determinants of innovation discussed by researchers in capturing the long-run and short-run relationship. This paper answers the question, "Among the determinants of innovation, which factor will be the main determinant and contributes to the success of innovation?" The result addressed that trade openness has played a significant and important role as a determinant of innovation in developing countries and surprisingly our results indicate that the stock market and trademark showed a negative impact on innovation. In line with past researchers, trade openness is one of the framework conditions that will improve, enhance and strengthen innovation in developing countries.

Keywords: Innovation; trade openness; panel generalized methods of moments; developing countries

ABSTRAK

Kajian ini bertujuan untuk mengkaji secara empirikal penentu inovasi di negara-negara sedang membangun dengan menggunakan 52 negara terpilih dengan data mencakupi tahun 2000 hingga 2010. Inovasi ditakrifkan sebagai satu proses yang cuba untuk menghasilkan atau memperbaharui barangan dan proses. Untuk mencapai peringkat ini, kajian lalu menekankan antara penentu inovasi adalah modal insan, paten, cap dagang, peraturan, pasaran saham dan keterbukaan perdagangan. Kajian empirikal yang sistematik berdasarkan kepada kaedah dinamik panel momen teritlak (GMM) telah dijalankan untuk melihat penentu inovasi yang dibincangkan oleh penyelidik dengan melihat hubungan jangka panjang dan hubungan jangka pendek. Kajian ini akan menjawab persoalan "Faktor manakah yang akan menjadi penentu inovasi yang penting di kalangan penentu-penentu inovasi yang dikaji?" Dapatan kajian menunjukkan keterbukaan perdagangan memainkan peranan penting sebagai penentu inovasi di negara-negara sedang membangun tetapi penentu inovasi yang dikaji seperti pasaran saham dan tanda dagangan menunjukkan kesan negatif terhadap sebagai penentu inovasi. Dapatan ini adalah selari dengan kajian yang lepas, yang menyatakan keterbukaan perdagangan adalah faktor yang penting dalam memperbaiki, meningkatkan dan mengukuhkan inovasi di negara-negara sedang membangun.

Kata kunci: Inovasi; keterbukaan perdagangan; kaedah panel momen teritlak (GMM); negara-negara sedang membangun

INTRODUCTION

Technological progress is considered as a crucial determinant of productivity growth. Host countries have benefited from the diffusion of new technology from other countries. FDI is a particular channel whereby it determines the technology spillover that exists from advanced to lagging countries. In some countries, latest technologies are been developed when innovation takes place. The role of innovation in economic development or productivity growth is important and it is among the issues of interest to economists. Kline and Rosenberg (1986), Bell and Pavitt (1993) defined innovation as an attempt to try out new or improved products, processes or ways to do things. It includes not only technologically new products and processes, but also improvements in areas such as logistics, distribution and marketing. In the neoclassical framework, Solow (1957) showed that the impact of innovation was treated as part of the Solow residual and hence a key contributing factor to economic progress and long-term convergence. In recent decades, due to the popularity of endogenous growth theories, Grossman and Helpman (1991) viewed that the differences in innovation capacity and potential are largely responsible for persistent variations in economic performance. A stepped-up rate of innovation was needed to speed productivity growth that is required to sustain healthy economic growth rates. Increasing the rate of innovation in many nations can improve their productivity and prosperity and collectively speed the rate of world economic growth. Innovation performance is a crucial determinant of competitiveness and national progress. In addition, innovation is important to help the global challenges, such as climate change and sustainable development. The modern technology will emerge when there is a strong growth rate of innovation. The subtle aspect of a country's institutional and macroeconomic environment participates in determining the productivity of investments in innovation.

According to Stern et al. (2006) the determinants of national innovative capacity are based on a few areas. The first area is the strength of a nation's common innovation infrastructure. The key elements of innovation infrastructure or resources for innovation are the national knowledge stock and policy measures. Resources for the creation and diffusion of new knowledge include research and development (R&D) expenditures, investment in higher education and funding of basic research and size and quality of scientists and engineers. Innovation policy areas are crucial for strong innovation infrastructure comprises the protection of intellectual property, the incentives supporting R&D and innovation (including tax exemptions), as well as the openness of the economy to trade and investment. A nation's common innovation infrastructure also depends on the level of overall technological development of a country. It is a result of prior investment in the development of technology reflected in knowledge accumulated in earlier periods. The second area of national innovative capacity is defined as 'cluster-specific innovation environment' that reflects to specific advantages for innovative activity concentrated in particular geographic areas. These advantages are results of a stronger local network that links technology, resources, information and talent as well as higher competitive pressure within the industry cluster. The focus is mainly on the clusters rather than individual industries because there are knowledge spillovers and externalities that increase the rate of innovation. According to Gans and Stern (2003), the characteristics of innovative capacity seen from cluster-specific, perspective is based on indicators that measure innovation, finance and output, such as a percentage of R&D expenditures funded by private industry and concentration of patents across broad technological areas. R&D spending has been widely used as a measure of innovation performance; however, R&D is a measure of the inputs that go into the innovation process rather than of innovation output or success.

The R&D activity closely relates with flow of FDI and country absorptive capacity. Technologies spillovers from FDI are significantly when countries implement an economic freedom policy. UNCTAD (2000) has proved that the main role of FDI in transfer of new technology is providing the fastest and most effective way to deploy new technologies in developing host countries. R&D is also important for productivity and economic growth. Domestic R&D has high spillover effects; it enhances the ability of the business sector to absorb technology coming from abroad. R&D is considered as an important vehicle to maintain competitiveness in the globalized economic environment and a powerful mechanism in generating new information in which it directly contributes to productivity growth. Previous scholars Romer (1990) and Coe and Helpman, (1995) showed that R&D is the driver of productivity growth.

