Vol 4 No 2 (2024) ISSN: 2785-9266

Issues and Perspectives in Business and Social Sciences

Inward foreign direct investment and innovation: Which comes first?

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This study re-examines the direction of causality between inward foreign direct investment (FDI) and innovation (residents and non-residents) by considering balanced panel data of 56 countries (2000-2020). The vector auto-regressive (VAR) Granger non-causality tests show a direction from FDI inflows to innovation (non-residents), where FDI comes first (FDI-led innovation), while there is bidirectional causality between innovation by non-residents and residents, in general. For developed economies, FDI causes innovation by non-residents, but is caused by residents' innovation. There is no causation between FDI and innovation in either developing economies or economies in transition. These findings were further complemented by impulse response functions and various decomposition tests. Some policy relevance is highlighted.

Keywords:
Causality;
Inward FDI;
Innovation;
Panel data;
Patent applications.

Received 30 Jul, 2023
Accepted 27 Aug, 2023
Published 30 Jul, 2024

1. Introduction

According to Erdal and Goçer (2015), foreign direct investment (FDI) is a vital channel for host countries to introduce new ideas and working practices and access new technologies available at the world frontier. The gains accruing to foreign direct investors due to a host country's locational advantages are reflected in inward FDI, making it a good indication of the desirability of countries as target investment sites. FDI comes from two primary sources: greenfield investments and mergers and acquisitions (M&As). A greenfield investment typically entails introducing novel technology in the host nation; it naturally comes with the simultaneous transfer of know-how and resources from the parent company to the new subsidiary. Meanwhile, the M&As of a local company provide foreign investors with entry into the host country's technological resources and access to the acquired firm's pre-existing business networks and knowledge exchange ties. (OECD, 2022).

Indeed, FDI inflows can be considered "... *an investment made by a non-resident direct investor in a company residing in the host economy, referred to as the reporting economy*." (Hintošová, 2021, p. 1027). Inward FDI can boost local enterprises' innovative activities through the following channels (Lin & Lin, 2010). Reverse engineering refers to the ability to study foreign technology through reverse engineering, which helps indigenous companies learn how to manufacture products with similar functionality or enhance local items. The second channel is skilled labour turnover, in which indigenous companies may acquire foreign know-how through the mobility of experienced people in the labour market. The last channel is the demonstration effect, which helps shorten domestic companies' trial-and-error process in their search for inventions, encouraging local companies to develop new products. "*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." (Cheung and Lin, 2004, p. 2).

Conceptually, inward FDI may either encourage or dampen domestic enterprises' innovation (Yue 2022). With the inflow of foreign capital, high-quality domestic resources will be seized by foreign enterprises, intensifying market competition. Increased competition due to inward FDI may drive or stifle innovation. Indeed, there are two contrasting effects on a firm's innovation level. First, the escape-competition effect, as illustrated by Chen et al. (2022, p. 918), "… *the stronger competition following foreign entry may motivate domestic firms to increase innovation in order to stay ahead of the competitors, which is the escape-competition effect*." This finding postulates that more competition increases innovation. Second, the Schumpeterian effect occurs when the market share of Multinational Companies (MNCs) decreases due to the entry of foreign competitors, lessening their profits and thus reducing their incentives for innovation. Increased competition may reduce a firm's profits, resulting in a reduction in innovation in the local market.

The OECD (2022) points out that innovation figures prominently in the Sustainable Development Goals (SDGs), particularly in SDG 9 (industry, innovation, and infrastructure), focus on fostering innovation. The Sustainable Development Goals Report 2022 (United Nations, 2022) documents that economies with well-established technology and diversified manufacturing industries can better sustain less damage and recover more rapidly from the global crisis, which highlights the importance of innovation in achieving SDG 9. Inward FDI can be a tremendous catalyst for sustainable innovation by facilitating knowledge transfer, technology diffusion, and access to resources arising from market interactions between multinational corporations (MNCs) and local companies. There is a growing body of research exploring the effect of inward FDI on innovation, with most studies indicating that innovation is positively associated with inward FDI (Liu and Zou, 2008; Erdal and Goçer, 2015; Chen et al., 2022).

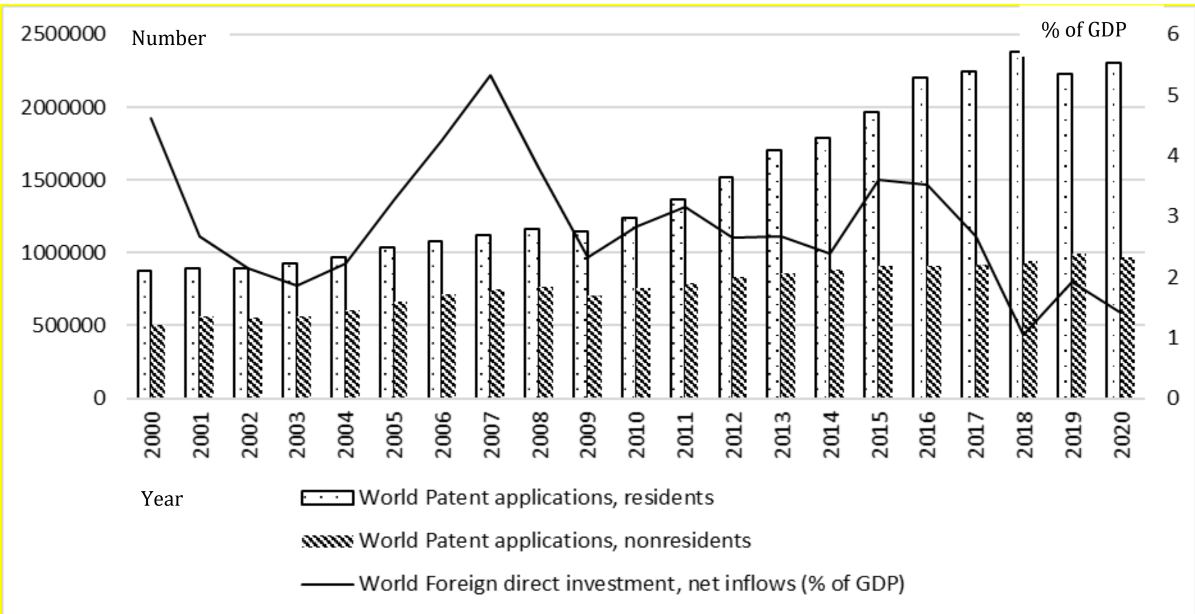


Figure 1: Resident Patent Application, Non-resident Patent Application and Inward FDI

As illustrated in Figure 1, the world FDI inflows (as % of GDP) are relatively volatile and gradually decreasing (especially, between 2009-2020) with a peak of 5.3% in 2007 and a trough of 1.1% in 2018. Innovation (patent applications) by residents took off in 2009 with 1.1 million applications, which gradually increase to 2.3 million in 2018. Nevertheless, global innovation by non-residents remains stable below one million applications. Indeed, both inward FDI and innovation are correlated; to some extent, inward FDI leads to a corresponding increase in innovation for the periods 2003-2007, 2009-2011, and 2014-2015. Figure 1 also shows an intriguing paradox, as innovation (by residents) increases despite a decline in inward FDI, as in the periods of 2000-2003, and 2011-2018. However, such observations do not reflect the direction of causation, which comes first.

The objective of this study is to ascertain the direction of causality between inward FDI and innovation by utilising balanced panel data from 56 countries for the period 2000-2020. The analysis was also complemented by impulse response functions and various decomposition tests. This study adds to the existing literature by generating global data showing that FDI inflows come first, followed by innovation. In addition, this study adds to the understanding of this nexus at three different levels of economic development: developed economies, developing economies, and economies in transition. These findings differ from each other. Understanding the causation between inward FDI and innovation is crucial for policymakers, governments, and enterprises to formulate effective strategies for attracting FDI and stimulating innovation. Policymakers can design targeted strategies to attract and leverage inward FDI for to drive innovation. Investors can gain insights into the complex dynamics between FDI and innovation, aiding investment decision-making.

2. Related literature

Existing studies such as Bertschek (1995), Blind and Jungmittag (2004), Liu and Zou (2008), Lin and Lin (2010), and Chen et al. (2022) consider the possible impact of inward FDI on innovation. Surprisingly, they consistently find that inward FDI has favourable implications for domestic innovation. Bertschek (1995) employs panel data on 1,270 German manufacturing industry enterprises for the period 1984-1989 and finds that inward FDI helps foster technological spillover through the innovation process in local businesses. The variables are realised process innovation, realised product innovation, relative firm size, market size, and the share of direct and indirect FDI. Chamberlain's random effects probit and pooled probit estimates show that FDI inflow positively affects product and process innovation, given the increasing competition in the local market, which results from inward FDI. This drives domestic businesses to boost their efficiency by increasing innovative activities to maintain their market position. Blind and Jungmittag (2004) considered 2,019 enterprises in Germany's service industry in 1999. They find that inward FDI and imports have a favourable impact on product and process innovation. That is, an increase in competition and transfer of production technologies from foreign firms with specific advantages can stimulate local firms' innovation activities.

On the other hand, Erdal and Goçer (2015) find that FDI inflows increased R&D and innovation activities in 10 developing Asian countries for the period 1996-2013. These countries are China, South Korea, India, Iran, Pakistan, Malaysia, Singapore, Thailand, Saudi Arabia, and Turkey. The variables to be included are research and development (R&D) expenditures, the number of total patent applications, domestic and foreign, and capital stock innovations. The panel Granger non-causality tests reveal that a one-point increase in FDI inflow is associated with a 0.83% increase in R&D expenditure and a 0.42% increase in patent applications in these countries. Jores and Law (2016) examine the case of Malaysia for a longer period of 1970-2010 on the possible factors affecting innovation activity–the number of patent applications granted. The underlying factors are inward FDI, human capital, trade openness, financial liberalisation, and R&D expenditure. The autoregressive distributed lag (ARDL) bounds tests suggest that all variables are cointegrated, that is, a long-run relationship (of various models). They find that inward FDI is negatively associated with innovation activities in the short run, possibly due to the inconstant market price, macroeconomic imbalances, unpleasant governance, and less liberalisation of economic reforms. On the contrary, it positively affects innovation activities in the long run, implying that FDI is a significant determinant of promoting innovation in Malaysia.

