ROLE OF ECONOMIC FREEDOM IN THE R&D-TFP GROWTH NEXUS: PANEL DYNAMIC ORDINARY LEAST SQUARE (OLS) EVIDENCE

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This paper addresses the role of economic freedom in mediating domestic and international Research and Development (R&D) on productivity growth by using Panel Dynamic Ordinary Least Square (P-DOLS) proposed by Stock and Watson (1993) in estimating 37 selected developing countries. In view of the fact that the domestic (international) R&D may enter the international (domestic) R&D and both have causality between each other. To encourage domestic and international R&D activities, host and home countries must have a 'good' institution like economic freedom, political freedom or civil freedom that applies to economy. Main focus of this study is on economic freedom that we examine the role of economic freedom as a mediating factor of domestic and international R&D on productivity growth in developing countries. The finding indicate that economic freedom are positively mediating both domestic and international R&D on productivity growth but the result indicate higher elasticity value of domestic R&D compare to international R&D.

KEYWORDS: Domestic and International Research and Development, Economic freedom, Panel Dynamic OLS, Developing countries.

1.0 Introduction

Developing countries look at FDI and location of MNC's as an engine of growth. These international investments will benefits to a host country in terms of capital inflows, employment,

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new technology, management skills, and most importantly Research and Development (hereafter referred to as R&D) spillover that will encourage innovation at host country. UNCTAD (2008), FDI and MNC's in developing countries plays a major role in the internationalization of R&D activities. More than 95% of the 700 firms worldwide with the largest R&D expenditure are from MNCs. In order to attract the MNC's to invest in the R&D, host countries itself must present the location advantages. UNCTAD (2005) state that developing countries especially in Asia and the Pacific that have a good infrastructure, attractive domestic market, highly trained workforces and reasonable intellectual property protection will attracted the significant FDI in R&D. Host countries will benefited from the opportunities that provided and only increase the demand of MNC's for inexpensive talent and for new developing markets. Host countries will focus to maximize the technology spillovers from FDI and will encourage them to engage in R&D activities. So there exist the relationship between the countries that actively involved in R&D activities and countries that shown the significant economic improvement. To catch up with the developed countries, it is essential for countries either developing or least developed countries to build R&D capacities to upgrade their technologies. R&D activities represent the most privileged method by which companies generate and acquire technological information. For the decades, R&D is the only factor that driven the technology change and innovation that be an important sources for the country productivity growth. The R&D intensive FDI is expected to bring significant benefit to host countries that will associated with a net increase in host country R&D activity that involving more R&D expenditure and create the job opportunities for highly skill labor. These benefits will be larger when the R&D investment by MNC's complements the R&D at host countries. To encourage more benefit from FDI and MNC, host countries should have a good institution that can be refer to especially the level of economic freedom. The level of economic freedom is very important in explaining the inflows of FDI (Pejovich 2002).

The concepts of economy freedom can be defined separately based on individual, society and economy itself. From the individual view, in economically free, the individual can controls their productivity based on labor and initiative, which is individual has empowered to decide where to live and work and at the same time, they have the right to own property and dispose of it as they choose. Succeed and fail individuals based on the effort and ability. The concept of freedom on government view is government decision making is characterized by transparency and openness, and the light of opportunity replaces the shadows where discrimination can be most subtle. Besides that, in an economically free, the power of economic decision making is widely dispersed, and the allocation of resources for production and consumption is on the basis of free and open competition so that every individual or firm has a fair chance to succeed. A country that provides for economic freedom allows for greater diversity, promoting creativity encourages new technology and innovation that impact on country economic growth. The relationship between growth and economic freedom is in one direction, which is the increase in the rating of economic freedom will enhance the economic growth, but there is no tendency for higher economic growth to increase the economic freedom.

Table 1 shows the relationship between economic freedom and economic performance; measured by percentage of GDP per capita growth rate.

Table 1. Economic Freedom and GDP growth rate per capita (1990-2010)

Economic Freedom Index	1st Quintile	2nd quintile	3rd quintile	4th quintile
GDP growth per capita	3.56	2.78	2.38	1.58

Note: 1st quintile: most free; 4th quintile is least free.

Table show the index of economic freedom and economic growth from 1990 to 2010, that the economic freedom are breaking into four quartiles ordered from high to low. From Table 1 we can see that countries that have higher economic freedom will have higher value of GDP growth per capita compare to the low level economic freedom countries. Previously, numerous researchers have studies these relationships and found that countries with higher and improving economic freedom grew more rapidly and achieve higher level of per capita GDP. According to James and Lawson (2008), countries with a large amount economics freedom grew significantly quicker than others, while those with the least economic freedoms experienced negative growth.

The economic freedom is key to overall economic well-being. Countries that enjoy higher levels of economic freedom should be more attractive for foreign investors. The link between economic freedom and growth is then strengthened, since economic freedom affects growth through two channels: directly (De Haan and Sturm, (2000)) and indirectly (i.e. by facilitating of FDI that, in turn, fosters economic growth). Countries with the economically free increase 50 percent to the productivity investment. Countries with an economic freedom index rating more than 7.0 (based on Fraser index) shows with a 1 percent increase in investment expand output by 0.35 percent and on the other side countries with economic freedom index less than 5.0 only contribute 0.23 percent increase in output. So, there is highly supportive of the proposition that countries or institutions that consistence with economic freedom will lead to the higher rate of investment and at the same time will contribute to the greater productivity of the investment.