According to Cohen and Levinthal (1989) and Goldberg and Kuriakose (2008), R&D is the key input into innovation. The increase of innovation capacities has played a vital role in the growth dynamics of successful developing countries. Previous studies have discussed the determinants of innovation and some of them examine the determinants of innovation solely on productivity growth. Romer (1986) observed that technological innovation is created in R&D by using human capital and the existing knowledge stock. Watson, Johnstone and Hascic (2009), stated that patent activity is frequently used as a proxy for technological innovation, that is, the method by which new or enhanced technologies are made available and brought into widespread use. Thus, to evaluate the determinants of innovation, this study will analyze by combining the determinants discussed by past scholars. Therefore, by focusing on the main determinants of innovation, developing countries will experience successful economic development, encourage inflows of FDI and technology spillovers that will boost country productivity growth.

This study contributes to the literature in several important aspects. This study will show the indicator that is robustly related to innovation. This objective contributes to the existing literature to fill the gap in addressing the determinants of innovation in developing countries. First, it provides panel evidence on the determinant of innovation in developing countries. Second, the implementation of Generalized Method of Moments (GMM) panel estimators, whereby the advantage of this method is that it can take account for country specific effect and simultaneity biases. Third, it provides empirical evidence of the factors that serve as determinants for innovation, where previously researchers just discuss the direct impact of the factors that determine innovation.

LITERATURE REVIEW

Innovation is a new or significantly improved good or service that has been introduced to the market. Also as the introduction within a company of a new or significantly improved process. Innovation is based on the results of new technological developments, new combinations of existing technology or utilization of other knowledge acquired by the company. Innovations are widely accepted as a key factor in receiving attention of stakeholders to sustain organizations competitiveness (Tidd, Bessant & Pavitt 2002). Utterback (1994) stated that innovation is like a life or death ingredient in firms. The innovation processes that are creation, dissemination and application of knowledge have become a major engine of economic growth and being a more and more precious tool for corporations and countries. According to Morrison, Roberts and Von Hippel (2000) innovation has become a key determinant of competitiveness and growth of nations, regions and clusters and firms. Pioneer economists and policy makers; Aghion and Howitt (1992); Romer (1990); Solow (1956) broadly diffused the idea that innovative capacity and ability to imitate new technology across regions are the key factors in determining the growth rate of an economic system. The role of innovation in economic development or growth has been of interest to economists for a long time. Innovation today is a crucial source of effective competition, of economic development and the transformation of society, and this is a "Schumpeterian Renaissance". The main components that drive economic growth and increase standards of living are innovation, enterprise and intellectual assets. Innovation is an instrument in creating new jobs, generating higher incomes, providing investment opportunities, controlling and solving social problems, protecting from disease, protecting the environment, and protecting our security.

Past researchers have carried out the empirical studies on the role played by innovation. According to Sarel (1997), Nelson and Park (1999) and Iwata, Khan and Murao (2002), some Asian countries have succeeded in mobilizing another powerful source of growth, which contributed to their rapid catch-up based on the role of technological change which is innovation. Hulya (2004) showed that innovation, both, in developed and developing countries in OECD and non-OECD countries have a positive effect on per capita outputs. However, only the large market OECD countries are able to increase their innovation by investing in R&D and the remaining OECD countries seem to promote their innovation by using the know-how of other OECD countries. Rosenberg (2004), showed the long term economic growth is that the dependent on technological innovation, with the latter, most commonly expressed in terms of the investment made in research and development (R&D).

The role of innovation discussed previously showed the importance of innovation to economic performance. The researchers broadly explore the key drivers of innovation. Economists tend to introduce various determinants of innovation such as intellectual property rights protection, market structure, financial structure, corporate governance, geography, demand, human capital, technology policy and also regulation. To shape the economic growth, intellectual property has helped in making possible conditions for innovation, entrepreneurship and market-orientedness. The system of property rights (IPRs) protection may affect the pace of innovation. IPRs protection is needed because it is the way in which incentives for inventive activities are provided. IPRs are policy instruments that play an increasingly important and positive role in driving innovation and expanding information. By stimulating innovation, information and creativity, IPRs directly affect economic performance and create economic growth through increased productivity, increased trade and investment, and expanded economic activity. Intellectual property (IP) refers to the exclusive rights granted by the state over the creations of the human mind, in particular, inventions, literary and artistic works, distinctive signs and designs used in commerce. IP is divided into two main categories: industrial property rights, which include patents, utility models, trademarks, industrial designs, trade secrets, new varieties of plants and geographical indication and copyright and related rights, which relates to literary and artistic works. According to Arrow (1962), there will be market failure if IPRs does not exist. Strong and effective IPRs is an essential tool for technology transfer and will encourage private and public enterprises to transfer technology not only through voluntary licensing and other contractual arrangements, but also through the development of innovative approaches for promoting technological development, direct investment, technology sales and dissemination, and cooperative ventures.