Employing panel data of 35 OECD member countries between 1996 and 2015 (annually), Ghimire and Paudel (2019) directly examined the impact of inward FDI (interacting with R&D) on innovation. Innovation is measured by both patent applications by residents and non-residents. The other variables are FDI inflow, R&D expenditure, and GDP per capita. Their random effects model and generalised method of moments (GMM) results indicate that rising inward FDI in the presence of R&D in the host nations has a negative effect on the innovation of residents but a positive effect on the innovation of non-residents. Yue (2022) found that FDI inflows can enhance the innovation performance of firms in China. This study utilises annual data of manufacturing enterprises in China between 2000 and 2007. By controlling enterprise size, factor density, average wage, enterprise age, government subsidy, and the Herfindahl–Hirschman index (HHI), the regression model reveals that as FDI increases, the innovation performance of domestic businesses will increase correspondingly. In contrast, a few studies have found that FDI inflows have a reversed (negative) impact on local innovation activities due to the existence of negative spillover effects (Buckley et al., 2002; Brambilla et al., 2009; Stiebale & Reize, 2011). García et al. (2013) find that FDI inflows into Spain are negatively associated with the ex-post innovation of local manufacturing firms, as shown by estimated quasi-differenced GMM models. It covers 1,799 Spanish manufacturing firms for the period 1990-2002 period. Patent applications and product innovations are used to capture innovation in output. Nyeadi and Adjasi's (2020) study is inconclusive. They employ the World Bank Enterprise Survey data of 2,310 firms in the service and manufacturing industry for Nigeria in 2014 and a survey on South Africa 2007, which consists of 908 firms. The variables included in the analysis were product innovation, process innovation, training, inward FDI, exports, age, employee size, and sales. They found that inward FDI has a positive impact on innovation in Nigeria through the infusion of funds into host companies, knowledge transfer, and technological spillovers. However, they found that FDI does not affect the innovation activities of South African firms. They explain that South Africa has advanced in the field of process innovation and is ahead of most countries in the world. Therefore, foreign investors entering the South African market may not be able to improve domestic companies' performance in any meaningful way.

In contrast, few studies have considered the impact of innovation on inward FDI. Using annual data of 14 developing countries from East, Southeast, and South Asia between 1994 and 2003, Palit and Nawani (2007) find that the innovation capacities of emerging Asian nations, especially those based on R&D, are the primary drivers of large FDI inflows. Inward FDI is expected to be affected by technological capabilities, the size of the domestic market, cost of capital, political stability, quality of communication infrastructure, exchange rate stability, and outward orientation policy. The consideration of feasible generalised least squares (FGLS) finds that domestic technological capabilities (innovative capacities), along with the ability to apply such innovations efficiently through advanced IT-based techniques, have become more important locational advantages than cheap labour in drawing inward FDI. Pham and Pham (2020) further confirmed the impact of patents registered (innovation) in Vietnam on inward FDI. They utilise data on resident patents, non-resident patents, and inward FDI in Vietnam for the period 1990-2018. The Johansen trace test indicates one cointegrating (long-run) equation among variables. The autoregressive distributed lag (ARDL) model suggests that non-resident patent applications are the only variable that explains an increase in FDI. Vietnamese patents play no role in attracting FDI. It is explained by the fact that the number of Vietnamese patents is substantially lower than of the number of non-resident patent applications, which is almost tenfold fewer.

3. Research method

This section first presents a conceptual framework that shows the proposed directions of causality between inward FDI and innovation (by non-residents and residents). Then, the data, variables, and their respective statistics, such as summary statistics and panel unit root tests, are analysed. Lastly is about the testing methods i.e. VAR panel Granger non-causality test, impulse response function and variance decomposition.

3.1 Conceptual framework

Hymer's Theory of Industrial Organisation (1960) postulates that FDI is not just a simple exchange of assets across borders, but it represents the transfer of a bundle of resources, including capital, management, and technology. More precisely, knowledge and technology spillovers from inward FDI can foster innovation through four transmission channels: reverse engineering, skilled labour turnover, the demonstration effect, and value chain linkages (Lin and Lin, 2010; OCED, 2022). Existing studies support the hypothesis that inward FDI is positively associated with innovation (Liu and Zou, 2008; Erdal and Goçer, 2015; Yue, 2022). Palit and Nawani (2007) point out that countries with higher technological capacities, particularly innovative capacities, can be attractive destinations for FDI that seeks to exploit local innovative capabilities in producing high-tech exports for third-country markets. This is expected to be bidirectional causation between inward FDI and innovation. Similarly, Singh (2007) acknowledges significant knowledge inflows from foreign MNCs to host country organisations and significant outflows from the host country to foreign MNCs. Non-resident firms or foreign MNCs often bring advanced technologies, expertise, and best practices from their home countries, which contributes to the transfer of knowledge and skills to local employees, stimulating local innovation. However, in contrast to laggard countries, countries already at or close to the technology frontier have domestic organisations with little knowledge to gain from MNC subsidiaries. Instead, they will likely possess valuable knowledge that foreign MNCs do not have and may contribute to knowledge outflows from domestic organisations to MNC subsidiaries. Hence, it is expected that there is bidirectional causation between innovation by non-residents and residents. Such hypothesised directions of causality are illustrated in Figure 2 and are conventionally tested by the Granger non-causality tests (Granger, 1969).

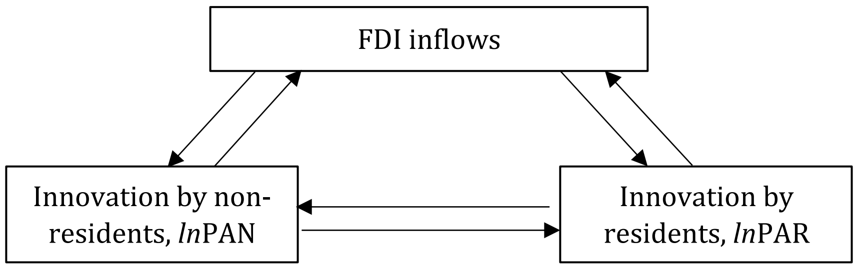


Figure 2: Conceptual framework

3.2 Variables and data source

Two variables are employed in this study: inflow of foreign direct investment (% of GDP) (*FDI)*, and patent applications for both residents (*PAR*) and non-residents (*PAN*) to proxy innovation, as used in Ghimire and Paudel (2019). Tang and Lai (2022) employed patent applications as technology (i.e., a new way of doing things or a new technical solution to a problem). The details of these variables are presented in Table 1. Based on data availability, this study collected balanced panel data consisting of 56 countries for the period 2000-2020 (annual). Table 2 depicts the list of 56 countries, sorted by their three states of economic development: developed economies (30 countries), developing economies (20 countries), and economies in transition (6 countries).

Table 1: Variables definitions and source

Variables	Definition	Data Source
Patent applications, residents, *PAR*	Resident patent applications are those for which the first-named applicant or assignee is a resident of the State or region concerned.	World Development Indicators, World Bank
Patent applications, non-residents, *PAN*	Non-resident patent applications are from applicants outside the relevant State or region.	World Development Indicators, World Bank
Foreign direct investment, net inflows (% of GDP), *FDI*	Foreign direct investment are the net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments. This series shows net inflows in the reporting economy from foreign investors and is divided by GDP.	World Development Indicators, World Bank

Table 2: List of the 56 sample countries

Developed economies (30 countries):	Australia, Austria, Belgium, Bulgaria, Canada, Croatia, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Japan, Latvia, Lithuania, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Slovak Republic, Spain, Sweden, Switzerland, United Kingdom and United States.
Developing economies (20 countries):	Argentina, Bangladesh, Brazil, Chile, China, Colombia, Costa Rica, Guatemala, India, Israel, Jamaica, Jordan, Korea, Malaysia, Mexico, Peru, Philippines, Singapore, South Africa and Thailand
Economies in transition (6 countries):	Belarus, Georgia, Moldova, Russian Federation, Ukraine, Uzbekistan

Table 3 tabulates the summary statistics of the underlying variables for all the 56 countries and their three economic groups. The medium is used to measure average inward FDI (% of GDP) and innovation by residents and non-residents because of possible outliers (s). The world inward FDI is approximately 2.832% of GDP, while the average innovation by residents and non-residents is 924 and 588 patent applications, respectively. Developed economies recorded the highest average innovation by residents (1,413 patent applications) among the three economic groups. By contrast, developing countries have the highest average innovation among non-residents, with 4,299 patent applications. Economies in transition received the highest average inward FDI (2.891%), followed by developed countries (2.872%) and developing countries (2.799%). However, economies in transition record the lowest average innovation by residents (463 patent applications) and non-residents (219 patent applications) compared to developed and developing economies.

Table 3: Summary statistics

	Mean	Median	Maximum	Minimum	Standard Deviation
All country					
FDI (% of GDP)	4.283	2.832	109.025	40.087	7.851
PAR	24,582	924	1,393,815	3	109,683
PAN	11,677	588	336,340	1	365,801
Developed economies					
FDI (% of GDP)	4.573	2.872	109.025	-40.087	9.928
PAR	22,003	1,413	387,364	13	69,725
PAN	13,181	283	336,340	1	45,678
Developing economies					
FDI (% of GDP)	3.968	2.799	29.690	-5.088	4.614
PAR	34,305	563	1,393,815	3	161,842
PAN	12,168	4,299	157,093	41	24,188
Economies in transition					
FDI (% of GDP)	3.885	2.891	18.599	-0.218	3.337
PAR	5,070	463	29,269	64	9,373
PAN	2,523	219	16,248	3	4,639

Note: Both PAR and PAN statistics are measured in the number of applications.