Countries that experience the economic freedom index more than 7 is group as mostly free economy show the productivity is higher that the countries that experience the index of economic freedom less than 7 that can be seen on Table 2, show the economic freedom rating and productivity during 1980 – 2010 and 2000 - 2010.

Table 2. Economic freedom rating and productivity during 1980 – 2010 and 2000 – 2010.

Economic Freedom	1980-2000	2000-2010
EF less than 5	0.19	0.18
EF between 5 and 7	0.27	0.28
EF greater than 7	0.33	0.35

A country must have an adequate legal system sustaining property rights, low corruption and with constant fundamentals in order to attract FDI also influence R&D location. The level of economic freedom is very important in explaining the inflows, whereas the more economic freedom a country encounters the higher the expected investment inflows and at the same time will increase the R&D activities by MNC's.

Figure 1, show the level of economic freedom and the inflows of FDI in 2010. Based on figure, countries that have the highest level of economic freedom which is most free economy will attract more inflows of FDI which is encourage the location of MNC's at the host countries and this will increase the investment in R&D. Figure show that most free economies attract 16.1 of foreign direct investment inflows (% of GDP) and the least free economies attract only 2.4 inflows of investment. The freest economies will have the investment in R&D at host countries compared to the least free economies.

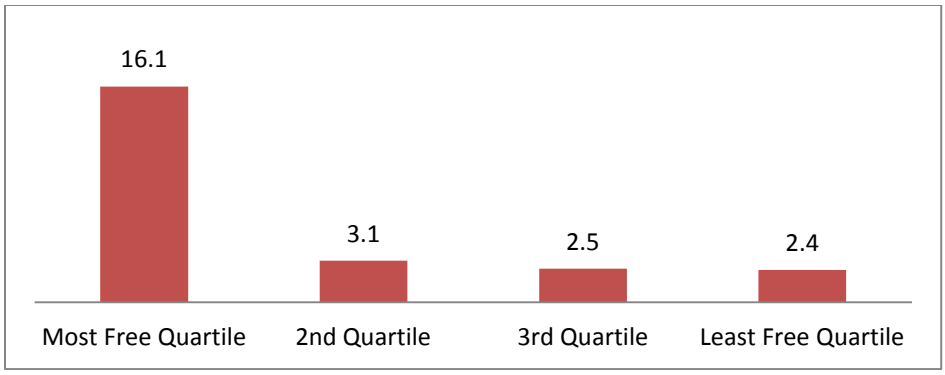

Figure 1. The level of economic freedom and inflows of FDI in 2010
(Source: Fraser Institute, Economic Freedom of the world: 2011 Annual Report)

The comprehensive data of relationship between FDI and economic freedom can be seen in Figure 2. As shown in figure countries with more economic freedom will attract more inflows of FDI and at the same time will boost countries growth and increase the productivity through the investment and establishment of MNC's at the host country.

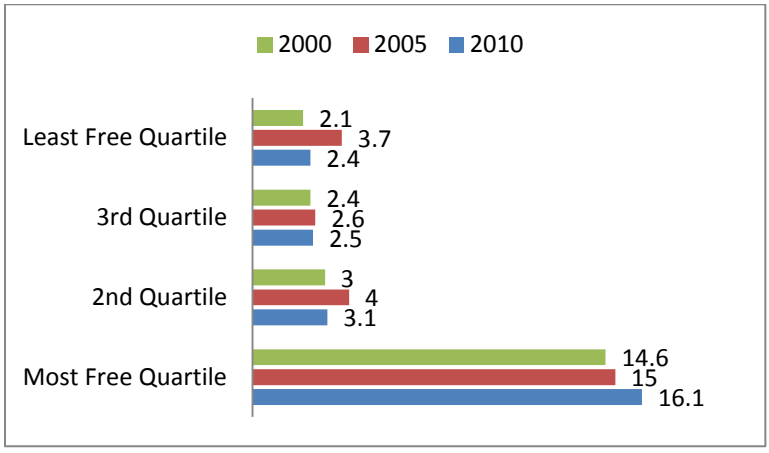

Figure 2. Economic Freedom and Foreign Direct Investment
(Source: Fraser Institute, Economic Freedom of the world: 2011 Annual Report)

Beside the international trade, the level of country economic freedom will attract the location of MNC's. MNC's operation at host countries can result in technology spillovers from FDI, whereby domestic firms adopts superiors MNC technology which enables them to improve their productivity and at the same time enhance the R&D activities and developed new innovation. The R&D activities by MNCs have rapidly increased, along with increasing inflows of FDI. MNC's R&D location decisions, and the relative levels of R&D investment in a given country location, are mostly influenced by broad, macroeconomic and development factors.

Investment in R&D by international firms will be increasing when countries implement an economic freedom policy. R&D is considered as an important vehicle to maintain competitiveness in globalized economic environment. R&D is the most powerful mechanism in generating the new information in which it directly contributes to productivity growth. Figure 3 show R&D expenditure in three groups of countries grouped together according to their level of

economic freedom. Where R&D expenditure is measure based on percentage of GDP. R&D expenditure is expenditures for research and development are current and capital expenditures (both public and private) on creative work undertaken systematically to increase knowledge, including knowledge of humanity, culture, and society, and the use of knowledge for new applications. R&D covers basic research, applied research, and experimental development. Based on figure, we can conclude that most freest economy contribute more R&D expenditure compare to the less free economy.

