Mutual Productivity Spillovers in Slovakia:
Absorptive Capacity, the Technology Gap and Non-Linear Effects

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Abstract:
We analyse traditional productivity spillovers from foreign to local firms and reverse productivity spillovers from local to foreign firms. We argue that the extent of mutual productivity spillovers depends on the absorptive capacity and technology gap. We tested our hypotheses with panel data on Slovak firms for the period 2003-2012. We find that traditional productivity spillovers through output are positive, but the spillover effects through capital are mostly negative. The effect of the technology gap on productivity spillovers is conducive. Non-linear effects were found in services and high-tech industries. Reverse productivity spillovers through capital were positive in the manufacturing industry.

Keywords: foreign direct investment, productivity spillovers, Slovakia, mutual spillovers, technology gap

Acknowledgements:
We would like to thank Lorraine Lee and Jessica Moore for their excellent research assistance and Brent Burmester and Alex Eapen for their comments on the earlier draft of this paper.

Note: this is authors' version of the forthcoming article accepted by *Eastern European Economics.*

1. INTRODUCTION

Foreign direct investment (FDI) is often associated with productivity spillovers from foreign to local firms (Wei, Liu and Wang 2008), prompting governments to attempt to attract foreign investors (Sinani & Meyer, 2004). Recently, studies have stopped assuming that spillovers only flow from foreign to local firms, suggesting instead that spillovers also flow from local to foreign firms (e.g., Driffield & Love, 2003; Wei et al., 2008; Driffield, Love & Yang, 2014; Amann & Virmani, 2015; Zámborský & Jacobs, 2016). The purpose of this paper is to study the existence of productivity spillovers both from foreign to local firms and from local to foreign firms. Wei et al. (2008) were the first authors to include reverse productivity spillovers in their study on the effects of FDI in transition economies. Building upon Wei et al. (2008), we ask the following questions: *Are there mutual productivity spillover effects between local and foreign firms in Slovakia?* There are several important concepts related to this research. The first concept to be explained is mutual productivity spillovers. In this paper, mutual productivity spillovers are defined as the combination of traditional and reverse productivity spillovers. Traditional productivity spillovers are defined as local firms' increase or decrease in productivity caused by the indirect effects of the presence of foreign firms (Barrios & Strobl, 2002). Reverse productivity spillovers are defined as foreign firms' increase or decrease in productivity caused by the indirect effects of the presence of local firms (Wei et al., 2008). FDI is defined as a foreign firm's investment to either establish a subsidiary in the host country or acquire a large, durable controlling interest in a local firm (Resmini, 2000).

There are several reasons that FDI is considered such an important topic to study in transition economies. First, FDI facilitates the transition process by encouraging firm restructuring and providing a more effective foundation for corporate governance. Second, FDI stimulates technical innovation and aids economic growth (Bevan & Estrin, 2004). It is argued that the growth potential of FDI goes beyond the growth potential of domestic savings, especially for poorer transition economies. This makes FDI especially important for the economic development of a transition economy. Third, there are several side effects that stem from FDI; those side effects can be both positive and negative (Lutz & Talavera, 2004), which results in a debate whose primary question is whether the productivity spillovers generated by FDI are positive or negative (Tian, 2007). This paper's goal is to provide a better picture of productivity spillovers and their directions in transition economies using Slovakia as a sample case. Although there is qualitative research on mutual productivity spillovers in Slovakia (Jacobs and Zámborský, 2014), there is little rigorous quantitative research on productivity spillovers in Slovakia, which makes it an interesting country to study. Moreover, productivity spillovers are likely to develop in transition economies comparable to Slovakia because of the skilled labour present in such countries (Javorcik, 2004). Current research of FDI spillovers in transition economies lacks agreement in its results: some studies have found that the spillover effects of FDI are positive (Liu, 2002; Sinani & Meyer, 2004), whereas others have found negative effects (Javorcik & Spatareanu, 2008; Konings, 2001). (Please see the appendix for Table 1, which summarises the existing studies on FDI spillovers in transition economies, along with their main results.) This problem is stressed by the meta-analysis performed by Meyer and Sinani (2009). Consequently, this paper's first objective is to critically analyse the existence of traditional productivity spillovers. In addition, although reverse spillovers have gained more interest in recent years, the existing studies primarily concern developed host countries. To the authors' knowledge, there are only two published quantitative studies—Wei et al. (2008) and Franco and Kozovska (2011)—that focus on mutual productivity spillovers in transition economies. Therefore, this paper's second objective is to critically analyse the existence of reverse productivity spillovers in Slovakia.

The lack of unity in the direction of traditional spillovers and the sparse literature on reverse spillovers in transition economies leaves a gap that requires additional research; this paper attempts to address that gap. To do so, this paper includes not only manufacturing firms but also service firms. Although a few studies also include service firms in their study (e.g., Vahter & Masso, 2007), the vast majority include only manufacturing firms (e.g., Liu, 2008; Wang & Yu, 2007). Like Zhang, Li, Li and Zhou (2010), we argue that for productivity spillovers to occur, local firms need to have both the opportunity to learn from foreign firms and the capacity to use any new information obtained and vice versa—hence, the inclusion of the technology gap and the absorptive capacity in our empirical analysis. Our analysis finds that traditional productivity spillover effects through output are mostly positive in Slovakia but that the spillover effects through capital are mostly negative. Reverse spillovers are positive only in the manufacturing industry when spillovers through capital are considered. The effect of the technology gap on productivity spillovers is mostly positive (with non-linear effects being most significant in high-tech industries). This study increases the amount of research on mutual productivity spillovers in transition economies and allows for the possibility of non-linear mutual productivity spillovers. Another contribution to the current literature is its insight into spillover effects during financial crises.

2. THEORY AND HYPOTHESES

2.1. Spillover Mechanisms

The presence of foreign firms can influence a local business environment in many ways; it may either increase competition or introduce new know-how, thereby contributing to productivity spillovers. The presence of foreign firms will be beneficial for the local economic environment provided the productivity gains are larger than the competition losses. If the competition losses outweigh the productivity gains, then the host company's productivity will be negatively affected (Wei et al., 2008).

Whereas the debate first focused mainly on the existence of productivity spillover effects, it now also includes the mechanisms through which these effects occur (Zámborský, 2012a). The literature has defined several spillover mechanisms through which productivity spillovers can occur. The mechanisms that are most commonly discussed in the literature are labour mobility/skills acquisition (Blomström & Kokko, 1998; Fosfuri, Motta & Rønde, 2001; Smeets, 2008; Ben Hamida, 2011; Görg & Greenaway, 2004; Halpern & Muraközy, 2007; Girma, Greenaway, & Wakelin, 2001; Wang & Yu, 2007), demonstration/imitation effects (Görg and Greenaway, 2004; Smeets, 2008; Zahra & George, 2002; Zhang et al., 2010), competition effects (Barrios & Strobl, 2002; Görg & Greenaway, 2004; Halpern & Muraközy, 2007; Aitken & Harrison, 1999; Tian, 2007) and backward/forward linkages (Blomström & Kokko, 1998; Smeets, 2008; Javorcik, 2004; Ferragina & Mazzotta, 2014).

