FOREIGN DIRECT INVESTMENT AND INNOVATION:
HETEROGENEOUS INTERNATIONAL EVIDENCE

By

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Abstract

Globalization has made countries around the world more economically and financially integrated. As a consequence, there are more opportunities to learn from one another through investment, knowledge acquisition, or technological spillovers as developed countries outsource their production to less developed economies that tend to provide lower labor costs. Foreign direct investments (FDI) benefit national and regional economic development by promoting more R&D spending, enhancing productivity, and providing higher wages. This paper will examine the linkage between FDI and product innovation for countries with different income levels using a panel of 50 countries from 1980-2016. The empirical results based on the Fixed-Effect estimator show that the relationship between FDI and patent applications (a proxy used for product innovation) is statistically significant and positive for upper middle income countries only. Within this group that includes some emerging markets and relatively rich developing countries, there exists some heterogeneity in the innovation development resulting from FDI. Exploring the reasons behind these cross-country differences using country-level factors such as quality of education system and R&D spending will be the next step of this research.

Acknowledgments

Many thanks to my faculty mentor, Dr. Dongwon Lee, for his guidance and mentorship.

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1. Introduction

In this research, I will attempt to examine the relationship between FDI and patent application for low income, lower middle income, upper middle income, and high income economies. As mentioned by Liu and Qiu (2016), patent application is generally considered as a better measure of innovation activities since it best captures the effectiveness of innovation effort, including both observable and unobservable inputs. A positive relationship between FDI and patent application means that as the amount of FDI inflows increase, the number of patent applications increase as well. Low income countries might not benefit from FDI inflows since those countries do not have sufficient skills, knowledge, or technological foundations to learn from or utilize new technologies. At the other extreme, high income economies might not benefit from additional FDI inflows since they already possess far superior technological advantage. Therefore, countries that would most likely benefit from FDI inflows are those that are in the process of rapid development with skilled workers and the ability to use new technologies in their existing production. The results support this claim by showing that FDI and patent application is statistically significant and positive at the 10% level for upper middle income countries only.

Even though there have been numerous attempts in trying to understand the channel that FDI plays in affecting economic growth, none of the papers have yet to specifically define the integral intermediate channel through which FDI impacts growth. Even though previous papers have stated that greater human capital enhances the level of FDI spillovers on growth, the use of other endogenous variables along with human capital could lead to inaccurate analyses. Alfaro, Chanda, and Ozcan (2003) use, in addition to human capital, measurements of financial markets, potential shortages of skills, knowledge, and infrastructure as the endogenous variables.

However, it is very likely that both human capital and financial markets increase with higher growth rates; moreover, other endogenous variables are just as important, if not more, than human capital in increasing growth. For this reason, instead of having many endogenous variables with similar impact on the dependent variable, there needs to be only one independent variable that, upon accurate analysis, has the potential to impact the dependent variable more than other explanatory variables in the regression. Specifically, it is important to ensure that all the independent variables are related to the dependent variable; however, none of them should have the same correlation power or exhibit similar characteristic to the main independent variable that we are utilizing. This paper will attempt to simplify the model by isolating a single factor, patent applications, in order to provide strong evidence for its significant relationship with FDI as a channel for boosting output and growth. The paper will present the theoretical background concerning patent applications and FDI, report previous findings, explain the empirical methodology, and provide significant results.

2. Theoretical Background

In past papers, multiple mechanisms which play a role in the transmission of FDI spillovers on patent (innovation) have also been proposed. According to Jaffe (1986), since knowledge is inherently a public good, the existence of technologically related research efforts of other firms may allow a given firm to come up with its own innovative product or technology with less research effort than otherwise. However, the innovations produced by these domestic firms tend to be minor patents with similar characteristics to those of multinational firms, which implied that the impact on long term growth will not be as significant. A more distinct process which links FDI to patents is discussed by Cheung and Lin (2003); FDI can benefit innovation activity in the host country via spillover channels such as reverse engineering, skilled labor turnovers, demonstration effects, and supplier-customer relationships. More specifically, firms use reverse engineering to learn about the products and technologies brought in by foreign investors and improve upon them to come up with new innovations as well as recruiting skilled workers from foreign firms in order to gain access to technological knowledge. Most importantly, demonstration effects constitute an integral aspect of the FDI-patent mechanism linkage. Just by having foreign companies in domestic markets, foreign products and technologies can inspire and stimulate local innovators to develop new products. As a result, the trial and error process of local firms in their search for new inventions is reduced significantly. In addition, since the products and technologies that FDI firms bring in have already been tested in foreign markets, the perceived risk of innovating along similar directions is lowered for local firms. This points to the fact that FDI and patent applications are positively correlated not only because of the increased motivation for domestic firms to innovate, but because these innovations are distinctively unique in nature. This idea is also recently echoed by Zhang (2016); with intense demonstration and competition from foreign invested enterprises, indigenous firms tend to make further technology progress in order to survive in the market.

