Foreign Direct Investment (FDI) Spillovers in Visegrad Countries

Eristian Wibisono

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Eristian Wibisono[1,2,*]

[1]Doctoral School of Regional Policy and Economics, Faculty of Business and Economics, University of Pecs, Hungary

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[*]Corresponding author, e-mail: wibisono.tian@gmail.com

ABSTRACT

Macroeconomic and microeconomic literature has raised the impact of FDI knowledge and technology spillovers in the host economy. However, there is still a research gap in addressing this topic in the knowledge economy. Based on a comprehensive literature review, this paper demonstrates the performance of FDI spillovers and their impact on the productivity of domestic firms in emerging and transition economies in Europe. Poland is the largest country in the Visegrad group but provides limited studies on FDI experience. The paper then shows the geographic distribution of FDI across Polish regions, where the western and eastern regions appear very different. There is a significant positive impact of FDI presence on the productivity of foreign-affiliated domestic firms. Unfortunately, the presence of FDI in these regions is not significant enough to induce knowledge and technology spillovers to improve firm productivity. The effectiveness of FDI knowledge and technology in boosting the productivity of the local economy may be worth questioning. Therefore, comparable spatial studies are encouraged to be conducted in future research with a more complete and robust data structure which is recognized as a limitation of this study.

Keyword: FDI; knowledge and technology; spillovers; Visegrad; Poland; spatial dependencies

JEL codes: B27; E22; O52; R11; R12

I. INTRODUCTION

Foreign direct investment (FDI) plays an essential role in the transfer of knowledge and technology and the productivity of firms. More broadly, FDI helps host countries adapt and innovate to foreign technologies (Newman et al., 2015)**.** Many experts emphasize that technology transfer through FDI can help reduce companies' operating costs when they want to increase technological innovation, which usually requires high costs (Iwasaki & Tokunaga, 2016). Unfortunately, the impact of FDI-generated technology transfer on host economies is limited to typical spillover mechanisms or externality impacts of FDI firms (Marin & Bell, 2005). There are conditions where FDI affiliate firms cannot fully absorb and utilize all the impacts of new technology within the firm. This condition can result in technology spillovers to the external environment of local firms, which in turn can increase the productivity of local firms (Meyer & Sinani, 2002)**.**

The literature on the technology spillover effects from FDI firms to regional and local firms has been widely discussed. The two most common reasons why FDI technology transfer may occur are that foreign multinational corporations (MNCs) have more technological

advantages than local firms in the host country. The following reason is that technology transfer from FDI-affiliated firms to local firms is generally due to public interest reasons (Kokko et al., 2001). As many factors influence this process, the impact of FDI technology spillover can be both positive and negative on the host country's economy.

Studies on FDI spillovers in developing countries or countries with transition economies show considerable variation in terms of their spillover effects. The most dominant issue addressed in these studies is the company's absorption of FDI spillovers (Blomström & Kokko, 1996). Absorption capacity indicates the technology gap between FDI source firms and domestic firms. Its size should be at a moderate and balanced level, not too large and not too small (Blalock & Gertler, 2008; Kokko, 1994; Wang & Blomström, 1992). Kinoshita (2001) showed that domestic firms in the Czech Republic active in R&D activities get more benefits from FDI. This finding is similar to what happened in India, a developing country (Kathuria, 2000). However, Damijan et al. (2003) found some variation in the effect of R&D on FDI; positive relationship was detected in Slovakia and Hungary, while negative relationship was detected in Estonia and Latvia. Firm size is also an important determinant of FDI spillovers. However, research findings are still heterogeneous, as in several European countries such as Greece, Hungary, Estonia, and Spain (Amendolagine et al., 2013; Dimelis & Louri, 2004a; Sinani & Meyer, 2004).

Four countries in Europe that are members of the Visegrad group (V4), namely the Czech Republic, Hungary, Slovakia, and Poland, have recorded the performance of FDI in increasing the host country's economic growth. Studies on the factors that influence FDI and how FDI affects economic productivity in a country have been widely discussed in macroeconomic and microeconomic literature. However, discussing the study of FDI from the perspective of knowledge economics, innovation, and technology, still has a gap that is very likely to be filled. The literature finds that the first three countries have been widely discussed. However, one last country, Poland, presents limited information on the subject, which could be more questionable given that Poland is the largest of the three countries.

This paper aims to present evidence of the effect of FDI presence and knowledge and technology transfer on the productivity of domestic firms affiliated with foreign firms in the region of Visegrad countries. Furthermore, emphasizing a unique approach to spatial econometric analysis, the paper presents a geographical description of the observed variables across regions in Poland. This raises many questions about the role of FDI in the region in improving firm productivity, what factors influence it, and how it is spatially related to the surrounding regions. The results of this study show that firms' technology absorption proxied by R&D activity significantly affects the presence of FDI in the regions in Poland. The results also show that firms oriented towards international trade through exports significantly affect firm productivity. Unfortunately, the availability of data at the NUTS2 level for Poland is not strong enough to identify spatial effects.

This study contributes scientifically in three ways. First, the paper presents the comprehensive literature that presents findings on FDI spillovers, especially in the European region. Then it focuses on the regions of the Visegrad group countries. Second, a spatial econometric analysis approach is chosen to present the empirical evidence. Third, the paper raises many follow-up questions that may provide opportunities for other scholars to deepen the study of FDI spillovers in host countries in the Visegrad region. The limitations of this study in accessing data sources also encourage further research to work with a more solid amount and structure of data.

The rest of the paper is presented as follows. In the second section, the paper outlines the methodological approach and the data used. A comprehensive literature study on the existence and mechanism of technology spillovers in FDI firms is presented in the third section. Furthermore, empirical findings that support the literature review are presented in section four.

This section also outlines the spatial description and empirical testing of FDI spillovers and their impact on firm productivity. The last section discusses the findings, concludes, and provides recommendations.

II. METHODOLOGY

The four transition economies belonging to the Visegrad-4 group (Poland, Czech Republic, Hungary, and Slovakia) have attracted relatively sizeable foreign capital into the host economy in the last few decades. The presence of MNCs in the V4 economy has become such an important part of country-level policy discussions that many other transition economies have attempted to emulate this success (Buch et al., 2003; Carstensen & Toubal, 2004; Estrin & Uvalic, 2014; Yao & Wei, 2007a)**.** The influx of foreign capital into the V4 region is also considered one of the contributing factors to prosperity. One of the reasons is that cross-border technology transfer is associated with increasing the country's productivity and economic growth, as (Yao & Wei, 2007) and (Ford et al., 2008) stated. Although in the end, this impact is often weakened due to alleged profit outflows where MNCs repatriate most of their profits to their parent firms outside the country (Akkermans, 2017; Graham et al., 2011).

