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THE CAUSALITY RELATIONSHIPS BETWEEN FDI AND R&D IN EUROPEAN UNION

Abstract

Technological development and R&D activities are accepted as one of the factors of basic production in endogenous growth theories. There has been an increasing interest towards R&D on the level of both firm and country. Moreover countries regard FDI as an important element which increase R&D activities. Although there are numerous studies which investigate relationship of both FDI and R&D on macroeconomic variables such as economic growth, employment and export; the number of studies which investigate the relationship between FDI and R&D is quite few. The aim of this study is to analyze relationships between FDI and R&D in the example of EU15 and EU27. For this aim, 1996–2009 period data of mentioned countries were considered and dynamic panel causality testing was done. According to the findings obtained from empirical test made in the study, there is one-way causality relationship among EU15 and EU 27 countries from FDI towards R&D. This finding points out to the existence of complementary relationship between FDI's and R&D for EU.

Keywords

European Union, FDI, Panel Causality, R&D

1. Introduction

Neoclassical growth theory which was developed under the leadership of Solow (1956) resulted in balanced growth. In the case of balanced growth, output per worker increases as much as technological development. Technological development which is accepted as exogenous in theory is a factor which determines increase in output per worker. However, in the endogenous growth theories which are developed under the leadership of Romer (1986), technological development is determined by intrasystem elements. The theory concluded that a growth rate could be achieved which is above balanced growth rate that was achieved by neoclassical theory. Technological development which is based on research

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and development (R&D) activities was regarded as an important factor in the increase of growth[6].

Technology transfer may have positive effects on economic growth. Foreign direct investment (FDI) may increase economic growth through technology channels such as R&D by contributing to the current technological knowledge. Also, FDI investors may contribute to more efficient usage of resources by getting into competitive environment with domestic firms in domestic market. Domestic firms may carry out R&D activities in order to compete with technology brought by foreign investors. On the other hand, in some cases firms can have the new technology without doing any R&D activities.

Today countries make competition in order to attract FDI investments. Forming an economic integration or accession to an integration is conducted in order to attract FDI. EU which is the most successful example of integration is in an important position for FDI investments. The aim of this study is to analyze relationships between FDI and R&D for EU with panel causality testing. Literature which analyzed FDI and R&D relationship was included in the second section of study. In the third section, econometric method and data set was discussed. In the fourth section, findings obtained as a result of analysis were given. A general evaluation of findings was made in the last section.

2. Theory and literature summary

Although there are numerous studies which investigate relationship of both FDI and R&D on macroeconomic variables such as economic growth, production, efficiency, export, employment etc.; the number of studies which investigate the relationship between FDI and R&D is quite few. An exact judgment cannot be made about relationship between FDI and R&D according to the results of this restricted number of studies. While some of the studies assert that there is a positive, complementary relationship between these two variables; some studies assert that there is a negative, substitution relationship between these mentioned variables.

According to the studies which assert that there is a positive relationship between FDI and R&D, FDI creates positive externality on domestic firms through technological spillover effect. That is; foreign firms which enter in a country with FDI may have direct or indirect contribution to R&D activities of the host country. For example, foreign firms pay attention to increasing R&D activities of host country in order to adapt economic conditions of host country or to compete with domestic firms. Similarly, existence of foreign firms in the sector can force domestic firms to develop new innovations and increase their technological

[6] See Romer (1990), Rivera-Batiz and Romer (1991a, 1991b), Grosmann and Helpman (1991), Aghion and Howitt (1992).

capacity. Moreover, foreign firms stepping into country can create technological spillover effects on behalf of domestic firms and cause increase in R&D activities of these firms (Sasidharan and Kathuria, 2011, p. 1226).

According to the studies which assert that there is a negative relationship between FDI and R&D, firms may choose to procure technology instead of doing R&D activities as a result of FDI inflow (Lee, 1996, p. 198). That is; domestic firms may decrease their R&D activities by procuring technology from abroad instead of competing with foreign firms. Sometimes firms stepping into foreign country prefer using technology of partner company and decide not to make R&D investment (Sasidharan and Kathuria, 2011, p. 1226). Then, FDI and R&D will become competitors instead of complements.

In the following section, specific studies which analyze relationships between FDI and R&D in literature were presented according to the year of analysis. Literature summary which is composed of these explanations is shown in Table 1.

Kumar (1987) analyzed relationship between technology import and R&D expenditures of 1334 firms in manufacturing industry in India for 1967–1977 and 1980–1981 periods with panel OLS method. According to the findings obtained from study, FDI inflows have reducing effect on domestic R&D expenditure.