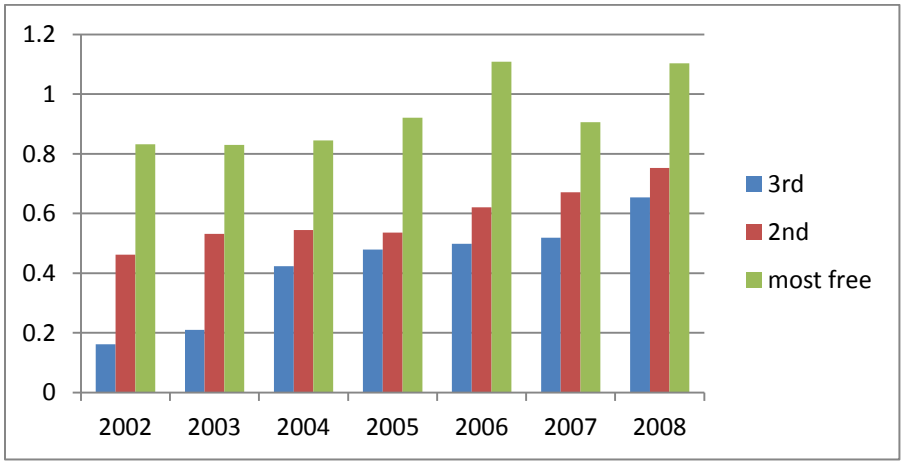

Figure 3. R&D expenditure (% of GDP) and economic freedom (2002-2008)
(Source: Fraser Institute, Economic Freedom of the world: 2011 Annual Report)

Overall the discussion about economic freedom illustrates the relationship of each component ceteris paribus, indicating that economic freedom index contribute most to economic growth, inflows of FDI and investment in R&D. Economic freedom proves to have a favorable effect on the economic condition at host countries.

1.2 Problem statement

For many years, researchers have debated about the economic growth and total factor productivity. Among the key factors of growth and productivity are the level FDI. FDI is believed to have beneficial effects on economic growth in the host country due to advantages related to the introduction of new technologies and innovation, new managerial techniques, development of additional skills, increased capital, job creation and improvement of working conditions, improving the human capital, the development of the industrial sector in the host country, broadening of the tax base transfer of the technology and other skills, boosting the economic activity, boosting of export, better integration into the world markets and etc. (Perez 1997; Haddad and Harrison 1993; Markusen and Venables 1999; Babic and Strucka 2001). Besides knowing whether the market is a growing market, investor will look also at the host countries institutional as factor to make the investment decision. Institution can be viewed as a social structures element of a country which has been instituted by law or customs. Since the 1990s, the importance of institutional quality has been highlighted and found to be very pertinent in addressing issues of growth and FDI with the literature by North (1990) and Williamson (2000). IMF (2003), quality institutions, and the rules of the game in a country are defined in terms of the degree of property rights protection, the degree to which laws and regulations are fairly applied and the extent of corruption. Civil liberties, organization rights, freedom of association and the freedom of expression, the rule of law and human rights, are all important influences on business decision-making. 'Good' institutions are an important determinant, or precondition for, economic

growth and development. Institution can be referring to freedom whether economic, political or civil freedom that apply to economy. Dawson (1998), in fact institutions affect aggregate economic activity indirectly through an effect on investment or directly through an effect on total factor productivity. Institutions that undertaking economic freedom probably has the capacity to provide the growth-enhancing kind of incentives, for several reasons; as argued in Murphy et al. (1991), they promote a high return on productive efforts through low taxation, an independent legal system, and the protection of private property and Johansson (2001) they promote the flow of trade and capital investment. Pejovich (2002), the level of economic freedom is very important in explaining the inflows of FDI. The higher the level of economic freedom of country will attract more inflows of FDI. R&D spillover does not limit in the specific country but can cross all the borders. Romer (1986) allows companies to invest in R&D with condition that marginal profitability equal to innovation cost. According to Bart (1997) the estimated rates of return to R&D investment, considered being the major input in technology generation. For many years people have debated about the role of economic freedom on FDI and economic growth and R&D effect on productivity. The intention of this dissertation is to establish the purpose for which of the role of economic freedom, which particular reference to whether they are using in mediating the domestic and foreign R&D and further, to gather ideas to expand the country productivity.

1.3 Research questions and objective.

The main research questions arise here is does economic freedom play a significant role in mediating R&D spillover on TFP growth? To answer question that arise in this study, we analyze the role of economic freedom in mediating R&D spillovers on total factor productivity.

1.4 Conceptual framework

Based on the goal of this study, we proposed a conceptual framework that diagrammatically reflects the intention.

