TRACK 4: FDI in and from emerging market economies

Session Format: Competitive

Foreign Direct Investment and Innovation in Emerging European Countries

A paper proposal for the 41st EIBA Annual Conference

December 1-3, 2015

Abstract

Since 1990s, the group of Central and Eastern European countries, after a successful transformation from planned to market economies, have become attractive places for location of FDI because they have speeded up their development processes and have been regarded as emerging markets. Among positive and negative effects of FDI inflows, the interrelationship between FDI and innovation has been of growing importance.

The objective of this paper is to study the relationship between inward FDI and innovation performance of these emerging European countries in 2001-2013. The main hypothesis is based on theoretical assumptions that this relationship is bi-directional. On the one hand, innovation performance of a host country can be a determinant of FDI. On the other hand, FDI may shape innovation performance of the host economy. In order to examine these causal relationships between inward FDI and innovation in emerging European countries measured by total and PCT patent applications, industrial design and trademarks we use Granger Causality test taking into account time lags of 2, 3 and 4 years. The results show one- or a bi-directional Granger Causation between FDI and innovation depending on: 1) a variable used as a proxy for innovation and 2) time lags taken into account.

FDI and Innovation in Emerging European Countries

Introduction

Since the beginning of the transition process in 1990s of the countries from the Central and Eastern Europe, the inflow of foreign direct investment to this region, as well as outflows of local capital abroad, have been continuously increasing. Foreign investors were attracted to (EU11[i], i.e. Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia) countries, not only because of their GDP growth and growing, promising, markets, but also by their membership in the European Union.

By 2013, FDI stock in the EU11 reached €571 billion. Since the first wave of the EU's eastward enlargement in 2004, around €30 billion (up to €50 billion) has been invested in the region every year, but the global financial crisis caused a huge slowdown in inward FDI flows to EU11 countries. This trend has reversed since 2012.

In 2013, in the region of EU11, four countries were the major recipients of FDI; namely, Poland (31.63%), the Czech Republic (17.06%), Hungary (13.93%) and Romania (10.61%). In 2013, the share of these four countries in the total FDI stock in EU11 constituted 73.2%.

Inflows and inward stocks of FDI are an important indicator of a country's ability to attract foreign resources, which it can then employ for building national competitiveness. Foreign companies can be attracted to a specific location by natural resources, the size and growth of a market, gains in efficiency, or the presence of strategic assets, such as qualified labor or technology (Dunning, 1988; Dunning, Lundan, 2008; Mathew, Mukherjee, 2014). This means that innovation performance of a host country can be a determinant of inward FDI.

On the other hand, according to the theory, FDI inflows have some important consequences for host country competitiveness injecting not only financial resources, but also new technology, organizational methods and, know-how. The competitiveness of the host economy, can be

improved by inflowing foreign direct investments chiefly by 1) more efficient production, 2) improvement and innovation in produced output (e.g., quality), production processes and organizational structures, 3) more efficient allocation of factors of production, 4) introduction to new markets, and 5) more efficient and more expedient responsiveness of the host to changes in global demand and supply framework (Dunning, Lundan, 2008). Impacts on the host country clearly depend on such things as the part of the value chain that is "exported" to the host, size of the host, its stage of development, industrial structure as well as the type of foreign direct investment.

When discussing the impact of FDI, it is very important to note that many researchers have pointed out the disconnect between the theory that predicts positive economic effects of FDI in a host country and empirical studies, which have failed to deliver conclusive evidence that would be in line with the theory. It is equally important to understand the notion that the economy as a whole is not impacted equally by inflow of foreign investments and that such effects are not always positive from the get-go (McGrattan, 2011, p. 1).

As much as the subject of the general impact of inward FDI on economic growth of the host is a widely cover topic, studies on its impact on the innovation of the host economy are much less common (issue also noticed in ECR, 2012, p. 140). Therefore, this paper aims to study the interrelationship between inward FDI flows and stocks and innovation.

There are a few questions that need to be answered, which relate to an existence of a causal relationship between innovation and inward FDI. Does it exist in the region of EU11? Is it bi-directional or one-directional? Does it depend on the time lag between a cause and an effect?

In order to answer these question we use Granger Causality and examine causal relationships between inward FDI and innovation performance of emerging European countries. We test this relationship taking into account time lags between a cause and an effect. We assume that there can be time lags of two, three or four years. As a proxy for innovation performance we follow

the relevant literature (e.g. Griliches, 1998; Nagaoka, et al., 2010; EC, 2013; Flikkemaa, et al., 2014) and use measures describing the intellectual property protection: total and PCT patent applications, industrial design, and trademarks.

Setting the scene: a literature review and research hypothesis

According to the theory, there is a two-way relationship between FDI and innovation. On the one hand, innovation can be a determinant of FDI (Dunning, 1988; Dunning, Lundan, 2008), while on the other, FDI can shape innovation performance of the host country (Dunning, 1994; Lipsey, 2002). The majority of empirical studies devoted to FDI and innovation interrelationship focus on the impact of FDI on innovation, while innovation performance of the host country as the FDI determinant has not been studied empirically very often. Nevertheless, as it has been already pointed out, theoretical concepts assume the two-way relationship between innovation and FDI; therefore, it will be verified in our study if this bi-directional causal link existed for the EU11 countries in the period of 2001-2013.