Early studies by Kamien and Schwartz (1972, 1976) stressed that the relationship of innovation and market structures, points out that market structure like monopoly market are more likely to engender innovative activities. Scherer (1983) also supported by stating that larger firms provide better conditions to invest in new technologies. The study conducted by Cabagnols and Le Bas (2002) had use market structure as one of the determinants of innovation. Mohnen and Dagenais (2002) found that the propensity to innovate in Denmark is significantly determined by industry type, firm size (measured by number of employees) and group subsidiary. Other than that, financial structure plays a crucial role in attracting investment as innovation purposes. Hall (2002) stated that innovative processes were characterized by extreme uncertainty, assets' intangibility, relevant asymmetrical information and moral hazard problems. On the other hand, Levine, (1997, 2004) stated that financial systems, composed of markets, institutions and instruments, have constant functions and changeable structures. Firms that are involved in innovative activities basically hold the specialize assets, equipment and a large share of immaterial assets, such as patents and research knowledge, where innovative firms will have much financial structure compared to the low innovative firms. Firms with higher productivity and guaranteed higher aggregate productivity are more capable to get funding by financial systems because differences in the propensity to innovate are likely to translate into differences in total factor productivity. Firms can be more innovative if there will be a greater degree of asymmetric information between insiders and outsiders, and hence these dilution costs will tend to be higher (Aghion et al. 2004). Dilution cost means an increase in the number of shares of a company's stock, causing the value of each share to decrease. Myers and Majluf (1984) showed that when managers are better informed than outside investors about the firm's financial prospect dilution costs of issuing outside equity will exist. More innovative firms are also likely to generate more attractive investment opportunities rather than less innovative firms, if this happens; firms are likely to be more reliant on external finance from either debt or new equity than less innovative firms, who are more likely to have sufficient internal funds to finance all their desired investment expenditures.

The empirical literature presents some evidence in favor of a positive role of human capital in shaping the pace of innovation. As an example Benhabib and Spiegel (1994), stated that using cross-country data, does not reject the presence of an additional source of influence of human capital on economic growth due to the interaction with technology. Hall and Jones (1999) who detected a strong correlation between human capital and TFP also used cross-country data. The level of human capital, which represents the level of schooling, skills and competencies of a given population, can be seen as a key determinant of economic growth (Lucas 1988; Mankiw, Romer & Weil 1992). Lucas (1988) showed that investments in human capital produce positive externalities that enhance the economic system's productivity and foster its growth rate. This can be explained, because technological change is positively affected by the average level of human capital, which determines, as Schultz (1975) argued, the ability of individuals to adapt to an environment characterized by technological dynamics. Nelson and Phelps (1966) gave a seminal contribution in the study of the interaction between human capital and technological change. Generally speaking, the intuition is that different levels of human capital determine the differences across countries in the technology adopted and affects the way in which those technologies are used. Acemoglu and Zilibotti (2001), build a model in which they found explicitly that a country with less skilled workers would have greater difficulties in implementing effective technologies belonging to the innovation possibilities frontier, because of the derived lack of absorptive capacity.

Based on the discussion, past literatures have discussed the intellectual property rights protection, market structure, financial structure, human capital, technology policy and the regulation as factors that influence innovation. This study examines the determinants of innovation in developing countries including by human capital, patent, trademark, regulation, stock market and trade openness in a single model.

METHODOLOGY

This study applied the generalized method of moments (GMM) panel estimators by Holtz-Eakin, Newey and Rosen (1988) and extended by Arellano and Bond (1991), Arellano and Bover (1995), and Blundell and Bond (1998). The empirical model is express as follows:

$$R_{it} - R_{it-1} = (1-\alpha)R_{i,t-1} + \beta_1 OP_{it} + \beta_2 RG_{it} + \beta_3 MC_{it} + \beta_4 T_{it} + \beta_5 P_{it} + \beta_6 H_{it} + \mu_i + \varepsilon_{it} \quad (1)$$

Equivalently, equation (1) is written as follows:

$$R_{it} = \alpha R_{it-1} + \beta_1 OP_{it} + \beta_2 RG_{it} + \beta_3 MC_{it} + \beta_4 T_{it} + \beta_5 P_{it} + \beta_6 H_{it} + \mu_i + \varepsilon_{it} \quad (2)$$

where i is country index, t is time index, is the logarithm of expenditure on R&D as a percentage of GDP as a proxy of innovation where data were extracted from Penn World table. OP is the logarithm of trade openness calculated as a ratio the total import over GDP, *RG* is the logarithm of regulation measure based on rule of law, *MC* is the logarithm of the stock market that measure based on stock market capitalization of listed companies and measurement based on percentage of GDP, T is the logarithm of trademark based on the number of total trademark application, P is the logarithm of patent based on total patent granted and H is logarithm of human capital measured based on life expectancy. All the data are extracted from the World Development Indicator (WDI), is unobserved country specific effect term and is the usual error term. Previous empirical study by Kanwar and Evenson (2003) noted that IPRs protection had a positive and significant impact on innovation; patents indicated a positive and significant effect on innovation (Thumm 2013); Mendonca, Peraira and Godinho (2004) indicated that trademark reliable results used as a method for capturing relevant aspects of innovation; meanwhile regulation showed the mixed results on innovation. There is indeed a positive role of stock market (Brown, Martinsson & Petersen 2012) and human capital is equally important in shaping innovation (Benhabib & Spiegel 1994; Hall & Charles 1999) and role of trade openness on innovation were supported by past literatures (Aw, Robert & Xu 2010; Bloom, Darca &Van Reneen 2008, 2011; Impullitti & Licandro 2011)