Studies on the impact of FDI spillovers at the beginning of the millennium show a positive effect of technology transfer due to the presence of FDI. However, to date, these findings are still very heterogeneous. For example, there is a negative impact the presence of an MNC has on the productivity of domestic firms. The source of heterogeneity in the results of this study arises because some studies use cross-sectional data while others use panel data. (Barrios et al., 2011) and (Aitken & Harrison, 1999) argue that the increase in firm productivity due to foreign technology spillovers is particularly appropriate when analyzed using panel data.

Damijan et al. (2013) comprehensively summarizes the three main analytical techniques for identifying FDI spillovers. Case studies and sectoral studies generally dominate the empirical analysis of FDI spillovers which mostly show positive effects. A third analytical technique that relies on panel data at the firm level has recently dominated the FDI abundance literature. The approach taken on this type of data is the regression of factors that affect FDI productivity by adding several control variables. Using this methodological approach, several later studies have shown doubts that FDI spillovers exist in developing countries, and if any, they are limited to certain types of industries. Empirical studies involving heterogeneous aggregations of firms or industries often find dead ends; no spillover effects or negative spillover effects are found. However, compiling a more homogeneous subset of firms makes the findings more encouraging (Görg & Greenaway, 2004). This reason then reinforces the importance of considering the effect of heterogeneity in empirical FDI studies.

Referring to the study conducted by Sinani & Meyer (2004), this paper aims to re-examine the hypothesis that there is an effect of FDI on the performance of domestic firms through the abundance of FDI knowledge and technology. There are three proxies for FDI spillovers suggested in the study. First is the share of workers in foreign firms (spillover through the labor channel). Second is the share of foreign capital (spillover through the equity channel). Third, the share of sales in foreign firms (spillover through sales channels).

In several studies, the identification of FDI spillover is proxied mainly by the share of employment in foreign firms and sales income in foreign firms. Due to data availability, this study can only identify FDI spillovers proxied using foreign capital variables from foreign-affiliated firms in Poland. Other research findings are also put forward to show that export-oriented foreign-affiliated domestic firms are better off with FDI and increase the productivity of domestic firms, as is the case in Estonia. In addition, knowledge and technology spillovers arising from research and development (R&D) activities are also raised to examine their influence on the presence of FDI and the productivity of domestic firms. The operationalization of these variables is presented in Table 1 below.

Table 1. Variable definition

Variables	Information
TOT_EMPL	Total number of employees
FORG_EQTY	Total foreign capital in firms with more than 10 employees (in million PLN)
VALUE_EXPO	Export value for firms with more than 10 employees
TOT_REVN	Total income for firms with foreign capital (in million PLN) for firms with more than 10 employees
RDP_EXP	Intramural expenditure on R&D by type of costs and voivodships in 2020 (IN PLN THOUSANDS)

SOURCE: https://stat.gov.pl/en/topics/economic-activities-finances/activity-of-enterprises-activity-of-firms/economic-activity-of-enterprises-with-foreign-capital-in-2020,26,4.html

Using a spatial analysis approach for this study is due to several things: First, geographic distance is likely to affect how technology diffusion channels work from MNCs to indigenous firms in the technology transfer process. Spatial analysis can identify and interpret loop-shaped interactions where technology transfer can occur between one location and neighbors, between neighbors and neighbors, and interact again with the initial location. Second, different spillover sources from different geographic locations should identify different spillovers. Thus, particular geographic coverage is expected to produce positive spillovers considering that in the current ICT development, the barriers to technology diffusion caused by expensive communication costs have been significantly reduced. Third, the cost of labor mobility increases with distance. Therefore, the FDI knowledge and technology spillover from the labor effect is also different due to the influence of geography. The effects of the theft of highly skilled domestic workers by foreign firms appear not only on a local scale but cover a wider geographic area (Lin & Kwan, 2016). The data used to test the hypothesis is quite limited. Therefore, the spatial econometric analysis process only utilizes the data of one Visegrad country, Poland, which has 16 viceroy divisions, with the latest data for 2020 obtained from the Statistics Poland website (https://stat.gov.pl).

III. LITERATURE REVIEW

FDI Knowledge and Technology Spillovers

Foreign Direct Investment (FDI) is often considered attractive because of the benefits of spillovers and technology transfer from multinational firms (MNCs) to their external environment, which are difficult to obtain if only relying on domestic firms (Sinani & Meyer, 2004). The transfer of knowledge and technology does not only occur between MNCs or foreign firms but also occurs with local business partners. Most of the world's technology and more than 75% of the world's private R&D expenditures involve significant participation from MNCs (Dunning, 1994). Their investments in developing countries are expected to transfer knowledge and technology to local firms, one of which is intangible asset affiliations (Blomström & Kokko, 1996).

FDI is the preferred mode of technology transfer by firms wishing to extract new, more complex technologies (Caves, 1999). In addition, there are several other technology transfer mechanisms, for instance, through international trade transactions and licensing or contractual agreements on the intellectual property owned by MNCs. The mode of technology transfer via FDI depends on the characteristics of the technology being transferred and the character of the host country in which the MNC is located. In this case, the readiness of human capital, an educated workforce, their skills and competencies, and market competition are essential factors in technology transfer through FDI. Many MNCs prefer to transfer their technology to affiliated firms or other firms wholly owned by the MNC in the host country rather than third-party firms with no formal engagement. Due to the complexity of MNC technology, it cannot easily be transferred to other firms (Mansfield & Romeo, 1980).

Technology transfer through FDI is an important driver for firms apart from investing in R & R&D. Technology transfer may occur directly into mutually affiliated firms and indirectly to other firms in the host economy through spillover mechanisms. FDI is an inexpensive means of technology transfer because firms that receive the impact of the transfer usually do not spend much money to absorb and adapt the new technology (J. Damijan et al., 2016). Compared to technology transfer mechanisms through international trade or licensing by contractual agreements, technology transfer through FDI has a more efficient and direct effect on firm performance (Mansfield & Romeo, 1980). FDI has become an essential driver of productivity and a source of technological innovation for firms in the host country's transitional economy (Blanchard, 1997).