There are two strands of economic literature devoted to FDI and innovation interrelationship in the host country. The one is related to FDI determinants, investigating, whether, and to what extent, innovation can be a factor attracting foreign investment. The other is focused on the impact of FDI on innovation performance of host countries.

When it comes to innovation as a factor attracting FDI inflow, it should be pointed out that both theoretical and empirical literature suggests that innovation performance of the host country can be a factor attracting strategic-asset seeking investment (Dunning, Lundan 2008). Technology variables as FDI determinants were introduced by Narula and Wakelin (1997) in their study of U.S. FDI in selected industrialized economies. They used patents in order to measure the importance of technological capabilities of host and home countries in attracting FDI (Narula, Wakelin, 1997, p. 11). Innovation and knowledge base was found as a determinant of FDI located in knowledge-intensive activities (Narula, Bellak, 2009; Hall, 2011). According

to Hall (2011) host country knowledge base measured the quality and specialization of local research organizations and universities as well as availability of local engineers are important determinant of FDI located in research and development oriented activities.

The importance of innovation as a factor attracting FDI differs across industries. Human capital and the quality of research infrastructure have been found to be particularly important in pharmaceuticals (Serapio, Dalton, 1999; Abramowsky et al., 2007).

Villaverde and Maza in their recent study of 260 EU NUTS2 regions, (2015, p. 218) conclude that technological progress (which the authors qualified as resource/asset-seeking) is a factor that significantly determines the location of FDI. However, it needs to be noted that this factor contains such variables as: R&D investment, R&D personnel, high-technology sector and human capital (Villaverde, Maza, 2015, p. 214). It is worth mentioning that the use of innovation (especially its output measures) is becoming absent from the literature with most of it focusing on the impact of FDI on innovation.

The second strand of the economic literature, which is related to the interrelationship between FDI and innovation focuses on the impact of inward FDI on innovation performance of a host country. Innovation in a host country can happen when an entire value chain is being transferred to the host (i.e., horizontal FDI) and through forward and backward linkages (i.e., vertical FDI) (see: ECR, 2012, pp. 138, 141; Smarzynska-Javorik, 2004). Therefore, transfers of knowledge and technology can occur through two general channels: directly through ownership and indirectly through spillovers (Damijan, et al., 2013, p. 896).

Examining the impact of FDI on innovation, it should be noted that FDI does not only comprise of financial activities but also of a set of assets, such as technology, knowledge, management and organizational practices. The complexity of the FDI package means that there can be trade-offs between different FDI effects, both static and dynamic. The impact of foreign firms on a host country's competitiveness and its economic development has been studied since the 1980s

and the results confirm that FDI and the host country's economic performance are interrelated and can be both, positive and negative (Ozawa, 1979; Dunning, Narula, 2004; Lipsey, 2002).

All studies confirmed that FDI inflow can shape the current competitive position of a host country by adding new resources, increasing competition or creating different technology and learning spillovers. FDI may have an impact on country's productivity through technology transfers, innovative activities of foreign firms undertaken on host markets as well as other positive or negative external effects on domestic firms through corporate linkages, which appear as a result of demonstration, competition and/or cooperation (Lipsey, 2002; Keller, 2009; Radosevic, Kaderabkova, 2011; Narula, 2011; Garcia, et al., 2013; Crescenzi, et al., 2015).

A positive relationship between FDI activity and innovation is found by Li, et al., (2013) in their study conducted on Chinese firms. To be more specific, the authors conclude that innovation at the national and subnational level improves with a growing presence of knowledge spillovers coming from FDI activity (Li, et al., 2013, p. 432). The positive impact of FDI on innovation (in addition to economic growth, labor productivity) has also been confirmed by D. Wang et al., (2013, p. 462) when examining 287 Chinese cities. Vahter (2010, pp. 29-30), who in his study focused on Estonia, finds evidence for the existence of positive spillovers on process innovation coming from a higher rate of FDI, while at the same time noting that these effects will, like discussed in the previous section, take time to manifest, i.e., they cannot be observed in short-term productivity growth. On a broader scope, Telatar et al., (2014, p. 113) have found that inward FDI activity in the EU economies has a positive impact of R&D activities in these economies. Some other studies proved that technology transfers occurred through FDI, however local absorptive capacity was found to be more important for innovation (Weresa, 2004).