Turning to the property of the underlying variables, especially their stationarity, this study considers five panel unit root tests, namely Levin, Lin, and Chu (2002), Breitung (2001), Im et al. (2003) and Fisher-type tests using ADF and PP tests (Maddala and Wu, 1999). They try to identify the degree of integration, I(d), of the variables, that is, all variables enter into Granger non-causality tests are stationary or $I(0)$ to be assumed with the ordinary least squares (OLS) estimator. The results are presented in Table 4. Overall, most of the variables (data) are stationary or $I(0)$, except for the cases between $I(0)$ and $I(1)$, that is, *lnPAR* for developed economies and developing economies, *lnPAN* for developed economies, and FDI for economies in transition. There is only one non-stationary $I(1)$ variable, *lnPAN* as in the case of economies in transition, but the PP-Fisher test suggests stationarity. Hence, this study employs data (variables) at this level for analysis. It is also justified that first-differencing level variable(s) may result in information loss in inclusive or $I(1)$ cases.

Table 4: The results of panel unit root tests

Variable	Levin, et al.	Breitung	Im, et al.	ADF-Fisher	PP-Fisher	Finding
All countries						
FDI	-12.375***	-4.935***	-13.311***	374.894***	424.612***	*I*(0)
lnPAR	-2.771***	2.955	-3.706***	208.294***	202.357***	*I*(0)
ΔlnPAR		-6.677***				
lnPAN	-1.275	-5.046***	-3.261***	184.745***	160.452***	*I*(0)
ΔlnPAN	-22.350***					
Developed economies						
FDI	-10.499***	-4.170***	-11.727***	232.469***	281.202***	*I*(0)
lnPAR	-0.719	4.303	-1.010	86.240**	94.409***	*I(0) & I(1)*
ΔlnPAR	-11.780***	-3.465***	-11.594***			
lnPAN	-0.896	-5.483***	-1.197	80.388**	54.792	*I(0) & I(1)*
ΔlnPAN	-11.281***		-12.654***		332.355***	
Developing economies						
FDI	-6.075***	-2.563***	-7.057***	123.896***	127.289***	*I*(0)
lnPAR	0.265	-0.584	-3.155***	89.210***	84.951***	*I(0) & I(1)*
ΔlnPAR	-14.464***	-5.189***				
lnPAN	-1.527*	0.620	-3.884***	86.106***	86.110***	*I*(0)
ΔlnPAN		-5.870***				
Economies in transition						
FDI	-2.545***	-1.347*	-1.600*	18.529	16.122	*I(0) & I(1)*
ΔFDI				78.582***	98.065***	
lnPAR	-4.98***	0.06	-3.20***	32.84***	23.00**	*I*(0)
ΔlnPAR		-5.37***				
lnPAN	1.054	1.296	-0.178	18.251	19.550*	*I*(1)
ΔlnPAN	-9.750***	-3.553***	-9.201***	79.874***		

*Notes: The reported value is their respective test statistics in which ***, **, and * denote significant at 1%, 5%, and 10%, respectively (based on p-value). Automatic lag length selection based on AIC from 0 to 4. Newey-West automatic bandwidth selection and Bartlett kernel. Null hypothesis is the series has a unit root. The tests assume common unit root process and individual unit root process. More precisely, Levin, Lin and Chu test and Breitung test consider the null hypothesis which represents the presence of "common unit root". While, Im, Pesaran and Shin test, and Fisher-type test are to test the null hypothesis which represents the existence of "individual unit root". The equations consider individual effects and individual linear trends for the data at levels.*

3.3 Granger non-causality tests

Broadly speaking, the Granger non-causality test (Granger, 1969) is a statistical test for testing whether a time-series variable (i.e., its past values) is useful in forecasting another. In layman's terms, it is about *Chicken or egg: which came first*? Indeed, the cause must come before the effect (Granger, 1988). Granger (2003) states that various causality definitions have been used with panel data, which can be considered a vector of time series, at least theoretically. When using G-causality, the test usually asks if some variable, say X_t, causes another variable, say Y_t, everywhere in the panel, in notation $X_{j,t-1} \Rightarrow Y_{j,t}$, for every *j* in the panel (also see, Dumitrescu and Hurlin, 2012). This method ascertains the potential directions of causation among the endogenous variables, namely inward FDI, innovation by residents, and innovation by non-residents, as illustrated in Figure 2. For example, if inward FDI is found to be less helpful (i.e., statistically insignificant at the 10% level) for forecasting innovation by residents (or non-residents), then it can be said that inward FDI does not Granger-cause innovation by residents (or non-residents); otherwise, it is said that inward FDI does Granger-cause innovation. Technically, the Granger non-causality test is based on a vector autoregression (VAR) framework that consists of a set of multiple OLS regressions, as in this case. The three trivariate VAR OLS equations (1), (2), and (3) were applied.

$$lnPAR_{i,t} = c_1 + \sum_{j=1}^{3} \alpha_{1i,j} lnPAR_{i,t-j} + \sum_{j=1}^{3} \beta_{1i,j} FDI_{i,t-i} + \sum_{j=1}^{3} \gamma_{1i,j} lnPAN_{i,t-j} + \varepsilon_{i,t} \quad (1)$$

$$lnPAN_{i,t} = c_2 + \sum_{j=1}^{3} \alpha_{2i,j} lnPAN_{i,t-j} + \sum_{j=1}^{3} \beta_{2i,j} FDI_{i,t-j} + \sum_{j=1}^{3} \gamma_{2i,j} lnPAR_{i,t-j} + \varepsilon_{i,t} \quad (2)$$

$$FDI_{i,t} = c_3 + \sum_{j=1}^{3} \alpha_{3i,j} FDI_{i,t-j} + \sum_{j=1}^{3} \beta_{3i,j} lnPAR_{i,t-j} + \sum_{j=1}^{3} \gamma_{3i,j} lnPAN_{i,t-j} + \varepsilon_{i,t} \quad (3)$$

where c denotes the intercept term, α, β and γ denote their respective coefficients for each regressor, t is the time dimension, i represents the cross-section (countries), and ε is the error term. The maximum lag length is three (3), given the annual data used in this short panel. More formally, the $Wald$-test (i.e., a joint significant test of the respective coefficients) rejects the null hypothesis (H_0) of $\beta_{1i,j} = 0$ (i.e. FDI does not Granger-cause innovation by residents), against the alternative hypothesis (H_1) of at least one of $\beta_{1i,j} \neq 0$ (i.e. FDI does Granger-cause innovation by residents) as in equation (1). The decision rule is to reject the null hypothesis if the computed $Wald$-test statistic is greater than (at least) the 10% significance level (or its p-value is less than 0.10). Similar applications are used for Equations (2) and (3).

Table 5 illustrates the test statistics of the various lag selection criteria: sequential modified LR test statistic (LR), final prediction error (FPE), Akaike's information criterion (AIC), Schwarz information criterion (SIC), and Hannan-Quinn information criterion (HQ). They determine the lag length of the VAR from a maximum of three years with their smallest values. However, they suggest different lag lengths. Therefore, both lag lengths were considered. For all countries, two and three lags are entered into equations (1)–(3): one lag and three lags for developed economies, three lags for developing economies, and one lag and two lags for economies in transition.

Table 5: The result of lag length Criteria

Lag	LR	FPE	AIC	SC	HQ
All Countries					
0	NA	0.145	6.580	6.595	6.586
1	8260.414	0.000	-1.629	-1.571	-1.607
2	80.384	0.000	-1.692	-1.589#	-1.653#
3	22.021#	0.000#	-1.696#	-1.550	-1.640
Developed economies					
0	NA	0.114	6.339	6.363	6.348
1	4259.859	0.000	-1.575	-1.480#	-1.538#
2	22.233	0.000	-1.584	-1.417	-1.518
3	29.433#	0.000#	-1.606#	-1.367	-1.513
Developing economies					
0	NA	0.008	3.732	3.764	3.745
1	2820.842	0.000	-4.142	-4.0121	-4.090
2	79.680	0.000	-4.317	-4.091	-4.227
3	56.479#	0.000#	-4.429#	-4.105#	-4.300#
Economies in transition					
0	NA	0.004	3.0388	3.113	3.069
1	738.329	0.000	-3.894	-3.596#	-3.773#
2	20.370#	0.000#	-3.929#	-3.407356	-3.717
3	9.870	0.000	-3.863	-3.118	-3.561

Notes: # indicates lag order selected by criterion. *Each test at 5% level. LR is sequential modified LR test statistic; FPE is Final prediction error; AIC is Akaike information criterion; SC is Schwarz information criterion; and HQ is Hannan-Quinn information criterion. For the FPE, the reported figures are rounded up to three decimal places.*

The VAR Granger non-causality tests are further complemented by the impulse response functions and variance decomposition tests because the causation does not capture the responsiveness among the endogenous variables and how a variable's innovation is explained by other variable(s). In brief, impulse response function analysis considers the impact of a one-time shock on one of the innovations (changes) on the endogenous variables' present and future values. Based on the VAR's dynamic (lag) structure, a shock to the i-th variable affects all other variables, not just the i-th variable. The i-th innovation is simply a shock to the i-th endogenous variable when the innovations are simultaneously uncorrelated. Meanwhile, variance decomposition analysis is used to determine how much of the variation of an endogenous variable can be explained (attributed) by its component innovations (other endogenous variables) or shocks. This study considers Cholesky decomposition orthogonal factorisations for variance decomposition with a *Monte Carlo* simulation of the standard error based on 100 repetitions.

4. Empirical results

The results (i.e., chi-squared statistics) of the panel VAR Granger non-causality tests are reported in Table 6. However, for visual convenience, their findings, which are the directions of causality among the variables, namely inward FDI (*FDI*), innovation by residents (*lnPAR*), and innovation by non-residents (*lnPAN*), are graphically illustrated in Figure 3. The findings are statistically significant, at least at the 10% level, rejecting the null hypothesis of no causality.