Spillover can occur in technology transfer through FDI from foreign-affiliated firms to domestic firms because foreign investors are not necessarily fully able to internalize all the benefits of the new technology (Griliches, 1992). The spillover of FDI technology transfer occurs through two main mechanisms, horizontally and vertically (Feng, 2020). Horizontal or intra-industry spillover occurs when an FDI firm transfers its knowledge and technology to other firms in the same sector. It may occur when there is a transfer of human capital which previously received education and training from FDI firms to domestic firms. Meanwhile, domestic firms obtain this spillover by seeing, studying, absorbing, duplicating, and applying it in their firms. However, FDI firms usually try to prevent their knowledge and technology from penetrating domestic competitors. It explains why several studies related to FDI spillovers in the host country show that horizontal spillover effects are not found in developing countries and countries in transition. For example, Görg & Greenaway (2004) analyzed 42 pieces of literature related to the impact of FDI in the period 1974-2002. Other empirical studies have also failed to prove any horizontal spillover effect on the productivity of domestic firms (e.g., Barrios et al. (2011)).

Vertical or inter-industry spillovers occur in the supply chain when interactions between foreign suppliers and local producer firms or between foreign firms and local suppliers (Feng, 2020). The mainstream FDI literature in developing countries tends to examine this vertical spillover effect by looking at the backward linkages between foreign firms and local suppliers and then looking at the productivity of domestic firms. The productivity of domestic firms will increase as a sign of the positive effect of the vertical spillover of FDI due to the presence of foreign suppliers around the downstream sector. Unfortunately, this spillover can be negative because foreign firms supplying inputs to domestic suppliers are likely to have a higher bargaining position (e.g., in contractual terms), so this condition can reduce the efficiency and profitability of domestic firms. Vertical spillovers can have a positive effect if domestic firms can produce varieties of inputs for local needs that are like those supplied by foreign firms (Girma & Wakelin, 2007a).

On the other hand, FDI in the upstream sector produces a forward spillover effect on domestic firms in the downstream sector. This effect can be positive and negative depending on the response of both and has the potential to extend to other domestic firms that they are not even related to. So, there is a slight possibility of positive externalities from this FDI spillover. Some empirical evidence suggests a positive vertical spillover effect of FDI in Indonesia by examining backward linkages and then finding an increase in the productivity of local firms supplying inputs to foreign firms (Blalock & Gertler, 2003, 2004). The findings of the same study also occur in Lithuania (Javorcik, 2004; Smarzynska & Spatareanu, 2002)**,** India, China, and the UK (Fujimori & Sato, 2015).

Several channels can channel FDI spillover in the host economy, namely through imitation, competition, training, and because of business relationships with foreign parties. The spillover impact of FDI in terms of positive externalities to its external environment can occur even if the MNC wants to maintain its technology only in its internal environment or only allows technology transfer to occur to other business partners at a reasonable price. The transfer of technology through FDI is also seen through the increased productivity of local firms where MNCs can obtain not all the benefits of technology.

FDI spillovers do not always positively impact firms in the host country. Negative externalities arise when directly or indirectly the presence of an MNC in an area forces a local firm to leave its position. Negative externality effects are also possible with the presence of MNCs in the domestic market with more advanced technology making the firm more productive and efficient with low marginal costs. It can push the productivity of the domestic market to lag behind or even decline. (Aitken & Harrison, 1999) suggest that this possibility may occur in the short term but that domestic firms can react to new competitive conditions by optimizing their existing technology or investing in new technology to survive (Blomström & Kokko, 1996). Aitken & Harrison (1999) call this the 'market stealing effect'. Another negative impact is related to the theft of talent from domestic firms to shift work to foreign firms, which can reduce domestic firms' productivity (Blalock & Gertler, 2008). The net impact of FDI presence on domestic firms can be summed up as the difference between these two externalities (Lin & Kwan, 2016).

The mechanism for transferring knowledge and technology from FDI firms to their external environment can occur in several ways. First, local firms observe higher FDI corporate technology demonstrations, which they can detect through innovative products, information dissemination, or imitating MNC organizational forms that local firms can adapt (Blomström & Kokko, 1996). Second is workers' movement from MNC to local firms by bringing the increased skills and competencies obtained from MNC. It has the potential also to reorganize local firms to adopt the standards and quality of international organizations. Their contribution can benefit the local firm they work for or even by setting up a new business. Third, through linkages/linkages that arise due to business relationships between affiliated firms, domestic

suppliers, and customers. Increased local productivity is possible if MNCs utilize domestic suppliers for their production efficiency but usually by emphasizing the quality of materials supplied by domestic firms or reliability in shipping transportation.

The empirical literature on the existence and spillover effects of FDI is still very heterogeneous, although conceptually, it is pretty well established. Empirical testing of the relationship between FDI and domestic firm productivity suggests the best practice is limited to the average impact of FDI across channels and dimensions but is very weak in revealing the underlying mechanisms of FDI spillovers. Lin & Kwan (2016) argue that this condition can lead to misleading conclusions. Identifying the primary mechanism of FDI spillover is still a challenge in enriching the FDI spillover literature.

Many still questions whether the flow of FDI to domestic firms is the same in every country. To enter into a country or region, there are several factors considered by the owner of a foreign firm, such as cultural and linguistic factors, the distance that affects transportation, the mode of transfer and the level of established technology, and the structure of the country's economic sector (Crespo & Fontoura, 2007). This factor also relates to the absorptive capacity of domestic firms to new technologies introduced by FDI. The entry of FDI firms from Japan to India, for example, started with standard technology with a small technology gap between the host country and the home country of FDI. In contrast to FDI from the US, which generally enters the host country with more sophisticated technology, it tends to be more capital intensive and with a more significant technological gap with the host country. In this case, a spillover of FDI technology transfer from Japan to the host country, India, is more likely.

Factors Affecting FDI Knowledge and Technology Spillovers

Farole & Winkler (2012) highlight the absorptive capacity of local firms as an essential determinant of FDI spillover effects and have been analyzed in great detail in many studies. Absorption capacity is the firm's ability to identify and utilize external technology spillovers for their commercial needs. The high absorption capacity of external technology spillovers from FDI can increase the productivity of domestic firms. However, this capability may be limited for some local firms, so the positive effects of FDI spillovers may not be apparent or may even have a negative effect.