Bertschek (1995) analyzed on 1270 German firms for 1984–1988 periods that import and FDI have no positive effect on innovative activities of domestic firms. In his analysis, Bertscheck (1995) used Chamberlain's random effects probit approach (1984) and determined that import and FDI have positive effect on both product innovations and process innovations.

Lee (1996) analyzed relationship between technology import (as an indicator of FDI) and R&D in manufacturing industry firms in Korea for the year 1884 with the help of Heckman two-stage estimation procedure (1979). In the first stage of procedure he applies Probit analysis by using all the firms (492 firms) in the sample and determined that firms which import technology have tendency of increasing their R&D activities. In the second stage of analysis, panel OLS was applied on firms which have R&D institutes (92 firms) and it was determined that there is no complementary relationship between FDI and R&D, on the contrary FDI have negative effects on international inventive activities.

Chuang and Lin (1999) analyzed relationship between FDI and R&D with the help of Heckman two stage estimation procedure (1976) by using 8846 firms in Taiwan for the year 1991. Probit model estimation was done in the first stage of econometric analysis and it was determined that FDI has increasing effect on R&D activities. In the second stage panel OLS method was applied for 679 firms which make R&D investment. It was determined that there is negative relationship between FDI and R&D investments.

Branstetter (2000) analyzed changes in R&D activities of Japanese firms which make FDI investments in USA. In the study panel OLS was applied on 208 Japanese and 209 American firms for 1986–1989 period and it was determined that there is a positive but weak relationship between FDI and R&D activities.

Fan and Hu (2007) investigated effects of FDI on domestic R&D activities on 998 firms in China for 1998–2000 period. In the study in which Panel OLS and Fixed Effects Models were used as econometric method, it was concluded that FDI inflows have negative effect on R&D activities. Fan and Hu (2007) stated that firms with more foreign participation allocate less resource for R&D activities.

Kathuria (2008) investigated what kind of changes FDI inflow for domestic firms in India (high and medium technology industries) had on R&D expenditures. In the study in which post 1991 period when corporatization reform was done is divided into two sub-periods; Probit model was used in the first sub-period which is covers the years 1994–1996. According to the findings obtained from estimation of Probit model it was determined that increase in FDI decreases R&D expenditures. Tobit model was used in the second sub-period which is covers the years 1999–2001; it was concluded that there is no causality relationship between FDI inflow and R&D expenditures.

Like Kathuria (2008; referenced by Sasidharan and Kathuria, 2011) analyzed the relationship between FDI and R&D in India for post-corporatization period with the help of Heckman's two-stage estimation method (1979). In the study in which 1843 firms which go into operation in manufacturing industry sector for 1994–2005 period were analyzed, first of all panel OLS estimation was done without making discrimination among firms. According to the findings obtained from this estimation, it was determined that FDI has no significant effect on R&D. Similar results were obtained when panel OLS analysis was done by grouping firms as high, medium and low technology firms. Finally when firms were divided according to stock ownership (as majority and minority owned foreign firm) and analyzed in this way, it was determined that there is positive relationship between FDI and R&D.

Author	Period	Country	Method	Applied Findings
Kumar (1987)	1976–1977 1980–1981	India (1334 firms)	Panel OLS	FDI→R&D (-)
Bertschek (1995)	1984–1988	Germany (1270 firms)	Chamberlain's Random Effect Probit Model	FDI→Product innovations (+) FDI→ Process innovations (+)
Lee (1996)	1984	Korea (1. stage 492 firms, 2. stage 92 firms)	Heckman (1979)'s two stage estimation	FDI→R&D (-)
Chuang and Lin (1999)	1991	Taiwan (1. stage 8846 firms, 2. stage 679 firms)	Heckman (1976)'s two stage estimation	FDI→R&D (-)
Branstetter (2000)	1986–1989	Japan (208 firms) and USA (209 firms)	Panel OLS	FDI→R&D (+)
Fan and Hu (2007)	1998–2000	China (998 firms)	Panel OLS and Fixed Effect Model	FDI→R&D (-)
Kathuria (2008)	1994–1996 1999–2001	India (190 firms)	Probit and Tobit model Estimation	• Probit: FDI→R&D (-) • Tobit: FDI↛ R&D (0)
Sasidharan and Kathuria (2011)	1994–2005	India (1843 firms)	Heckman (1979)'s two stage estimation	• Full Sample: FDI↛ R&D (0) • Technology discrimination: FDI↛ R&D (0) • Majority- and minority-owned discrimination: FDI→R&D (+)

Note: Table was formed by authors; (+) reflects positive, (-) negative, (0) meaningless effects in the table, (↔) and (→) symbols respectively point out to the existence of two-way an done-way causality relationships between variables.