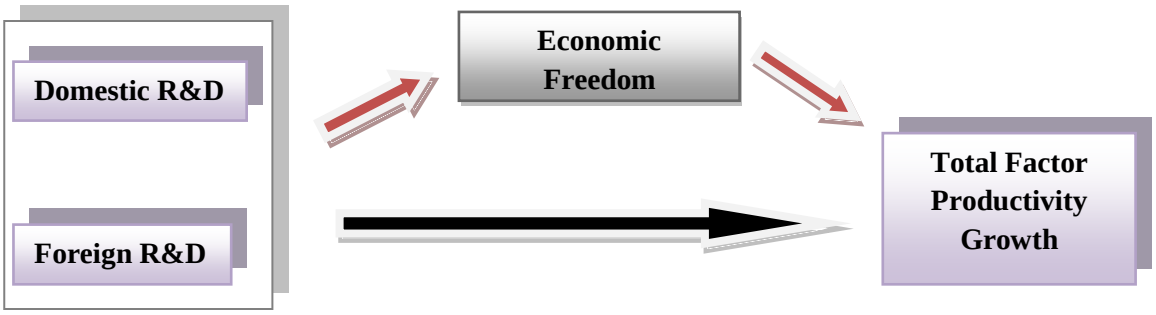

Figure 3: The Conceptual framework

1.5 Significant of the study.

This study contributes to the literature by providing the empirical evidence on the significant role of economic in mediating the impact of domestic and foreign R&D on the productivity growth. Panel dynamic ordinary least square (P-DOLS) analysis is better way to understanding the relationship between the economic freedom and domestic and foreign R&D

and it can accommodate the meaningful possibility that both domestic and foreign R&D kick in country productivity growth only after including the economic freedom as a mediating factor.

1.6 Organization of study.

The rest of the paper is structures as follow. In section 2, we provide an overview of related empirical work on domestic and foreign R&D, FDI, economic freedom and TFP growth. In section 3, we describe the data set that we use and methodology to analyze. The empirical analysis based on threshold in section 4 and finally in section 5 is conclusion and recommendation

2.0 Literature Review

According to the pioneer study, the growth process is fundamentally one of improvement in TFP. It has long been recognized that TFP is about much more than "technology", understood as recipe like advances in scientific knowledge (Erken, Donselaar and Thurik, 2008; Acs Braunerhjelm, Audretsch and Carlsson, 2009). Since the initial identification of the "unexplained" cause of growth (Solow, 1956), significant attention has been devoted to R&D as a driver growth (Romer, 1990; Coe and Helpman, 1995). Acs et al. (2009), R&D itself does not drive the TFP, but the innovation that emerges from R&D will drive the TFP. The traditional literature (Chandler, 1989; Cohen and Levin 1989; and Griliches 1979), innovation and technological change for most theories of innovation have been the firm. In such theories firms are exogenous and their performance in generating technological change is endogenous (Cohen and Klepper, 1991 and 1992). Griliches (1979), the most prevalent model of technological change is the model of the knowledge production function. According to this model, incumbent firms engage in the pursuit of new economic knowledge as an input into the process of generating the output of innovative activity. The new economic knowledge is most important input in this model. The greatest source generating new economic knowledge is generally considered to be R&D (Cohen and Klepper, 1991 and 1992). Human capital, skilled labor, and educational levels considered as inputs in the knowledge production function.

Doing R&D is important for productivity and also economic growth. Domestic R&D has high spillover effects, it is enhances the ability of the business sector to absorb technology coming from abroad. R&D spillover does not limit in the specific country but can cross all the borders. Romer (1986) allows companies to invest in R&D with condition that marginal profitability equal to innovation cost. According to Bart (1997) that although the significance of the spillover effects is beyond doubt, the estimated rates of return to R&D investment, considered being the major input in technology generation, vary over a large range. Researchers also discuss the role of foreign R&D and domestic R&D in influencing the host country productivity. A number of studies for developing countries document that a foreign presence promotes higher productivity in host country sectors, while other studies point to limited or no significant efficiency spillovers. Lichtenberg and Van Pottelsberghe (1998) show that foreign R&D can affect domestic performance through both imports and outward FDI that is through technology sourcing and learning practices. Coe and Helpman (1985), found a significant contribution of foreign R&D on the total factor productivity in 22 industrialized countries. They found in smaller countries, the effects of foreign R&D capital are as a big as those domestic R&D, while in the larger countries, domestic R&D play a crucial role rather than foreign R&D.

Bernstein (1994) and Bernstein and Yan (1995), foreign R&D exert a greater influence rather than domestic R&D not only in industry specific but also in country specific. Fors (1996) analyzed the productivity effects of domestic and foreign R&D in Swedish firms and found that

domestic R&D impacts growth in foreign subsidiaries, but found no evidence of a reverse effect of foreign R&D. Coe and Helpman (1993) shown that the rate of return R&D is not only high in the performing countries, but that significant benefits are also derived by their industrial country trade partners. Coe and Helpman (1995) found evidence among 21 OECD economies, foreign R&D has beneficial effects on domestic productivity which are stronger the more open economy to trade. Jungsoo (2002), show that domestic R&D and foreign R&D spillovers across countries on economic growth provide potential explanations for the productivity gain in the recent years.

Belderbos et al. (2006) found that there is positive interdependence between the domestic and foreign R&D by examined the interdependence between foreign and domestic R&D by include the technology transfer and absorptive capacity. They found that foreign R&D activities by MNC is demand oriented, an increase in domestic R&D activities will enhance the complexity of technology transfer. Griliches and Lichtenberg (1984) examined relationship of R&D investment and TFP growth on sectoral level and find that strong relationship between foreign R&D expenditures and TFP growth in 1960s and 1970s. R&D activities either foreign or domestic R&D will benefited countries. This argument has been studied by Samimi and Alerasoul (2009) R&D is a key long run determinant of productivity and economic growth. Aghion and Howitt (1992) discussed the important contribution of R&D and economic growth and at the same time R&D activities can lead to improve innovations like improvement in the technology.