The first factor that can be attributed to the absorptive capacity of local firms concerning the spillover effect of FDI is their technological gap with FDI firms (Blomström & Kokko, 1996; *Kokko, A., Tansini, R., & Zejan, M. C. (1996)*, n.d.). Some studies believe that a significant technology gap allows a large increase in the positive spillover impact because there is enough room for improvement (Wang & Blomström, 1992). However, a too large or too small gap will also not benefit productivity (Blalock & Gertler, 2008). (Kokko, 1994) asserts that to gain high returns from technology transfer, the technology gap should be moderate. A technology gap that is too small can reduce its benefits. A study conducted by (Kokko, et.al., 1996) by utilizing cross-sectoral data of cross-sectoral industries in Mexico, stated that a significant technology gap indicates a small FDI technology spillover effect. Conversely, a small technology gap increases its spillover. The study conducted by (Sjöholm, 1999) found this effect to be the opposite in the case of Indonesia. The absorption capacity of domestic firms can generally be seen from their R&D contribution ((Cohen & Levinthal, 1989).

The firm's absorption capacity emerges as the most dominant determinant in the FDI spillover study. Domestic firms in the Czech Republic were found to benefit more from FDI spillovers only if they were active in R&D activities targeting technology renewal ((Kinoshita, 2001). The effect of R&D activity on the ability to absorb FDI spillovers is also corroborated by Keller & Yeaple, (2003) findings in the USA and Kathuria, 2000) in India. The findings of Damijan et al., (2003) seem somewhat different. In the same study, the relationship between

FDI spillover and R&D spending was positive in Slovakia and Hungary but negative in Latvia and Estonia.

Studies conducted in Russia show that education greatly influences the flow of FDI in the region ((Yudaeva et al., 2003)). The same thing happened in Italy, where large firms concentrated in the Northwest region benefited from FDI spillovers due to R&D activities. Sgard (2001) considers geographical factors that cause differences in the absorption of FDI spillovers in Hungary. The capital city of Budapest and several areas bordering Austria received a better FDI spillover impact than the areas bordering Romania, Yugoslavia, and Ukraine. However, both regional divisions had the same positive effect on FDI. This study then confirms that in addition to providing significant benefits for the productivity of domestic firms on a national or country level, the presence of FDI in a region also has the potential to create regional disparities.

The spillover of FDI that considers regional geographic factors has its place in empirical evaluation. As has been done by Torlak (2004) for the case in five European countries, FDI spillovers have proven to have a positive impact at the regional level in Poland and the Czech Republic. However, when the agglomeration factor was added as a control variable by including the number of firms in each region, a negative effect appeared in Bulgarian observations while a strong positive effect only appeared in Czech. This finding reinforces the proposition that the geographical dimension reduces the spillover effect as the area gets more expansive. In other words, areas that are geographically close to the source of FDI are more likely to have spillovers than those farther away (Audretsch, 1998; Audretsch & Feldman, 1996). Another argument is that the diffusion of FDI technology will be more substantial at the regional level, where labor, transportation costs, demonstration effects, and competition effects are spatially constrained (Driffield & Girma, 2003; Jordaan, 2005; Torlak, 2004).

The second factor is the size of the firm. (Sinani & Meyer, 2004) states that the challenges in competition and the ability to absorb knowledge transfer and FDI technology are better handled by larger local firms than smaller ones. Larger local firms have a better ability to replicate the management experience of FDI firms, or it could be because they can pay higher wages to attract FDI firm workers. (Amendolagine et al., 2013) show evidence that large corporations in 19 sub-Saharan economies positively affect FDI spillovers. The opposite finding was shown by Dimelis & Louri (2004) on more than three thousand firms in Greece. Sinani & Meyer (2004) found a similar situation where the spillover effect of FDI was more common in small firms in Estonia, especially those with skilled workers. The spillover effect of FDI in the host country of the transition economy is also different from that of developed countries due to differences in the characteristics of local state-owned or privately-owned firms.

The third factor, the firm's export orientation, is related to the absorption capacity of local firms to the spillover of FDI. The heterogeneity of research related to the export behavior of domestic firms is also common in several countries. One stream believes that the export behavior of domestic firms can reduce the negative spillover effects of FDI (Crespo & Fontoura, 2007). Another argument with the same intent is to believe that export-oriented local firms can take advantage of FDI externalities such as absorbing FDI knowledge and technology (Sinani & Meyer, 2004). Prior to that, (Barrios et al., 2011) conducted a study in Spain and found that in 1990-1998, FDI spillovers were more significant for local exporting firms. The same thing happened in Hungary (Schoors & van der Tol, 2002). Domestic firms with an export orientation are believed to have a greater capacity to compete with MNCs or FDI firms in the local market. Thus, through this competitive channel, the negative impact of FDI spillovers can be overcome.

The fourth factor that affects the absorptive capacity of FDI spillovers is related to the skills of the workforce of local firms. Investment to improve HR skills aims to increase the

ability to absorb and adapt external knowledge for the firm's commercial interests. Sinani & Meyer (2004) show evidence that a large proportion of skilled labor can increase the spillover effect of FDI in large Estonian firms. The same phenomenon occurred in Indonesia as (Blalock & Gertler, 2003, 2004, 2008) did in Indonesian manufacturing firms from 1988 to 1996. Unfortunately, the skilled labor factor only affects the FDI spillover in small business groups in developed countries like the UK (Girma & Wakelin, 2007). Cuyvers et al (2008) show that the skilled labor factor does not affect FDI spillovers in domestic manufacturing firms in Cambodia.

In addition to the four microeconomic factors above, macroeconomic factors also influence the spillover effect of FDI in the host country. Countries with high economic growth tend to be more attractive to foreign investors who could have a positive FDI spill effect on the host country (Fujimori & Sato, 2015). At a certain threshold, the spillover effect of FDI will be optimal, especially if the country has a much more open economy but remains at a moderate level of openness (Guo et al., 2013). In addition, a strong market system and the financial development of the host country also affect the absorption of FDI spillovers (Alfaro et al., 2010). Unfortunately, a strong market system discourages local firms from absorbing the advanced technology from FDI firms. As a result, this spillover effect becomes insignificant (Chen et al., 2014).