The market- and labour-stealing effects make it clear that spillover effects are not necessarily positive (Marcin, 2008). Spillover effects are often negative in the short run. The overall spillover effect of FDI depends on whether the disadvantages of the competition effect are stronger than the benefits of the demand effect (Halpern & Muraközy, 2007), backward and forward linkages, labour mobility and demonstration effects (Sinani & Meyer, 2004). For instance, depending on the quantity of intermediate inputs used by foreign firms relative to local firms, the demand effect can be stronger than the competition effect (Halpern & Muraközy, 2007). One of the negative spillover effects is known as the market-stealing spillover effect. Sometimes local firms are much weaker than foreign firms in terms of technology and/or business practices. They would normally depend on a protected market; however, with the entry of foreign firms, their productivity decreases (Buckley et al., 2002). We suggest that the positive spillover effects outweigh the negative spillover effects and therefore, we believe that positive traditional spillovers exist in Slovakia. More formally,

> *Hypothesis 1a: The presence of foreign firms has a positive influence on the productivity of local firms in Slovakia.*

The aforementioned spillover mechanisms are considered to generate traditional spillovers; however, reverse spillovers are generated through similar spillover mechanisms. As local knowledge and technology do not involve rivalry and can only be kept within a firm to a limited extent, spillovers from local to foreign firms can occur (Wei et al., 2008). It is not unlikely that reverse productivity spillovers may arise through backward and forward linkages: these linkages can help analyse the local practices used in local firms. In addition, the intermediate inputs produced or demanded by local firms will be customised for local needs. Furthermore, foreign firms often hire local employees who bring local knowledge with them. Although the competition effect may be modest, local firms have a home advantage, thus creating competitive pressures for foreign firms. Depending on both the location of the transition economy and the current export relations, foreign firms could also learn from local firms. Local firms, for instance, might be more experienced than foreign firms with respect to exporting to other transition or developing economies. We believe that foreign firms in Slovakia can gain local knowledge and technologies from local firms, thereby increasing their productivity. More formally,

> *Hypothesis 1b: The presence of local firms has a positive influence on the productivity of foreign firms in Slovakia.*

2.2. Absorptive Capacity

Absorptive capacity, which refers to a firm's ability to absorb knowledge and technology spillovers from surrounding firms (Dimelis, 2005; Leahy & Neary, 2007), is an important element in the spillover literature, especially because the degree to which practices and technologies from FDI spillovers can be used depends on the firm's absorptive capacity (Zhang et al., 2010). The term absorptive capacity was first coined by Cohen and Levinthal (1989), who argued that research and development (R&D) not only stimulates innovations but also helps the firm to develop its capability to "identify, assimilate, and exploit knowledge from their environment" (p. 569). This ability was called the absorptive capacity. Absorptive capacity also includes the ability to use knowledge obtained through, for instance, research that can be used as a foundation for applied research and developments in the future.

For FDI (reverse) spillovers to occur, two elements need to be present. First, the local (foreign) firm requires the *opportunity* to receive knowledge and technology from foreign (local) firms. Second, the local (foreign) firm requires the *capacity* to receive knowledge and technology from foreign (local) firms (Zhang et al., 2010). This second element refers to the firm's absorptive capacity, which is generated through investments in both human capital and R&D. Absorptive capacity provides a foundation of knowledge and technology that is needed to exploit the knowledge and technology that becomes available through FDI spillovers (Smeets, 2008). A firm's level of absorptive capacity is determined not only by its current level of technological competence but also by the investment and learning efforts that have been made that render it capable of using foreign knowledge productively (Ben Hamida, 2011). Furthermore, absorptive capacity also depends on organisational structures and cultures (Lane & Lubatkin, 1998). Girma (2005) finds that the relation between absorptive capacity and spillovers is an inverted U-shape relationship. Conversely, Buckley, Clegg and Wang (2002) have found a positive relationship between productivity spillovers and absorptive capacity.

Previous research has shown that Central and Eastern European countries (CEECs) generally have high levels of absorptive capacity because their levels of human capital are relatively high. Consequently, foreign firms are now interested in local R&D potential (Franco & Kozovska, 2011).

Since it is argued that foreign firms are technologically more advanced, we assume that their absorptive capacity is relatively strong. Therefore, we developed the following two hypotheses:

Hypothesis 2a: Local firms' absorptive capacity has a conducive effect on traditional spillovers.

Hypothesis 2b: Foreign firms' absorptive capacity has a conducive effect on reverse spillovers.

2.3. Technology Gap and Non-Linear Effects

It is acknowledged in literature that the technical capabilities of both local and foreign firms play an important role in the strength of productivity spillovers (Wei & Liu, 2006). Often, research examines the technology gap between foreign and local firms to discuss the extent of productivity spillovers. The technology gap is defined as the difference between the technology in an industry's local and foreign firms (Gerschenkron, 1962); in the case of transition economies, it is generally assumed that the foreign firms possess more advanced technology.

That said, there are two opposing views of how the technology gap affects productivity spillovers and therefore, the extent to which firms are able to adopt new knowledge and technologies. The first stream believe that potential gains from technology spillovers are negatively related to the technology gap between local and foreign firms (Lapan & Bardhan, 1973), which in turn, is closely related to absorptive capacity. This argument assumes that the degree to which outside knowledge can be exploited by firms depends on both the level of absorptive capacity and the complexity of the external knowledge. If the technology possessed by local and foreign firms is too different, or if the technology possessed by the foreign firm is too advanced, it is quite possible that local firms cannot adopt the foreign technology because it is too difficult for them to comprehend (Sinani & Meyer, 2004). In addition, it is believed that if there is a technology gap, lower-quality technology is transferred because that is all that the local firms can comprehend, resulting in a lower potential for positive spillover effects (Glass & Saggi, 1998). In short, the first stream believes that productivity spillovers are more likely when the technology gap between foreign and local firms is relatively small (Franco & Kozovska, 2011).

The second stream is driven by Findlay (1978) and is known as the catching-up hypothesis. Unlike the first stream, this stream argues that a larger technology gap between local and foreign firms is more beneficial for productivity spillovers. These scholars believe that technology transfer will be quicker when foreign firms rapidly create their downstream and upstream networks, thus not only enabling the local firms that are part of these distribution and supply networks to access the new technology but also facilitating technology diffusion (Findlay, 1978). In other words, the catching-up hypothesis predicts that a relatively larger technology gap between foreign and local firms is more likely to stimulate spillover effects (Franco & Kozovska, 2011). However, Schoors and van der Tol (2002) argue that in the presence of a large technology gap, productivity effects will only take place when human capital is well developed. Again, absorptive capacity proves to be an important element of productivity spillovers.

Several empirical papers show that for FDI to produce productivity spillovers, firms must have both a reasonable level of absorptive capacity and a technology gap that is not too large (Borensztein, De Gregorio, & Lee, 1998; Kinoshita, 2001; Kokko, 1994). More recent work elaborates on this observation by demonstrating that a large technology gap hinders industries' ability to receive positive productivity spillovers (Tian, 2007). R&D and export participation may indicate a firm with a reasonably small technology gap. In general, such firms will have the ability to take advantage of potential spillover effect (Barrios & Strobl, 2002) because they have sufficient levels of technology.

Similar to Zhang et al. (2010), we believe that to some extent, both lines of argument are correct. A large gap will mean that the technology imported by foreign firms is more advanced and presents huge opportunities for spillovers. However, it also means that the local firms will probably not have a level of absorptive capacity sufficient to realise spillover benefits from the foreign firms' advanced technologies and know-how (Zhang et al., 2010). Conversely, when the technology gap is too small, there is limited potential for productivity spillovers, and sometimes local firms are even more productive than foreign firms (Gerschenkron, 1962; Sjöholm, 1999). Combining these two assumptions, we believe that the effect of productivity spillovers will be the strongest somewhere in the middle—when the gap is neither too large nor too small. In the case of an intermediate technology gap, there remains a great deal of potential for spillover effects because foreign knowledge and technology is more advanced than local knowledge and technology. Simultaneously, local firms and foreign firms are likely to have some overlapping knowledge and technologies, thus easing the process of technology diffusion. Furthermore, local firms are more likely to have sufficient levels of absorptive capacity, so they can both comprehend foreign knowledge and use it for their benefit (Zhang et al., 2010). Additionally, research has shown that levels of human capital in the CEECs is relatively high and therefore, their levels of absorptive capacity should be high enough to benefit from foreign technology and knowledge (Ferencikova & Ferencikova, 2012). This results in a quadratic (non-linear) relation between the technology gap and productivity spillovers for local firms. A similar relation also holds for foreign firms and the technology gap: if the technology gap is too large, then the level of knowledge and technology is too low to generate any positive spillovers to foreign firms. If the technology gap is too small, the knowledge and technology possessed by local and foreign firms is too similar to generate productivity spillovers to foreign firms. Accordingly, we formulate the following two hypotheses:

> *Hypothesis 3a: The positive relationship between the presence of foreign firms and the productivity of local firms is the strongest when there is an intermediate technology gap between local and foreign firms.*
>
> *Hypothesis 3b: The positive relationship between the presence of local firms and the productivity of foreign firms is the strongest when there is an intermediate technology gap between local and foreign firms.*

In summary, there are several mechanisms through which spillovers can occur: backward and forward linkages, labour mobility, demonstration and imitation effects, competition effects and exports. Spillovers will only occur when positive spillover effects outweigh negative spillover effects. It is believed that in Slovakia, this is the case for both traditional and reverse spillover effects. In addition, both absorptive capacity and the technology gap are expected to influence the traditional and reverse spillover effects. A conducive effect is expected for absorptive capacity, whereas an intermediate technology gap is expected to result in the highest spillovers. Figure 1 presents a graphical overview of the hypotheses developed in this section.

INSERT FIGURE 1 HERE

3. METHODOLOGY

3.1. Data Sources and Sample

We used firm-level data for Slovakia for the period 2003-2012. These data were obtained from the Amadeus database, which was published by Bureau van Dijk. This database is also used by Damijan et al. (2003), Franco and Kozovska (2011), Nicolini and Resmini (2010) and Schoors and van der Tol (2002). One of this database's primary advantages is that it includes not only individual firms' financial information but also their characteristics, such as industry classification and ownership information.

We collected the following data of the financial information of firms: sales, material costs, the declared value of tangible fixed assets, the number of employees and the declared value of intangible assets. The data are reported in units of thousands of Euros. For the firms' characteristics, we have obtained information on the industry classification (given by NACE Rev. 2 primary code) and ownership information. A firm is classified as foreign owned when its direct foreign ownership is greater than ten per cent. This classification is similar to that used by many other studies in the spillover literature and is also the common definition used by the IMF and OECD (Barrios & Strobl, 2002; Javorcik, 2004; Nicolini & Resmini, 2010).

Although most spillover research focuses on the manufacturing sector, e.g., Li et al. (2001) and Wang and Yu (2007), our research also includes the services industry, similar to the study performed by Marcin (2008). We chose to include the services industry in our study because of the development of FDI inflows in Slovakia. During the 1990s, the FDI inflows to the manufacturing sector were the most pronounced; however, during the 2000s, there was a shift in FDI inflows. FDI flows were no longer mostly directed towards the manufacturing sector: it was the services industry that received the most FDI inflows (Ferencikova & Ferencikova, 2012). Therefore, it makes sense to include the services sector when studying productivity spillovers. Although FDI inflows to the services sector have surpassed the FDI inflows to the manufacturing sector, we believe that it remains important to include the manufacturing sector, especially because some authors argue that the most important effects occur in the manufacturing sector (Halpern & Muraközy, 2007). Thus, we have included both the manufacturing and services sectors in our dataset.

To create our dataset, we retrieved all financial information and firm characteristics, as described above, for all firms located in Slovakia that are represented in the Amadeus database. This led to a sample of 229,518 firms. To obtain a workable dataset, we first eliminated all firms whose industries are unknown. Second, we deleted all firms that are not in the manufacturing or services industries. Third, we excluded all firms for which information on the shareholders' location and ownership percentages were missing because such firms cannot be classified as either local or foreign. Finally, we removed all firms for which the total direct ownership reported was less than 10% or where the total direct Slovakian ownership was less than 90% with information insufficient to label the firm as foreign. A limitation of the data is that many small firms were probably excluded from the Amadeus dataset which could potentially lead to overrepresentation of foreign firms in our sample. Another limitation of the data is that ownership information is only provided for one point in time. Therefore, we have to assume unchanged ownership throughout the research period. This is a similar assumption to that of Damijan et al. (2003). Therefore, this research does not allow us to specifically examine the spillover effects of a joint venture with a foreign firm or an acquisition by a foreign firm. Further limitation of our data is that it does not account for the possibility of vertical spillovers. Many firms try to prevent horizontal spillovers, whereas the vertical spillovers through forward or backward linkages can benefit the host of the spillover effect (Javorcik, 2004; Javorcik & Spatareanu, 2011).

Table 2 provides an overview of the number of firms included in the dataset. The table immediately makes it clear that in each year, there are more foreign manufacturing firms than local manufacturing firms. Conversely, in most years, there are more local services firms than foreign services firms. Additionally, a decline in the total number of firms can be observed beginning in the year 2008. This could have been caused by the financial and/or Euro crisis. However, this conclusion is pure speculation, and further research is necessary to determine the cause of the decline in firms.

INSERT TABLE 2 HERE

3.2. Model Specification

To estimate the traditional and reverse spillover effect, we have used a model based on the Cobb-Douglas production function in which productivity spillovers are measured indirectly (Damijan et al., 2003). This is a common approach used in the FDI literature to assess the spillover effect (Damijan et al., 2003; Nicolini & Resmini, 2010; Wei & Liu, 2006). The basic model for traditional spillovers is as follows:

$$lnY_{ijtD} = \alpha_{ijD} + \beta_1 lnK_{ijtD} + \beta_2 lnL_{ijtD} + \beta_3 Spillover_{jt} + \varepsilon_{ijt}, \ (1)$$

where the subscripts *i*, *j* and *t* stand for firm *i* in the industry j at time *t,* and the subscripts *D* and *F* indicate that the firm is local or foreign, respectively. Furthermore, Y is the output, K is the capital stock, L is labour, and Spillover is the spillover variable that measures a foreign presence in the industry. In addition, α_{ijD} is an unobserved effect for local firm *i* in the industry *j,* and ε_{it} is the error term. The basic model for reverse spillovers is similar and is estimated as follows:

$$lnY_{ijtF} = \alpha_{ijF} + \beta_1 lnK_{ijtF} + \beta_2 lnL_{ijtF} + \beta_3 ReverseSpillover_{jt} + \varepsilon_{ijt}, \ (2)$$

where the ReverseSpillover is the spillover variable that measures local presence in the industry.

Several studies use total factor productivity (TFP) as a proxy for output when analysing productivity spillovers (e.g., Barrios & Strobl, 2002; Djankov & Hoekman, 2000). Using TFP as the output variable also allows the measurement of the diffusion of technology, organisational competence and managerial capabilities; increasing returns to scale; embodied technological progress; and R&D (Felipe, 1999). It is shown that current production function methods allow for possible endogeneity problems in the firm inputs because firms can experience idiosyncratic shocks that influence their labour inputs but are not noticeable to the researcher (Halpern & Muraközy, 2007). The method for estimating TFP introduced by Levinsohn and Petrin (2003) controls the correlation between the idiosyncratic shock and input levels. The idiosyncratic shock is computed adopting a semi-parametric approach in which intermediate inputs are used as a proxy for these unobserved effects (Halpern & Muraközy, 2007; Javorcik, 2004). In other words, the method uses an observable variable to control for the unobservable shock, creating consistent estimates for TFP (Halpern & Muraközy, 2007). The simultaneity bias that underlies the endogeneity problem is therefore accounted for using this method (Javorcik & Spatareanu, 2008). Another similar method is advanced by Olley and Pakes (1996), who use investment to proxy for unobservable idiosyncratic shocks. Generally, the Levinsohn and Petrin method is preferred to estimate TFP in transition economies because of the unreliability of investment data in transition countries (Halpern & Muraközy, 2007). Therefore, we use the Levinsohn and Petrin estimation method for the estimated TFP of firms in Slovakia. The following Cobb-Douglas production function is used to generate TFP:

$$lnY_{ijt} = \alpha_{ij} + \beta_1 lnK_{ijt} + \beta_2 lnL_{ijt} + \beta_3 M_{ijt} + \omega_{ijt} + \varepsilon_{ijt}, (3)$$

where M_{ijt} is material input for firm *i* in the industry *j* at time *t*, and ω_{ijt} represents the unobservable—but observable for the firm—idiosyncratic shock (Damijan et al., 2003).