Many researchers state that economic freedom is important factors for country because it is one of the main drivers of prosperity and growth. According to economic theory, economic freedom will affects incentives, productive effort, and the effectiveness of resource use. Numerous studies state that countries with having initial level of economic freedom will leads to the growth of that countries (Ali 1997; Easton and Walker 1997; Goldsmith 1997; Dawson 1998; Wu and Davis 1999; Hanson 2000; Pitlik 2002; Scully 2002; Weede and Kamph 2002; Haan et al. (1996). McQuillan and Murphy (2009), state that the main finding on their research is that economic freedom promotes not only higher incomes but growth rate in output and incomes especially in developing countries. Islam (1996) indicated that economic freedom has a direct relation with per capita income and economic growth rate by using cross-section data analysis in 98 low, middle and high-income countries. On the other hand, Cole (2003) looked at 106 countries and found that economic freedom had significant explanatory power across competing theories of economic growth, where Cole looked at the factors that different groups economist believed are important for economic growth and showed that adding the factor economic freedom shed more light on which countries grow fasters that others.

Gwartney et al. (1996), that develop the measurement of economic freedom in Fraser Institute's, note that the countries with the highest economic freedom scores have an average annual growth rate of per capita real GDP while those with the lowest economic freedom scores have an average of negative growth rate per capita real GDP. This supported by the Holcombe and Gwartney (2010), Gwartney and Lawson (2005), Berggren (2003), countries that have more economic freedom have on average higher per capita incomes and countries that increase their economic freedom exhibit higher rates of economic growth, which is the level of economic freedom can be seen when countries have lower unemployment rates, lower percentages of children in labor forces, higher life expectancies and more political freedom. Depken and Sonara (2005), investigate the impact of economic freedom and trade flows by estimating a gravity model using the freedom index developed by the Fraser Institute and find that higher level of economic freedom is strongly correlated with increased of trade flows. Calvo and Robles (2003) explore the economic freedom and FDI flows and found that greater economic freedom in host country increases FDI inflows in the 18 Latin American countries. They also postulate that FDI is

also positively correlated with economic growth in the host country with the adequate human capital, liberalized markets and economic stability to promote from long term capital flow. Pourshahabi et, al. (2011) supported this finding by indicates that economic freedom in OECD countries has positive and non significant effect on FDI and consistence with theoretical expectation and according to them it is not significant because there is not any large economic freedom gap between these set of countries that can lead to significant differences of FDI. Hanke and Walters (2000), development cannot achieve its goals without economic freedom because economic freedom can fuel economic growth and spur growth. Berggren (2003), show the clear about this complexity of economic freedom, by saying that some EFI components causing growth, some EFI components being caused by growth, and some EFI components being jointly determined with growth.

An economist who argues that economic freedom is a key ingredient for economic growth process fall in the institutional views. According to Powell (2003), the degree of economic freedom either hinders or helps in achieving economic growth is supported by the key institutional factor. The institutional which stresses the importance of creating an institutional and policy environment conducive for smooth operation of markets and realization of gains from trade and entrepreneurs activity (North, 1990; Hayek 1945, 1960). The other view by Berggrren (2003), economic growth will be boost if the institutions itself guarantee the economic freedom by promote capital investment where returns are highest, facilitate predictable and rational decision making through a low and stable inflation rate, by foster a dynamic economy in which competition can occur because regulations are few, enable talents to be located to where it generate highest value, and promote high return through low taxation, sound legal system and protection of private property. Gwartney et al. (1999) postulate that an economy with higher economic freedom can make the market operate well through offering the well-defined rule of trade and securing property rights. The strong protection of private property and a well functioning judicial system are the most importance of various institutions and policy variables for economic growth without consider to the economic freedom index (Torstensson 1994; Goldsmith 1995; Barro 1997,1999; Nelson and Singh 1998; Norton 1998a; Hall and Jones 1999; Keefer 1999; Kneller, Bleaney and Gemmell 1999; Olson, Sarna and Swamy 2000; Vijayaraghavan and Ward 2001; Feld and Voight 2000).

3.0 Methodology

3.1 Introduction

This section comprises the discussion regarding the estimation model, data and econometric methodology that will be built and used to test the role of economic freedom in mediating R&D spillovers on total factor productivity. The econometric model designed is a total factor productivity (TFP) model, based on the extension of Mansfield (1984) model. The Dynamic Ordinary Least Square (DOLS) test is conducted, to test the long run and cointegration relationship between the variables.

3.2 Theoretical Model

The empirical model used in this study is an extension of endogenous growth framework. The endogenous framework proposed by Romer (1990), Grossman and Helpman (1991) and Aghion and Howitt (1992) links total factor productivity and innovation. The endogenous framework provides a link between total factor productivity and foreign R&D spillovers. Following Coe and Helpman (1995) model can be seen as an extension of Mansfield's (1984) by

assume Cobb-Douglas production technology, the output (Y) as depending on the labor (L), physical capital (K) and knowledge capital (S) as follows:

$$Y = AL^{\alpha}K^{\beta}S^{\lambda}e^{\varepsilon} \quad (1)$$

Where Y is output, A is constant, L is labor, K is physical capital, S is knowledge capital, e is white noise error term. Since knowledge capital for open economies may come from both domestic and foreign sources that can be domestic research and development and foreign research and development (DRD and FRD). Following the latter, the production function

$$Y = AL^{\alpha}K^{\beta}[(DRD)^{\alpha 1}(FRD)^{\alpha 2}]^{\lambda}e^{\varepsilon} \quad (2)$$