3. Previous Findings

Previous literatures have also attempted to analyze the standard determinants that affect patent applications. One of the earlier works on this topic is by Jaffe (1986), which states that the level of R&D spending and the level of spillover pool are statistically significant for the number of patent applications. In the subsequent work by Cheung and Ping (2006), the effect of FDI on patent applications is examined for each of the provinces in China. Along with FDI, the standard determinants for patent applications used in this analysis include the number of personnel for and expenditures on science and technical development, share of foreign funded enterprises' export to its gross output, and GDP per capita in each of the provinces. While FDI, the number of personnel for and expenditures on science and technical development, and GDP are positive and statistically significant in terms of patent applications, the share of foreign funded enterprises' export to its gross output yields inverse relations. Since FDI firms with larger export-output shares are likely to be linked with incentives for cheaper labor rather than market oriented, the associated spillover effects on domestic innovation tend to be weak because the technologies they bring in are mostly labor intensive. In a more recent work by Mancusi (2008), using a model where innovation in a particular industry is set equal to the stock of R&D in that industry as well as the stock of external accessible domestic and foreign R&D, international spillovers are found to be effective in increasing innovative productivity in laggard countries. Moreover, Mancusi (2008) directly link the level of new technological output to the number of new patents utilizing a model where innovation in an industry located in the home country results from the stock of own R&D (10% increase in R&D expenditure = 1.4% increase in patents) and the stocks of external accessible domestic as well as foreign R&D. Wang and Wu (2015) also discuss some determinants for assessing patent applications such as firm age, full time employees, and firm assets.

4. Empirical Methodology

4.1 Identification Strategy

Since a cross country data will be employed, I propose the following standard determinants for each country in addition to inward FDI: exports of goods and services as a percentage of GDP, research and development expenditure as a percentage of GDP, percentage of annual growth, and researchers in R&D (per million people). My decisions for the choice of these standard determinants are as follow: past literatures, including Cheung and Lin (2003), argued that the number of personnel for science and technical development as well as the expenditures on science and technical development are the most major determinants of innovation output. Exports is also crucial since the ability to successfully export depends on the uniqueness of a particular product or service to the world market, which is determined partly by a firm's innovativeness. This research uses a multiple regression model (country fixed effects) relating FDI to the number of patent applications, using independent variables similar to Cheung and Lin (2003). The model is as follows (where 'i' represents country and 't' represents the year being observed):

$$\Delta PA_{it} = \alpha_{it} + \Delta FDI_{it} + \Delta EX_{it} + GROWTH_{it} + \Delta RD_{it} + \Delta RES_{it} + \square_{it}$$

where PA = number of patent applications, FDI = foreign direct investment inflows (% of GDP), EX = export (% of GDP), GROWTH = annual % growth, RD = research and development expenditure (% of GDP), and RES = researchers (per million people). PA and RES are scaled by total population. All the variables except for GROWTH is in logarithm.

4.2 Data

This paper will utilize data on the number of resident patent applications, foreign direct investment net inflows (% of GDP), exports of goods and services (% of GDP), research and development expenditure (% of GDP), and researchers in R&D (per million people) from The World Bank's online database. Low income, lower middle income, upper middle income, and high income economies are determined by the data provided by the United Nations. The observations are from 1980-2016.