To test the spillover effects, we apply a two-step procedure. First, we estimate the TFP for both local and foreign firms. Second, we run an extension of the following regression for traditional spillovers:

$$lnTFP_{ijtD} = \alpha + \beta_1 Spillover_{jt} + \varepsilon_{ijt}, (4)$$

where TFP_{ijtD} is the TFP for local firm *i* in the industry *j* at time *t.* The following regression is run for reverse spillovers:

$$lnTFP_{ijtF} = \alpha + \beta_2 ReverseSpillover_{ijt} + \varepsilon_{ijt}, (5)$$

where TFP_{ijtF} is the TFP for foreign firm *i* in the industry *j* at time *t.*

Because we are interested in not only the traditional and reverse spillovers but also the effect of the absorptive capacity and technology gap on spillover effects, proxies for the absorption capacity and technology gap are also included in the regressions. The final regressions are based on the regressions used by Zhang et al. (2010); however, we adjusted their method to meet our research needs. This has resulted in the following estimation model for traditional spillovers:

$$lnTFP_{ijtD} = \alpha + \beta_1 Spillover_{jt} + \beta_2 Spillover^2_{jt} + \beta_3 R\&D_{ijtD} + \beta_4 R\&D_{ijtD} * Spillover_{jt} + \beta_5 Technology\ Gap_{ijtD} + \beta_6 Technology\ Gap^2_{ijtD} + \beta_7 Technology\ Gap_{ijtD} * Spillover_{jt} + \beta_8 Technology\ Gap^2_{ijtD} * Spillover_{ijt} + \varepsilon_{ijt}, (6)$$

where $R\&D_{ijtD}$ measures the R&D levels for local firm *i* in the industry *j* at time *t*, and Technology Gap_{ijtD} is the indicator that measures the difference in technology for local firm *i* in the industry *j* at time *t* and its industry average. The following estimation model is used for reverse spillovers:

$$lnTFP_{ijtF} = \alpha + \beta_1 ReverseSpillover_{jt} + \beta_2 ReverseSpillover^2_{jt} + \beta_3 R\&D_{ijtF} + \beta_4 R\&D_{ijtF} * ReverseSpillover_{jt} + \beta_5 Technology\ Gap_{ijtF} + \beta_6 Technology\ Gap^2_{ijtF} + \beta_7 Technology\ Gap_{ijtF} * ReverseSpillover_{jt} + \beta_8 Technology\ Gap^2_{ijtF} * ReverseSpillover_{ijt} + \varepsilon_{ijt}, (7)$$

where $R\&D_{ijtF}$ measures the R&D levels for foreign firm *i* in the industry *j* at time *t*, and Technology Gap_{ijtF} is the indicator that measures the difference in technology for foreign firm *i* in the industry *j* at time *t* and its industry average. In both the traditional and reverse spillover estimation models, year and industry dummies are included.

3.3 Measurement

To calculate TFP, we used the following variables: *Output*, which is proxied by sales (similar to Bosco (2001) and Wang and Yu (2007)); *Capital*, which is proxied by the declared value of tangible fixed assets (similar to Abraham et al. (2010)); *Labour*, which is proxied by the number of employees (similar to Damijan et al. (2003)); and *Material Inputs*, which are proxied by material costs (similar to Altomonte and Pennings (2009)). These variables are all directly imported from the Amadeus database.

Similar to Buckley et al. (2002), Tian (2007) and Wei et al. (2008), we use various measures estimating the spillover and reverse spillover effects to analyse the productivity spillovers in Slovakia. As explained in the theory and hypotheses section, there are several spillover mechanisms through which spillovers can occur. Therefore, it is important to develop multiple spillover and reverse spillover variables to capture the effects of most of these spillover mechanisms. The first measure is the most commonly used to estimate spillovers/reverse spillovers and measures the share of foreign/local firms' output to total industry output. This measure estimates spillovers from demonstration effects (Ben Hamida & Gugler, 2009). Two other frequently used measures also exist (Buckley et al., 2002). The second measure, which is also employed by, e.g., Li et al. (2001), uses the share of foreign/local employees to the total number of employees in the industry to estimate spillover/reverse spillover effects. These spillover variables intend to measure mutual productivity spillovers through labour mobility. The last measure, which is also adopted by Wei et al. (2008), uses the share of foreign/local capital to total capital in the industry to measure the spillover/reverse spillovers. Spillovers shown by the capital variable are also related to demonstration effects (Wei et al., 2008). Moreover, Wang and Yu (2007) argue that most of the literature suffers from the limitation of assuming a linear relationship between the inward flows of FDI and the productivity of local firms. Therefore, we have included the squared form of the spillover and reverse spillover variables in line with Wei et al. (2008). The proxies for spillovers and reverse spillovers are not included in the same model because they are highly correlated and will result in a multicollinearity problem (Tian, 2007).

From the theory and hypotheses discussion, it is clear that absorptive capacity and the technology gap are expected to play an important role in productivity spillovers. R&D is often believed to increase productivity because it can reduce costs not only by creating new processes and products but also by enhancing current processes and products (Wei & Liu, 2006). Thus, R&D is included in the model and is proxied by the declared value of intangible assets, similar to Franco and Kozovska (2011). Furthermore, a common method of proxying absorptive capacity is R&D activities (Marcin, 2008) because R&D not only generates new information but can also increase the firm's ability to use its current knowledge more effectively (Cohen & Levinthal, 1989). Because Hypotheses 2a and 2b argue that absorptive capacity has a conducive effect on spillover and reverse spillover effects, an interaction term for lnR&D and the spillover and reverse spillover variables is also included (Damijan et al., 2003). The regressions also control for the technology gap, which is measured as the difference in TFP of the individual local/foreign firm and the local/foreign TFP average in that particular industry (Franco & Kozovska, 2011). Furthermore, because we expect the technology gap to reach its maximum effect on productivity at intermediate levels, we introduce a squared term to the regression. Additionally, because Hypotheses 3a and 3b argue that the conducive effect of the technology gap on spillover and reverse spillover effects is strongest at intermediate levels, an interaction term for the technology gap and the spillover/reverse spillover variable and an interaction term for the technology gap squared and the spillover/reverse spillover variable are included in the final estimation models for spillover and reverse spillover effects.

In addition, the control variables *year* and *industry dummies* are included in the final estimation models. Year dummies are used to capture the effect of an increase in the productivity of Slovakian local and domestic industrial firms. Industry dummies are included to control for the differences in industries (Zhang et al., 2010). Table 3 provides a schematic overview of the variables used, along with their abbreviations, definitions and sources.

Moreover, the models are estimated for several subsamples to determine whether there are any substantial differences between the subsamples. We used two subsamples. The first subsample analyses the difference between manufacturing and services industries in Slovakia. The second subsample examines the difference between low- and high-technology industries. Low technology includes less knowledge-intensive services, whereas high technology includes knowledge-intensive services. The distinctions between manufacturing and services and between low and high technology are made based on their NACE Rev2. primary code industry classifications.