In the above moment conditions, Arellano and Bond (1991) proposed the two steps GMM estimation. Equation (2) hereby can be extended as follows:

$$R_{i,t} - R_{i,t-1} = \alpha(R_{i,t-1} - R_{i,t-2}) + \beta_1(OP_{i,t} - OP_{i,t-1}) + \beta_2(RG_{i,t} - RG_{i,t-1}) + \beta_3(MC_{i,t} - MC_{i,t-1}) + \beta_4(T_{i,t} - T_{i,t-1}) + \beta_5(P_{i,t} - P_{i,t-1}) + \beta_6(H_{i,t} - H_{i,t-1}) + (\varepsilon_{i,t} - \varepsilon_{i,t-1}) \quad (3)$$

This model eliminates the country specific effects, but at the cost of (i) introducing serial correlation in the error term and introducing regressor error correlation (endogeneity). To address the possible simultaneity bias of explanatory variables and the correlation between $(R_{i,t-1} - R_{i,t-2})$ and $(\varepsilon_{i,t} - \varepsilon_{i,t-1})$, Arrelano and Bond (1991) lagged the regressor used as an instrument variable. This is valid under the assumptions that the error term is not serially correlated and lag of the explanatory variables is weakly exogenous. This approach is known as the difference GMM estimation and the GMM dynamic panel estimators used the following moment conditions:

$$E[R_{i,t-s}.(\varepsilon_{i,t} - \varepsilon_{i,t-1})] = 0 \text{ for } s \geq 2;\ t = 3, ..., T \quad (4)$$

$$E[OP_{i,t-s}.(\varepsilon_{i,t} - \varepsilon_{i,t-1})] = 0 \text{ for } s \geq 2;\ t = 3, ..., T \quad (5)$$

$$E[RG_{i,t-s}.(\varepsilon_{i,t} - \varepsilon_{i,t-1})] = 0 \text{ for } s \geq 2;\ t = 3, ..., T \quad (6)$$

$$E[MC_{i,t-s}.(\varepsilon_{i,t} - \varepsilon_{i,t-1})] = 0 \text{ for } s \geq 2;\ t = 3, ..., T \quad (7)$$

$$E[T_{i,t-s}.(\varepsilon_{i,t} - \varepsilon_{i,t-1})] = 0 \text{ for } s \geq 2;\ t = 3, ..., T \quad (8)$$

$$E[P_{i,t-s}.(\varepsilon_{i,t} - \varepsilon_{i,t-1})] = 0 \text{ for } s \geq 2;\ t = 3, ..., T \quad (9)$$

$$E[H_{i,t-s}.(\varepsilon_{i,t} - \varepsilon_{i,t-1})] = 0 \text{ for } s \geq 2;\ t = 3, ..., T \quad (10)$$

To express the moment condition of GMM dynamic panel estimators Equation (4) above work, first we assume the first difference without independent variable in the equation:

$$R_{i,t} - R_{i,t-1} = \alpha(R_{i,t-1} - R_{i,t-2}) + (\varepsilon_{i,t} - \varepsilon_{i,t-1}) \quad (11)$$

For t = 3;

$$R_{i,3} - R_{i,2} = \alpha(R_{i,2} - R_{i,1}) + (\varepsilon_{i,3} - \varepsilon_{i,2}) \quad (12)$$

$R_{i,1}$ is a valid instrument, since it is highly correlated with $\alpha(R_{i,2} - R_{i,1})$ and not correlated with $(\varepsilon_{i,t} - \varepsilon_{i,t-1})$. This utilizes the moment condition of $E[R_{i,1}\Delta\varepsilon_{i,3}) = 0$. The moment conditions formed by assuming that particular lagged levels of the dependent variable are orthogonal to the differences disturbances that are known as GMM-type moment condition. Equation (4) to (10), known as standard moments conditions, which the moments conditions formed using the strictly exogenous covariates are just standard instrumental variables moment conditions. Using the moments conditions Equations (4) to (10), Arellano and Bond (1991) proposed a two-step GMM estimator. In the first step, the error terms are assumed to be both independent and homoscedastic, across countries and over time and in the second step, the residuals obtained in the first step are used to construct a consistent estimate of the variance-covariance matrix, thus relaxing the assumptions of independence and homoscedasticity. Theoretically, in the large samples, application of the second step is more efficient.

Although the difference estimator above is able to control for country specific effects and simultaneity bias, it nevertheless has one major shortcoming. Blundell and Bond (1998) stated that if the lagged dependent and the explanatory variables are persistence over time, the lagged levels of these variables are weak instruments for the regressions in differences. They showed that weak instruments might lead to biased parameter estimates in small samples and larger variance asymptotically. Arelano and Bover (1995) proposed an alternative method that estimates the regression in differences jointly with the regression in levels known as System GMM. The system GMM estimator has been proven to perform much better that is less bias and more precision, especially when the series are persistent or the autoregressive process is persistence, which is the first differences, might be weakly correlated with its lagged levels. Arelano and Bover (1995) and Blundell and Bond (1998), proposed using additional moments conditions in which lagged differences of the dependent variable are orthogonal to the levels of the disturbance. To get these additional moments conditions, they assumed that panel level effect is unrelated to the first observable first difference of the dependent variable. The additional moment conditions for the second part of the system (the regression in levels) are set as follows:

$$E[(R_{i,t-s} - R_{i,t-s-1})(\lambda_i - \varepsilon_{i,t})] = 0 \text{ for } s = 1 \quad (13)$$