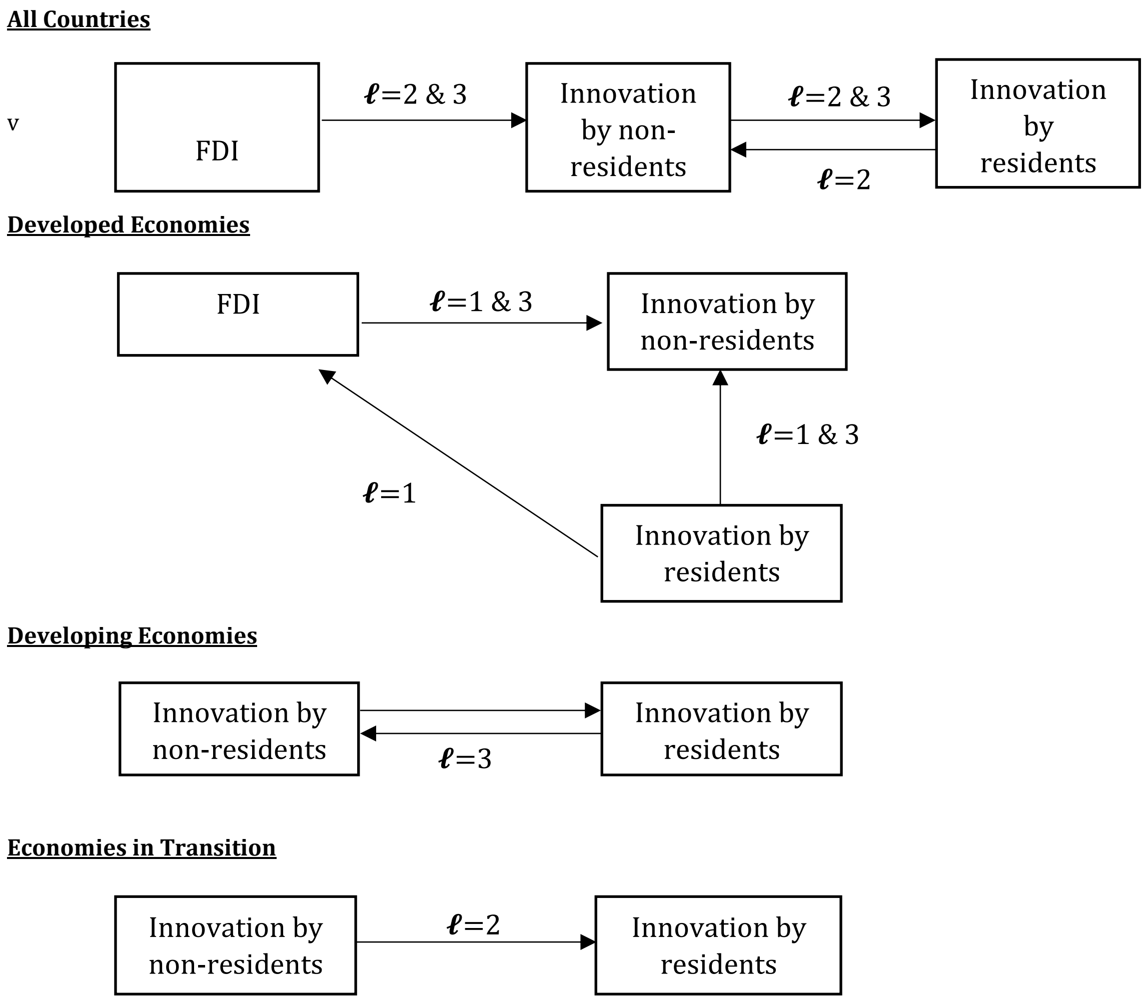
Table 6: The estimates of Granger non-causality tests

Null Hypothesis	1 Lag	2 Lags	3 Lags
All Countries			
FDI =/=> lnPAR		1.019 (0.601)	0.638 (0.888)
FDI =/=> lnPAN		12.121 (0.002)***	11.092 (0.012)**
lnPAR =/=>FDI		1.950 (0.377)	2.643 (0.450)
lnPAN =/=> FDI		0.152 (0.927)	0.499 (0.919)
lnPAR & lnPAN =/=>FDI		3.319 (0.506)	3.365 (0.762)
lnPAN =/=> lnPAR		14.654 (0.001)***	16.466 (0.001)***
lnPAR =/=> lnPAN		4.844 (0.089)*	5.325 (0.150)
Developed economies			
FDI =/=> lnPAR	0.010 (0.921)		0.999 (0.802)
FDI =/=> lnPAN	2.985 (0.08)*		6.842 (0.077)*
lnPAR =/=>FDI	2.732 (0.098)*		4.420 (0.220)
lnPAN =/=> FDI	0.549 (0.459)		1.558 (0.669)
lnPAR & lnPAN =/=>FDI	3.714 (0.156)		5.878 (0.437)
lnPAN =/=> lnPAR	2.548 (0.110)		6.194 (0.103)
lnPAR =/=> lnPAN	38.061 (0.000)***		55.947 (0.000)***
Developing Economies			
FDI =/=> lnPAR			2.583 (0.461)
FDI =/=> lnPAN			3.890 (0.274)
lnPAR =/=>FDI			0.398 (0.941)
lnPAN =/=> FDI			3.396 (0.335)
lnPAR & lnPAN =/=>FDI			3.852 (0.697)
lnPAN =/=> lnPAR			6.425 (0.093)*
lnPAR =/=> lnPAN			11.170 (0.011)**
Economies in transition			
FDI =/=> lnPAR	0.313 (0.576)	1.976 (0.372)	
FDI =/=> lnPAN	0.005 (0.945)	1.241 (0.538)	
lnPAR =/=>FDI	0.440 (0.507)	2.744 (0.254)	
lnPAN =/=> FDI	0.024 (0.877)	0.228 (0.892)	
lnPAR & lnPAN =/=>FDI	1.113 (0.573)	3.608 (0.462)	
lnPAN =/=> lnPAR	2.331 (0.127)	5.222 (0.074)*	
lnPAR =/=> lnPAN	2.458 (0.117)	1.444 (0.486)	

*Notes: "=/=>" stands for "does not Granger cause". The value in (.) is p-value, ***, **, and * denote significant at 1%, 5%, and 10%, respectively.*

Using global data (all 56 countries), FDI does Granger-cause innovation by non-residents at two and three lags, and the latter causes innovation by residents, which is a bidirectional causality between innovation by non-residents and innovation by residents, as explained by Singh (2007). More formally, FDI comes first before innovation, while interaction occurs between non-residents and residents for innovation. These findings are partly similar to those of developed economies, in which FDI causes innovation by non-residents. However, unidirectional causality from innovation by residents to non-residents and the former (innovation by residents) also causes FDI (at one lag) in developed countries. The estimates are in line with the findings of Palit and Nawani (2007) that countries with higher innovative capacities can attract FDI inflows.

Interestingly, for both developing economies and economies in transition, inward FDI is found to be statistically insignificant at 10% to reject the null hypothesis of no causation. Hence, inward FDI does not Granger-cause innovation or reverse causation for these two economic groups. An interaction (i.e., bidirectional causality) is observed between non-residents and residents for innovation in developing economies at three lags, as expected by Singh (2007). For economies in transition, only one-way causality is found, from innovation by non-residents to innovation by residents at two lags. No reverse causation.



Note: **ℓ** stands for lag. *The figures illustrate the direction of causation among the underlying variables, at least at 10% level of significant.*

Figure 3: Granger non-causality tests

As noted, the causality findings do not further inform how one variable responds (or interacts) with each other. Their findings are complemented by the impulse response functions initially based on VAR(d) (where d is the lag length) used for the Granger non-causality tests. Figures 4-7 demonstrates plots of the impulse response function of all 56 countries and the three economic groups, namely developed economies, developing economies, and economies in transition. As Figure 4 shows, for all countries, both the two and three lags have relatively consistent results for their impulse response functions. Inward FDI shocks cannot contemporaneously impact innovation by residents but a slight decrease in innovation by non-residents over the period. Indeed, inward FDI responds to its own shocks contemporaneously with a large decrease until period 3, and the impact mostly converges back to zero in period 10. A shock in innovation by non-residents gradually increases innovation by residents. The responses of innovation by non-residents to the initial shock to innovation by residents increased until period 2 and decreased to period 3 before gradually increasing to period 10.

Figure 5 reports the impulse response functions for the developed economies with 1 lag and 3 lags both are comparably consistent. Innovation by residents respond positively to a shock in inward FDI. The inward FDI shows (slightly) similar responses to all three shocks (i.e., its own, innovation by residents, and by non-residents as above for in the case of all countries. However, a shock to innovation by non-residents, results innovation by residents drops during the periods 2 and 3, before increasing steadily toward the equilibrium (i.e. converges back to zero) in the period 10. While innovation by non-residents increase in response to the shocks in innovation by resident the periods, except for the periods 2 and 4. For the developing economies, Figure 6 shows that inward FDI shocks have no impact on both innovations by non-residents and residents after period 2 at their initial positions. A shock in innovation by non-residents, innovation by residents rises immediately to period 2 then grow gradually until period 10. Innovation by non-residents increase progressively in response to a shock in innovation by residents, except for the periods 1-2. Inward FDI largely responses to its own shocks which falls immediately to the period 3 and increases then before decreasing gradually for the periods 5-10.

Figure 7 is the impulse response functions for the economies in transition in which VAR (2) i.e. 2 lags is preferred. As shown, a shock in inward FDI immediately increases innovation slightly by residents, gradually moves downward, and is almost constant toward Period 10. Similar responses of non-residents to inward FDI. Indeed, inward FDI demonstrates similar responses to all three shocks (i.e., own, innovation by residents, and non-residents), as in the case of developing countries. When there is a shock to innovation by non-residents, innovation by residents grows gradually, except in periods 1-2. However, residents' innovation responds negatively to their own shocks. Innovation by non-residents showed a progressive increase in response to a shock in innovation by residents over the observed period.

