FDI Spillover Channel and its Effect on Innovation

Raymond Darfo-Oduro and Jan Stejskal
Faculty of Economics and Administration University of Pardubice, Czech Republic
raymond.darfo-oduro@upce.cz
jan.stejskal@upce.cz

Abstract: In an increasingly globalized environment, one of the important aspects for knowledge development and usage has been the advantage of benefiting from knowledge spillover across international boundaries. The knowledge literature recognizes the importance of the combining internal and external knowledge in the innovation process. Knowledge spillover from abroad is an important channel of external knowledge needed to complement the innovation activities in the domestic economies of countries. However, the complementarities of external knowledge and domestic innovation activities also remains a thorny issue that remain unresolved in the knowledge literature. On one hand, there is a believe that combinatorial efforts of domestic and foreign knowledge activities are a good recipe for innovation. There are other strands of literature that are concerned that when foreign knowledge is not complementary with domestic innovation activities increased innovation may not be realized. Contrary to the widely held view of the positive impact of FDI on host economies, the literature shows a rather complex relationship between FDI and economic outcomes in V4 countries. OECD countries, being the main trading partners of V4 countries, the study therefore investigates the FDI channel for knowledge spillover from OECD countries and how such knowledge spillover complements V4 countries innovation activities to affect innovation outcomes. Data for the study is panel data on the V4 countries, spanning 2003 to 2012 which is sourced from the OECD database. The study applies panel regression analysis and controls for country and time fixed effect to determine the role of FDI knowledge spillover from OECD countries on innovation outcome in V4 countries. The findings of the study indicate that proportionate change in innovation is greater than a proportionate change in FDI knowledge spillover in the opposite direction. The results of the analysis show that knowledge spillover from FDI does not complement V4 countries' internal R&D activities to improve innovation. FDI knowledge spillover channel is not a good complement to domestic R&D activities to enhance V4 countries' innovation performance. It is concluded that, FDI knowledge spillover channel does not complement innovation activities to improve innovation outcome. The study provides useful practical implications and recommendations.

Keywords: FDI, Knowledge Spillover, Innovation, R&D intensity, Visegrad 4 countries

1. Introduction

The enormous channels of knowledge spillover and their role in innovation have not received the attention they require to be able to address the challenges of innovation performance in economies. There is consensus among authors that FDI provides an important channel through which knowledge from abroad is transferred to other economies (Kayani, et al., 2021). The Visegrad Four (V4) countries have relied so much on Foreign Direct Investment (FDI) as a channel to bring into their economies skilled intensive activities (Capik & Drahokoupil, 2011). The literature has been focused more on FDI projects with limited attention on the knowledge spillover that comes with FDI (Vojtovic, et al., 2019; Mallick & Zdražil, 2018). Considering the importance of innovation and the need to broaden the sources of innovation (hylinska, et al., 2020), it has become imperative to consider the foreign knowledge spillover channel to enhance innovation performance in the V4 countries. Technological diffusion has been linked to FDI to host country (Vojtovic, et al., 2019) making it important source of innovation for countries such as the V4 that are making effort to improve their innovation performance. As V4 countries continue to make efforts to transform their economies to knowledge driven economies, the current study provides new insights into how this objective can be realized by considering FDI knowledge spillover channel. In this study therefore, the role of FDI and its moderating effect on the relationship between R&D intensity and innovation performance is investigated.

2. Theoretical Background

2.1 Foreign Direct Investment and Innovation

Knowledge spillover from FDI is a source of knowledge transfer from foreign firms into domestic economies for innovation (Todo & Miyamoto, 2006). In a study by Hoang, et al.(2021) on the spillover effect of FDI on technology innovation in Vietnam, the authors used survey data on 3,166 enterprises in Vietnam. It has also been argued that the quality of human capital is important in determining the impact of FDI knowledge spillover on innovation performance of economies (Ali, et al., 2016). Several other factors have accounted for the effectiveness of FDI spillover. Branstetter (2006) has shown for example that in the USA, Japanese FDIs are aimed at exploiting technologies in the USA as strategy to stay competitive in their home country. Thus, the type of FDI