4.3 Concerns about patent data: Patent granted vs. Patent applied

The choice of dependent variable used in this paper is motivated by previous literatures which examine the pros and cons of using patent granted vs. patent application. According to Cheng and Lin (2003), some innovators may have chosen not to file patent application in order to prevent their competitors from utilizing the information; in addition, the number of patent applications does not reflect the quality of the inventions concerned. However, the most important benefit of using patent application is that it includes both product and process innovations, which improve the production technology for existing products. Zhang (2016) states that it is easy to fulfill the requirement of filing a patent application by investing in R&D activities, but the researchers will have to double their efforts to guarantee that the application be granted successfully. For this reason, in the model with patent application as the dependent variable, R&D stock has a stronger impact to the innovation output; in contrast, in the model with patent granted as the dependent variable, the research labor is more important to produce innovation. Nonetheless, the majority of previous literatures have used patent application as the dependent variable. This is due to the fact that, with regards to patent application, there are more availability of data and that patent application is a better approximation for technological output. According to Comanor and Scherer (1969), for a sample of 57 pharmaceutical manufacturing firms, even though there is a positive relationship between patent application, patent granted, and sales, there is an overall larger influence of patent application on sales. Most importantly, patent applications provide evidence of the companies' willingness and ability to innovate as the result of increased contact and influence from foreign companies. This is because the trial-and-error process associated with patent application is a better indicator of knowledge and technological spillovers than patent granted since the latter ignores minor inventions in patent applications that have the potential to grow into larger inventions or be incorporated into the productiveness of a company in the long term. Therefore, this paper will examine the relationship between FDI and patent using patent application as the dependent variable.

Table 1: Summary Statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
year	1,850	1998	10.68	1980	2016
country	1,850	126.5	75.82	9	255
PA	1,850	1097.94	900.03	1	2931
FDI	1,850	4372.17	2682.8	6	8864
EX	1,850	5132.94	3332.6	1	10478
GROWTH	1,850	4854.24	3144.87	3	10973
RD	1,850	558.89	714.92	1	2073
RES	1,850	360.26	507.54	1	1591
POP	1,850	4802.79	2651.83	3	9397

Note: PA = patent application; FDI = foreign direct investment, net inflows; EX = exports of goods and services; GROWTH = Annual Growth; RD = research and development expenditure; RES = researchers; POP = Population.

Table 2: Evidence Across Income Levels

Estimation method: Fixed effect model

Dependent variable: ΔPA_t

	Low Income	Lower Middle Income	Upper Middle Income	High Income
ΔFDI_t	-0.02 (0.056)	0.024 (0.021)	**0.043*** (0.025)	0.001 (0.012)
ΔEX_t	0.078 (0.128)	-0.004 (0.01)	0.011 (0.015)	0.007 (0.011)
$\Delta GROWTH_t$	**-0.0001**** (0.00003)	-4.38e-06 (3.75e-06)	-4.14e-06 (4.63e-06)	-2.83e-06 (3.74e-06)
ΔRD_t	0.016 (0.0577)	0.009 (0.008)	**0.021***** (0.008)	**0.02***** (0.006)
R^2	0.1417	0.0388	0.0216	0.0134
Sample Period	1980-2016	1980-2016	1980-2016	1980-2016
# countries	1	3	15	31
Observations	36	108	540	1,116

Note: PA = patent application; FDI = foreign direct investment, net inflows; EX = exports of goods and services; GROWTH = Annual Growth; RD = research and development expenditure. PA is normalized by the number of population, and the rest except for GROWTH is by the nominal GDP. All variable except for GROWTH are in logarithm. All specification control for country fixed effects. Robust standard errors are reported in parentheses. ***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 3: Statistical Significance of Independent Variables in Upper Middle Income Countries

Estimation Method: Fixed effect model

Dependent Variable: ΔPA_t

	(1)	(2)	(3)	(4)	(5)
ΔFDI_t	**0.044*** (0.025)	**0.044*** (0.025)	**0.046*** (0.025)	**0.043*** (0.025)	0.041 (0.025)
ΔEX_t		0.009 (0.015)	0.009 (0.015)	0.011 (0.015)	0.011 (0.015)
$GROWTH_t$			-3.94e-06 (4.66e-06)	-4.14e-06 (4.63e-06)	-3.90e-06 (4.63e-06)
ΔRD_t				**0.021***** (0.008)	0.011 (0.011)
ΔRES_t					0.012 (0.0095)
R^2	0.0061	0.0068	0.0081	0.0216	0.0247
Sample Period	1980-2016	1980-2016	1980-2016	1980-2016	1980-2016
#countries	15	15	15	15	15
Observations	540	540	540	540	540

Note: PA = patent application; FDI = foreign direct investment, net inflows; EX = exports of goods and services; GROWTH = Annual Growth; RD = research and development expenditure; RES = researchers. PA and RES normalized by the number of population, and the rest except for GROWTH is by the nominal GDP. All variable except for GROWTH are in logarithm. All specification control for country fixed effects. Robust standard errors are reported in parentheses. ***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