Lastly, the results of the variance decomposition of all 56 countries, including their three development levels, are documented in Appendices A - D. In general, for the global data of 56 countries, the results (based on three lags) show that the variation in innovation by residents is almost explained by itself, which is approximately 98% over the observed periods. Similarly, innovation by non-residents is also explained by its own, at about 96.1%. Only a small portion of the variation in non-residents' innovation (approximately 3.7%) is explained by inward foreign direct investment (FDI). Inward FDI is also fully explained by itself, accounting for about 99.1% of its variation over the entire period.

For developed economies, the variance decomposition results are slightly different between the one lag and three lags. Based on 3 lags results (for a longer period), the variation of innovation by residents is almost entirely contributed by its own, which is about 98.9% in period 10. A similar case exists for innovation by non-residents (96.3%) and the remaining (3.6%) by FDI. Inward FDI is explained by itself (99.1%), as in the last period. Consistent findings are found for developing economies. The variation in residents' innovation is fully explained by their own (97.1%) over the 10 periods. For non-residents' innovation, which is largely explained by its own, declining gradually from 98.1% in period 1 to 90.3% in period 10. Indeed, it [innovation by non-residents] is roundly 8.6% explained by innovation by residents at periods 9-10, and inward FDI eventually has no contribution, 1%. FDI was also explained by its own 97%. Turning to the economies in transition, 93% of the variation in residents' innovation is primarily explained by itself (in period 10), while only 4.4% of the variation in innovation by residents is explained by non-resident patent applications. Innovation by non-residents is explained by its own but drops gradually from 98.9% (period 1) to 94.2% (period 10). About 5.5% is explained by residents' innovation, while FDI eventually has no contribution (1%). Inward FDI was also explained on its own (94.6%).