and the reasom for establishing a subsidiary in a foreign land is an important reason why some FDIs may not ensure knowledge spillover. Some other considerations for the effectiveness of FDI knowledge spillover have been cited in the literature. The posture of firms in the recipient towards inflow of FDI is an important determinant of the effect FDI knowledge spillover will have on the innovation performance of the recipient country. Hongling, et al. (2006), in their study to determine whether FDI inflows hamper technology development of host countries, the study revealed some pertinent issues worth highlighting. The findings of the study showed that host countries consider knowledge spillover from FDI as a substitute to domestic R&D effort. Diruptive technologies have been observed to conflict with dominant technologies of the host countries (Liu, et al., 2020). Thus, knowledge spillover from FDI channels will lead to innovation only when the foreign technology does not seek to replace but complement existing technologies.

In the context of V4 countries, there is empirical evidence of FDI Knowledge spillover. The main trading partners of the V4 countries, Russia, Ukraine, Italy, Great Britain, Germany, Austria, Romania and France (Babunek, 2012). The structural characteristics and location has positioned these 4 countries and given the capacity to attract Multinational Enterprises (MNE) (Altomonte & Guagliano, 2003). The low labour cost and high labour productivity in V4 countries have been the basis for increased FDI inflows (Jablonska, 2020). With increasing industrialisation of V4 countries, high R&D investment and efforts to increase knowledge transfers from the large MNE in the V4 countries, it is argued that increasing FDI knowledge spillover inflows can expalin changes in innovation performance in V4 countries. It is therefore postulated for testing the following hypothesis:
H_1: FDI knowledge spillover inflows to V4 countries is significantly related to changes in innovation performance

2.2 R&D Intensity and Innovation

Characteristically, contrary to countries where the literature focuses on, such as western developed countries and Asian countries where there are large firms which have better capacity to engage in and utilize R&D (Audretsch, 1988), the V4 countries have large SME sector. It is therefore important to access how the large SME sector can translate R&D activities into innovation outcome. There is generally an agreement among authors that engaging in R&D ensures increased innovation (Prokop & Stejskal, 2019). Countries that have shown commitment to R&D investments have seen rapid increase in innovation whilst those that have not witnessed very moderate, little or no innovation (Stejskal, et al., 2018).

In a study by Krammer (2009), the determinants of innovation was investigated based on data from sixteen Eastern European Countries including V4 countries. The findings of the study showed that the complementarity between national knowledge base and R&D is important in ensuring enhanced innovation performance. It is therefore clear at this point that R&D, even though, a cine quanon for innovation, it must be compatible with any other knowledge base within the economic system to ensure innovation.

Emprical findings that indicate positive relationship between R&D intensity and innovation dominates the literaure. In the league of these studies include Love and Mansury (2007) who showed that R&D is important conduit to improving innovation in US business services. In Visegrad 4 countries, there has been an increased investment in R&D (Jablonska, 2020) and related studies have shown that rising investment levels have enhanced innovation performance (Odei, et al., 2020). In this study, based on the position of the literature and as a necessary precursor to accessing the moderating effect of FDI knowledge spillover channel in the relationship between R&D intensity and innovation performance, the following hypothesis is stated for testing:
H_2: R&D intensity of Visegrad 4 countries is significantly related to their innovation performance

2.3 Moderating Effect of FDI Spillover Channel in the Relationship between R&D Intensity and Innovation

Even though there is evidence to suggest that R&D is an important determinant of innovation performance of countries, the literature also recognises that R&D of countries are not the only source of knowledge but other knowledge sources such as knowledge spillover from FDI combines with internal R&D to affect innovation (Prokop, et al., 2021; Akinwale, 2018). One of the reasons why countries have not been able to advance innovation despite increased inflow of imported knowledge through trade and FDI is the inability to assimilate imported knowledge (Akinwale, 2018). Knowledge inflows to domestic economies have been a major determinant of innovation performance in domestic economies alongside internal R&D efforts (Ali, et al., 2016). It has however, been shown that the compatibility and complementarity between foreign knowledge and internal R&D of the domestic economies is important in ensuring innovation performance (Qiua, et al., 2017). Wang and Wu (2016) in a study to assess how innovative activities of foreign firms influence innovation performance in the domestic economy, the findings of the study showed that FDI knowkedge spillover effect on

innovation in the domestic economy is positive and is reenforced by domestic innovative activities. Thus, the interaction between foreign knowledge spillover with innovation activities in the domestic economy to positively influence innovation.