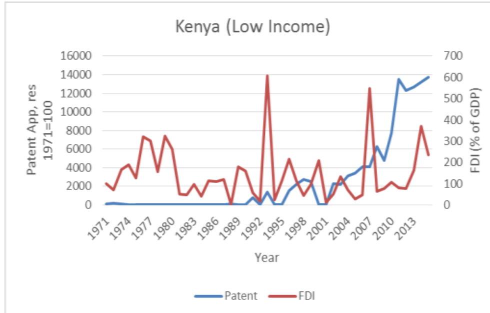
Table 4: Individual Upper Middle Income Countries

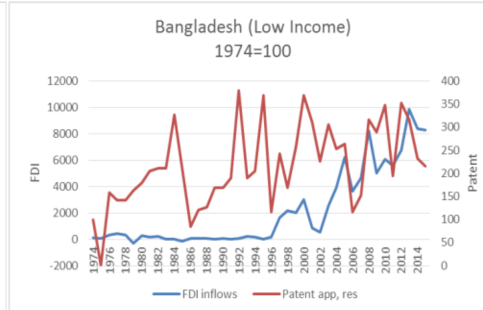
Estimation Method: Fixed effect model

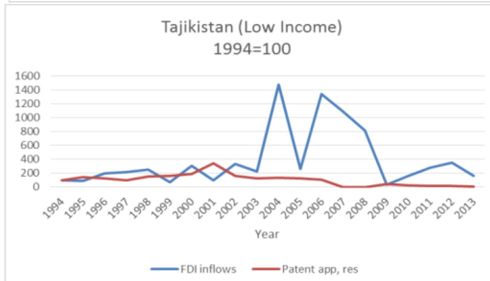
Dependent Variable: ΔPA_t

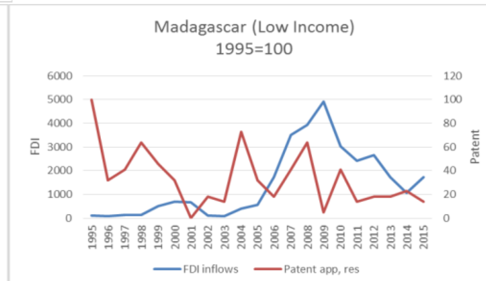
	Romania	Peru	Malaysia	Ecuador	Colombia	China	Bulgaria	Azerbaijan
ΔFDI_t	0.146 (0.152)	0.062 (0.047)	**0.144*** (0.082)	**0.177*** (0.095)	-0.019 (0.14)	-0.344 (0.494)	0.027 (0.03)	**0.049***** (0.014)
ΔEX_t	-0.022 (0.034)	**0.246***** (0.08)	0.016 (0.048)	0.285 (0.287)	0.046 (0.065)	-0.022 (0.093)	**0.179**** (0.087)	0.0009 (0.004)
$\Delta GROWTH_t$	0.00001 (0.00001)	1.63e-06 (0.00001)	**-0.00002*** (0.00001)	**-0.00005*** (0.00003)	**-0.00003**** (0.00001)	-2.29e-06 (0.00003)	1.54e-06 (2.97e-06)	2.91e-06 (1.75e-06)
ΔRD_t	**0.066**** (0.027)	0.028 (0.026)	-0.002 (0.01)	**0.082*** (0.044)	**0.053*** (0.019)	**0.119**** (0.054)	0.0096 (0.006)	0.0005 (0.004)
R^2	0.2088	0.3068	0.1190	0.2270	0.2745	0.1396	0.2367	0.3206
Sample period	1980-2016	1980-2016	1980-2016	1980-2016	1980-2016	1980-2016	1980-2016	1980-2016
#countries	1	1	1	1	1	1	1	1
Observations	36	36	36	36	36	36	36	36

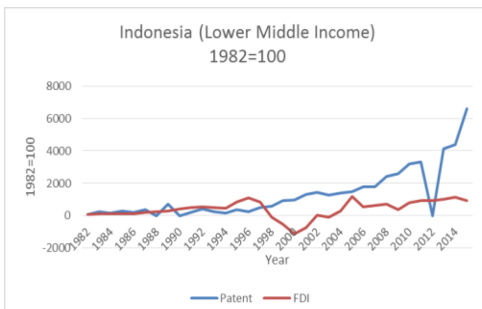
Note: PA = patent application; FDI = foreign direct investment, net inflows; EX = exports of goods and services; Growth = Annual Growth; RD = research and development expenditure. PA is normalized by the number of population, and the rest except for GROWTH is by the nominal GDP. All variable except for GROWTH are in logarithm. All specification control for country fixed effects. Robust standard errors are reported in parentheses. ***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