INSERT TABLE 3 HERE

3.4 Endogeneity Check

First, this paper aims to analyse the effect of the presence of foreign firms on the productivity of local firms. Second, it aims to examine the effect of the presence of local firms on the productivity of foreign firms. The possibility of endogeneity is a relatively large problem in a regression analysis. Endogeneity problems can be created in several ways. First, there is the issue of the simultaneity bias, which has been discussed previously. Second, endogeneity problems can be caused by reverse causality. With respect to this research, reverse causality would mean that highly productive industries attract local firms instead of foreign firms, causing increased productivity in local firms in the case of traditional spillovers. In the case of reverse spillovers, reverse causality would mean that highly productive industries attract foreign firms instead of local firms, causing increased productivity in foreign firms (Sinani & Meyer, 2004; Smeets, 2008).

To analyse whether our data contain indicators of reverse causality, we have performed an endogeneity check similar to that of Zhang et al. (2010). In the case of the spillover effect, we have regressed the change in foreign presence (spillover variable) on the average productivity of local firms. For the reverse spillover effect, we have regressed the change in local presence (reverse spillover variable) on the average productivity of foreign firms. Essentially, we have altered formulas 4 and 5: the dependent variables are now the independent variables, and the independent variables are now the dependent variables. The output is shown in Table 4.

INSERT TABLE 4 HERE

As shown in Table 4, the coefficients for the average productivity of local firms and the productivity of foreign firms are significant for all three measures of spillovers and reverse spillovers. A significant coefficient is an indicator of a possible causal relationship that causes endogeneity problems. We will address this issue in section 3.5. where we comment on our econometric approach.

3.5. Data Analysis

The analysis uses unbalanced panel data for local and foreign firms in Slovakia for the period 2003-2012. Previously, many spillover studies used cross-sectional data to analyse the effect of a foreign presence in an economy. One of the most important drawbacks of the use of a cross-sectional data analysis in the spillover literature is its inability to account for dynamics and unobservable idiosyncratic shocks. This can result in inconsistent, biased estimates (Dimelis, 2005). More recently, as indicated in the literature review, researchers have moved from cross-sectional data to firm-level panel data. A panel data analysis overcomes the flaw of cross-sectional methods because it can account for both dynamics and unobservable idiosyncratic shocks (Görg & Greenaway, 2004).

The procedures utilised for analysing the data are similar to those of Zhang et al. (2010). All of the variables are normalised using natural logarithms, thus fulfilling the underlying assumptions of the estimation methods. To identify the appropriate estimation method, the first step is to determine whether a pooled ordinary least squares (OLS) approach or the panel data method is the more appropriate estimation method. We performed a Breusch-Pagan Lagrange Multiplier test in Stata to examine whether the pooled OLS or panel data method is more appropriate. The outcome of this test is that the panel data method is indeed more appropriate than the pooled OLS estimation method; therefore, we use the panel data method for our analysis.

The second step is to analyse whether the random effects model or the fixed effects model is more appropriate for our dataset. We therefore ran the Hausman test in Stata to determine which method is more appropriate. The results show that in the data used, the observed explanatory variables and the unobserved idiosyncratic shocks are correlated, indicating that the fixed effects model is more appropriate than the random effects model.

The final step is to test whether heteroscedasticity is a problem in the model used. If heteroscedasticity is present, the variance of the error term is not constant. Consequently, although an unbiased but consistent estimate will still be reported, it no longer gives the minimum variance, resulting in t-statistics that are no longer valid (Wooldridge, 2009). To test whether heteroscedasticity occurs in the regressions, the Modified Wald test is run in Stata. This test indicated that heteroscedasticity is indeed present and, therefore, a robustness correction model is applied in Stata when running the regressions. This corrects for the heteroscedasticity problem, and the estimates and standard errors produced after correcting for heteroscedasticity are thus correct.

We have shown in section 3.4 that we should allow for the endogeneity of our explanatory variables. The standard econometric approach is then to use instruments. The Generalised Method of Moments (GMM) class of estimators is particularly well suited for that purpose. The idea is that we define independence conditions between our instruments and the error term as moment conditions to solve. The GMM estimator also provides, in principle, efficient estimators. Given that we have a panel data structure, and given that we do not have outside variables we could use as instruments, we use lagged values as instruments. In practice, to satisfy the GMM conditions, we may have to try different lag structures. Indeed, it may not be always desirable to use all the available lagged values as instruments (too many instruments could create problems), and we may also have to include lagged values of the dependent variable as explanatory variables if necessary. In the latter case, we have a dynamic panel data model.

4. RESULTS

4.1. Summary statistics

Tables 5 and 6 (in the appendix) present the descriptive statistics and pairwise correlations for the local and foreign firms, respectively. All of the variables are included except for the industry and year dummies. The correlations between the variables for local firms are low, except for the relations between lnL, lnK, and lnM. Therefore, multicollinearity does not seem to affect our estimation models. Similar results are found for the correlations for foreign firms. The mean statistics are higher for the foreign firms than for the local firms for all of variables except for the technology gap (excluding the variable spillover and reverse spillover). The technology gap is defined as the difference between the TFP of individual local/foreign firms and the TFP average of foreign/local firms in the industry. Therefore, our assumption that foreign firms have more advanced technology than local firms seems valid. This assumption is also validated by Table 7, which gives an overview of the sample means of lnTFP and lnR&D sorted by the various subsamples. Note that in both local and foreign firms, high-technology and knowledge-intensive industries have higher averages than do low-technology and less knowledge-intensive industries. Furthermore, foreign firms always have higher averages for lnTFP and lnR&D than local firms in the same sample. This result reconfirms that foreign firms possess more advanced technology and knowledge than local firms. Based on Driffield and Love's (2007) taxonomy of motivations for FDI, this could indicate that FDI in Slovakia has an efficiency-seeking nature. This also means that it is likely that firms engage in FDI to exploit their existing technology and knowledge, signalling that traditional spillovers are likely to occur. As suggested by Wang and Yu (2007), we expect most spillovers to occur in high-technology sectors and manufacturing sectors, as suggested by Halpern and Muraközy (2007). Because reverse spillovers are primarily caused by the movement of local knowledge and technologies, which are generally considered to be less advanced than foreign knowledge and technologies, we suggest that reverse spillovers are possible in all subsamples. This is primarily because the lnR&D levels are used as a proxy for absorptive capacity and the lnR&D means for foreign firms are high, so we expect these firms not only to be able to learn about local knowledge but also to have the ability to convert that knowledge into higher productivity.

INSERT TABLE 7 HERE

4.2. Analysis of Traditional Spillovers

Because the endogeneity check performed in the methodology section indicates that a reverse causal relationship might exist, the models were analysed using first-differenced one step Generalised

Method of Moments (GMM) estimations. Tables 8, 9 and 10 present the results. With respect to Hypothesis 1a, all of the models show a significant spillover effect (b_{oo}=1.506, $p<0.01$; b_{ol}=1.345, $p<0.05$; b_{oh}=1.401, $p<0.01$; b_{om}=1.395, $p<0.05$; b_{os}=1.855, $p<0.01$) when the output spillover variable is used. The spillover squared is negative and significant for all firms (b_{oo}=-0.888, $p<0.05$), manufacturing (b_{om}=-1.061, $p<0.05$) and services (b_{os}=-1.090, $p<0.1$), indicating a non-linear relationship (a decreasing quadratic effect).

When labour is used for the spillover variable, the results for spillovers and squared spillovers are not significant for any of the five models other than manufacturing, where we obtained a weakly significant coefficient (b_{om}=1.365, $p<0.10$). When capital is used for the spillover variable, a significant non-linear relation is found for high-technology firms, for which SP is negative and significant (b_{ch}=-1.596, $p<0.1$), and SP^2 is positive and significant (b_{ch}=1.448, $p<0.1$). For low-technology firms, a significant negative spillover effect is found (b_{ol}=-1.63, $p<0.05$). All of the other capital spillover effects are not statistically significant. In short, evidence for positive spillover effects is robust only when using an output spillover variable. Negative spillovers from capital are found in both high- and low-technology sectors, while no statistically significant spillovers occur from labour (other than weakly significant spillovers in the manufacturing sector).