The economic gains of Visegrad 4 countries have made them destination for FDI (Lomachynska, et al., 2020). Visegrad 4 countries have benenfted from inflows of FDI from its trading partners mainly the OECD countries with considerable amount of FDI knowledge spillover (Capik & Drahokoupil, 2011). Considering the high investment in R&D among the Visegrad 4 countries (Jablonska, 2020), the innovation process in Visegrad 4 countries must necessarily involve the combination of both internal R&D and FDI knowledge spillover. The study therefore tests the following hypothesis:
H_3: FDI moderates the relationship between R&D and innovation performance in V4 countries.

3. Data and Methodology

Data for the study is sourced from OECD database. The data is a panel data on Visegrad 4 countries of Czech, Republic, Hungary, Slovakia and Poland spanning from 2003 to 2012. The data is a country level data on patent count, trade openness, FDI knowledge spillover and R&D intensity. The heterogeneity of economic openness of these countries is recognized and taken advantage of by estimating the relationship based on panel data analysis and controlling for unobserved country fixed effect. In this study, besides controlling for unobserved fixed effect, being panel data, the cross-sectional nature of the data imposes some challenges on the performance of the regression models which requires remedy. To deal with cross sectional dependence to improve the consistency of the regression model, Seemingly Unrelated Regression (SUR) estimation using Feasible Generalised Least Square (FGLS) is employed. This is inspired by Zellner (1962) who argued that SUR estimation using FGLS is an important approach to dealing with cross-sectional dependence in panel regression model. Again, endogeneity of regressors is known to introduce biasness into regression model (Rehman, et al., 2020). To ensure the robustness of the regression model and to deal with the endogeneity in the regression model, Panel Two Stage Least Square (PTSLS) using the one lag period of the regressors and lag dependent variable as instruments. Panel Two Stage Least Square is inspired by Wooldridge, (2002) who touts the gains of PTSLS in addressing the challenges of endogeneity.

3.1 Empirical Model and Measures

The study links innovation to innovation activities such as R&D intensity and other determinants of innovation such as trade openness, technological capabilities of a country and a control for country specific fixed effect. The logic of this model is that R&D intensity, being a measure of research capability of countries, it is expected to translate into country's innovation performance. This agrees with empirical studies cited in the knowledge literature (Tsung-chun, et al., 2019). The link between technological capabilities of a country and innovation assumes that technological capabilities of a country is important in determining the extent of innovation in a country. Innovation is based on existing technological knowhow of a country (Schumpeter, 1947). Trade openness is a measure of the extent to which an economy is linked to other economies or opened to international trade (Hu, et al., 2021). This is considered as a channel through which external knowledge is imported into an economy. In this study knowledge spillover from Foreign Direct Investment (FDI) is considered as a moderator in the relationship between R&D intensity and innovation. Panel regression estimation technique is used to estimate the regression that links innovation to trade openness, technological progress and R&D intensity:

$$Inn_{it} = \beta_0 + \beta_1 logtrade_{it} + \beta_2 logtechprogress_{it} + \beta_3 Country_i + \beta_4 logR\&D_{it} + e_{it} \quad (1)$$

where logtrade is the natural log of trade openness, logtechprogress is natural log of technological progress, country is country specific fixed effect and logR&D is the natural log of R&D intensity whilst inn is innovation performance. The disturbance term is represented by e. Country and time dimensions of the panel data are represented by i and t respectively.

The study, recognising the cross sectional nature of the regression model, anticipates the possibility of the model being cross sectionally dependent. The study therefore tests for the presence of cross sectional dependence using Breusch Pagan LM test.