The effect of FDI on innovation does not have to be positive. When studying German enterprises, Stiebale and Reize (2011, p. 165) found that FDI via acquisition has a large and a negative effect on the probability to engage in R&D activities in the acquired company, which may be the result of, e.g., relocation of R&D activities. At the same time, the authors do not claim that FDI and MNEs activity hamper the innovation process, but what they are highlighting is that, from the policy point of view, greenfield investments should be favored over M&A activity. The negative relation between inward FDI activity and innovation may be a result of the fact that "most innovation in developing countries may actually be imitation or adaptive in nature" (Schneider, 2005, p. 543) (also see Branstetter, 2006) and that knowledge spillovers enjoyed by these economies are no "true knowledge spillovers." Another research in this vein is the study conducted by García, et al., (2013, p. 242), where authors find that inward FDI activity is negatively related to the level of innovation displayed by local firms as measured by ex post patent applications (also used in this study). To explain these results, the authors suggest that home firms do not rely on host (Spanish in this case) firms for their innovation, but either shift these activities to a non-host location (a possibility mentioned earlier) or bring innovation with them. This scenario is also discussed by Melnyk, et al., (2014, p. 19), where authors say that if MNE brings R&D, then the host economy will benefit via spillovers, but if R&D is located in a different economy, then FDI can actually negatively impact job placements of highly-qualified/educated researchers, which can lead to a domestic brain drain.

As this review shows, the impact of FDI on innovation is ambiguous and it is even hard to make a general statement in regards to its direction (unlike in the case of its impact on host's GDP) as even in the developed economies (e.g., Germany) this impact can be negative, while being positive in the catching-up economies (e.g., China).

Based on the above literature review, the empirical section of this paper (which is to follow) will test the hypothesis saying that in the 21st century, the level of innovation in the new EU

member states from the Central and Eastern Europe economies was impacted (i.e., caused) by inward foreign direct investment allocated in those economies. Although it is clear, we do not test the direction of this impact, nor do we dare to claim its size.

Testing the causality: empirical results

The goal of this part of the paper is to confirm the causal relationship from inward FDI to innovation "produced" in the host economies, which was discussed earlier. To do so, the Granger Causality test will be implemented.

The following economies have been selected for the analysis: Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania and Slovakia, i.e. new EU member states from the Central and Eastern Europe. This group has been dubbed EU11 and usually includes Slovenia as well. However, because there was no newest (2012 and 2013) data available for Slovenia's patents in the WIPO database, we have decided to exclude it from this study.

The study looks at data from 2001 to 2013. The selection of the presented timeframe was guided with the maximization of the number of observations in our panel dataset.

Inward FDI defined according to UNCTAD (2015a) can be measured in two different ways (i.e., flows and stock), both of which, due to their nature (i.e., composition) can interact differently with the innovation in the host economy. Therefore, we decided to include both of those measures.

Data on the following variables has been collected:

1. Inward FDI flows (IFDIF), which is measured in U.S. Dollars at current prices and current exchange rates in millions and has been obtained from UNCTAD (2015e)
2. Inward FDI stock (IFDIS), which is measured in U.S. Dollars at current prices and current exchange rates in millions and has been obtained from UNCTAD (2015e)

3. Total patent applications (PATENTS_TOTAL), for which the data has been obtained from WIPO (2015e)
4. Total trademark applications (TM_TOTAL), for which the data has been obtained from WIPO (2015e)
5. Total industrial design application (IND_DES), for which the data has been obtained from WIPO (2015e)
6. PCT applications (PCT), for which the data has been obtained from WIPO (2015e)

The patent applications (total and PCT), trademarks and industrial design have been defined according to WIPO (2015a; 2015b; 2015c; 2015d).

The first step in the analysis of a causal relationship (per Granger, 1969, p. 429) is to test all variables for individual (Im, Pesaran and Shin W-stat, ADF-Fisher Chi-square and PP-Fisher Chir-square testes) and common roots (Levin, Lin and Chu test) and if needed corrected in order to achieve stationarity by differencing. The results of a set of tests for stationarity show that IFIDF (Table 1), IND_DES (Table **3**) and PATENTS_TOTAL (Table 4) do not have to be differenced, while the remaining variables (IFDIS – Table 2; PCT – Table 5; TM_TOTAL – Table 6) need to have their first differences, D(X), taken in order to eliminate the unit root. Now, because all of the used series are stationary, they can be used in a study of a causal relationship between both measures of inward FDI and the selected measures of innovations.

The second step is the a set of tests for Granger causality with the null of H_0 : X_{it} *does not Granger Cause* Y_{it} with the alternative that $X_{it} \rightarrow Y_{it}$. We say that X_{it} Granger Causes Y_{it} if "we are better able to predict [Y_{it}] using all available information than if the information apart from [X_{it}] had been used" (Granger, 1969, p. 428). Despite the fact that innovation output is not often used as a determinant of inward FDI, we allow for a possibility for feedback where $X_{it} \rightarrow Y_{it}$ and $Y_{it} \rightarrow X_{it}$ (see Granger, 1969, p. 428).

We are aware that the literature (both, theoretical – Hurlin, Dumitrescu, 2012 – and empirical – Tekin, 2012) has introduced and used the notion of heterogeneity when it comes to testing for causality in a panel setting. Because we are interested in the relationships for the studied group as a whole (i.e., we are not interested in cross-section specific effects), we treat the entire data set as stacked and allow for coefficients in regressions ran for our panel data to be the same across all cross-sections. In other words, we carry out the Granger Causality test regularly while not allowing data from one cross-section enter lagged values of data from the next one. In order to make sure that our results do not vary with the number of lags selected, we run the Granger Causality tests for the time lags of 2, 3, and 4 years.