Table 1: *Literature Summary about Relationship between FDI and R&D*

3. Method and data

In the literature study it was seen that all the studies were based on data at firm level. Publishing of R&D data of countries in database recently and developments in econometric methods enables testing of relationship between FDI and R&D. Therefore, in this study panel data analyses which pay attention countries different from available literature was included.

In the study relationships between FDI and R&D was analyzed for EU 15 and EU 27 countries. As an indicator of R&D and FDI for mentioned country groups, shares of R&D expenditures and FDI in GDP were used respectively. The data were compiled from the World Bank's Development Indicators online database, available on http://www.worldbank.org. The panel covers annual data for the period 1996–2009. The data set of the study is unbalanced.

For determination of causality relationships between FDI and R&D in EU 15 and EU 27 countries, the method developed by Holtz-Eakin, Newey and Rosen (1988) was used. This method can be explained through a VAR system formulated as follows:

$$Y_{it} = \alpha_{0t} + \sum_{l=1}^{m} \alpha_{jt} Y_{it-l} + \sum_{l=1}^{m} \beta_{jt} X_{it-l} + \emptyset f_{yi} + u_{it} \quad (1)$$

$$X_{it} = \varphi_{0t} + \sum_{l=1}^{m} \varphi_{jt} X_{it-l} + \sum_{l=1}^{m} \mu_{jt} Y_{it-l} + \tau f_{xi} + \varepsilon_{it} \qquad (i = 1, \dots, N; t = 1, \dots, T) \quad (2)$$

Here Y represents R&D; X denotes FDI; i is the number of the cross-section units from 1 to N; t is the time period from 1 to T; f_{yi} and f_{xi} refer to the time-invariant fixed effects unique to cross-section units. This fixed effects of cross-section units were eliminated by taking difference of the equations (1) and (2) so these equations were turned to equations (3) and (4) as follows[7]:

$$\Delta Y_{it} = \sum_{l=1}^{m} \alpha_j \Delta Y_{it-l} + \sum_{l=1}^{m} \beta_j \Delta X_{it-l} + \Delta u_{it} \quad (3)$$

$$\Delta X_{it} = \sum_{l=1}^{m} \varphi_j \Delta X_{it-l} + \sum_{l=1}^{m} \mu_j \Delta Y_{it-l} + \Delta \varepsilon_{it} \qquad i = 1, \dots, N;\ t = 1, \dots, T;\ l = 1,2 \quad (4)$$

Since error terms in equations (3) and (4) can be related with lags of dependent variable; instrumental variables should be used in the estimations. Therefore, the equations (3) and (4) were estimated by using the Generalized Method of Moment (GMM). The direction of causality in GMM estimations were determined by Wald statistics obtained by evanishing independent variables as a group.

On the other hand, it was decided with Sargan test whether instrumental variables used in GMM estimations are valid or not (Liang and Liang, 2009, p. 152).

4. Findings

Causality results were determined by Wald test for independent variables obtained from GMM estimation of equations (3) and (4) for EU 15 and EU 27 are presented in Table 2. On the other hand, the results of GMM estimation of equations (3) and (4) are given in the Appendix.

[7] Δ represents difference operator.

	Equations	Wald Test χ2 Statics	Sargan Test P-Value	Directions of Causality
EU 15	$\Delta R\&D_{it} = \sum_{l=1}^{m} \alpha_j \Delta R\&D_{it-l} + \sum_{l=1}^{m} \beta_j \Delta FDI_{it-l} + \Delta u_{it}$	6.62022[b]	0.32090	FDI ⟹ R&D
	$\Delta FDI_{it} = \sum_{l=1}^{m} \alpha_j \Delta FDI_{it-l} + \sum_{l=1}^{m} \beta_j \Delta R\&D_{it-l} + \Delta \varepsilon_{it}$	3.29655	0.29297	FDI ⟹/ R&D
EU 27	$\Delta R\&D_{it} = \sum_{l=1}^{m} \alpha_j \Delta R\&D_{it-l} + \sum_{l=1}^{m} \beta_j \Delta FDI_{it-l} + \Delta u_{it}$	7.81654[b]	0.39797	FDI ⟹ R&D
	$\Delta FDI_{it} = \sum_{l=1}^{m} \alpha_j \Delta FDI_{it-l} + \sum_{l=1}^{m} \beta_j \Delta R\&D_{it-l} + \Delta \varepsilon_{it}$	2.70283	0.33244	FDI ⟹/ R&D

Notes: b is meaningful at %5 significance level. Lags of dependent and independent variables were taken as 2 in the GMM estimations. Instrumental variables used in the GMM estimations are lags of level values of dependent and independent variables from 2 to 5. Δ represents difference operator.