IV. EMPIRICAL RESULT

Spatial description of FDI and productivity of foreign-affiliated domestic firms: A case study in Poland

As shown in Figure 1 and Figure 2 below, the variables of foreign capital (FDI) and productivity (total revenue) that have high intensity (quantile 1, the most contrasting color) are in five regions. To facilitate analysis, three divisions or groups were made, namely WOJ14_ mazowieckie (group 1), WOJ30_ wielkopolskie and WOJ2_ dolnośląskie (group 2), and WOJ24_ łąskie and WOJ12_ małopolskie (group 3). The highest intensity (quantile 1) is seen in the capital city area, namely Warsaw, the WOJ14_ mazowieckie region. In Poland's southern and western parts, two adjacent regions have the same FDI intensity and productivity, namely group 2 and group 3. The high intensity of FDI and productivity in these two groups is spillover in the surrounding region, although not with the same intensity (quantile 3).

Source: Data processed by the author

Figure 1. Intensity of Foreign Direct Investment (FDI)

Source: Data processed by the author

Figure 2. Intensity of productivity (total income)

Since the character of FDI cannot be separated from its export orientation, in Figure 3 below, the value intensity of exports in the Polish region is presented. The pattern is similar to FDI intensity and productivity. However, one area of WOJ8_ Lubuskie has a high export

orientation (at quantile 2) even though this region has FDI density and productivity at quantile 3. Next, the intensity pattern similar to exports is also seen in labor conditions. (Figure 4). It can be assumed that the character of industry and exports in this region is related to labor intensity.

Source: Data processed by the author

Figure 3. Intensity of Export

Source: Data processed by the author

Figure 4. Intensity of Total Employee

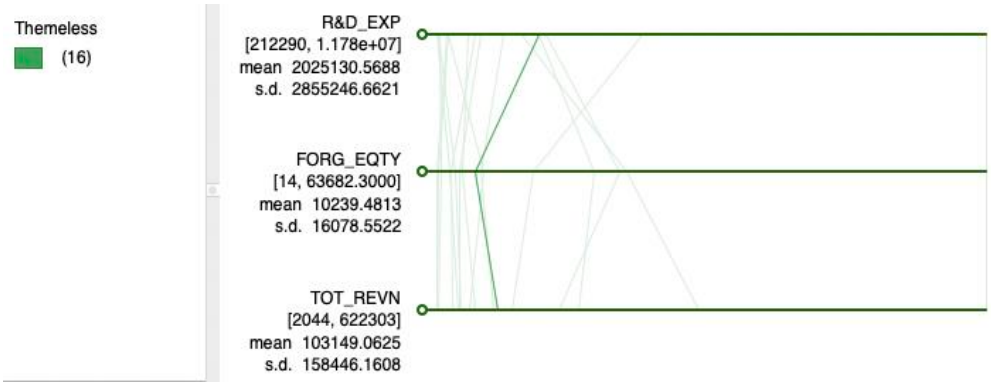
Technology transfer from FDI cannot be separated from knowledge transfer mechanisms, especially through research and development activities proxied by R&D expenditure by region. In Figure 5 below, it can be seen that the distribution of knowledge transfer intensity in Poland is somewhat different from the pattern of FDI and productivity seen in the previous figure. The intensity of R&D looks similar to group 1 and group 3 on FDI and productivity variables. However, the next R&D intensity was divided into two parts, namely WOJ2_ dolnośląskie and WOJ22_ pomorskie.

Source: Data processed by the author

Figure 5. Intensity of R&D expenditure

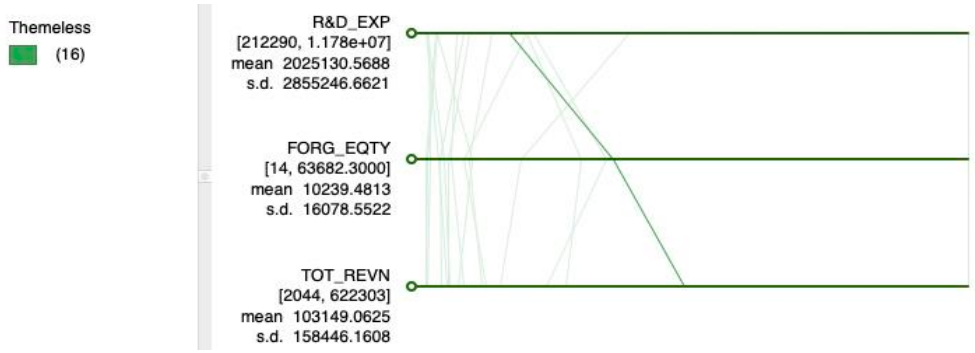
The previous description does not find that WOJ22_ pomorskie appears with high intensity in FDI, productivity, export activity, and labor. However, this area has a high density (quantil 1) for R&D activities. The relationship of R&D to FDI and corporate productivity in the region thus far may be questioned.

Figure 6 below can illustrate why the WOJ22_pomorskie region has a pattern of R&D intensity that is not in line with FDI and productivity. It seems that while the WOJ22_pomorskie region has high R&D activity, they have FDI and productivity in the opposite direction (Figure 6). The opposite occurs in WOJ30_wielkopolskie where this region has a high intensity of FDI and productivity even with R&D activity in the opposite direction (Figure 7). It is why the intensity decreases to quantile 2 in Figure 5.