At a 5% level of significance, the results show that there is a bi-directional Granger Causation between industrial design and inward FDI flows and a one-directional one (from IND_RES to IFDIS) in terms of inward FDI stock (Table 7). These results stay consistent when we increase lags to 4, but when lags are set at 3, there is no Granger Causality from IFDIF to IND_DES. However, given that the p-value for that pair is less than 0.1 (0.0869), we say that the results for the IFDIF-IND_DES and IFDIS-IND_DES pairs do not vary with the number of lags. The situation for patent applications (Table 8) is a bit different. For lags = 2, the results lead to the same conclusions as for IND_DES, but if more lags are introduced, additionally the null hypothesis of inward FDI stock not Granger Causing patent applications is rejected. When looking PCT (Table 9), both inward FDI flows and stock do Granger Cause PCT and this relationship is one-directional only and these results stay constant for 3 and 4 lags. Lastly, it has been found that with 2 lags, the only Granger Causality relationship between inward FDI measures and trademark application is from inward FDI stock to trademark applications (Table 10). For 3 lags, there is also evidence of TM_TOTAL Granger causing IFDIS, which becomes less significant (p-value decreases from 0.0046 to 0.0876) for 4 lags.

Above observations fall in line with the presented literature, i.e. they support the stated research hypothesis that inward FDI activity into New EU Member States from the Central and Eastern Europe studied impacts innovation in these host countries. In addition, the results show that a) the impact is not simultaneous and that b) it can be one- (e.g., IFDIF-PCT and IFDIS-PCT) and bi-directional (e.g., IFDIF-PATENTS_TOTAL and IFDIS-PATENTS_TOTAL).

Conclusion

The goal of this paper was to confirm the hypothesis that there exists a causal relationship between inward FDI activity (measured here as both, flows and stock) and innovation (expressed as patent applications, industrial design, PCT and trademarks applications) in the new EU member states from the Central and Eastern Europe represented by Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania and Slovakia. The first tool used in the process of confirming this hypothesis was an extensive literature study, which lead to a conclusion that such a causal relationship is not always present, and when is, it can be either positive or negative. Therefore, we can say that the stated hypothesis has been confirmed on both, the theoretical and previous-empirical levels, which set the framework for the second part, i.e. the test for Granger Causality between the tested concepts. The results of the said analysis fall well in line with those suggested by the literature. In addition, they show that the causality can differ based on the variable used to represent innovation; e.g. there is not Granger Causality from inward FDI stock to industrial design applications, but there is to PCT patent applications. Also, the type of the causal relationship (one- or bi-directional) depends on the pair of variables used (see PCT and patent applications accordingly). Bi-directional Granger Causation appears between inward FDI flows and industrial design as well as between both inward FDI flows and stock and patent applications, but in the latter case only for very short lags (2 years). A one-directional Granger Causation has been proved between inward FDI stocks and patent applications (both total and PCT patents) regardless of the time lags taken

into account. Lastly, it has been found that with time lag of 2 years, the only Granger Causality relationship between inward FDI measures and trademark application is from inward FDI stock to trademark applications. Lastly, we see a difference between the relationship between inward FDI as measured by flows and stock (e.g., see trademarks).

Overall, the empirical part of our study also confirms our hypothesis.

Further research on the topic of the relationship between inward FDI and innovation output could focus on using the latter as a determinant of the prior to see at what stage of development host economies become attractive for foreign investors due to their innovation capabilities as measured by innovation output.

References

Abramowsky, L., R. Harrison, Simpson, H., (2007), *University Research and the Location of Business R&D*, The Economic Journal, No. 117.

Böheim M., Reinstaller A., Unterlass F., (2009), *Sectoral Innovation Modes and Innovation Policy: Implications for the New member States*, Paper presented at the workshop Innovation for Competitiveness INCOM Prague / 22.1. – 23.1. 2009

Crescenzi R., Gagliardi L.,Iammarino S. (2015), *Foreign multinationals and domestic innovation: Intra-industry effects and firm heterogeneity*, Research Policy, No. 44.

Damijan, J.P., Rojec, M., Majcen, B., Knell, M., (2013), *Impact of Firm Heterogeneity on Direct and Spillover Effects of FDI: Micro-evidence from Ten Transition Countries*, Journal of Comparative Economics, Vol. 41.

Dunning J., (1988), *Multinationals, Technology and Competitiveness*, London: Unwin Hyman.

Dunning J.H. and Narula R., (2004), *Multinational and Industrial Competitiveness: A New Agenda*, Cheltenham: Edward Elgar.

Dunning, J., Lundan, S., (2008), *Multinational Enterprises and the Global Economy*, Edward Elgar Publishing, Cheltenham.

EC, (2013), *Innovation Union Scoreboard 2013*, http://ec.europa.eu/enterprise/policies/innovation/facts-figures-analysis/innovation-scoreboard/index_en.htm.

ECR, (2012), *European Competitiveness Report 2012. Reaping the Benefits of Globalization*, European Union, Luxembourg.

Flikkemaa M., De Mana A-P, Castaldi C., (2014), *Are Trademark Counts a Valid Indicator of Innovation? Results of an In-Depth Study of New Benelux Trademarks Filed by SMEs*, Industry & Innovation, Vol. 21, No. 4.