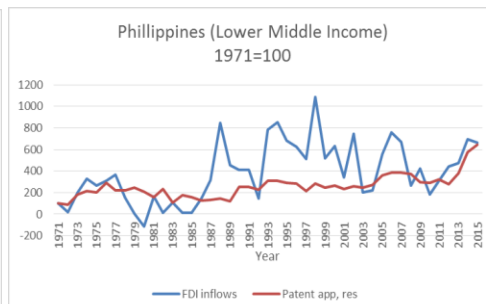

Kenya (Low Income)
Patent App, res 1971=100
FDI (% of GDP)
Year
Patent
FDI

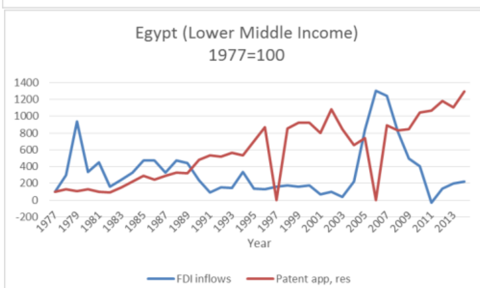

Bangladesh (Low Income)
1974=100
FDI
Patent
FDI inflows
Patent app, res

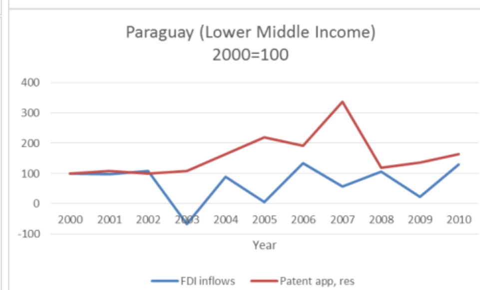

Tajikistan (Low Income)
1994=100
Year
FDI inflows
Patent app, res

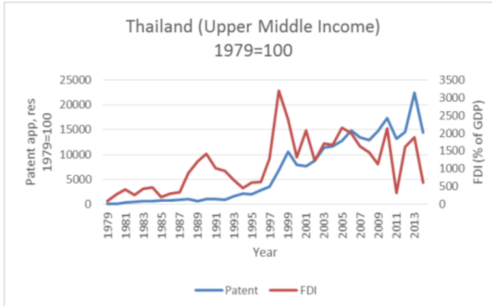

Madagascar (Low Income)
1995=100
FDI
Patent
FDI inflows
Patent app, res

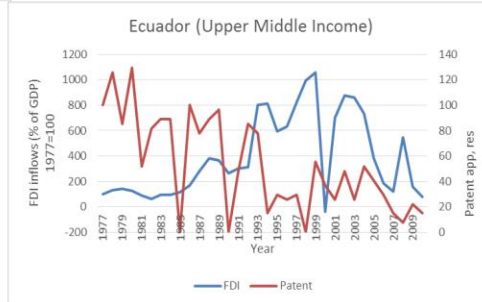

Indonesia (Lower Middle Income)
1982=100
1982=100
Year
Patent
FDI

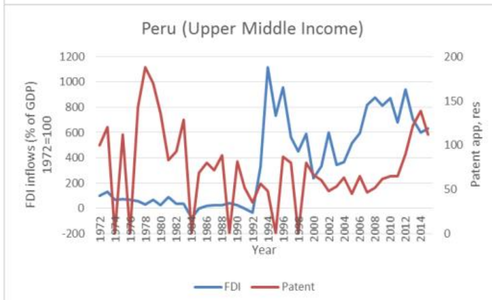

Phillippines (Lower Middle Income)
1971=100
Year
FDI inflows
Patent app, res

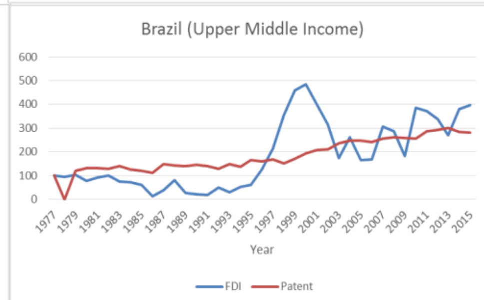

Egypt (Lower Middle Income)
1977=100
Year
FDI inflows
Patent app, res

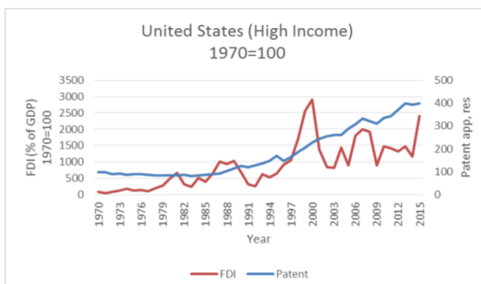

Paraguay (Lower Middle Income)
2000=100
Year
FDI inflows
Patent app, res

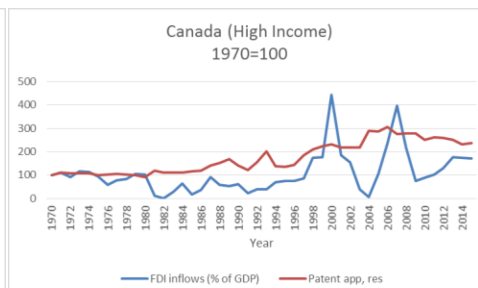

Thailand (Upper Middle Income)
1979=100
Patent app, res
1979=100
FDI (% of GDP)
Year
Patent
FDI

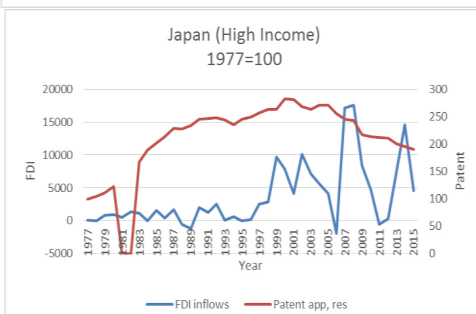

Ecuador (Upper Middle Income)
FDI inflows (% of GDP)
1977=100
Patent app, res
Year
FDI
Patent

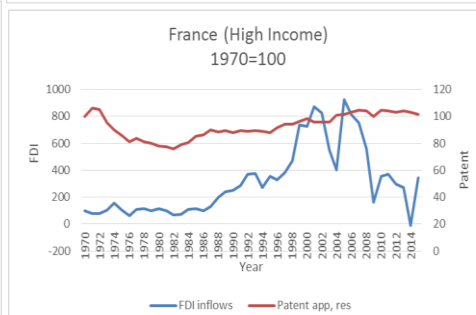

Peru (Upper Middle Income)
FDI inflows (% of GDP)
1972=100
Patent app, res
Year
FDI
Patent


Brazil (Upper Middle Income)
Year
FDI
Patent


United States (High Income)
1970=100
FDI (% of GDP)
1970=100
Patent app, res
Year
FDI
Patent


Canada (High Income)
1970=100
Year
FDI inflows (% of GDP)
Patent app, res


Japan (High Income)
1977=100
FDI
Patent
Year
FDI inflows
Patent app, res


France (High Income)
1970=100
FDI
Patent
Year
FDI inflows
Patent app, res

Appendix: Correlation

	PA	FDI	EX	GDP	RD	RES
PA	1					
FDI	0.0875	1				
EX	0.1544	0.2944	1			
GDP	0.1095	0.3140	0.1601	1		
RD	0.1812	0.3245	0.2110	-0.0107	1	