If one defines total factor productivity TFP as $TFP = \frac{Y}{L^{\alpha}K^{\beta}}$, then, substituting this production function

$$TFP_{it} = A + DRD^{\alpha 1} + FRD^{\alpha 2} + e^{\varepsilon} \quad (3)$$

Taking the logarithm of both sides yields the baseline specification of Coe and Helpman which may be express as:

$$\text{Log } TFP_{it} = \beta_i + \beta_1 \log DRD_{it} + \beta_2 \log FRD_{it} + e_{it} \quad (4)$$

Where i denotes countries and t denotes time periods. Log TFP is the logarithm total factor productivity, β_i captures individual country specific effect, DRD is domestic R&D capital stock, FRD is foreign capital stock, β_1 is a elasticity of TFP with respect to domestic R&D, β_2 is the elasticity of TFP with respect to foreign R&D, and e is random error term.

3.3 Empirical Model specification

To analyze the role of economic freedom in mediating the R&D spillovers, the econometric model can be expressed as equation (5);

$$\text{Log } TFP_{it} = \beta_i + \beta_1 \log DRD_{it} + \beta_2 \log FRD_{it} + \beta_3 DRD \text{ x } EF_{it} + \beta_4 FRD \text{ x } EF_{it} + e_{it} \quad (5)$$

where i is a developing countries and t is time index. TFP is total factor productivity, DRD is domestic R&D, *FRD* is foreign R&D, EF is index of economic freedom. In order to estimate the role of economic freedom in mediating R&D spillover, the interaction term will be used by DRD x EF and FRD x EF, whereas the interaction term is given by EF, DRD and FRD to ensure that interaction term does not proxy for economic freedom or domestic R&D and foreign R&D, because these variables also include in the regression model. All variables are in logarithmic form. β_i is country specific intercept, β_1 is the elasticity of TFP respect to domestic R&D, β_2 is the elasticity of TFP respect to foreign R&D, β_3 is the elasticity of TFP respect to economic freedom, β_4 is the elasticity TFP respect to interaction term of domestic R&D and economic freedom, β_5 is the elasticity TFP respect to interaction term of foreign R&D and economic freedom and e is the random error term.

3.4 Long-run elasticities: Stock-Watson Dynamic OLS

One method that proposed by Stock and Watson (1993) in estimation long run equlibria is dynamic OLS (DOLS). This method correct for possible simultaneity bias among the regressors. Beside that, this method suggest a parametric approach for estimating long run

equilibria in system which may involves variables integrated of different orders but still cointegrated. The procedure advocated is similar to recent estimators proposed by Phillips and Loretan (1991) and Saikkonen (1991), but is much more practically convenient to implement and estimate. Stock and Watson DOLS parameters estimates of the long run parameters with all variables appearing in levels, along with their approximate asymptotic standard errors, in Table 3. The entire tested models are estimated based on automatic leads and lags specification (based on AIC criterion). Results of dynamic OLS are reported in Table 3 based on seven models we examine before.

$$LTFP_t = \alpha + \beta_1\ LDRD_t + \beta_2\ LDRDEF_t + \beta_3\ LFRDFDI_t + \beta_4\ LFDRDFDIEF_t + \sum_{j=-p}^{p} \delta_1 \Delta \ln TFP_{t-j} + \sum_{j=-p}^{p} \delta_2 \Delta\ LDRD_{t-j} + \sum_{j=-p}^{p} \delta_3\ LDRDEF_{t-j} + \sum_{j=-p}^{p} \delta_4 \Delta\ LFRDFDI_{t-j} + \sum_{j=-p}^{p} \delta_5\ LFDRDFDIEF_{t-j} + \varepsilon_t \quad (6)$$

This model examines domestic R&D with foreign R&D for FDI and interaction between economic freedom with DRD and FRDFDI

3.5 Short-run elasticities: Error Correction Term (ECT)

For short run estimation, we used error correction term estimates of all models in this study. According to Hendry's (1995), ECT is general to specific modeling approach that used to derive a satisfactory short run dynamic model. The value of ECT indicates the evaluation process on the variable concern by which adjusts for prediction errors made in the last periods. The regression results for the short run equations show several desirable statistical features. The coefficient of ECT measures the speed of adjustment back to the long run equilibrium value, and negative value of ECT indicate that error correction mechanism exist in the model. The literature postulates that the coefficient of the lagged error correction term should be negative and statistically significant to further confirm the existence of a long-run relationship.

$$\Delta \ln\ TFP_t = \alpha_1 - \lambda_t ECT_{t-1} + \sum_{i=1}^{p-1} \beta_{1,t} \Delta \ln\ TFP_{t-i} + \sum_{i=0}^{q-l} \beta_{2,t} \Delta\ LDRD_{t-i} + \sum_{i=0}^{r-1} \beta_{3,t} \Delta LDRDEF_{t-i} + + \sum_{i=0}^{s-1} \beta_{4,t} \Delta\ LFRDFDI_{t-i} + \sum_{i=0}^{u-1} \beta_{5,t} \Delta LFDRDFDIEF_{t-i} + \varepsilon_t \quad (7)$$

3.6 Data set

The data set consists of panel data observation for 37 selected developing countries over the 2000 – 2010 periods (list of countries in Appendix 1). Variable that we used in this study are total factor productivity (TFP), economic freedom, domestic R&D and foreign R&D. Where TFP measure based on Klenow and Rodriguez (1997) specification; economic freedom based on Fraser index developed by Gwartney et al (1996); domestic R&D based on R&D capital stocks were calculated using the perpetual inventory procedure and foreign R&D based on the inward FDI weighted foreign R&D capital stock following Van Pottelsberghe and Lichtenberg (2001).