García F., Jin B., Salomon R., (2013), *Does inward foreign direct investment improve the innovative performance of local firms?*, Research Policy, No. 42.

Granger, C.W.J., (1969), *Investing Causal Relationships by Econometric Models and Cross-spectral Methods*, Econometrica, Vol. 37, No. 3.

Griliches Z. (1998), *Patent Statistics as Economic Indicators: A Survey*, in: Z. Griliches (ed.) R&D and Productivity: The Econometric Evidence.

Hall B.H., (2011), *The internationalisation of R&D*, UNU-MERIT Working Paper Series N°049, United Nations University, Maastricht.

Hurlin, Ch., Dumitrescu, E., (2012), *Testing for Granger Non-causality in Heterogeneous Panels*, Economic Modeling, Vol. 29. No. 4.

Keller W., (2009), *International Trade, Foreign Direct Investment, and Technology Spillovers*, NBER Working Papers, No. 15442, 2009, http://www.nber.org/papers/w15442

Kuzel M., (2007), *Rola bezpośrednich inwestycji zagranicznych w dyfuzji wiedzy i umiejętności na przykładzie gospodarki Polski*, Wydawnictwo „Dom Organizatora", Toruń.

Li, J., Chen, D., Shapiro, D.M., (2013), *FDI Spillovers at the National and Subnational Level: The Impact on Product Innovation by Chinese Firms*, Management and Organization Review, Vol. 9, No. 3.

Lipsey, R.E., (2002), *Home and Host Country Effects of FDI*, National Bureau of Economic Research, Working Paper No. 9293, http://www.nber.org/papers/w9293

Lipsey, R.E., (2006), *Measuring the Impacts of FDI in Central and Eastern Europe*, National Bureau of Economic Research, Working Paper No. 12808 http://www.nber.org/papers/w12808.

Mathew A.J., Mukherjee A., (2014), *Intellectual property rights, southern innovation and foreign direct investment*, International Review of Economics and Finance, No. 31.

McGrattan, E.R., (2011), *Transition to FDI Openness: Reconciling Theory and Evidence*, NBER Working Paper 16774

Melnyk, L., Kubatko, Pysarenko, S., (2014), *The Impact of Foreign Direct Investment on Economic Growth: Case of Post Communism Transition Economies*, Problems and Perspectives in Management, Vol. 12.

Mencinger, J., (2003), *Does Foreign Direct Investment Always Enhance Economic Growth?* Kyklos, Vol. 56(4), 2003.

Nagaoka, S., Motohashi, K., Goto, A., (2010). *Patent Statistics as an Innovation Indicator*, in: B.A. Hall, N. Rosenberg, N. (eds.), Handbook of the Economics of Innovation, Vol. 2, Amsterdam: Elsevier.

Narula, R., Wakelin, K., (1997), *The Pattern and Determinants of US Foreign Direct Investment in Industrialised Countries*, Maastricht University, Maastricht Economic Research Institute on Innovation and Technology, http://digitalarchive.maastrichtuniversity.nl/fedora/objects/guid:3b609a52-39d8-4cb4-95e4-d63c8c73e91a/datastreams/ASSET1/content

Narula R., Bellak C., (2009), *EU enlargement and consequences for FDI assisted industrial development*, Transnational Corporations, Vol. 18, No. 2.

Narula R., (2011), *Attracting and Embedding R & D in Multinational Firms: Policy Options for EU New Member States*, in: Radosevic S. Kaderabkova A., *Challenges for European Innovation Policy*, E. Elgar.

OECD, (2001), *Growth, Technology Transfer and Foreign Direct Investment*, paper for the OECD Forum on International Investment, Mexico City, 26-27 November 2001.

Ozawa T., (1979), *International Investment and Industrial Structure: New Theoretical Implications from the Japanese Experience*, Oxford Economic Papers, New Series, Vol. 31, No. 1, 1979.

Schneider, P.H., (2005), *International Trade, Economic Growth and Intellectual Property Rights: A Panel Data Study of Developed and Developing Countries*, Journal of Development Economics, Vol. 78.

Serapio M., Dalton D., (1999), *Globalisation of Industrial R&D: An Examination of Foreign Direct Investments in R&D in the United States*, Research Policy, No. 28.

Smarzynska-Javorcik, B., (2004), *Does Foreign Direct Investment Increases the Productivity of Domestic Firms? In Search of Spillovers through Backward Linkages*, American Economic Review, Vol. 94, No. 3.

Stiebale, J., Reize, F., (2011), *The Impact of FDI through Mergers and Acquisitions on Innovation in Target Firms*, International Journal of Industrial Organization, Vol. 29.

Tekin, R.B., (2012), *Economic growth, exports and foreign direct investment in Least Developed Countries: A Panel Granger Causality Analysis*, Economic Modeling, Vol. 29.

Telatar, O.M., Gnec, M.C., Keser, H.Y., Ay, S., Deger, M.K., (2014), *The Causality Relationship between FDI and R&D in European Union*, Journal of Economic and Social Development, Vol. 1, No. 1.