RES	0.1595	0.3061	0.1573	0.0616	0.7291	1

Note: PA = patent application; FDI = foreign direct investment, net inflows; EX = exports of goods and services; GROWTH = Annual Growth; RD = research and development expenditure; RES = researchers.

Conclusion

Based on the country-fixed effect results provided by the logarithmic regression model, the relationship between FDI and patent application is statistically significant and positive at the 10% level for upper middle income countries only. From examining all 15 countries in the upper middle income level, FDI and patent application show a positive relationship in countries that are currently in the initial stages of infrastructure development. According to Cheng et.al, the level of economic development is a major determinant of innovation activities across different provinces of China; their finding indicates that the most developed province in China tends to have the strongest effect of FDI on patent. Therefore, this paper contributes to the existing literature by not only examining this linkage globally, but also demonstrate that the case for the most developed economy having the most statistically significant impact of FDI on patent does not always hold true. Furthermore, among this group of upper middle income countries that includes some emerging markets and relatively rich developing countries, there exists some heterogeneity in the innovation development resulting from FDI. These upper middle income countries may be characterized by middle-level technology so that they benefit most from FDI inflows. Exploring the reasons behind these cross-country differences using country-level factors such as quality of education system and R&D spending in order to understand the regional structure and policy of each country will be the next step of this research.

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