5.0 Result and Discussion

5.1 Introduction

This section will discussed the empirical result of role of economic freedom in mediating research and development (R&D) on productivity growth. Based on previous discussion in chapter 3, our interest on developing countriesThe methodologies that we used to examine the

role of economic freedom are panel dynamic OLS (DOLS) proposed by Stock and Watson (1993) and supported basic test of unit root test of ADF and PP test, cointegration test of Pedroni and Johansen Juselius and we estimate error correction term to support the dynamic OLS test.

5.2 Univariate integration: Test of the unit root hypothesis

As a necessary test for multivariate cointegration, two types of unit root test were carried out, that are Augmented Dickey Fuller test and Phillips-Perron test from now on called ADF and PP test. Both ADF and PP test based on the null hypothesis that a unit root exists in the autoregressive representation of the data variable. The results of ADF and PP tests are presented in Table 3 for full sample and income group basis for time period 2000 to 2010. The ADF and PP tests model are intercept, intercept and trend and none are reported based on p=1, p=2 and p=3. Table 3 (a) and (b) presents results from two test discussed earlier. The results suggest that at level, there are mixed result of significant and not significant, however at first difference all variables are rejected null hypothesis, thus the variables are integrated of order 1 or known as I(1). So it is possible that there is a long term relationship among them.

Table 3. Unit root of Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) test.

Variable	Level			First Difference		
	p=1	p=2	p=3	p=1	p=2	p=3
Augmented Dickey Fuller (ADF) test						
LTFP	73.7581	60.9100	75.7832	161.083***	161.083***	261.218***
LEF	100.990**	78.0877	30.9880	242.710***	182.142***	404.890***
LDRD	149.852***	119.628***	109.131***	228.653***	182.596***	342.205***
LFRDFDI	70.0158	138.421***	90.7986*	275.385***	198.987***	441.318***
Phillips-Perron (PP) test						
LTFP	111.044***	79.1506	92.0062*	179.267***	169.386***	271.377***
LEF	130.583***	110.514***	30.7398	305.342***	342.893***	427.774***
LDRD	145.699***	138.270***	116.093***	255.531***	256.714***	344.838***
LFRDFDI	75.5831	142.111***	128.746***	351.526***	300.318***	446.305***

Notes: H_o: Unit root process for ADF. ***, ** and * indicate significance at the 1,5 and 10% levels. Optimal lag lengths in ADF were selected based on AIC. The PP tests for model intercept, intercept and trend and none are reported based on p=1, p=2 and p=3.

5.3 Panel Cointegration Test: Pedroni and Johansen Juselius Test

To determine whether a cointegrating exist and to examine our fitted regression model is not spurious, we employed the developed methodology cointegration analysis proposed by Pedroni (1999). Basically, under Pedroni cointegration test, it employs four panel statistics and three group panel statistics to test the null hypothesis of no cointegration against the altenative hypothesis of cointegration. Based on seminal paper Pedroni (1999a), the results shows in two group , first group is "within dimension", that the statistics are constructed based on summing both the numerator and the denominators terms of the panel cointegration statistics over the N dimension. The second group is "between dimension" that the statistics referred to as a group cointegration statistics, which constructed by first dividing the numerators by the denominator prior to summing over the N dimension. The results are reported in Table 4. The result of Pedroni statistics in Table 4(i) indicate that, we can easily reject null hypothesis at intercept and trend. When we conduct Johansen test (Table 4(ii)), value of trace and max eigenvalue show there are easily reject the null hypothesis and indicate there are cointegrated among the variables.

Table 4(i). Pedroni Panel Cointegration Test

	Intercept	Intercept and trend	None
Within dimension			
v-Statistic	-2.172934	5.189180***	-2.779744
rho-Statistic	5.004078	6.352809	5.292380
PP-Statistic	-1.358367*	-5.278080***	2.963306
ADF-Statistic	-1.318635*	-3.817687***	-2.459776***
Between dimension			
rho-Statistic	7.411047	8.462227	5.923025
PP-Statistic	-3.915980***	-11.41754***	-5.467992***
ADF-Statistic	-2.097055***	-4.906857***	-6.347653***

Note: Figure in parentheses are p-values and ***, ** and * indicate significance at the 1,5 and 10% levels. Optimal lag lengths were selected based on AIC

Table 4(ii). Johansen and Juselius's test for multiple cointegrating vectors

Vector	Hypotheses		Test Statistics	
	Ho	H1	Max Eigenvalue	Trace
Panel A: Full sample				
	r = 0	r > 0	323.8***	323.8***
	r≤ 0	r > 1	525.2***	467.6***
	r≤ 2	r = 3	209.2***	209.2***

Notes: r indicates the number of cointegrating relationship. The optimal lag structure for the VAR was selected by minimizing Akaike's FPE criteria. Critical values are sourced from Johansen and Juselius (1990). ** indicates rejection at the 95% critical values and *** indicates rejection at the 99% critical values.

5.4 Result of long-run elasticities: Stock-Watson Dynamic OLS

Based on model (6), we estimate the long run estimation of dynamic OLS. This model examines domestic R&D with foreign R&D and interaction between economic freedom with DRD and FRD. Results are reported in Table 5.