UNCTAD, (2015a), *Sources and definitions*, Access date: 27-APR-2015, http://unctad.org/en/Pages/DIAE/FDI%20Statistics/Sources-and-Definitions.aspx

UNCTAD, (2015b), *UNCTADSTAT*, Access date: 25-APR-2015, http://unctadstat.unctad.org/wds/ReportFolders/reportFolders.aspx?sRF_ActivePath=P,5,27&sRF_Expanded=,P,5,27

Vahter, P., (2010), *Does FDI Spur Innovation, Productivity and Knowledge Sourcing by Incumbent Firms? Evidence from Manufacturing Industry in Estonia*, William Davidson Institute Working Paper 986, April 2010.

Villaverde, J., Maza, A., (2015), *The Determinants of Inward Foreign Direct Investment: Evidence from the European Regions*, International Business Review, Vol. 24.

Wang, D.T., Gu, F.F., Tse, D.K., Yim, C.K., (2013), *When Does FDI Matter? The Roles of Local Institutions and Ethnic Origins of FDI*, International Business Review, Vol. 22.

Weresa M. A., (2004), *Can foreign direct investment help Poland catch up with the EU?*, Elsevier B.V, Communist and Post-Communist Studies, No. 37.

WIPO, (2015a), *Patents*, Access date: 27-APR-2015, http://www.wipo.int/patents/en/

WIPO, (2015b), *Trademarks*, Access date: 27-APR-2015, http://www.wipo.int/trademarks/en/

WIPO, (2015c), *Industrial Designs*, Access date: 27-APR-2015, http://www.wipo.int/designs/en/

WIPO, (2015d), *PCT – The International Patent System*, Access date: 27-APR-2015, http://www.wipo.int/pct/en/

WIPO, (2015e), *WIPO IP Statistics Data Center*, Access date: 26-APR-2015, http://ipstats.wipo.int/ipstatv2/

Table 1. Unit root test for inward FDI flows (IFDIF) in levels

Panel unit root test: Summary				
Series: IFDIF				
Sample: 2001 2013				
Exogenous variables: Individual effects				
User-specified lags: 1				
Newey-West automatic bandwidth selection and Bartlett kernel				
Balanced observations for each test				
Method	Statistic	Prob.**	Cross-sections	Obs.
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-2.90514	**0.0018**	10	110
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-2.06586	**0.0194**	10	110
ADF - Fisher Chi-square	32.1669	**0.0416**	10	110

PP - Fisher Chi-square	36.1811	**0.0146**	10	120
** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.				

Source: Own table based on data from UNCTAD (2015b) and WIFO (2015e). Calculations conducted with EViews 8 software.

Table 2. Unit root test for inward FDI stock (IFDIS) in levels and in first differences

Panel unit root test: Summary				
Series: IFDIS				
Sample: 2001 2013				
Exogenous variables: Individual effects				
User-specified lags: 1				
Newey-West automatic bandwidth selection and Bartlett kernel				
Balanced observations for each test				
Method	Statistic	Prob.**	Cross-sections	Obs.
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-3.25399	**0.0006**	10	110
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	0.56228	0.7130	10	110
ADF - Fisher Chi-square	12.5576	0.8955	10	110
PP - Fisher Chi-square	19.8979	0.4643	10	120
** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.				

Panel unit root test: Summary				
Series: D(IFDIS)				
Sample: 2001 2013				
Exogenous variables: Individual effects				
User-specified lags: 1				
Newey-West automatic bandwidth selection and Bartlett kernel				
Balanced observations for each test				
Method	Statistic	Prob.**	Cross-sections	Obs.
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-4.04866	**0.0000**	10	100
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-2.34264	**0.0096**	10	100
ADF - Fisher Chi-square	34.4236	**0.0234**	10	100
PP - Fisher Chi-square	63.9313	**0.0000**	10	110
** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.				

Source: Own table based on data from UNCTAD (2015b) and WIFO (2015e). Calculations conducted with EViews 8 software.

Table 3. Unit root test for Industrial Design (IND_DES) in levels

Panel unit root test: Summary		
Series: IND_DES		

Sample: 2001 2013				
Exogenous variables: Individual effects				
User-specified lags: 1				
Newey-West automatic bandwidth selection and Bartlett kernel				
Balanced observations for each test				
Method	Statistic	Prob.**	Cross-sections	Obs.
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-5.39983	**0.0000**	10	110
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-1.94796	**0.0257**	10	110
ADF - Fisher Chi-square	32.4818	**0.0384**	10	110
PP - Fisher Chi-square	38.9787	**0.0067**	10	120
** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.				

Source: Own table based on data from UNCTAD (2015b) and WIFO (2015e). Calculations conducted with EViews 8 software.

Table 4. Unit root test for patent application (PATENTS_TOTAL) in levels

Panel unit root test: Summary				
Series: PATENTS_TOTAL				
Sample: 2001 2013				
Exogenous variables: Individual effects				
User-specified lags: 1				
Newey-West automatic bandwidth selection and Bartlett kernel				
Balanced observations for each test				
Method	Statistic	Prob.**	Cross-sections	Obs.
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-14.6349	**0.0000**	10	110
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-6.63835	**0.0000**	10	110
ADF - Fisher Chi-square	73.6019	**0.0000**	10	110
PP - Fisher Chi-square	40.9412	**0.0038**	10	120
** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.				