Next, only partial evidence for the conducive effect of absorptive capacity is found. A significant negative effect is found for all firms when using output as the spillover variable (b_{oo}=-0.07, $p<0.10$). A significant positive effect of absorptive capacity is found for services (b_{ls}=0.10, $p<0.10$) and high-technology firms (b_{ho}=0.15, $p<0.01$) using labour as the spillover variable. All of the other interaction terms are insignificant. Therefore, support for Hypothesis 2a is rather weak and mixed.

Hypothesis 3a assumes that the technology gap has a non-linear conducive effect on spillovers. The interaction term between the spillover and technology gap is positive and significant for all models when the output spillover variable is used (b_{oo}=-0.49, $p<0.01$; b_{ol}=-0.44, $p<0.01$; b_{oh}=0.37, $p<0.05$; b_{om}=-0.6, $p<0.01$; b_{os}=-0.34, $p<0.01$). The result for high-technology firms and service firms are the only ones that indicate a non-linear conducive effect because the technology gap squared is negative and significant (b_{oh}=-0.15, $p<0.05$; b_{os}=-0.34, $p<0.01$), indicating that the conducive effect of the technology gap is positive at a decreasing rate.

When labour spillover is used, the interaction term between spillover and the technology gap is positive and significant for all models (b_{lo}=0.52, $p<0.01$; b_{ll}=0.52, $p<0.01$; b_{lh}=0.58, $p<0.01$; b_{lm}=0.78, $p<0.10$; b_{ls}=0.45, $p<0.01$). However, there is no evidence of non-linear effects in these specifications. Similar results were obtained for the role of the technology gap in capital spillovers. The interaction term between the spillover and technology gap was positive and significant in all models (b_{co}=0.67, $p<0.01$; b_{cl}=0.73, $p<0.01$; b_{ch}=0.41, $p<0.01$; b_{cm}=0.99, $p<0.01$; b_{cs}=0.46, $p<0.01$). However, there was again no evidence of non-linear effects in these specifications. In summary, although the technology gap has a conducive effect on traditional spillovers, it only has a non-linear effect for high-technology and service industries when spillovers through output are considered.

INSERT TABLE 8 HERE

INSERT TABLE 9 HERE

INSERT TABLE 10 HERE

4.3. Analysis of Reverse Spillovers

Table 11 presents the results for the GMM model for the output reverse spillovers. The evidence for reverse spillovers was not statistically significant. There was neither robust support for the conducive effects of absorptive capacity or the technology gap (although for high-tech industries, there was a weak evidence for non-linear effects of the technology gap, b_{oh}=0.25, $p<0.10$). The reverse spillover specification using labour (Table 12) did not show statistically significant evidence for reverse spillovers or conducive effects of absorptive capacity. However, for the overall sample, there was weak support for a conducive effect of the technology gap (b_{lo}=0.80, $p<0.10$), and for manufacturing, there was weak support for a conducive non-linear effect of the technology gap (b_{lm}=-0.17, $p<0.10$). In summary, the support for reverse spillovers in Slovakia or the hypothesised conducive effects of absorptive capacity in the reverse spillovers through output or labour is weak, while there is some support for the conducive effects of the technology gap.

Table 13 presents results for reverse productivity spillovers through capital. There are significant positive reverse spillovers through capital, but only in the manufacturing sector (b_{cm}=2.07, $p<0.10$), with significant non-linear effects (decreasing quadratic effect) in that sector only (b_{cm}=-1.9, $p<0.05$). There is also evidence for the conducive effect of absorptive capacity in that sector (b_{cm}=0.01, $p<0.10$), but there are no conducive effects of the technology gap in manufacturing. On the other hand, there is evidence for conducive effects of the technology gap in the overall sample (b_{cm}=1.16, $p<0.05$), high tech (b_{cm}=0.31, $p<0.10$) and services (b_{cm}=0.66, $p<0.01$).

INSERT TABLE 11 HERE

INSERT TABLE 12 HERE

INSERT TABLE 13 HERE

4.4. Effects of the Global Financial Crisis

Our dataset includes the period of the Global Financial Crisis of 2008-09. For all the main specifications (Tables 8-13), we have checked whether there is a significant difference in the spillover effects during the crisis by interacting the spillovers variables with the crisis dummy variable (the crisis is defined as the years 2008 and 2009). The inclusion of the crisis dummy variable has not affected the main results significantly. However, in almost all of the models, the crisis dummy variable that interacted with the spillover variable proved to be significant and negative, indicating that the spillover effects were lower during the period of the financial crisis. It was only in the high-tech industries (in the model for traditional spillovers through output, labour and capital) and services (in the model for traditional spillovers through labour and capital and in the model for reverse spillovers through output) that the financial crisis did not have a significant effect on spillovers.

5. DISCUSSION

5.1. The Existence of Mutual Productivity Spillovers in Slovakia

Most papers studying spillovers from FDI in transition economies only study traditional spillovers. Although such studies have previously been conducted, this paper is exceptional because it also incorporates reverse spillovers. In our analysis, we find positive traditional spillovers via output. The output spillover squared is negative and significant for all firms, manufacturing and services, indicating a non-linear relationship (a decreasing quadratic effect). When labour is used for the spillover variable, the results for spillovers and squared spillovers are not significant for any of the five models (other than weakly positive results for manufacturing). When capital is used for the spillover variable, significant negative spillovers are found for both high-technology and low-technology firms, although non-linear relation is found only for high-technology firms (a decreasing quadratic effect).

The results for the output variable are in line with some research (Liu, 2008). The findings of negative capital spillovers may be caused by the fact that longer time lag was not used, which did not allow for enough time to capture the full effect of traditional spillovers from capital investments by foreign multinationals. The regression analysis looks at the combined effects of spillover mechanisms. The negative and insignificant results in some specifications could indicate that the negative effects of competition outweigh the positive effects of the other spillover mechanisms. Perhaps local firms' current technologies are unable to adjust for the new technologies and there are not enough funds to upgrade the technologies to reach the new knowledge's full potential, thus increasing productivity.

The results concerning the traditional productivity spillover effects differ from some results found in previous literature. A vast amount of literature has found either negative or insignificant results, e.g., Bosco (2001) and Pawlik (2006). Pawlik (2006) finds negative productivity spillovers and pinpoints long-term competition effect as the primary cause. This finding is probably why our paper also found negative traditional capital productivity spillovers: foreign firms often enter and dominate less competitive local industries, which are unable to quickly adapt to the foreign productivity levels. Consequently, the competition effect is fairly strong in these sectors, leading to negative productivity spillovers (Wang & Yu, 2007). Bosco (2001) finds non-significant results for spillover effects in Poland and suggests that this is because the transition period is not fully completed and therefore, some structural changes that will affect firm performance have not yet occurred. This argument could also hold for some of the non-significant spillovers in this research. However, another possible explanation could be similar with respect to why negative spillover effects are found. Perhaps the negative competition effects are of a strength similar to that of the positive spillover effects and the two thereby counteract each other, leading to non-significant results.

We expected the traditional spillovers to occur primarily in the high-technology sectors, as suggested by Wang and Yu (2007), and manufacturing industries, as suggested by Halpern and Muraközy (2007). Our results indicate that they occur in wider range of industries including low-tech industries and services but only through output. The lack of evidence for labour spillovers is somewhat intriguing. Ben Hamida (2011) suggests that labour mobility is a more dominant spillover channel in the services than in the manufacturing sectors because training and human capital development are usually more important in the services sectors. This paper does not find evidence of labour spillovers in services sectors though.