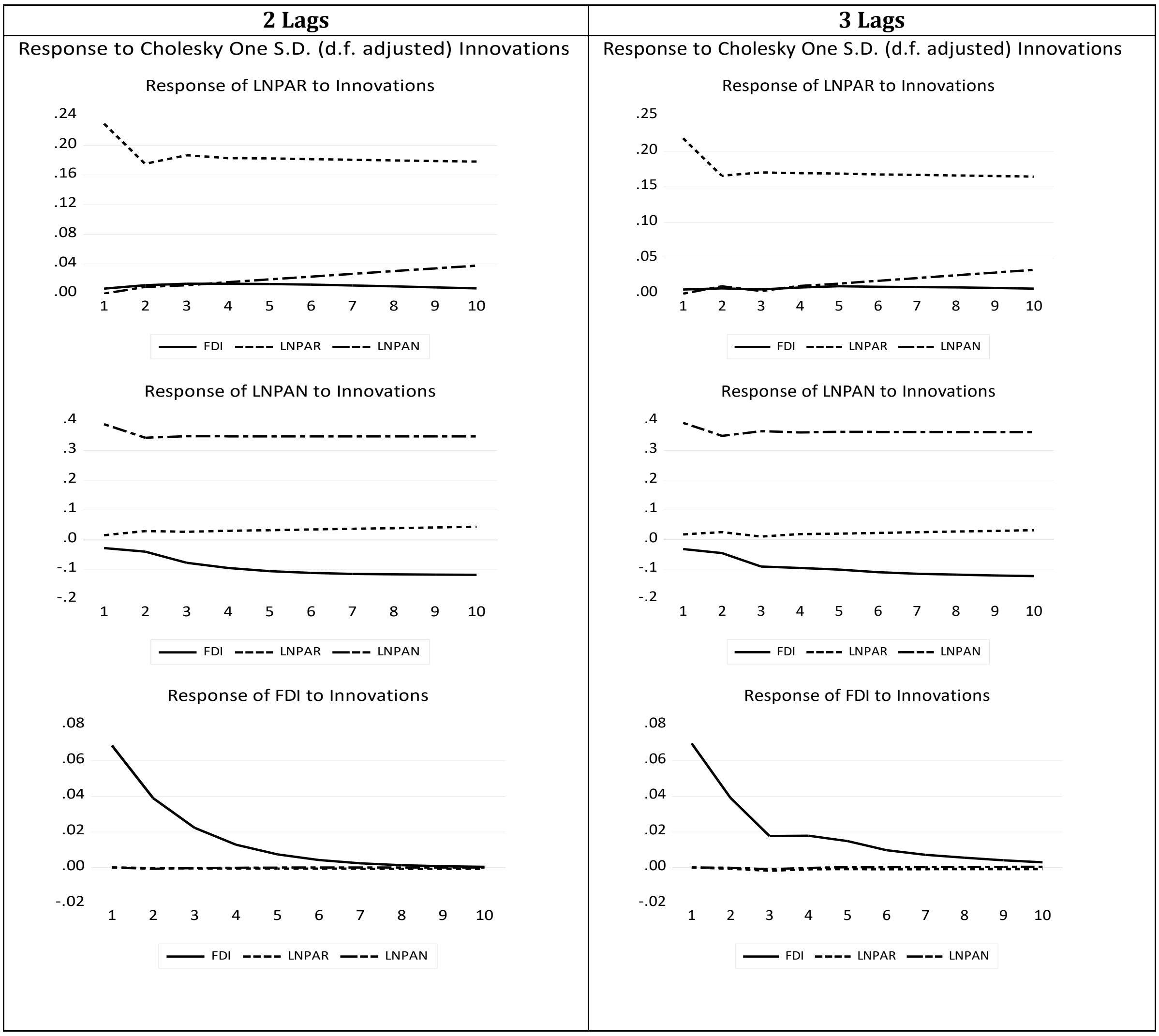


Figure 4: Impulse response for all countries

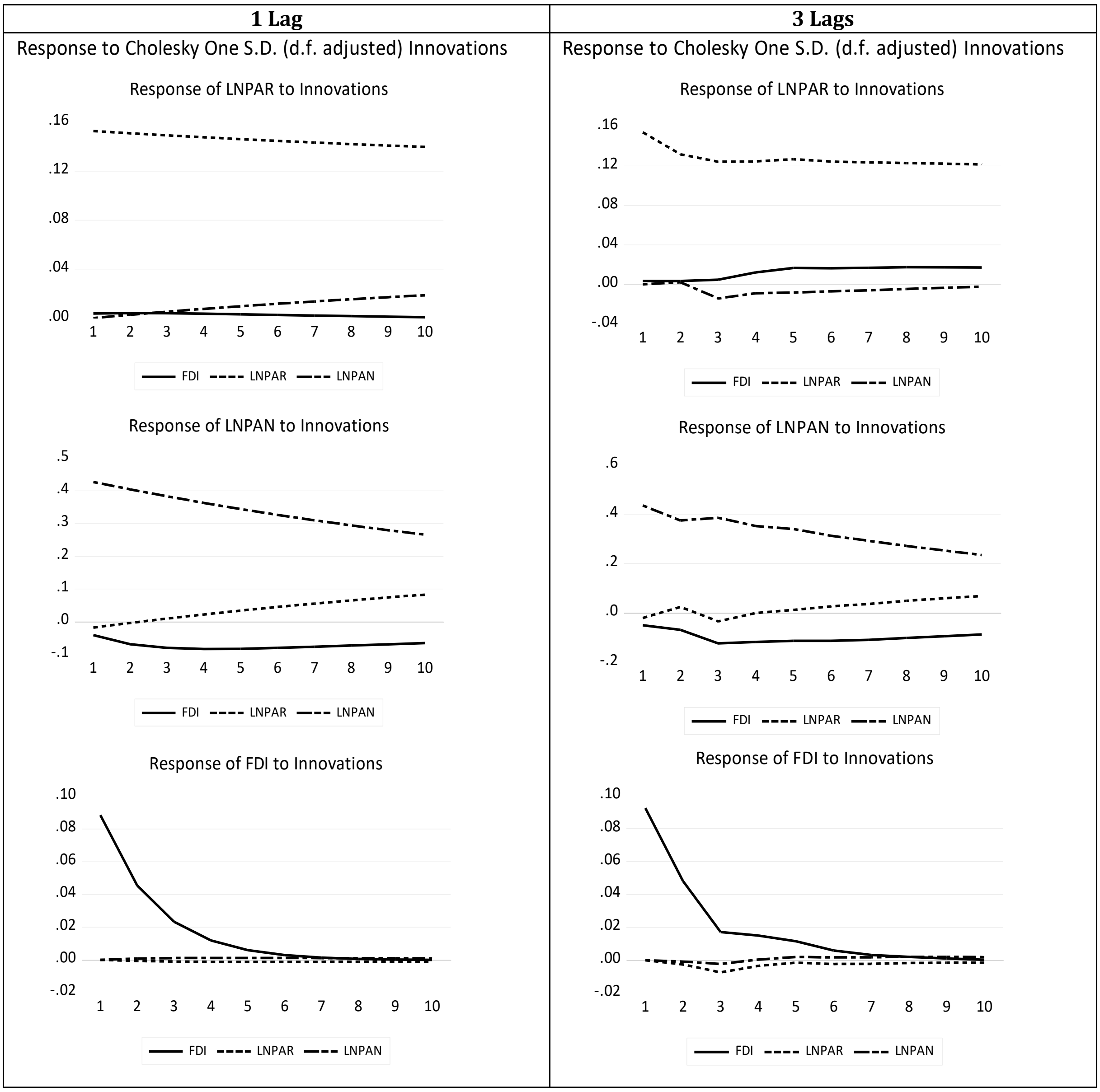


Figure 5: Impulse response for developed economies

3 Lags

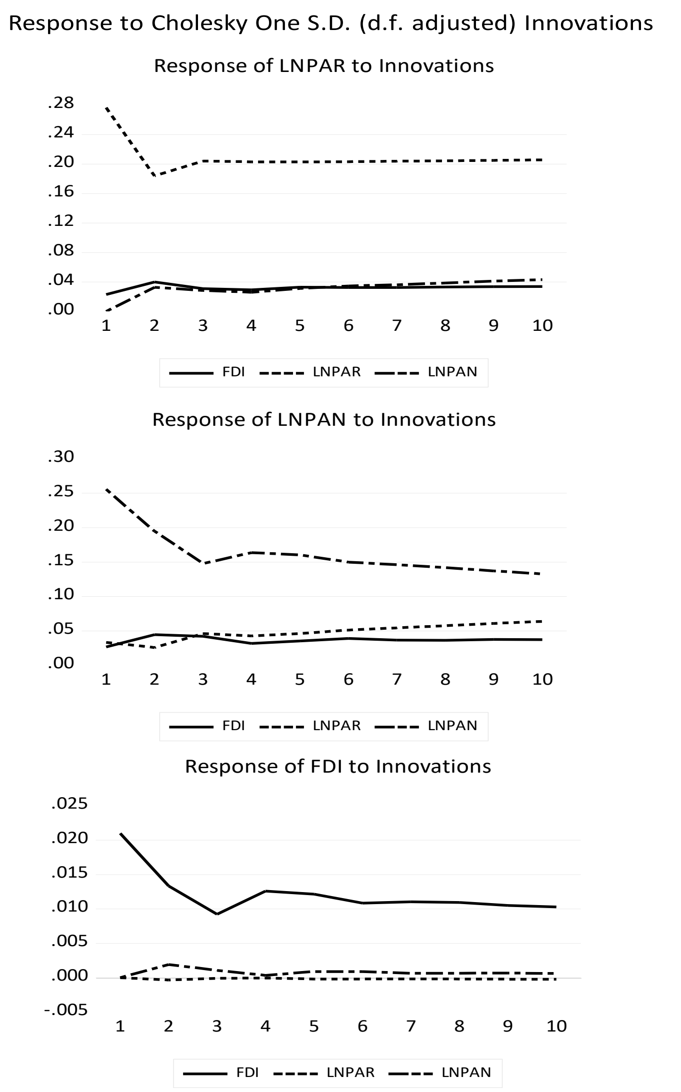


Figure 6: Impulse response for developing economies

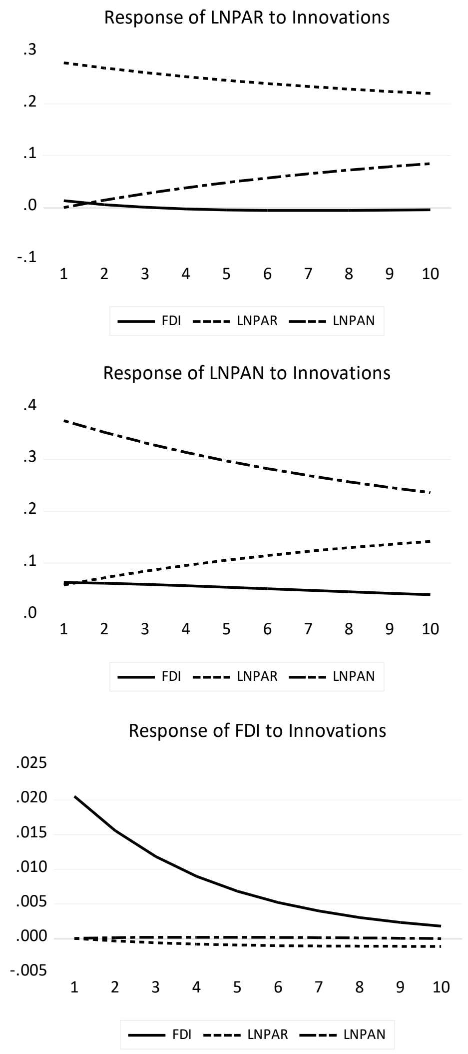
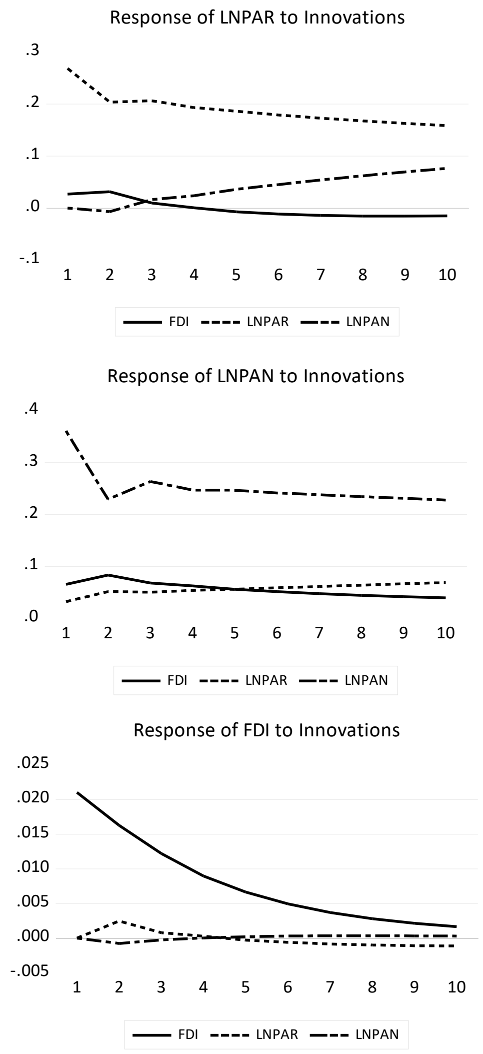
1 Lag	2 Lags
Response to Cholesky One S.D. (d.f. adjusted) Innovations	Response to Cholesky One S.D. (d.f. adjusted) Innovations
	

Figure 7: Impulse response for economies in transition

5. Conclusion

This study generates that inward FDI comes first then innovation by non-residents with global data of 56 countries for the period 2000-2020 (balanced panel data), or to say, "FDI led innovation," while a bidirectional causality occurs between innovation by non-residents and resident. Different levels of economic development (i.e., developed, developing, and transition) offer different findings. Similarly, in developed economies, FDI causes innovation by non-residents, but innovation by residents causes both FDI and innovation by non-residents. For both developing economies and economies in transition, inward FDI disappears, and causality occurs only between innovation by non-residents and residents.

Some policy repercussions have also been highlighted. In general, goverments' policies are to encounge inward FDI in a conventioanl fashion via. financial incentives; well-established infrastructure; desirable administrative processes and regulatory environments; educational investment; and political, economic, and legal stability.[1] Then, to promote innovation between non-residents and residents, countries have to invest in R&D, education, and infrastructure and create a supportive environment encouraging entrepreneurship and risk-taking,[2] which is also recommended for both developing economies and economies in transition. More precisely, it is also important to emphasise policies that support intellectual property rights regimes, legal frameworks for investment, and regulatory incentives (OECD, 2022). The OECD (2015) highlights the importance of intellectual property rights (IPR) regimes, and there is a positive correlation between the strength of intellectual property rights and the likelihood of foreign firms investing in the host country. With strong intellectual property rights, foreign companies are more inclined to conduct research and development in the host nation and share new cutting-edge technologies with domestic enterprises through licensing agreements and joint ventures.

Specifically, for both developing economies and economies in transition, policies should enhance domestic innovation capabilities and promote knowledge exchange and collaboration with foreign innovators. These can be implemented through investments in education and skill development to cultivate a skilled workforce that contributes to domestic innovation efforts. Indeed, countries can benefit from international collaboration and partnerships with developed economies. It considers fostering international networks, promoting participation in global research and innovation initiatives, and facilitating knowledge-sharing. In addition, governments should encourage technology transfer mechanisms between domestic firms and foreign innovators, including creating technology transfer offices, establishing innovation hubs, and providing financial and technical support to facilitate the transfer and absorption of foreign technologies (OCED, 2022).

It is important to note that this study is restricted by the use of available patent applications to capture innovation, instead of patent grants, for better indication. According to Khachoo and Sharma (2016), patent grants may be a better and direct measure of innovation, given that patent applications do not contain any new ideas or inventions; patent grants are not available from the data source used in this study, that is, World Development Indicators, from the World Bank. Such alternative proxies for innovation must be considered in future studies. Another limitation of this study is the omission of other relevant control variables. This study focuses on the causation between FDI and innovation (by resident and non-resident applications) in a trivariate VAR framework, without considering other control variables that may affect this relationship. Future studies should examine a multivariate VAR framework by adding other variables, such as product innovation, process innovation, R&D expenditure, market size, economic growth, and trade openness, to provide a more comprehensive understanding of the causation between FDI and innovation.

Acknowledgment

The authors acknowledge the contributions of the following individuals in the completion of this research: peers in the Faculty of Business and Economics, Universiti Malaya, and the reviewers.