Source: Own table based on data from UNCTAD (2015b) and WIFO (2015e). Calculations conducted with EViews 8 software.

Table 5. Unit root test for PCT (PCT) in levels and in first differences

Panel unit root test: Summary				
Series: PCT				
Sample: 2001 2013				
Exogenous variables: Individual effects				
User-specified lags: 1				
Newey-West automatic bandwidth selection and Bartlett kernel				
Balanced observations for each test				
Method	Statistic	Prob.**	Cross-sections	Obs.
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	1.44893	0.9263	10	110

Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	2.00750	0.9777	10	110
ADF - Fisher Chi-square	10.2573	0.9633	10	110
PP - Fisher Chi-square	26.4975	0.1500	10	120
** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.				

Panel unit root test: Summary				
Series: D(PCT)				
Sample: 2001 2013				
Exogenous variables: Individual effects				
User-specified lags: 1				
Newey-West automatic bandwidth selection and Bartlett kernel				
Balanced observations for each test				
Method	Statistic	Prob.**	Cross-sections	Obs.
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-5.05270	**0.0000**	10	100
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-6.13723	**0.0000**	10	100
ADF - Fisher Chi-square	72.4683	**0.0000**	10	100
PP - Fisher Chi-square	126.334	**0.0000**	10	110
** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.				

Source: Own table based on data from UNCTAD (2015b) and WIFO (2015e). Calculations conducted with EViews 8 software.

Table 6. Unit root test for trademark applications (TM_TOTAL) in levels and in differences

Panel unit root test: Summary				
Series: TM_TOTAL				
Sample: 2001 2013				
Exogenous variables: Individual effects				
User-specified lags: 1				
Newey-West automatic bandwidth selection and Bartlett kernel				
Balanced observations for each test				
Method	Statistic	Prob.**	Cross-sections	Obs.
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-2.24270	**0.0125**	10	110
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	1.06418	0.8564	10	110
ADF - Fisher Chi-square	11.0318	0.9454	10	110
PP - Fisher Chi-square	21.5020	0.3681	10	120
** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.				

Panel unit root test: Summary				
Series: D(TM_TOTAL)				
Sample: 2001 2013				

Exogenous variables: Individual effects				
User-specified lags: 1				
Newey-West automatic bandwidth selection and Bartlett kernel				
Balanced observations for each test				
Method	Statistic	Prob.**	Cross-sections	Obs.
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-5.60670	**0.0000**	10	100
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-3.34963	**0.0004**	10	100
ADF - Fisher Chi-square	46.4637	**0.0007**	10	100
PP - Fisher Chi-square	86.7380	**0.0000**	10	110
** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.				

Source: Own table based on data from UNCTAD (2015b) and WIFO (2015e). Calculations conducted with EViews 8 software.

Table 7. Granger Causality test between IFDIF, IFDIS and IND_DES

Pairwise Granger Causality Tests			
Sample: 2001 2013			
Lags: 2			
Null Hypothesis:	Obs.	F-Statistic	Prob.
IND_DES does not Granger Cause IFDIF	**110**	**10.8694**	**5.E-05**
IFDIF does not Granger Cause IND_DES		**3.00336**	**0.0539**
IND_DES does not Granger Cause D(IFDIS)	**100**	**17.8252**	**3.E-07**
D(IFDIS) does not Granger Cause IND_DES		1.43009	0.2444

Pairwise Granger Causality Tests			
Sample: 2001 2013			
Lags: 3			
Null Hypothesis:	Obs.	F-Statistic	Prob.
IND_DES does not Granger Cause IFDIF	**100**	**9.22872**	**2.E-05**
IFDIF does not Granger Cause IND_DES		2.25680	0.0869
IND_DES does not Granger Cause D(IFDIS)	**90**	**5.53668**	**0.0016**
D(IFDIS) does not Granger Cause IND_DES		1.97112	0.1246

Pairwise Granger Causality Tests			
Sample: 2001 2013			
Lags: 4			
Null Hypothesis:	Obs.	F-Statistic	Prob.
IND_DES does not Granger Cause IFDIF	**90**	**5.52936**	**0.0005**
IFDIF does not Granger Cause IND_DES		**2.53589**	**0.0463**
IND_DES does not Granger Cause D(IFDIS)	**80**	**7.02411**	**8.E-05**
D(IFDIS) does not Granger Cause IND_DES		1.44596	0.2279

Source: Own table based on data from UNCTAD (2015b) and WIFO (2015e). Calculations conducted with EViews 8 software.