For the reverse spillovers, most of the results are insignificant with the exception of reverse spillovers through capital in the manufacturing sector. This adds to the results of Franco and Kozovska (2011) and Wei et al. (2008). Where the regression analysis performed by Wei et al. (2008) confirms the existence of positive reverse productivity spillovers in China, this paper finds that they occur only in the manufacturing sector and when measured through capital. Franco and Kozovska (2011), however, find non-significant (and significant negative) reverse spillovers for several of their subsamples in Poland and Romania. It seems that the local knowledge obtained through spillovers is not enough to increase foreign firms' productivity in most of the industries in Slovakia with the exception of manufacturing. The fact that reverse spillovers are insignificant or negative in some of the specifications could also be explained by the fact that awareness of both local business practices and how to operate in Slovakia do not necessarily mean that productivity will immediately increase because the firm knows better how to manage its operations there. Firms first have to process knowledge before they can use it. It might be a long time before this process shows an increase in productivity.

5.2. The Conducive Effects of Absorptive Capacity and Technology Gap

The main finding on the conducive effect of absorptive capacity on mutual productivity spillovers is that absorptive capacity is generally not important for mutual productivity spillovers. However, there are exceptions. A significant negative effect is found for all firms when using output as the spillover variable in traditional spillovers. A significant positive effect is found for high-technology and services firms (for traditional spillovers through labour) and manufacturing firms (for reverse productivity spillovers through capital).

This could be explained by the fact that absorptive capacity includes the ability to learn. The labour variable, which attempts to capture spillover effects from labour mobility, captures an important aspect of the absorptive capacity (in particular human capital). The negative effects for the output variable are in line with the results found by Damijan et al. (2003) for the Czech Republic and Poland, which also show the negative impact of absorptive capacity. The insignificant results for the conducive effect of absorptive capacity on reverse spillovers (with the exception of manufacturing) can be explained because foreign firms generally do not search for spillovers from more advanced technology. Instead, they search for spillovers from, for instance, local knowledge or local technology (Franco & Kozovska, 2011), which may be more important in manufacturing where local industrial tradition is key attractor to FDI in key sectors such as automotive and other mechanical engineering.

The findings regarding the conducive effect of the technology gap on spillovers are more robust and indicate a strong positive effect on output, labour and capital spillovers in most of the sub-samples in the traditional spillovers. However, a non-linear effect is only found in high-technology and services industries when traditional spillovers through output are considered. They are also present in the high-tech industries (when reverse spillovers through output and capital are considered) and service industries (when reverse spillovers through labour and capital are considered). This contributes to the literature that is somewhat divided on the impact of the technology gap on spillovers. Findlay (1978), for example, argues that a larger technological gap is beneficial for productivity spillovers, while another stream of the literature argues that the technology gap has a negative effect on productivity spillovers. Franco and Kozovska (2011), for example, find a positive moderating effect for the technology gap, but Li et al. (2001) find that the technology gap has a negative moderating effect on reverse spillovers. Our findings of non-linear effects for the output spillovers in the high-technology industries are generally consistent with the findings of Zhang et al. (2010), who found that the moderating effect of the technology gap is strongest at the intermediate level.

6. CONCLUSIONS

This paper was motivated by the fact that mutual productivity spillovers from FDI in transition economies are an understudied topic. To the best of our knowledge, this paper is one of the first studies to analyse mutual productivity spillovers in a transition economy. This study’s primary contribution is its insights into the existence of mutual productivity spillovers in Slovakia. Slovakia has rarely been studied rigorously with a large-sample quantitative analysis in the context of productivity spillovers, so analysing mutual productivity spillovers in Slovakia adds a new CEEC to the current studies on productivity spillovers in transition economies. This research also contributes in several other ways to the current literature. Because the literature on reverse spillovers (and in particularly in transition economies) is sparse, this research increases the number of studies in existence. Second, it includes the possibility of a non-linear spillover variable, which is often ignored in the literature. This paper analysed whether there are mutual productivity spillovers effects between local and foreign firms in Slovakia during the period 2003-2012. It considered the opportunity of local firms to learn from foreign firms and vice versa by including the effect of the technology gap and the ability of local and foreign firms to use their new knowledge by including the effect of absorptive capacity in the analysis. We argue that local firms can learn from the advanced knowledge and technology that foreign firms bring to Slovakia, while foreign firms can learn from local firms' local knowledge and technology. Using several spillovers to proxy for mutual productivity effects, several spillover mechanisms were addressed. The results of the regression analysis show strong support for positive traditional spillovers through output but negative spillovers through capital. Non-linear effects were found only for spillovers in high-tech industries and services. Traditional spillovers through labour were insignificant. Reverse spillovers were only significant in the manufacturing sector when spillovers through capital were considered. We also found robust support for the conducive effect of the technology gap (with non-linear effects for high-technology industries and services). Absorptive capacity mostly did not have a significant effect.

The design of this research suffers from a few methodological limitations that must be taken into account when analysing the results and drawing conclusions. The limitations also create opportunities for future research. First, ownership information is only provided for one point in time. Therefore, we have to assume unchanged ownership throughout the research period. This is a similar assumption to that of Damijan et al. (2003). Therefore, this research does not allow us to specifically examine the spillover effects of a joint venture with a foreign firm or an acquisition by a foreign firm. Second, the dataset is skewed towards foreign firms. All firms with less than 90% Slovakian ownership but no indication that the firm is more than 10% foreign-owned are deleted from the dataset. This also includes firms that are classified as majority owned by Slovakian shareholders. This is performed to ensure that all of the firms in the dataset comply with the definition of local and foreign firms. The skewness towards foreign firms could influence the outcome of the analysis. Eapen (2013) confirms that the use of incomplete datasets in studies analysing productivity spillovers can lead to biased results. Third, measuring foreign presence and thus the (reverse) spillover effect as output, labour and capital as a share of industry could just measure market performance and would therefore be unrelated to spillovers. However, when one assumes that market performance is an outcome of efficiency and firm-specific organisational characteristics, the spillover variable indeed captures the spillover effects, whereas the reverse spillover variable captures the reverse spillover effects (Bosco, 2001). Fourth, the use of output, labour and capital as measures of the spillover effects primarily capture the spillover effects from demonstration and labour mobility. The regression analysis therefore does not fully account for the competition and export effects, and the competition effect is only accounted for implicitly. Similarly, backward and forward linkages are not considered in this paper's quantitative analysis. Finally, FDI inflows are considered homogenous. Several studies have determined both that FDI is heterogeneous and that its diversity influences the existence of spillover effects (Javorcik & Spatareanu, 2011; Zhang et al., 2010); again, this research does not consider those issues.

This paper has opened up several new avenues for research on the effect of FDI on both local firms and the foreign firms that engage in FDI. There are several opportunities to further enhance the analysis performed for this research. First, several studies suggest that geographic proximity influences productivity spillover effects (e.g., Franco & Kozovska, 2011). It would be interesting to see how this factor influences the mutual productivity spillover effects in Slovakia (especially in the Bratislava/Western Slovakia region, where there is an automotive cluster, Zámborský 2012b). Second, vertical spillovers should also be included in a study on mutual productivity spillovers because it is believed that firms try to prevent horizontal spillovers, whereas the existence of vertical spillovers can benefit the source as the host of the spillover effect. Backward and forward linkages are a possible form of spillover mechanisms, so it would thus be interesting to include them in a future study on mutual productivity spillover effects. Similarly, directly accounting for the competition effect would benefit research on mutual productivity spillovers.

In terms of policy implications, the results of this paper offer several relevant insights. Policy-makers seeking to attract foreign direct investment to their countries need to consider the potentially different impact of foreign presence in the country's overall capital expenditures or output. While capital investments are often considered a key benefit to the economy, it seems that their spillover effects are low or even negative, and what is important to the productivity of local firms is foreign presence in the output. Sectoral considerations are also important, with our research showing that industries such as high tech and services may benefit from a higher resilience of spillovers to the economic downturn. These industries also show that a moderate technology gap between foreign and domestic firms can be conducive to FDI spillovers. The traditional focus on and the attractiveness of manufacturing industries in Central and Eastern Europe (CEE) may be reconsidered in light of structural changes in the world economy following the Global Financial Crisis (the rise of emerging markets other than CEE) and future shocks to come. Policies that create an attractive investment environment for sophisticated foreign and local investors in the high-tech and services industries may be the way of the future.