$$E[(OP_{i,t-s} - OP_{i,t-s-1})(\lambda_i - \varepsilon_{i,t})] = 0 \text{ for } s = 1 \quad (14)$$

$$E[(RG_{i,t-s} - RG_{i,t-s-1})(\lambda_i - \varepsilon_{i,t})] = 0 \text{ for } s = 1 \quad (15)$$

$$E[(MC_{i,t-s} - MC_{i,t-s-1})(\lambda_i - \varepsilon_{i,t})] = 0 \text{ for } s = 1 \quad (16)$$

$$E[(T_{i,t-s} - T_{i,t-s} - 1)(\lambda - \varepsilon_{i,t})] = 0 \text{ for } s = 1 \quad (17)$$

$$E[(P_{i,t-s} - P_{i,t-s-1})(\lambda_i - \varepsilon_{i,t})] = 0 \text{ for } s = 1 \quad (18)$$

$$E[(H_{i,t-s} - (H_{i,t-s-1})(\lambda_i - \varepsilon_{i,t})] = 0 \text{ for } s = 1 \quad (19)$$

The system GMM has theoretical advantages over the difference GMM. Blundell and Bond (1998) showed that the system GMM has better finite sample properties in the case of short panels with moderately persistent series (autoregressive term around 0.8 and 0.9). The moment conditions in Equations (4) to (10) and (13) to (19) were employed to generate consistent and efficient parameter estimates based on GMM procedure.

The estimation of difference GMM and system GMM estimate based on one-step, two-step and VCE robust. The one-step estimators use weighting matrices that are independent of the estimated parameters, whereas the two-step GMM estimator uses the so-called optimal weighting matrices in which the moment conditions were weighted by a consistent estimate of their covariance matrix. This makes the two-step estimator asymptotically more efficient than the one-step estimator. However, the use of the two-step estimator of small samples will have several problems that result from the proliferation of instruments. In a simulation analysis, Windmeijer (2005) showed that the two-step GMM estimation with numerous instruments could lead to biased standard errors and parameter estimates. The robust specifies that the resulting standard errors are consistent with panel-specific autocorrelation and heteroskedasticity in one-step estimation.

The consistency of GMM estimators depends on two specification tests. First Arellano and Bond (1991) proposed to test the overall validity of the instrument with Sargan's over identification test, which is based on the overall validity of the instruments by analyzing the sample analogue of the moment conditions used in the estimation process (Baltagi 2005). The hypothesis are tested with the Sargan test is, that the instrumental variable are interrelated to some set of residuals, and therefore they are acceptable, healthy instruments or "the instruments as a group are exogenous". If the null hypothesis are confirmed statistically (that is, not rejected) the instrument passes the test. They are valued by this criterion. Therefore, the better estimation indicates the higher the p-value of the Sargan test. The test statistics result is not misleading of the model.

The second test is the serial correlation that refers to first order and second order serial correlation in the residuals. When we use time series, data auto-correlation generally occurs. Auto-correlation is a special case of correlation, and refers not to the relationship between two or more variables, but to the relationship between successive values of the same variable. One of the assumptions of regression analysis is that the error terms are independent from one another. Formally, this assumption is expressed as $E(\varepsilon_i\varepsilon_j) = \mathrm{Cov}(\varepsilon_i\varepsilon_j) = 0$ for all $i \neq j$. The violation of this assumption gives rise to auto-correlation. If this assumption is not satisfied it means that the values of the error term are not independent, that is, the error in some period influences the error in some subsequent period next period or beyond. Windmeijer (2004) showed that the estimated asymptotic standard error of the two step GMM estimator can be severely biased downward in the case of small sample. Hence, the auto correlation test in the dynamic panel model is very important together with the parameter estimations. The first and second order serial correlation tests are reported by the AR (1) and AR (2) respectively. At the 5 % significance level the first order serial correlation test AR (1) usually rejects the null hypothesis. The second order test AR (2) is more important because it will detect auto correlation in levels. The second order serial correlation and the Hansen over identification test indicate that the model is adequately specified. The GMM estimators are consistent if there is no second order serial correlation in the residuals. The dynamic panel data model is valid if the estimator is consistent as well as the instruments are valid and failing to reject the null of both tests provides support to estimate the model.

EMPIRICAL RESULTS

This section will report on estimation results. Table 1 provides informative, descriptive statistics of the indicators determinants of innovations for the 52 selected developing countries. Table 2 reports the correlation matrix among the determinants of innovations with a log scale except for trade openness. The indicator that showed high correlation to innovation is patent with coefficient 0.44. The correlation between trademarks and innovation is 0.28, stock market is 0.25, regulation is 0.13, human capital is 0.13 and trade openness is 0.11.

By using Generalized Method of Moments (GMM), a few tests are examined. At the first and second stage of estimation with Difference GMM and System GMM, the best estimations are listed in Table 3. The time dummy variable has no impact on significant level, which means this model does not influence by time dummy. The specification test showed the consistence result without including time dummy. The valid result for Difference GMM and System GMM is at two-stage estimation. Since the lagged dependent variable of difference GMM (0.4576) is underestimated than the value at

TABLE 1. Summary of descriptive statistics

Variable	Mean	Standard Error	Overall Standard Deviation	95% Confidence Intervals	Minimum	Maximum
R	3.34	0.05	1.25	[3.23; 3.43]	-0.99	6.18
OP	0.84	0.02	0.59	[0.78;0.88]	0.21	4.46
RG	1.88	0.01	0.14	[1.86;1.89]	1.22	2.21
MC	3.23	0.05	1.31	[3.12;3.32]	-0.99	6.41
T	8.73	0.08	2.04	[8.55;8.89]	0	13.87
P	7.33	0.10	2.45	[7.13;7.53]	-0.05	13.44
H	16.22	0.09	2.16	[16.04;16.40]	4.98	20.73

Notes: R = innovation, OP = trade openness, RG = regulation, MC = stock market, T = trademark, P= patent application, H = human capital. Number of countries=52, list of countries in Appendix. All the variables are in logarithmic form.