To correct for the presence of cross sectional dependence, equation 1 is re-estimated with Seemingly Unrelated Regression using Feasible Generalised Least Square. It is argued that the FGLS estimates are efficient in the presence of serially correlated error terms (Rao & Griliches, 1969; Bai, et al., 2021).

The study also investigates the effect of FDI Knowledge spillover channel on innovation of the Visegrad four countries innovation performance. The model is estimated using Panal Least Square and controlled for country specific fixed effect. The model is specified without R&D intensity for a good reason. The study aims to determine the moderating effect of FDI knowledge spillover channel on the relationship between R&D intensity and innovation. It is therefore important to determine the separate effect of R&D intensity and FDI knowledge spillover channel on innovation before estimating the moderating effect. Model 3 is therefore specified as follows:

$$Inn_{it}=\beta_0+\beta_1 Inn_{it}+\beta_2 logtrade_{it}+\beta_3 logtechprogress_{it}+\beta_4 Country_i+\beta_5 FDIspill_{it}+e_{it} \quad (2)$$

The study also contend with endogeneity in the regression model after subjecting the regression model to Wald test. Dynamic Panel Two Stage Least Square estimation is used. The model used one period lag of the regressors and one period lag dependent vatiable as instruments. This is consistent with (Serrasqueiro, et al., 2016; Reed, 2015) who showed that lags of dependent and expalanatory variables are important instruments for 2SLQ in dealing with endogeneity. The regression model for the Dynamic Panel Two Stage Least Square is specified as below in equation 3:

$$Inn_{it}=\beta_0+\beta_1 Innovation_{it-1}+\beta_2 logtrade_{it-1}+\beta_3 logtechprogress_{it-1}+\beta_4 Country_i+\beta_5 logR\&D_{it-1}+e_{it} \quad (3)$$

Equation 3 tests effect of technological progress and R&D intensity on innovation performance. The regression control for trade openness and country specific fixed effect.
In testing for the moderating effect of FDI knowledge spillover channel in the relationship between R&D intensity and innovation performance the study estimated another Panel Two Stage Least Squares in equation 4:

$$Inn_{it}=\beta_0+\beta_1 Inn_{it-1}+\beta_2 logtrade_{it-1}+\beta_3 logtechprogress_{it-1}+\beta_4 Country_i+\beta_5 logR\&D_{it-1}*FDIspill_{it}+e_{it} \quad (4)$$

Variables are mentioned in Table 1.
Equation 4 is re-estimated to control for the financial crisis of 2008 to 2012. The idea is to assess whether the global financial crisis have an effect on the moderating effect of FDI knowledge spill-over in the relationship between R&D intensity and innovation.

Table 1: Variables

Variables	Measures
Innovation	Patent application Count
R&D Intensity	Gross expenditure on R&D/GDP
FDI knowledge spillover	$(FDI\ inflows_i*R\&D_i)/GDP_j$ i=trading partners, j=host country
Trade openness	(import+export)/GDP
Technological progress	Labour productivity

Source: OECD Data Base

4. Results and Discussion

The results of the data analysis are presented in Tables 2 and 3. Table 2 presents three models. Model 1 estimates the relationship between R&D intensity and innovation performance using panel least square estimation technique. Model 2 is the same model as in model 1. However, model 2 is estimated using generalized least square to deal with the problem of cross-sectional dependence. Model 3 estimates the effect of FDI Knowledge spillover on innovation. The regression results from Table 2 links innovation to its key determinants, R&D intensity and trade openness and an important knowledge spillover channel, FDI knowledge spillover as an independent variable and a moderator.