Source: Data processed by the author

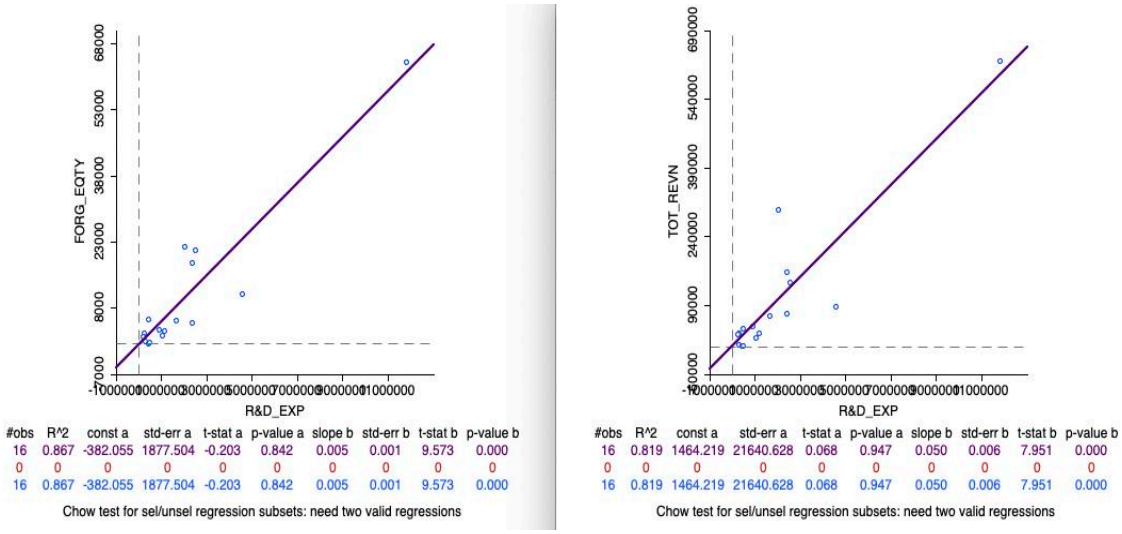
Figure 6. Intensity pattern between R&D expenditure, FDI, and productivity in WOJ22_pomorskie



Source: Data processed by the author

Figure 7. Intensity pattern between R&D expenditure, FDI, and productivity in WOJ30_wielkopolskie

From the following scatter plot, it can be seen that the relationship between R&D and FDI with firm productivity has a high correlation although the relationship between R&D and total revenue is not as high as the relationship with FDI. The slope of R&D of Total Revenue is 0.05 higher than that of Foregin Equity (0.005), which means that the latter is closer to the diagonal point. However, at this point it cannot be decided whether R&D also has a strong influence on FDI and productivity.



Source: Data processed by the author

Figure 8. Relationship between R&D vs FDI and R&D vs Productivity

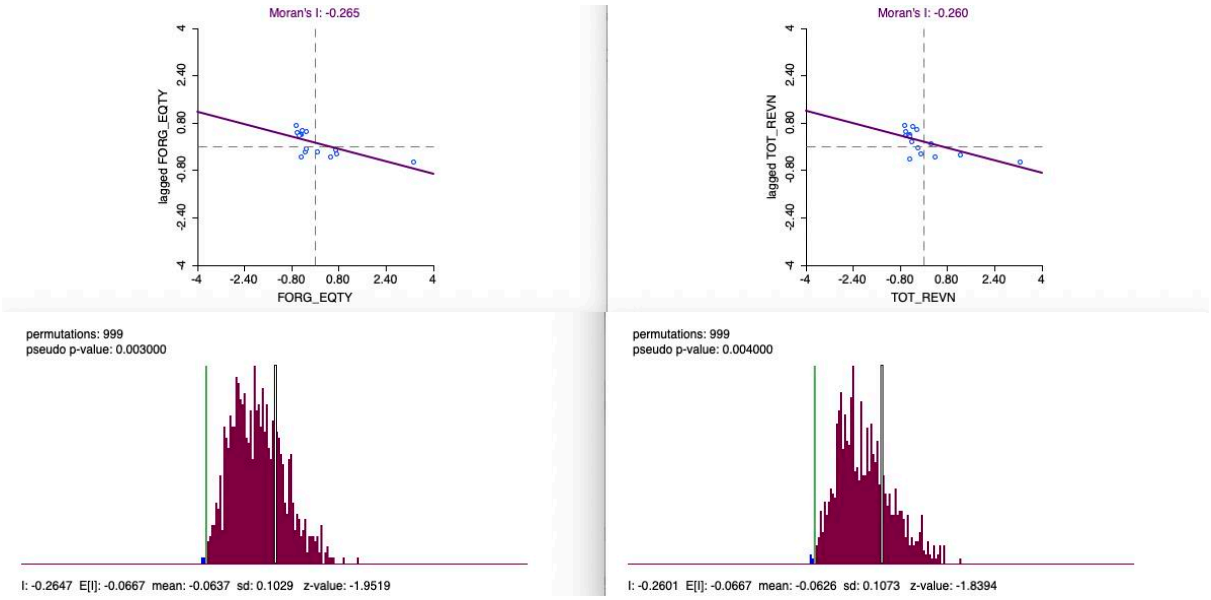
Empirical Result

The following section provides empirical evidence on the effect of FDI presence on firm productivity in the Polish region. There are two steps in this analysis. The first is to estimate the effects of R&D and labor (as control variables) on foreign capital in firms that have a share of foreign capital in Poland. The second is to estimate the effect of foreign capital (FDI) on firm productivity. At this stage, the value of R&D and the value of exports are included as control variables. The estimation is then performed using a spatial econometric analysis approach using Geoda software.

The first step is to determine the weighting matrix, as in Table 2 below. Poland has 16 regions (NUTS-2) called voivodships. By selecting the queen type weight, information is obtained that each region has a minimum of 3 neighbors and a maximum of 7 neighbors that intersect with the side of the region. The average area has 4 neighbors.

Table 2. Weighting matrix of Poland NUTS2 region

Property	Value
type	queen
symmetry	symmetric
file	Województwa_QUEEN2.gal
id variable	POLY_ID
order	1
# observations	16
min neighbors	3
max neighbors	7
mean neighbors	4.25
median neighbors	4.00
% non-zero	26.56%

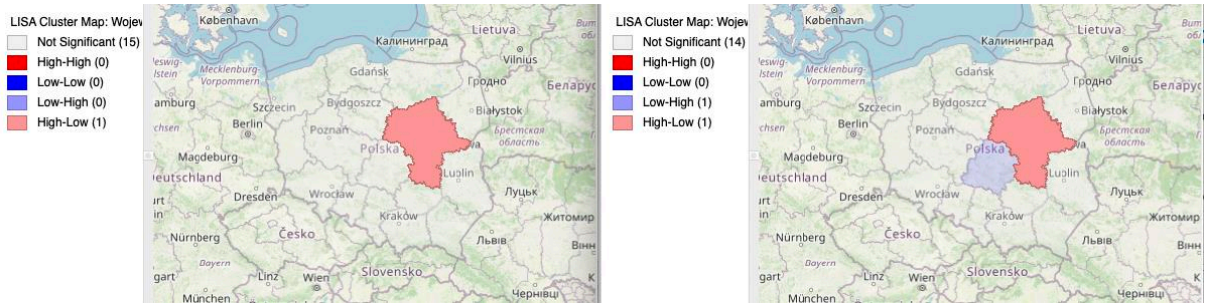


Source: Data processed by the author

Figure 9. Identify global autocorrelation/spatial autocorrelation

The second step is to identify the presence of global autocorrelation in the analyzed region using Moran's I statistics. Figure 9 on the Moran's I scatter plot graph shows the spatial autocorrelation value for the foreign capital variable (FDI) which is -0.265 and for the productivity variable (total revenue) is -0.260. This means that the spatial correlation of foreign capital and firm productivity by region level is very weak. However, there is strong evidence of spatial autocorrelation in this region (significant pseudo p-value at alpha 1%). In addition, the distribution of foreign capital (FDI) and firm productivity also tend to cluster.