TABLE 2. Correlation matrix

	R	OP	RG	MC	T	P	H
R	1.00						
OP	0.11	1.00					
RG	0.13	0.41	1.00				
MC	0.25	0.32	0.40	1.00			
T	0.28	0.05	0.15	0.17	1.00		
P	0.44	0.19	0.20	0.44	0.55	1.00	
H	0.13	-0.22	-0.16	0.06	0.41	0.28	1.00

N\otes: R = innovation, OP = trade openness, RG = regulation, MC = stock market, T = trademark, P = patent application, H = human capital. Number of countries=52. All the variables are in logarithmic form.

system GMM (0.6499) based on Table 3, so we decided to select the System GMM specification. As Blundell and Bond (1999 p. 10) noted "If the instruments used in the first-differenced estimator are weak, then the difference GMM results are expected to be biased in the direction of within groups." Although, the Sargan test does not reject our choice of instruments (p=0.6490), it does not exclude the weak instruments problem. The system GMM provided sensible parameter estimators with greater value of lagged dependent variable and supported. Here, the Sargan test clearly indicates the validity of all instruments.The other reasons of system GMM it estimate the advantage over difference GMM in variables that are "randomwalk" or close to be random-walk variables (Bond 2002; Roodman 2006; Baum 2006; & Roodman 2007). The System GMM approach generally produces more efficient and precise estimates compared to difference GMM by improving precision and reducing the finite sample bias (Baltagi 2008). Hence, we proceed from the system GMM and keep in mind that the estimators are probably downward biased.

Several studies have assessed the role of trade openness on innovation. They generally found out that openness to trade is one of the framework conditions that can strengthen innovation (e.g Coe & Helpman 1995; OECD 2010; Aw et al. 2010; Van Long et al. 2011). In lines with the past literature, our empirical results indicate that in developing countries, trade openness play an important role in improving or enhancing innovation. Based on results reported in Table 3, the coefficient values of trade openness is 0.2363. The economic interpretation of these coefficients is that 1

TABLE 3. Specification of Difference GMM and System GMM

Variable	Two-Step Difference GMM	Two-Step Difference GMM with Robust SE	Two-Step System GMM	Two-Step System GMM with Robust SE
Constant	0.7097	0.7097	0.5127	0.5127
	(1.46)	(1.15)	(1.33)	(0.66)
Lag	0.4576***	0.4576***	0.6499***	0.6499***
	(13.48)	(4.29)	(25.69)	(6.34)
	0.2053***	0.2053**	0.2363***	0.2363**
	(3.36)	(2.55)	(3.55)	(1.98)
	0.6006***	0.6006**	0.1350	0.1350
	(2.83)	(2.12)	(0.87)	(0.27)
	-0.0817**	-0.0817*	-0.0456*	-0.0456*
	(-3.55)	(-2.41)	(-1.68)	(-0.87)
	-0.1687	-0.1687	-0.1673	-0.167
	(-2.71)	(-2.36)	(-4.34)	(-2.06)
	0.1653***	0.1653**	0.2009***	0.2009**
	(3.82)	(2.95)	(7.05)	(2.34)
	0.0418***	0.0418***	0.0409***	0.0409**
	(5.76)	(3.52)	(7.53)	(2.16)
Sargan Test	10.5440		15.7830	
	(0.6490)		(0.6077)	
AR(1)	0.1574	0.1448	-0.2396	-0.2263
	(0.8749)	(0.8849)	(0.8106)	(0.8209)
AR(2)	0.0268	0.02519	-0.4026	-0.3860
	(0.9786)	(0.9799)	(0.6872)	(0.6995)
T		2000-2010		

Notes: The variables are defined as follows: R = innovation, OP = trade openness, RG = regulation, MC = stock market, T = trademark, P = patent application, H = human capital. AR(1) = Auto-covariance of order 1, AR(2)= Auto-covariance of order 2, T= time. Figures in parenthesis are t-statistics, except for Sargan test, which is p-value *** and ** indicate significance at the 1% and 5% levels, respectively. All the variables are in logarithmic form.

percentage point increase in trade openness would lead to an increase of 0.2363 percentage point in innovation in developing countries. The second determinant that showed high influence on innovation in developing countries based on our analysis is the patent that showed positive sign with innovation and the value of coefficient is 0.2009 by the differences only 0.0354 with trade openness. These results indicate the importance of patent in developing countries in improving or enhancing innovation. OECD (2004) supports this where patents are important to new technology-based firms because such firms often have few assets and need patent protection to attract venture capital. Besides that, the regulation also plays a significant role on innovation. The past literature had discussed the effect of regulation, according to Geroski (1991); Koch, Rafiquzzaman and Rao (2004); and Aghion et al. (2005) where regulation has a positive effect on innovation. The role of human capital toward innovation showed the coefficient value of 0.0409. Although the contribution of human capital is only 4.09 percent on innovation with a one percent increase in human capital, but the value showed that there is a positive impact to innovation. This is line with the past literature that human capital is a relevant driver of innovation (Benhabib & Spiegel 1994; Hall & Jones 1999; Zilibotti 2001).