[1] Retrieved from https://opentext.wsu.edu/mktg360/chapter/2-5-foreign-direct-investment/#:~:text=Governments%20encourage%20FDI%20through%20financial,%2C%20economic%2C%20and%20legal%20stability. Accessed 24.8.2023
[2] Retrieved from https://www.linkedin.com/pulse/what-makes-some-countries-more-innovative-than-others-adam-ryan#:~:text=To%20become%20more%20innovative%2C%20countries,encouraging%20entrepreneurship%20and%20risk%2Dtaking. Accessed 24.8.2023

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Appendixes

Appendix A: Variance decomposition of all countries

Variance Decomposition of *lnPAR*:	2 lags				3 lags			
Period	S.E.	*lnPAR*	*lnPAN*	*FDI*	S.E.	*lnPAR*	*lnPAN*	*FDI*
1	0.229	100.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.218	100.000 (0.000)	0.000 (0.000)	0.000 (0.000)
2	0.289	99.855 (0.239)	0.088 (0.169)	0.057 (0.162)	0.274	99.851 (0.237)	0.130 (0.207)	0.020 (0.114)
3	0.344	99.742 (0.345)	0.156 (0.208)	0.102 (0.282)	0.323	99.878 (0.282)	0.104 (0.215)	0.017 (0.173)
4	0.390	99.601 (0.482)	0.265 (0.275)	0.135 (0.420)	0.365	99.802 (0.396)	0.165 (0.290)	0.033 (0.249)
5	0.431	99.446 (0.607)	0.401 (0.345)	0.154 (0.540)	0.402	99.695 (0.538)	0.247 (0.375)	0.058 (0.357)
6	0.469	99.270 (0.718)	0.567 (0.426)	0.163 (0.634)	0.436	99.556 (0.692)	0.371 (0.472)	0.073 (0.470)
7	0.503	99.073 (0.820)	0.762 (0.519)	0.165 (0.704)	0.467	99.385 (0.847)	0.531 (0.577)	0.084 (0.578)
8	0.535	98.851 (0.918)	0.987 (0.624)	0.161 (0.753)	0.497	99.180 (1.003)	0.729 (0.693)	0.091 (0.680)
9	0.565	98.604 (1.017)	1.241 (0.742)	0.155 (0.786)	0.524	98.942 (1.159)	0.963 (0.819)	0.095 (0.772)
10	0.594	98.330 (1.125)	1.524 (0.873)	0.147 (0.805)	0.550	98.671 (1.316)	1.233 (0.957)	0.096 (0.854)
Variance Decomposition of *lnPAN*:								
Period	S.E.	*lnPAR*	*lnPAN*	*FDI*	S.E.	*lnPAR*	*lnPAN*	*FDI*
1	0.390	0.117 (0.293)	99.883 (0.293)	0.000 (0.000)	0.395	0.168 (0.292)	99.832 (0.292)	0.000 (0.000)
2	0.522	0.341 (0.484)	99.567 (0.491)	0.092 (0.167)	0.529	0.292 (0.462)	99.602 (0.493)	0.106 (0.195)
3	0.633	0.371 (0.518)	98.874 (0.698)	0.755 (0.510)	0.649	0.206 (0.430)	98.841 (0.770)	0.953 (0.689)
4	0.729	0.413 (0.557)	98.086 (1.051)	1.501 (0.930)	0.749	0.198 (0.462)	98.304 (1.038)	1.499 (0.983)
5	0.815	0.450 (0.590)	97.367 (1.409)	2.183 (1.324)	0.839	0.197 (0.492)	97.880 (1.303)	1.923 (1.260)
6	0.894	0.490 (0.624)	96.753 (1.728)	2.757 (1.661)	0.921	0.207 (0.521)	97.437 (1.591)	2.357 (1.553)
7	0.967	0.533 (0.660)	96.242 (1.998)	3.225 (1.941)	0.996	0.221 (0.551)	97.027 (1.866)	2.752 (1.831)
8	1.035	0.578 (0.698)	95.818 (2.223)	3.604 (2.172)	1.067	0.241 (0.582)	96.667 (2.118)	3.092 (2.080)
9	1.099	0.627 (0.738)	95.462 (2.410)	3.911 (2.361)	1.133	0.264 (0.613)	96.345 (2.345)	3.391 (2.303)
10	1.159	0.679 (0.780)	95.159 (2.566)	4.162 (2.517)	1.196	0.291 (0.507)	96.056 (2.542)	3.653 (2.478)
Variance Decomposition of *FDI*:								
Period	S.E.	*lnPAR*	*lnPAN*	*FDI*	S.E.	*lnPAR*	*lnPAN*	*FDI*
1	0.069	0.087 (0.180)	0.558 (0.478)	99.355 (0.527)	0.070	0.071 (0.169)	0.688 (0.606)	99.241 (0.607)
2	0.079	0.077 (0.216)	0.636 (0.505)	99.287 (0.551)	0.080	0.056 (0.203)	0.701 (0.643)	99.243 (0.634)
3	0.082	0.071 (0.213)	0.645 (0.518)	99.283 (0.558)	0.082	0.082 (0.226)	0.754 (0.731)	99.164 (0.758)
4	0.083	0.070 (0.210)	0.647 (0.523)	99.283 (0.560)	0.084	0.083 (0.231)	0.760 (0.760)	99.157 (0.794)
5	0.083	0.072 (0.208)	0.647 (0.526)	99.281 (0.561)	0.085	0.083 (0.234)	0.754 (0.769)	99.163 (0.804)
6	0.083	0.076 (0.207)	0.647 (0.528)	99.277 (0.563)	0.086	0.090 (0.242)	0.750 (0.777)	99.160 (0.817)

7	0.083	0.082 (0.208)	0.647 (0.531)	99.272 (0.566)	0.086	0.098 (0.250)	0.747 (0.782)	99.156 (0.825)
8	0.083	0.088 (0.210)	0.647 (0.534)	99.266 (0.570)	0.086	0.105 (0.256)	0.744 (0.784)	99.151 (0.830)
9	0.084	0.094 (0.214)	0.646 (0.538)	99.259 (0.576)	0.086	0.113 (0.262)	0.742 (0.786)	99.145 (0.835)
10	0.084	0.101 (0.218)	0.646 (0.542)	99.253 (0.583)	0.086	0.122 (0.279)	0.741 (0.719)	99.137 (0.808)

Appendix B: Variance decomposition of developed economies

Variance Decomposition of *lnPAR*:		1 lag			3 lags			
Period	S.E.	*lnPAR*	*lnPAN*	*FDI*	S.E.	*lnPAR*	*lnPAN*	*FDI*
1	0.153	100.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.154	100.000 (0.000)	0.000 (0.000)	0.000 (0.000)
2	0.215	99.985 (0.106)	0.015 (0.020)	0.001 (0.105)	0.203	99.989 (0.302)	0.010 (0.208)	0.001 (0.208)
3	0.261	99.951 (0.239)	0.048 (0.063)	0.001 (0.234)	0.238	99.628 (0.815)	0.371 (0.736)	0.001 (0.370)
4	0.300	99.901 (0.363)	0.097 (0.127)	0.001 (0.348)	0.269	99.479 (1.114)	0.427 (0.919)	0.094 (0.597)
5	0.334	99.837 (0.474)	0.162 (0.208)	0.001 (0.441)	0.298	99.282 (1.415)	0.457 (1.028)	0.261 (0.921)
6	0.364	99.760 (0.579)	0.239 (0.306)	0.001 (0.514)	0.323	99.167 (1.678)	0.457 (1.095)	0.376 (1.199)
7	0.392	99.671 (0.682)	0.328 (0.417)	0.001 (0.572)	0.347	99.080 (1.910)	0.447 (1.144)	0.473 (1.446)
8	0.417	99.573 (0.789)	0.426 (0.5390	0.001 (0.618)	0.368	99.011 (2.110)	0.425 (1.170)	0.564 (1.665)
9	0.440	99.465 (0.902)	0.534 (0.672)	0.001 (0.656)	0.388	98.961 (2.278)	0.400 (1.190)	0.639 (1.845)
10	0.462	99.351 (1.023)	0.648 (0.813)	0.002 (0.687)	0.407	98.929 (2.419)	0.373 (1.208)	0.699 (1.993)
Variance Decomposition of *lnPAN*:								
Period	S.E.	*lnPAR*	*lnPAN*	*FDI*	S.E.	*lnPAR*	*lnPAN*	*FDI*
1	0.429	0.201 (0.430)	99.799 (0.430)	0.000 (0.000)	0.438	0.262 (0.492)	99.738 (0.492)	0.000 (0.000)
2	0.594	0.115 (0.330)	99.630 (0.463)	0.255 (0.309)	0.581	0.301 (0.393)	99.494 (0.470)	0.204 (0.321)
3	0.712	0.090 (0.252)	99.353 (0.731)	0.557 (0.678)	0.708	0.478 (0.611)	98.159 (1.152)	1.363 (0.994)
4	0.803	0.131 (0.223)	99.055 (1.019)	0.814 (0.997)	0.800	0.378 (0.631)	97.620 (1.473)	2.002 (1.327)
5	0.879	0.238 (0.264)	98.747 (1.262)	1.015 (1.251)	0.876	0.326 (0.601)	97.285 (1.761)	2.389 (1.646)
6	0.942	0.413 (0.358)	98.421 (1.460)	1.166 (1.448)	0.937	0.346 (0.569)	96.887 (2.099)	2.767 (2.008)
7	0.996	0.655 (0.481)	98.065 (1.624)	1.280 (1.598)	0.988	0.425 (0.571)	96.493 (2.425)	3.082 (2.3420
8	1.043	0.962 (0.622)	97.673 (1.766)	1.365 (1.714)	1.031	0.590 (0.624)	96.102 (2.708)	3.308 (2.615)
9	1.085	1.334 (0.778)	97.237 (1.896)	1.429 (1.803)	1.067	0.831 (0.733)	95.696 (2.955)	3.473 (2.835)
10	1.122	1.766 (0.947)	96.757 (2.022)	1.477 (1.872)	1.098	1.147 (0.891)	95.259 (3.173)	3.594 (3.011)
Variance Decomposition of *FDI*:								
Period	S.E.	*lnPAR*	*lnPAN*	*FDI*	S.E.	*lnPAR*	*lnPAN*	*FDI*
1	0.089	0.061 (0.346)	0.902 (0.760)	99.038 (0.760)	0.092	0.051 (0.420)	1.297 (0.940)	98.653 (1.032)
2	0.100	0.049 (0.325)	0.845 (0.739)	99.106 (0.736)	0.104	0.061 (0.477)	1.399 (0.942)	98.540 (1.003)