Next is to determine the presence of local autocorrelation to see which regions specifically affect global autocorrelation. Based on Moran's I Scatterplot, four quadrants are formed for the 16 regions. Unfortunately, quadrant 1 shows that regions with high FDI and high productivity do not appear to cluster. This quadrant only contains low-high and high-low clusters, as shown in Figure 10 (on the left for FDI and on the right for total income). The level of regional aggregation by voivodeship in Poland may not be strong enough to display the spatial correlation between regions. From the LISA Significance Map and LISA Cluster Map, it can be seen that for the productivity condition, only region WOJ14_mazowieckie is significant at p=0.05 (left figure). In contrast, the other 15 regions are not significant. Meanwhile, the significant regional FDI conditions are WOJ14_ mazowieckie and WOJ10_ Lódzkie (the right figure).



Source: Data processed by the author

Figure 10. LISA Significance Map and LISA Cluster Map of spatial correlations

The third step is to estimate the model using a spatial econometric analysis approach. Decision making of the spatial regression model follows Anselin (2005) to estimate the best model between the method of ordinary least squares analysis (OLS), the spatial lag model (SLM), and the spatial error model (SEM). The best model estimation (SLM or SEM) is based on the significance of which one or Lagrange Multiplier is the most significant (if both are significant). Table 2 and Table 3 below present the results of the OLS regression at the same time to see the classical assumption test of the data.

Based on the estimation results of the first OLS regression, the dependent variable FDI (Foreign Equity) in Table 2 is statistically strongly influenced by total workers and R&D expenditures in that region. The two independent variables have a positive and significant effect simultaneously or partially. The Adjusted R-squared value of 0.978 means that the independent variable in this model can explain the dependent variable of 97.8%. This model also does not have the classical assumption problem. The probability value of Jarque-Bera for the normality test and the probability value of the Breusch-Pagan Test for the heteroscedasticity test is greater than alpha = 0.05. The value of Collinearity Statistics for the two independent variables is TOL = 0.178 and VIF = 5,607 so that this model does not have multicollinearity problems.

Tabel 2. First OLS regression result: FDI (Foreign Equity)

Ordinary Least Squares Estimation Dependent Variable : FORG_EQTY			
Variables	Coefficient	Std-error	Probability
CONSTANT	-1982.83	744.859	0.01956
TOT_EMPL	0.0764292	0.00847613	0.00000
R&D_EXP	0.00115951	0.000499834	0.03726
Adjusted R-squraed	0.978923		
F-statistic	349.332		
Prob(F-statistic)	5.02162e-12		
Regression Diagnostics			
Multicollinearity	6.438583		
Test On Normality of Errors: *Jarque-Bera*	DF	VALUE	PROB
	2	*0.8388*	*0.6574*
Diagnostics For Heteroskedasticity:	DF	VALUE	PROB
Breusch-Pagan Test	*2*	*2.6690*	*0.25936*

Based on the second OLS estimation results, the dependent variable of firm productivity (total revenue) in Table 2 is simultaneously strongly influenced by R&D spending, foreign capital (FDI), and export activities in the region. Two independent variables, namely foreign capital (FDI) and export activities have a positive and partially significant effect on productivity (total revenue) while R&D spending has no effect. The Adjusted R-squared value of 0.926 means that the independent variable in this model can explain the dependent variable of 92.6%.

This model also does not have the classical assumption problem. The probability value of Jarque-Bera for the normality test and the probability value of the Breusch-Pagan Test for the heteroscedasticity test is greater than alpha = 0.05. Collinearity Statistics values for the two independent variables are TOL = 0.396 and VIF = 2.526 for the R&D expenditure variable, TOL = 0.145 and VIF = 6.918 for the foreign capital variable (FDI), and TOL = 0.115 and VIF = 8,684 for the export variable. Thus, this model does not have multicollinearity problems.

Table 3. Second OLS regression result: Firm productivity (Total Revenue)

Ordinary Least Squares Estimation Dependent Variable : L_REVN			
Variables	Coefficient	Std-error	Probability
CONSTANT	-0.329074	0.851255	0.70584
L_RD_EXP	0.151113	0.157068	0.35499
L_FORG_EQT	0.397194	0.145376	0.01819
L_EXP	0.604537	0.314722	0.07882
Adjusted R-squraed	0.925845		
F-statistic	63.4261		
Prob(F-statistic)	1.24541e-07		
Regression Diagnostics			
Multicollinearity	67.271483		
Test On Normality of	DF	VALUE	PROB
Errors: Jarque-Bera	2	1.3891	0.49930
Diagnostics For	DF	VALUE	PROB
Heteroskedasticity:			
Breusch-Pagan Test	3	3.5526	0.31400

The next step is to analyze spatial dependence by looking at the significance value of the Lagrange Multiplier. This analysis stage did not find any significant LM values from Tables 4 and 5 obtained from the OLS estimation. Therefore, based on the last analysis, the best model that can be proposed for these two estimates is the OLS model.