This study discusses and analyzes six determinants of innovation in developing countries. Four indicators were discussed before that showed positive relationships with innovation, and the other two indicators showed negatively relationship with innovation. From our analysis, it was clear that trademark and stock market indicated the negative sign with innovation with the coefficient value of -0.1673 and -0.0456. This indicates that in developing countries, the role of stock market fails in enhancing innovation activities. The ability of stock market as an internal source of funding in enhancing the innovation activities in developing countries is still not enough to speed the innovation and needs supports from external funding. According to Rajan and Zingales (1998) industrial sectors are in more need of external finance (from developed countries) to develop faster in countries with higher financial sector development. Thus, we can state that in developing countries, trade openness plays a crucial role in enhancing innovation followed by patent, regulation and human capital. The estimated coefficient reported previously in Table 3 measured the short-term impact on the determinants of innovation. The long run estimation can be estimated based on the equation (20).

$$R_{it} = \alpha_i + \gamma R_{i,t-1} + \beta_1/(1-\gamma)OP_{it} + \beta_2/(1-\gamma)RG_{it} + \beta_3/(1-\gamma)MC_{it} + \beta_4/(1-\gamma)T_{it} + \beta_5/(1-\gamma)P_{it} + \beta_6/(1-\gamma)H_{it} + \mu i + \epsilon_{it} \quad (20)$$

In addition, the model is a partial adjustment model, and the long run value can be calculated based on). Papke and Wooldridge (2004) provided an explanation of how to obtain both the coefficient and the standard error for the long-run effect in a dynamic panel data model; it can be calculated by using the command "nlcom" in STATA; the results are reported in Table 4.

TABLE 4. Long-run effect of determinants of innovation

Variable	Long Run Coefficient	Standard error	t-statistics
OP	0.6753***	0.1989	3.39
RG	0.3857	0.4470	0.86
MC	-0.1303	0.0829	-1.57
T	-0.4780	0.1110	-4.3
P	0.5740***	0.0814	7.16
H	0.1171***	0.0140	8.35

Notes: The variables are defined as follows: OP= trade openness, RG = regulation, MC=stock market, T= trademark, P = patent application, H= human capital. *** and ** indicate significance at the 1% and 5% levels, respectively. All the variables are in logarithmic form.

The obtained coefficient in Table 4 is a measure of the responsiveness of the dependent variable to the independent variables in the long-run (Greene, 2003); in this study the change of innovation level to the changes in the variable of investigating variables. The highly determinant of innovations are based on coefficient rank which are trade openness, patent, regulation and human capital with significant at 1% except for regulation that not significant at any level. The other two determinants of innovation that were examined are the variables tested. It showed that there are positive relationships and the other two of the variables have negative relationship among the interest, which are trade openness, patent, human capital, regulation, trade mark and stock market. The results of long run coefficient show there mixed results consistence with the short run sign trade mark and stock market that indicate negatively relationship toward innovation.

This study performs a number of alternative tests to ensure that the estimates are robust to the estimation procedure and variables used. First, by conducting the sensitivity analysis using the different variable of trade openness, which is the ICT import data. The estimation results are reported in Table 5. As before, result of the system GMM is valid than difference in GMM. Based on reported results in Table 5, ICT import indicated the main determinant of innovation. The coefficient of ICT import is 0.2320 and is highly significant at 1% significant level and slightly higher than the other variables. Thus, these results support that, trade is the main important factor as a determinant for innovation in developing countries; either the value of trade is measured based on openness of trade that ratio of total trade over GDP or measure based on the ICT import. Therefore, the previous interpretation of the important

TABLE 5. Sensitivity analysis of specification of Difference and System GMM (ICT import)

Variable	Two-Step Difference GMM	Two-Step Difference GMM with Robust SE	Two-Step System GMM	Two-Step System GMM with Robust SE
Constant	0.8335 (1.41)	0.8335 (1.06)	0.8031 (1.63)	0.8031 (0.80)
Lag R	0.4476*** (13.64)	0.4476*** (4.33)	0.6537*** (28.83)	0.6537*** (7.86)
ICTIM	0.2624** (1.53)	0.2624** (1.06)	0.2320*** (11.28)	0.2320** (2.33)
RG	0.0256 (1.83)	0.0256 (1.29)	-0.1461 (-0.73)	-0.1461 (-0.32)
MC	-0.0590 (-2.78)	-0.0590 (-1.61)	-0.0369 (0.144)	-0.0369 (-0.62)
T	-0.1318 (-2.31)	-0.1318 (-2.04)	-0.1708 (-4.25)	-0.1708 (-1.94)
P	0.1769*** (4.19)	0.1769*** (3.24)	0.0156 (1.09)	0.0156 (0.45)
H	0.0389*** (4.14)	0.0389** (2.44)	0.0316*** (4.65)	0.0316 (0.145)
Sargan Test	13.1004 (0.4401)		18.1544 (0.4455)	
AR(1)	0.1001 (0.0202)	0.09288 (0.0260)	-0.3172 (0.0751)	-0.3046 (0.0760)
AR(2)	0.3091 (0.7572)	0.29619 (0.7671)	-0.3059 (0.7596)	-0.2947 (0.7682)
T	2000-2010			

Notes: The variables are defined as follows: R = innovation, ICTIM is ICT import, RG = regulation, MC = stock market, T = trademark, P = patent application and H = human capital. AR(1) = Auto-covariance of order 1, AR(2) = Auto-covariance of order 2, T = time. Figures in parenthesis are t-statistics, except for Sargan test, which is p-value. *** and ** indicate significance at the 1% and 5% levels, respectively. All the variables are in logarithmic form.

role of trade openness as a main determinant of innovation is unchanged. The result is robust and trade remain a main important determinant of innovation in developing countries.