3	0.102	0.050 (0.313)	0.814 (0.731)	99.136 (0.726)	0.106	0.503 (0.819)	1.519 (1.076)	97.977 (1.301)
4	0.103	0.058 (0.309)	0.803 (0.728)	99.139 (0.721)	0.107	0.582 (0.876)	1.503 (1.094)	97.915 (1.352)
5	0.103	0.070 (0.309)	0.804 (0.729)	99.126 (0.723)	0.108	0.591 (0.884)	1.487 (1.070)	97.922 (1.336)
6	0.103	0.084 (0.312)	0.810 (0.734)	99.106 (0.730)	0.108	0.630 (0.917)	1.490 (1.061)	97.880 (1.351)
7	0.103	0.099 (0.316)	0.817 (0.742)	99.084 (0.742)	0.108	0.670 (0.940)	1.504 (1.061)	97.826 (1.3740
8	0.103	0.113 (0.321)	0.825 (0.752)	99.062 (0.757)	0.108	0.695 (0.948)	1.528 (1.069)	97.778 (1.394)
9	0.103	0.126 (0.326)	0.833 (0.763)	99.041 (0.773)	0.108	0.715 (0.954)	1.555 (1.088)	97.730 (1.422)
10	0.103	0.139 (0.330)	0.840 (0.775)	99.021 (0.790)	0.108	0.735 (0.961)	1.582 (1.112)	97.683 (1.454)

Appendix C: Variance decomposition of developing economies

Variance Decomposition of *lnPAR*:		3 lags		
Period	S.E.	*lnPAR*	*lnPAN*	*FDI*
1	0.277	100.000 (0.000)	0.000 (0.000)	0.000 (0.000)
2	0.337	98.536 (1.114)	1.065 (0.913)	0.399 (0.578)
3	0.396	98.305 (1.368)	1.328 (1.189)	0.367 (0.632)
4	0.447	98.254 (1.433)	1.408 (1.273)	0.338 (0.597)
5	0.493	98.060 (1.631)	1.593 (1.461)	0.346 (0.650)
6	0.535	97.857 (1.875)	1.797 (1.691)	0.346 (0.714)
7	0.574	97.675 (2.125)	1.982 (1.921)	0.343 (0.774)
8	0.612	97.486 (2.398)	2.170 (2.168)	0.344 (0.852)
9	0.647	97.290 (2.694)	2.366 (2.432)	0.345 (0.946)
10	0.681	97.094 (3.006)	2.561 (2.707)	0.345 (1.052)
Variance Decomposition of *lnPAN:*				
Period	S.E.	*lnPAR*	*lnPAN*	*FDI*
1	0.259	1.851 (1.636)	98.149 (1.636)	0.000 (0.000)
2	0.328	1.949 (1.757)	97.517 (1.816)	0.534 (0.598)
3	0.366	3.404 (2.121)	95.719 (2.225)	0.876 (0.906)
4	0.404	4.035 (2.325)	95.147 (2.417)	0.818 (0.844)
5	0.438	4.667 (2.565)	94.495 (2.713)	0.838 (0.901)
6	0.468	5.439 (2.832)	93.631 (3.056)	0.930 (1.054)
7	0.494	6.201 (3.090)	92.828 (3.384)	0.971 (1.172)
8	0.519	6.978 (3.354)	92.017 (3.728)	1.005 (1.312)
9	0.541	7.792 (3.632)	91.155 (4.096)	1.054 (1.482)

10	0.562	8.631 (3.920)	90.272 (4.476)	1.097 (1.662)
Variance Decomposition of *FDI:*				
Period	S.E.	*lnPAR*	*lnPAN*	*FDI*
1	0.021	0.689 (0.838)	0.853 (0.972)	98.457 (1.235)
2	0.025	0.584 (1.120)	2.176 (1.721)	97.240 (1.886)
3	0.027	0.575 (1.292)	2.431 (2.164)	96.994 (2.354)
4	0.029	0.586 (1.319)	2.245 (2.111)	97.169 (2.317)
5	0.032	0.567 (1.395)	2.315 (2.221)	97.118 (2.421)
6	0.034	0.552 (1.471)	2.391 (2.417)	97.057 (2.608)
7	0.035	0.544 (1.525)	2.374 (2.527)	97.082 (2.713)
8	0.037	0.533 (1.574)	2.368 (2.635)	97.098 (2.813)
9	0.039	0.522 (1.624)	2.374 (2.765)	97.103 (2.933)
10	0.040	0.512 (1.669)	2.366 (2.885)	97.121 (3.048)

Appendix D: Variance decomposition of economies in transition

Variance Decomposition of *lnPAR*:		1 lag			2 lags			
Period	S.E.	*lnPAR*	*lnPAN*	*FDI*	S.E.	*lnPAR*	*lnPAN*	*FDI*
1	0.279	100.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.270	100.000 (0.000)	0.000 (0.000)	0.000 (0.000)
2	0.388	99.835 (0.484)	0.108 (0.192)	0.057 (0.448)	0.340	99.859 (1.533)	0.021 (0.832)	0.120 (1.257)
3	0.468	99.498 (1.298)	0.348 (0.610)	0.154 (1.155)	0.398	99.653 (1.441)	0.142 (0.731)	0.205 (1.239)
4	0.533	99.033 (2.255)	0.702 (1.215)	0.265 (1.924)	0.443	99.250 (2.005)	0.323 (0.997)	0.426 (1.781)
5	0.589	98.469 (3.260)	1.154 (1.963)	0.377 (2.667)	0.482	98.523 (2.753)	0.688 (1.407)	0.789 (2.554)
6	0.638	97.830 (4.267)	1.689 (2.813)	0.481 (3.351)	0.516	97.629 (3.611)	1.182 (1.989)	1.190 (3.373)
7	0.682	97.137 (5.252)	2.289 (3.730)	0.574 (3.968)	0.547	96.589 (4.477)	1.817 (2.682)	1.594 (4.146)
8	0.723	96.403 (6.203)	2.942 (4.682)	0.655 (4.520)	0.576	95.453 (5.334)	2.576 (3.459)	1.971 (4.844)
9	0.761	95.642 (7.115)	3.634 (5.647)	0.724 (5.012)	0.603	94.242 (6.176)	3.449 (4.294)	2.309 (5.464)
10	0.797	94.864 (7.987)	4.353 (6.608)	0.782 (5.451)	0.628	92.974 (6.998)	4.423 (5.166)	2.603 (6.008)
Variance Decomposition of *lnPAN*:								
Period	S.E.	*lnPAR*	*lnPAN*	*FDI*	S.E.	*lnPAR*	*lnPAN*	*FDI*
1	0.384	2.506 (2.713)	97.494 (2.7130	0.000 (0.000)	0.368	1.112 (2.150)	98.888 (2.150)	0.000 (0.000)
2	0.529	3.310 (3.068)	96.689 (3.089)	0.001 (0.279)	0.445	2.568 (3.607)	96.698 (3.754)	0.734 (1.208)
3	0.633	4.206 (3.503)	95.792 (3.603)	0.002 (0.779)	0.524	3.039 (3.824)	96.323 (4.038)	0.638 (1.165)
4	0.715	5.180 (4.022)	94.818 (4.259)	0.002 (1.379)	0.586	3.489 (4.246)	95.939 (4.544)	0.572 (1.302)
5	0.783	6.217 (4.622)	93.781 (5.020)	0.002 (2.004)	0.640	3.845 (4.543)	95.663 (4.964)	0.493 (1.484)
6	0.842	7.305	92.694	0.002	0.689	4.183	95.388	0.429

		(5.289)	(5.843)	(2.608)		(4.858)	(5.414)	(1.743)
7	0.893	8.431 (6.007)	91.567 (6.696)	0.002 (3.172)	0.733	4.508 (5.175)	95.114 (5.858)	0.379 (2.014)
8	0.939	9.585 (6.762)	90.413 (7.557)	0.002 (3.688)	0.774	4.829 (5.507)	94.830 (6.299)	0.341 (2.276)
9	0.981	10.756 (7.538)	89.240 (8.412)	0.003 (4.156)	0.811	5.149 (5.852)	94.537 (6.731)	0.313 (2.516)
10	1.020	11.937 (8.323)	88.058 (9.252)	0.006 (4.578)	0.846	5.470 (6.208)	94.236 (7.157)	0.293 (2.731)
Variance Decomposition of *FDI*:								
Period	S.E.	*lnPAR*	*lnPAN*	*FDI*	S.E.	*lnPAR*	*lnPAN*	*FDI*
1	0.021	0.218 (1.071)	2.490 (2.361)	97.292 (2.402)	0.021	1.002 (2.124)	2.840 (3.033)	96.158 (3.616)
2	0.026	0.157 (1.029)	2.569 (2.568)	97.274 (2.544)	0.027	2.970 (3.167)	2.285 (2.684)	94.745 (4.030)
3	0.028	0.130 (1.048)	2.632 (2.836)	97.238 (2.826)	0.029	2.921 (3.235)	2.257 (2.746)	94.822 (4.128)
4	0.030	0.138 (1.133)	2.678 (3.126)	97.184 (3.207)	0.031	2.815 (3.211)	2.316 (2.873)	94.869 (4.215)
5	0.031	0.176 (1.280)	2.708 (3.420)	97.116 (3.640)	0.031	2.704 (3.139)	2.388 (3.013)	94.909 (4.288)
6	0.031	0.238 (1.475)	2.726 (3.706)	97.035 (4.091)	0.032	2.638 (3.071)	2.457 (3.178)	94.905 (4.395)
7	0.031	0.320 (1.704)	2.735 (3.982)	96.945 (4.539)	0.032	2.622 (3.023)	2.515 (3.358)	94.864 (4.542)
8	0.031	0.416 (1.952)	2.736 (4.248)	96.848 (4.972)	0.032	2.648 (2.999)	2.559 (3.557)	94.793 (4.734)
9	0.032	0.522 (2.210)	2.733 (4.506)	96.745 (5.385)	0.032	2.706 (3.003)	2.592 (3.765)	94.702 (4.963)
10	0.032	0.633 (2.474)	2.728 (4.758)	96.640 (5.778)	0.032	2.786 (3.035)	2.615 (3.978)	94.599 (5.223)