Table 2: *Results for Panel Causality Test*

As it is seen in Table 2, Wald statistics is meaningful both for EU 15 and EU 27 in the estimations of the equations where R&D is dependent variable. This result points out one-way causality relationship from FDI to R&D. According to the estimation results presented in the appendix, the FDI coefficients have positive signs which means that FDI have positive effect on R&D. Small values of the coefficients can be interpreted as weak relationship. The coefficients of the estimations made for EU 15 being higher than EU 27 means that relationship is more powerful in the sense of EU 15. Moreover, significance levels of sargan test put forward that instrumental variables used in the GMM estimations are valid.

5. Concluding remarks

Endogenous growth theories have been put forward in 1980's. Technological development, R&D, human capital, background information and distribution have reached basic factors of production together with endogenous growth theories. Therefore, technological development and R&D activities becoming an important determinant in competitiveness of firms and growth of national economy resulted in increase of investments towards these in the level of both firm and country.

Increasing importance of R&D activities impelled countries towards different strategies for increasing R&D activities. In this sense, many countries regard FDI as an important factor which increases R&D activities. For example, FDIs may have important contributions to R&D activities in host country through technology transfer and spillover effects. Moreover, foreign firms which get into national economy with FDIs enable usage of resources more efficiently by increasing competitiveness environment in the country. Competitiveness which increases due to foreign firms impel domestic firms to carry out more R&D activities. FDI can

also have negative effects apart from positive ones which contribute to national economy and R&D activities. For example, domestic firms may not enter into competition with FDIs and prefer purchasing manufacturing technology and therefore cause national R&D investments to decrease. Similarly, foreign firms which make investments in the country prefer using technology of partner company and decide not to make R&D activities.

Liberalization of international capital mobility and globalization of financial markets in recent years resulted in increase of interest towards FDIs which are thought to have contribution in R&D activities. Especially developing countries regard FDIs as an important tool both in meeting their technological deficits and increasing R&D activities. Today countries evaluate economic integration as an alternative in attracting more FDI. More clearly, economic integrations result in scale economy with expanding market opportunities and causes increase of FDI inflows of countries both within and out of integration.

This study aims to put forward the kind of relationship between FDI and R&D and EU which is accepted as the most advanced integration. In this sense, it was analyzed through dynamic panel causality test whether FDI and R&D are complement or substitute of each other in EU 15 and EU 27. According to panel causality tests, while there was no relationship from R&D variable towards FDI variable both for EU 15 and EU 27; there was one way and statistically meaningful causality relationship from FDI towards R&D. That the coefficients of related FDI variables have positive signs can be interpreted as that there is a complementary relationship between FDI and R&D in the sense of EU. However, small values of these estimation coefficients points out to weak complementary relationship between FDI and R&D. On the other hand, Coefficients of estimations made for EU 15 being higher than EU 27 means that relationship is more powerful in the sense of EU 15. Recent developments in 2004 and 2007 which include transition economies (apart from Malta and Cyprus) and inclusion of small countries in EU both in the sense of population and economy can be effective in these findings.

As a result findings put forward positive and one-way causality relation from FDI to R&D in EU countries. FDI made in EU countries have positive effects on R&D activities in these countries. This study may have contribution to literature in the sense of future researches for applying different econometric methods on various country groups.

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APPENDIX

Independent Variables	Dependent Variables			
	EU 15		EU 27	
	ΔRD	ΔFDI	ΔRD	ΔFDI
ΔRD(-1)	0.98752[a]	-1.62323	1.11264[a]	24.93975
ΔRD(-2)	-0.08050	-9.02578	-0.15797	-18.59077
ΔFDI(-1)	0.00093	-0.22895	0.00070	0.45957
ΔFDI(-2)	0.00351[b]	0.24564	0.00269[b]	0.59864[c]
Wald Test χ2 Statics	6.62022[b]	3.29655	7.81654[b]	2.70283
Sargan P-Value	0.32090	0.29297	0.39797	0.33244

Notes: a, b and c, respectively, is meaningful at %1, %5 and %10 significance level. Δ represents difference operator.

Appendix 1: *Results for Panel Causality Test*