Table 2: Relationship Between R&D intensity, trade openness, FDI Knowledge spillover channel and innovation

Variables	Model 1 (PLS) **Innovation**	Model 2 (FGLS Cross sec. SUR) **Innovation**	Model 3 (PLS) **Innovation**
Intercept	-28.22722** (12.09953)	-22.64573 (13.02418)	-15.75188* (8.309859)
Trade openness	0.611871***	0.595759***	1.365287***

Variables	Model 1 (PLS) **Innovation**	Model 2 (FGLS Cross sec. SUR) **Innovation**	Model 3 (PLS) **Innovation**
	(0.091712)	(0.093819)	(0.259356)
Techprogress	19.57754*** (5.628806)	17.16162*** (6.039463)	2.371955*** (0.900207)
Country dummy	yes	yes	yes

As expected, the findings of the analysis in model 1, estimated using panel least square estimation technique controlling for country fixed effect shows that the log of trade openness, the log of technological progress and the log of R&D intensity are significant at 1% significant level. The model is also significant at 1% significant level. Model 1 explains 97.7% of the variation. However, the Breusch Pagan LM test for cross sectional dependence in model 1 shows that the disturbance terms are correlated. Generalised least square estimation technique is employed to improve the performance of the regression in model 2. Model 2 presents similar results as model 1 but eliminates the cross-sectional dependence in the model. Model 2, however, fails the endogeneity test based on Wald test.

Table 2: Relationship Between R&D intensity, trade openness, FDI knowledge spillover channel and innovation

R&D Intensity	1.186394*** (0.163175	1.354034*** (0.115657)	
FDIspill			-0.543030*** (0.213622)
R-Squared	0.976683	0.970157	0.950517
Adjusted R Square	0.972443	0.964731	0.941520
F-Statistics (Prob)	230.3758***	178.7995***	105.6491***
Breusch Pagan LM Probability	7.860583 0.000000***	7.082562 0.3133	0.042207 0.979117
Durbin Watson	1.724383	2.011232	1.430873
Observation	40	40	40

Standard errors in parentheses; *P< 0.1, **P<0.05, ***P<0.01. Dependent variable is patent count. Both dependent and independent variables are in log

Model 3 tests hypothesis H_1 and confirms that there is a significant relationship between FDI knowledge spillover and innovation performance. The results from model 3 indicates that a proportionate change innovation performance is greater than a proportionate change in FDI knowledge spillover in the opposite direction. The model links FDI knowledge spillover to innovation performance. Model 3 is robust as it shows an insignificant Breusch Pagan LM test indicating the absence of cross-sectional dependence. Wald test also showed the absence of endogeneity. Panel 2 Stage Least Square (P2SLS) is employed to correct the endogeneity problem in model 2 as a basis for estimating model 4 in Table 3.

Table 3: Moderating effect of FDI Knowledge Spillover on the Relationship between R&D Intensity and Innovation

Variables	Model 4 (Panel 2SLS) **Innovation**	Model 5 (Panel 2SLS) **Innovation**	Model 6 Panel 2SLS **Innovation**
Intercept	-10.85543 (7.034803)	-7.517622 (6.995862)	-6.409163 (8.931965)
Logtradeopenness	0.65695*** (0.148624)	0.508967*** (0.163383)	0.547072* (0.281427)
Logtechprogress	2.901982*** (0.820126)	2.290876*** (0.820036)	2.370152** (1.015233)
Country dummy	yes	yes	yes
Log R&D Intensity	1.109385*** (0.220146)		
LogR&D intensity*FDIspill		-0.048993*** (0.009509)	-0.044691*** (0.010740)
Crisis Dummy			-0.000488 (0.096125)
R-squared	0.976136	0.976952	0.976533

Table 3: Moderating effect of FDI Knowledge Spillover on the Relationship between R&D Intensity and Innovation

Adjusted R-squared	0.971198	0.972183	0.970666
F-statistic(prob)	119.6677***	120.3156***	113.2724***
Breusch Pagan LM test		8.14885 0.2274	8.041283 0.5557
Jarque Bera stat Probability		0.104421 0.949129	0.052740 0.973975
Observation	36	36	36

Standard errors in parentheses; *P< 0.1, **P<0.05, ***P<0.01 Dependent variable is patent count. Both dependent and independent variables are in logs