Table 4. Diagnostics For Spatial Dependence: foreign equity (FDI)

TEST	MI/DF	VALUE	PROB
Moran's I (error)	-0.1244	-0.4583	0.64671
Lagrange Multiplier (lag)	1	0.0775	0.78066
Robust LM (lag)	1	0.2835	0.59442
Robust LM (error)	1	0.7090	0.39976
Lagrange Multiplier (SARMA)	2	0.7866	0.67483

Table 5. Diagnostics For Spatial Dependence: productivity (Total Revenue)

TEST	MI/DF	VALUE	PROB
Moran's I (error)	-0.1071	- 0.1985	0.84265
Lagrange Multiplier (lag)	1	0.1006	0.75116
Robust LM (lag)	1	0.7059	0.40082
Robust LM (error)	1	0.9781	0.32268
Lagrange Multiplier (SARMA)	2	1.0786	0.58315

The mathematical equations for the two models are as follows:

$$FORG\_EQTYi = -1982.83 + 0.0764\ TOT\_EMPLi + 0.0011\ R\&D\_EXPi + \epsilon$$

$$L\_REVNi = -0.3290 + 0.1511\ L\_RD\_EXPi + 0.3972\ L\_FORG\_EQTi + 0.6045\ L\_EXPi + \epsilon$$

V. DISCUSSION, CONCLUSION, AND RECOMMENDATION

The factors that influence the transfer of FDI knowledge and technology to the host country or the impact of this transfer on the country's economic conditions are still being discussed in many study areas. In economics, the microeconomic and macroeconomic impacts of FDI have been discussed in a very well-established portion, especially when talking about investment in a country. However, studies in knowledge economy may still have many gaps to discuss theoretically and empirically.

The widely discussed factor related to FDI spillovers is the influence of the firm's absorption capacity on FDI spillovers. This absorptive ability can be seen from the R&D activities in the areas where FDI firms are located. The absorption factor becomes very important considering that theoretically the firm's ability to absorb knowledge and technology inputs from outside also determines the firm's productivity in addition to capital and labor factors. Unfortunately, some findings, especially in developing and transition economies, suggest that the spillover effect can be potentially negative if the absorptive capacity of local firms is weak. It can cause firms to exist in areas where FDI is lagging in terms of technology and then impact the firm's commercialization process. A moderate technological gap in a region will potentially have a more positive FDI spillover effect than if FDI is in a particular area where the technology gap is very large or very small. This related study has been conducted in several European regions. For example, in the Czech Republic, a region that is active in R&D activities for technological innovation is more likely to receive positive spillovers from FDI. The same study findings were also evident in other Visegrad countries such as Hungary and Slovakia, but negative impacts were found in Estonia and Latvia.

Two other factors related to FDI spillovers are firm size and firm export orientation. Firms and regions require sufficient human resource capacity to absorb all external spillovers. It means that the labor market provides the main factor for the resources needed by firms for production efficiency. Larger firms may have more ability to take advantage of the presence of FDI in their area for reasons of firm management and ability to pay workers' wages. These two reasons also allow large firms to take advantage of labor migration from other firms to their firms. This channel allows firms to get the benefits of foreign knowledge and technology more quickly. Small firms with a skilled workforce have the same opportunities, as is the case in Estonia.

On the other hand, export orientation by firms was found to impact firm productivity due to the positive externality impact of the presence of FDI. The competition of domestic firms with MNCs in international trading activities has been proven to increase the absorption capacity of FDI spillovers and firm productivity. Several findings in Europe show this evidence as in Spain and Hungary.

Our study limits the analysis area to Visegrad countries, namely the Czech Republic, Hungary, Slovakia, and Poland. The V4 Group has attracted a lot of FDI to their region in recent decades to boost their country's economic growth. In addition, the entry of FDI into this region has also been proven to improve people's welfare. Studies on FDI spillovers in the first three countries seem to be abundant in the literature review, but there is limited information for the same case in Poland. Most of the FDI spillover studies conducted in Visegrad countries have the same results where FDI knowledge and technology spillovers positively impact the productivity of domestic firms. In addition, the heterogeneity of research results is still widely found in other regions or countries, one of which is due to differences in the data structure used.

In this paper, our final aim is to find evidence of the influence of the presence and spillover of FDI on the productivity of foreign capital-affiliated domestic firms in Polish regions. The foreign capital share proxy in the firm's total capital ownership structure is deemed appropriate to detect the presence of FDI. In the end, the positive impact felt by firms from the presence of FDI is expected to appear in the form of increased productivity.

Through spatial description, the paper shows that five voivodship regions in Poland have similarly high FDI intensity and productivity, namely Mazowieckie, Wielkopolskie, Dolnośląskie, Śląskie and Małopolskie regions. The high intensity of FDI in this region seems to be spilling over into the surrounding areas although it is not evenly distributed. The question that has the potential to arise is why most of the areas that are directly adjacent to the strategic Mazowieckie area do not show the same effect, only the western region tends to have a high density both in terms of FDI and productivity. It was also found that one region, Lubuskie, showed high export intensity despite not having high FDI intensity.

Another interesting finding is the distribution pattern of technology spillover from FDI proxied by R&D activities. It is noticeable that one area emerges later, namely Pomorskie, which has high R&D activity but not FDI intensity and productivity. This condition further raises questions about the effectiveness of the spillovers of knowledge and FDI technology in the region, in contrast to the Wielkopolskie region which can have high intensity of FDI and productivity with less intensive R&D activities.

In the empirical testing, the objective of the analysis is divided into two, namely, to examine the knowledge and technology spillover effects of FDI proxied by R&D expenditure on firms' foreign capital (FDI component) followed by analyzing the effects of FDI on firms' productivity. The spatial econometric analysis method is applied in this case which then indicates the presence of spatial autocorrelation across Polish regions although its value is quite low. In addition, the distribution of this activity tends to be clustered, just like our initial vision, that only certain parts of the western region are very dense while the eastern part is not.

The results of the first estimation using the OLS method show that total workers and R&D expenditures in the Polish voivodship area have a positive and significant effect on foreign capital (FDI). Meanwhile, although the variables of R&D expenditure, foreign capital (FDI), and export value have a significant effect on productivity, partially, only foreign capital (FDI) and export value have a positive and significant effect on FDI productivity in Poland. It then raises further questions whether the presence of FDI in Poland is not strong enough to mediate the effect of knowledge transfer on firm productivity.

The OLS model run at the beginning of the process did not detect any deviations from classical assumptions, so it can be concluded that modeling using cross section data for 2020 is robust. Since there is no spatial dependency in the model, the OLS model is considered the best model in the estimation process. The most likely conjecture in this case is that the aggregation of data at the NUTS2 (voivodeship) level to spatially analyze all Polish regions is not strong enough to show spatial dependence between regions. Therefore, for better spatial modeling, further studies are strongly recommended to use data at lower regional administrative levels (e.g., Polish NUTS3 regions or company level) or NUTS2 regions for all Visegrad group countries (V4), which is also a limitation of this study in obtaining them.

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