Table 8. Granger Causality test between IFDIF, IFDIS and PATENTS_TOTAL

Pairwise Granger Causality Tests Sample: 2001 2013 Lags: 2			
Null Hypothesis:	Obs.	F-Statistic	Prob.
PATENTS_TOTAL does not Granger Cause IFDIF	**110**	**15.4302**	**1.E-06**
IFDIF does not Granger Cause PATENTS_TOTAL		**5.93983**	**0.0036**
PATENTS_TOTAL does not Granger Cause D(IFDIS)	**100**	**23.1314**	**7.E-09**
D(IFDIS) does not Granger Cause PATENTS_TOTAL		1.38620	0.2550
Pairwise Granger Causality Tests Lags: 3			
Null Hypothesis:	Obs.	F-Statistic	Prob.
PATENTS_TOTAL does not Granger Cause IFDIF	**100**	**9.78818**	**1.E-05**
IFDIF does not Granger Cause PATENTS_TOTAL		**6.60958**	**0.0004**
PATENTS_TOTAL does not Granger Cause D(IFDIS)	**90**	**8.80456**	**4.E-05**
D(IFDIS) does not Granger Cause PATENTS_TOTAL		**5.25612**	**0.0023**
Pairwise Granger Causality Tests Sample: 2001 2013 Lags: 4			
Null Hypothesis:	Obs.	F-Statistic	Prob.
PATENTS_TOTAL does not Granger Cause IFDIF	**90**	**7.77537**	**2.E-05**
IFDIF does not Granger Cause PATENTS_TOTAL		**15.8551**	**1.E-09**
PATENTS_TOTAL does not Granger Cause D(IFDIS)	**80**	**22.0305**	**7.E-12**
D(IFDIS) does not Granger Cause PATENTS_TOTAL		**4.20743**	**0.0041**

Source: Own table based on data from UNCTAD (2015b) and WIFO (2015e). Calculations conducted with EViews 8 software.

Table 9. Granger Causality test between IFDIF, IFDIS and PCT

Pairwise Granger Causality Tests Sample: 2001 2013 Lags: 2			
Null Hypothesis:	Obs.	F-Statistic	Prob.
D(PCT) does not Granger Cause IFDIF	100	0.67069	0.5138
IFDIF does not Granger Cause D(PCT)		**13.6434**	**6.E-06**
D(PCT) does not Granger Cause D(IFDIS)	100	0.92837	0.3988
D(IFDIS) does not Granger Cause D(PCT)		**3.77963**	**0.0263**
Pairwise Granger Causality Tests Sample: 2001 2013 Lags: 3			
Null Hypothesis:	Obs.	F-Statistic	Prob.
D(PCT) does not Granger Cause IFDIF	90	2.35042	0.0783
IFDIF does not Granger Cause D(PCT)		**6.76193**	**0.0004**
D(PCT) does not Granger Cause D(IFDIS)	90	0.86090	0.4648
D(IFDIS) does not Granger Cause D(PCT)		**3.54861**	**0.0179**
Pairwise Granger Causality Tests Sample: 2001 2013 Lags: 4			
Null Hypothesis:	Obs.	F-Statistic	Prob.
D(PCT) does not Granger Cause IFDIF	80	1.92292	0.1160
IFDIF does not Granger Cause D(PCT)		**4.75067**	**0.0019**
D(PCT) does not Granger Cause D(IFDIS)	80	1.60691	0.1820
D(IFDIS) does not Granger Cause D(PCT)		**2.98189**	**0.0246**

Source: Own table based on data from UNCTAD (2015b) and WIFO (2015e). Calculations conducted with EViews 8 software.

Table 10. Granger Causality test between IFDIF, IFDIS and TM_TOTAL

Pairwise Granger Causality Tests			
Sample: 2001 2013			
Lags: 2			
Null Hypothesis:	Obs.	F-Statistic	Prob.
D(TM_TOTAL) does not Granger Cause IFDIF	100	1.30272	0.2766
IFDIF does not Granger Cause D(TM_TOTAL)		2.11764	0.1260
D(TM_TOTAL) does not Granger Cause D(IFDIS)	100	0.99083	0.3751
D(IFDIS) does not Granger Cause D(TM_TOTAL)		**6.17943**	**0.0030**
Pairwise Granger Causality Tests			
Sample: 2001 2013			
Lags: 3			
Null Hypothesis:	Obs.	F-Statistic	Prob.
D(TM_TOTAL) does not Granger Cause IFDIF	90	1.18642	0.3200
IFDIF does not Granger Cause D(TM_TOTAL)		1.77537	0.1582
D(TM_TOTAL) does not Granger Cause D(IFDIS)	**90**	**4.67481**	**0.0046**
D(IFDIS) does not Granger Cause D(TM_TOTAL)		**5.10292**	**0.0027**
Pairwise Granger Causality Tests			
Sample: 2001 2013			
Lags: 4			
Null Hypothesis:	Obs.	F-Statistic	Prob.
D(TM_TOTAL) does not Granger Cause IFDIF	80	1.41245	0.2387
IFDIF does not Granger Cause D(TM_TOTAL)		1.62562	0.1773
D(TM_TOTAL) does not Granger Cause D(IFDIS)	80	2.11666	0.0876
D(IFDIS) does not Granger Cause D(TM_TOTAL)		**4.06996**	**0.0050**

Source: Own table based on data from UNCTAD (2015b) and WIFO (2015e). Calculations conducted with EViews 8 software.

[i] The EU11 group consists of 11 countries from Central and Eastern Europe that joined the EU in 2004 and later (the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia, Bulgaria and Romania, and Croatia).