Table 5. Results of Long Run elasticies of Dynamic OLS.

Variable	Coefficient
LDRD	-0.8385
LDRDLEF	0.8068***
LFRDFDI	-0.0427
LFRDFDILEF	0.0322**
R-squared	0.961800

Note: ***, ** and * indicate significance at the 1, 5 and 10% levels

From the Table 5, the results report the coefficient value of domestic R&D and foreign R&D indicates negative relationship with the TFP growth by -0.8385 and -0.0427. When we include the interaction term between domestic R&D and economic freedom and foreign R&D with economic freedom in the model, interestingly the results showed the positive coefficient value, where we can conclude that economic freedom plays an important role in mediating the impact of domestic R&D and foreign on TFP growth. From Table 5, interaction term between domestic

R&D and economic freedom indicate the value of 0.8068 with statistically significant at 1 percent significant level and the value of the interaction term between foreign R& and economic freedom is 0.0322 significant at 5 percent significant level. From this estimation result, we can conclude in long run that economic freedom play a significant role in mediating the impact of R&D on TFP growth, but the impact is more on the domestic R&D compare to the foreign R&D.

5.5 Result of short-run elasticities. Error Correction Term (ECT)

Table 6 provide the results of the short run estimation based on the ECT that estimated by the dynamic OLS. The ECT value show negative value where this indicate that there are error correction mechanism exist and existence of long-run relationship in this model. From the results, we can explain that in short run economic freedom play an important role as a mediating factor on domestic R&D and foreign R&D, but the impact of economic freedom on domestic R&D is more compare to foreign R&D where the coefficient value show interaction term between domestic R&D and economic freedom is 0.5533 with 1 percent significant level and coefficient value for interaction term between foreign R&D and economic freedom is only 0.0466 with 5 percent significant level. The coefficient value of domestic R&D and foreign R&D indicate negatively relationship with TFP growth, where this result is consistence with the estimation in long run that we discussed above.

Table 6. Short run dynamics of the model 5 estimated by Dynamic OLS.

Variable	Coefficient
ECT	-0.2618***
ΔLDRD	-0.5804
ΔLDRDLEF	0.5533***
ΔLFRDFDI	-0.0970
ΔLFRDFDILEF	0.0466**
R-squared	0.3774

Note: ***, ** and * indicate significance at the 1, 5 and 10% levels,

Thus based on short run results that we discussed above, we can conclude that economic freedom play an important and significant role in mediating the impact of domestic R&D on TFP growth. These results are consistence with the past researchers that indicate the important role of economic freedom on countries growth (McQuillan and Murphy, (2009); Williomson and Matthers (2010) and Cole (2003)).

6.0 Conclusion and recommendation

This study investigates the role of economic freedom in mediating the impact of domestic R&D and foreign R&D which for foreign R&D we examine based on three channels of FDI, outward FDI and import for a panel of 38 developing countries over the period 2000 to 2010. First we carry out panel unit root tests to ensure that all panel variables are integrated of order 1. Visual inspection of the data reveals that the variables seem to follow a common trend over time so that we include constant and trend terms and none in the panel unit root and integration tests. Fisher-*ADF* and Fisher-*PP* panel unit root tests are employed and we have found that the variables are mixed of stationary and nonstationary in levels. After first-differencing the variables, all of the tests reject the null of nonstationarity. It implies that the first-differenced variables come from a stationary process where means and variances are constant over time. Seven panel cointegration tests have been carried out who are proposed by Pedroni (1999). Since

there are mixed result of cointegrated and non cointegrated then we add another cointegration test estimation based on the Johansen and Juseliues test. At this stage we find that there exist a cointegration within them.

This dynamic panel data model we estimate for long run of dynamic OLS and short run of error correction term test. There are two important conclusions emerging from long run and short runs panel dynamic OLS results. First, in long run and short run economic freedom plays an important role in mediating domestic R&D on TFP growth. Second although economic freedom is seen to be more important factor in mediating impact on domestic R&D, but the result indicate that for foreign R&D economic freedom is positively mediating the impact on TFP growth but with the lower elasticities value compare to the domestic R&D. Thus we can conclude that economic freedom play an important role as mediating factor on domestic and foreign R&D but in developing countries, it seem more effective toward domestic R&D to boost countries productivity growth.

Economic environments that conducive and support for economic freedom will allows greater diversity, promoting creativity, encourage new technology and innovation. Policy marker and government should provide or formulate policy and ready to reduce their intervention to ensure that country is freer because economic freedom is one of the main drivers of prosperity and growth. On the other hand, government and policy makers should develop policy that provide good environment for domestic firm and foreign firm do business and trade. In other words, less regulation on trade, open the economy, flexible labor market, more developed stock market and financial market that will encourage more inflows of FDI and location of MNC's where they will bring along new technology that will encourage R&D activities that will boost country productivity.

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Appendix I

Hong Kong SAR, China
Iceland
Israel
Kuwait
Singapore
Trinidad and Tobago
Korea, Rep.
Algeria
Argentina
Brazil
Chile
China
Colombia
Costa Rica
Ecuador
Iran, Islamic Rep.
Malaysia
Mauritius
Mexico
Panama
Peru
South Africa
Thailand
Tunisia
Turkey
Uruguay
Bolivia
Egypt, Arab Rep.
Guatemala
India
Morocco
Pakistan
Paraguay
Philippines
Burkina Faso
Madagascar
Uganda