Model 4 therefore presents a robust regression model, free of cross-sectional dependence and endogeneity problem. H_2 based on model 4 is confirmed. Thus, the log of R&D intensity is significantly related to the log of patent count at 1% significant level. A proportionate change in R&D intensity leads to a greater proportionate change in innovation in the same direction. Model 5 estimates the moderating effect of FDI in the relationship between R&D intensity and innovation using P2SLS to test H_3. The results confirm the hypothesis that FDI knowledge spillover moderates the relationship between R&D intensity and innovation. Model 6 is a replication of model 5 but controls for global financial crisis between 2008 and 2012. Model 6 produces similar results as model 5. This indicates that the global financial crisis has no effect on the moderating effect of FDI knowledge spillover on the relationship between R&D intensity and innovation. In both models, the moderation is not complementary. Increasing FDI knowledge spillover over has negative effect on the relationship between R&D intensity and innovation performance. It can be observed from model 4 that the log of R&D intensity is positive but the interaction between the log of R&D intensity and FDI knowledge spillover in model 5 is negative. Thus, H_3 is confirmed, however the results show that FDI knowledge spillover does not complement R&D intensity for innovation performance.

This is a mixed finding. Whereas the findings confirm the general position that R&D intensity is a good determinant of innovation performance, the outcome of the current study has also shown that FDI knowledge spillover channel is inimical to innovation performance. Contrary to the position of Wang and Wu (2016), the findings of the current study has shown that knowledge spillover from FDI does not complement knowledge generation activities in Visegrad 4 countries to enhance innovation performance. FDI inflows into V4 countries come from OECD countries which are wealthier, hence technologies from these OECD countries that spillover to the V4 countries are superior and are likely to be disruptive. Thus, the conflict between new technology from FDI and existing technology as opined by Liu, et al., (2020) may be important in explaining the inverse relationship between knowledge spillover from FDI and innovation. Again uncomplementarity between spillover knowledge from FDI inflows and R&D intensity in V4 countries can be explained by the superiority of knowledge from FDI inflows and disruptive nature of such knowledge. It has been argued that when foreign knowledge is superior there is a tendencies for the superior to replace the dominant technology with the consequence of reduing innovation performance temporarily. V4 countries, lag behind most of its OECD trading partners in terms of development. With the fear of being out competed, domestic firms may adopt a competitive posture rather than a corporative which is necessary to assimilate external knowledge for innovation. This is in agreement with (Hongling, et al., 2006) whose findings show that one of the reasons why knowledge spillover from FDI have not improved innovation is the competitive posturing of indigenous firms. Indegenous firms may feel threatened by the presence of Multinational Companies (MNC) hence, the chances that local firms will adopt competitive strategies which will not auger well for foreign knowledge adaptation is high.

One important process external knowledge go through before usage is assimilation. The findings of the study confirm Akinwale (2018) who argues that being able to assimilate external knowledge is an important step to ensuring that external sources of knowledge work to improve innovatioon performance of countries. The findings of the study could also be an indication of incompatibility of foreign knowledge and indigenous indigenous as indicated by (Qiua, et al., 2017). The widely held believe that FDI knowledge spillover ensures innovation performance cannot therefore be generalised.

5. Conclussions, implications and recommendations

The study is aimed at providing insight on the role of FDI Knowledge spillover in the relationship between R&D intensity and innovation performance of V4 countries. The study, based on its findings conclude that knowledge

spillover from FDI does not complement R&D intensity of V4 countries to improve innovation performance. Rather when V4 countries combine knowledge spillover from FDI with R&D activities the consequence is a reduction in innovation performance. However, when V4 countries apply on home grown R&D innovation performance is enhanced. FDI Knowledge spillover from FDI inflows into V4 countries is considered superior relative to the knowledge base of the economy and therefore disruptive and therefore can be viewed as an undesirable shock to the innovation process. The disruptive nature of the technology inflow could explain why knowledge spillover from FDI inflows from OECD countries have not been complementary with R&D intensity of V4 countries to enhance innovation performance.

From the findings of the study it is concluded that the effect of FDI knowledge spillover is dependent on the R&D activities of a country. The complementarity between knowledge spillover from FDI and R&D activities of the country is important to ensure enhanced innovation performance. It is therefore recommended that V4 countries to regulate the type of FDI inflow into their economies. V4 countries are encouraged to target only FDIs that complement domestic economies' R&D to improve innovation.

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