The second test of sensitivity analysis is, the estimation based on the different indicator of IPRs,whereas according to World Intellectual Property Organization (WIPO) IPR's measure using patents, trademark, industrial design and geographical indication (utility model). The estimation results are reported in Table 6. As explained before, results of system GMM is more valid than difference GMM. Thus Table 6 only report results of system GMM.

Based on the estimation results (Table 6), indicator of IPR indicates positive and significant toward innovation and estimation result of trade openness is consistent with previous estimation that becomes the most important determinant of innovation in developing countries. Thus, this sensitivity analysis indicates that, although estimation is based on different indicator of trade or IPRs indicators examine separately in the model, results of the estimation support the main findings of this study.

CONCLUSION

Our results suggest that the main determinants of innovation in developing countries are trade openness and supported by patent, regulation and human capital. This finding showed trade openness as a main determinant of innovation in developing countries. Thus, the government plays an important role in order to encourage inflows of trade by providing the environment that is conducive for foreign investors such as elimination of tariff and no-tariff barriers for goods and investment. Trade is one of the most important channels of technology spill overs as mentioned by Acharya and Keller (2009); Coe, Helpman and Hoffmaister (2009); Azman-Saini (2009) and Ang and Madsen (2013). From the finalized result discussed above, there are two recommendations that can be made from this study; first, the developing countries have to open their trade in order to encourage innovation activities and supported by the regulation (social, government and institutional), because based on our empirical analysis, trade openness plays a crucial role as a determinant of innovation. Besides

TABLE 6. Sensitivity analysis of different indicators of IPR

IPR Indicator	Patent	Trademark	Industrial Design	Utility
Variable	System GMM	System GMM	System GMM	System GMM
Constant	9.7893***	9.5222	2.6414	9.9727***
	(0.64)	(0.72)	(0.840)	(3.84)
Lag R	0.9807***	1.0138	0.9817***	0.9482***
	(1.37)	(0.35)	(1.58)	(1.02)
OP	5.2727***	5.0133***	9.8607***	8.9661**
	(3.31)	(1.28)	(5.81)	(5.98)
RG	0.9081***	0.9101	0.4361	1.1967*
	(1.75)	(0.98)	(1.42)	(1.89)
MC	1.6531***	-0.6380	1.7999***	1.2558***
	(4.35)	(-0.39)	(3.51)	(3.51)
IPR	0.9668***	3.0582*	0.8765***	4.1408***
	(10.76)	(1.69)	(4.16)	(14.10)
H	0.5280***	-0.8161	0.3367	0.6065***
	(2.83)	(-0.35)	(1.29)	(2.61)
Sargan Test	3.6634	1.6409	1.2765	3.7504
	(0.8061)	(0.1347)	(0.7891)	(0.1414)
AR(1)	2.0915	-3.0392	-2.6317	-2.1781
	(0.0365)	(0.0024)	(0.0085)	(0.0294)
AR(2)	0.8323	-0.7870	-0.1334	0.7344
	(0.4052)	(0.4313)	(0.8941)	(0.4627)
T		2000-2010		

Notes: The variables are defined as follows: R = innovation, OP = trade openness, RG = regulation, MC = stock market, IPR = intellectual property rights as measure by patent, trademark, industrial design, and utility and H = human capital. AR(1) = Auto-covariance of order 1, AR(2)= Auto-covariance of order 2, T= time. Figures in parenthesis are t-statistics, except for Sargan test, which is p-value. *** and ** indicate significance at the 1% and 5% levels, respectively. All the variables are in logarithmic form.

that, the role of human capital on innovation in developing countries needs more attention. According to Falk (2006), human capital is a key factor for innovation. Governments may invest in human capital via providing education and training. This is because skilled and trained workers are also vital for the successful transfer of new technologies that will enhance the R&D activities and educate workers with availability along with quality science and technology that will accelerate the innovation process.

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APPENDIX: LIST OF SELECTED DEVELOPING COUNTRIES

Algeria	Hong Kong SAR, China	Myanmar
Argentina	Iceland	Pakistan
Bolivia	India	Panama
Brazil	Indonesia	Paraguay
Burkina Faso	Iran, Islamic Rep.	Peru
China	Israel	Philippines
Colombia	Jamaica	Saudi Arabia
Congo, Dem. Rep.	Jordan	Singapore
Costa Rica	Korea, Dem. Rep.	South Africa
Cuba	Kuwait	Sri Lanka
Ecuador	Lesotho	Thailand
Egypt, Arab Rep.	Madagascar	Trinidad and Tobago
El Salvador	Malaysia	Tunisia
Ethiopia	Mauritius	Turkey
Gabon	Mexico	Uganda
Gambia, The	Morocco	Uruguay
Guatemala	Mozambique	Zambia
Honduras		