In terms of reverse spillovers, our study offers related insights to foreign firms, especially those investing in manufacturing industries, where we found positive spillover effects of high local share in capital on foreign productivity. The presence of local firms with a strong capital base in this sector may be beneficial to foreign investors. Policy makers in transition economies may also benefit from understanding the nature mutual spillovers. In their negotiations with foreign investors, they may stress that spillovers can flow in both directions and that there may be a case for a level playing field for all firms rather than rules skewed towards foreign investors based on the assumption of one-way spillovers that may not be valid.

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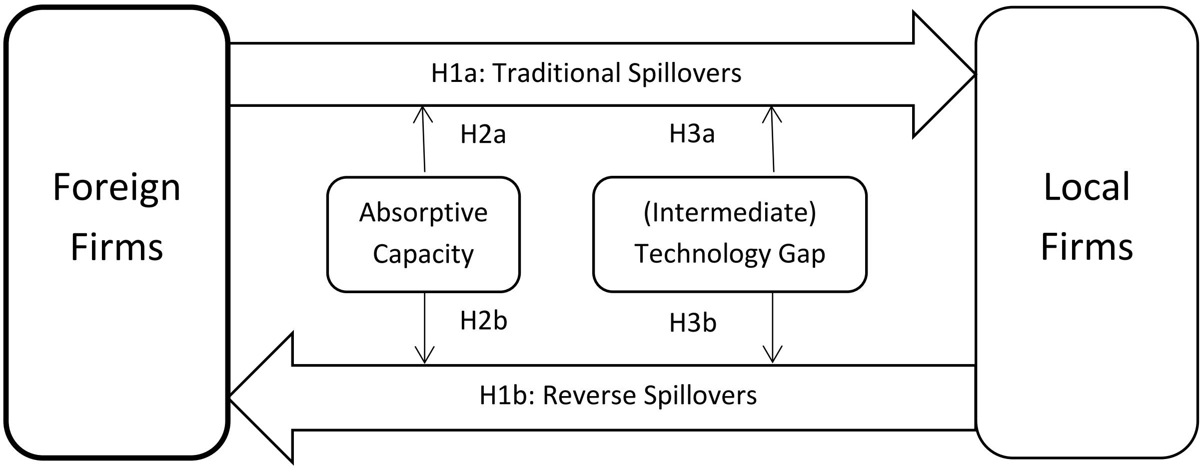
APPENDIX

Figure 1: Overview Hypotheses



Notes: Figure 1 provides an overview of the hypotheses developed in this paper. The arrows indicate the direction of the relationships.

Table 2: Overview of the Number of Firms in the Dataset

Sector	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Manufacturing - Local	81	130	220	287	293	257	260	247	186	74
Manufacturing - Foreign	228	309	434	513	547	517	518	519	447	236
Manufacturing - Total	*309*	*439*	*654*	*800*	*840*	*774*	*778*	*766*	*633*	*310*
Services - Local	323	702	1481	2351	2444	1772	1774	1757	1373	371
Services - Foreign	438	665	1131	1527	1598	1282	1232	1190	993	383
Services - Total	*761*	*1367*	*2612*	*3878*	*4042*	*3054*	*3006*	*2947*	*2366*	*754*
Total	***1070***	***1806***	***3266***	***4678***	***4882***	***3828***	***3784***	***3713***	***2999***	***1064***

Notes: Table 2 presents an overview of the total number of firms in the dataset per year. It also presents the number of firms for local manufacturing firms, foreign manufacturing firms, local services firms and foreign services firms separately.

Table 3: Overview of Variables

Variable	Abbreviation	Definition	Source
Output	lnY	Log of sales of firm i at time t in sector j	Amadeus
Capital	lnK	Log of declared value of tangible fixed assets	Amadeus
Labour	lnL	Log of number of employees	Amadeus
Material Input	lnM	Log of declared value of material costs	Amadeus
Absorptive Capacity	RaD	Log of declared value of intangible assets	Amadeus
TFP	lnTFP	Log of total factor productivity estimated using the Levisohn and Petrin (2003) method	Amadeus / Own calculations
Technology Gap	TG	The difference of the TFP of individual local/foreign firm and the TFP average of foreign/local firms in the industry	Amadeus / Own calculations
Spillover	SP (spillover)	The share of foreign firms' output to total industry output	Amadeus / Own calculations
Reverse Spillover	reversespillover	The share of local firms' output to total industry output	Amadeus / Own calculations
Spillover Labour	spilloverL	The share of foreign firms' employees to total number of employees in the industry	Amadeus / Own calculations
Reverse Spillover Labour	reversespilloverL	The share of local firms' employees to total number of employees in the industry	Amadeus / Own calculations
Spillover Capital	spilloverC	The share of foreign firms' capital to total industry capital	Amadeus / Own calculations
Reverse Spillover Capital	reversespilloverC	The share of local firms' capital to total industry capital	Amadeus / Own calculations

Notes: Table 3 provides an overview of the variables used throughout the regression analysis. Column 3 explains how the variables are measured. Column 4 displays the source of the variable.

Table 4: Endogeneity Checks for the Spillover and Reverse Spillover Effects

Spillover Effect Output			**Reverse Spillover Effect Output**		
Variable	*Coefficient*	*Constant*	*Variable*	*Coefficient*	*Constant*
d.AveragelnTFP$_D$	-0.03***	0.08***	d.AveragelnTFP$_F$	0.01***	-0.03***
	(0.00)	(0.01)		(0.00)	(0.01)
Spillover Effect Labour			**Reverse Spillover Effect Labour**		
Variable	*Coefficient*	*Constant*	*Variable*	*Coefficient*	*Constant*
d.AveragelnTFP$_D$	0.00*	-0.01**	d.AveragelnTFP$_F$	-0.00***	0.01***
	(0.00)	(0.00)		(0.00)	(0.00)
Spillover Effect Capital			**Reverse Spillover Effect Capital**		
Variable	*Coefficient*	*Constant*	*Variable*	*Coefficient*	*Constant*
d.AveragelnTFP$_D$	0.01***	-0.01**	d.AveragelnTFP$_F$	-0.01***	0.02***
	(0.00)	(0.00)		(0.00)	(0.00)

Notes: Table 4 presents the output from the endogeneity check for both the spillover effect and the reverse spillover effect for all of the spillover and reverse spillover measures. The significant levels of the correlations are given by *** p < 0.01, ** p < 0.05 and * p < 0.10

Table 7: Overview Sample

			Local Firms		Foreign Firms		Overall	
			lnTFP mean	*lnR&D mean*	*lnTFP mean*	*lnR&D mean*	*lnTFP mean*	*lnR&D mean*
Manufacturing	*Low Technology*		2.53	1.92	2.83	3.08	2.72	2.85
		Obs	1148	385	2107	1506	3255	1891
	High Technology		2.69	3.12	2.92	3.68	2.87	3.61
		Obs	348	183	1299	1166	1647	1349
Services	*Less Knowledge-Intensive*		2.88	1.59	3.34	2.12	3.11	2.02
		Obs	5725	1183	5584	2650	11309	3833
	Knowledge-Intensive		3.08	1.99	3.95	2.70	3.38	2.40
		Obs	2480	710	1318	970	3798	1680

Notes: Table 7 presents an overview of the mean values for local, foreign and overall lnTFP and lnR&D. It further differentiates and presents the mean values for low-technology, high-technology, less knowledge-intensive and knowledge-intensive firms, respectively.

Table 8: First differenced-One Step GMM of Local Firm Production Function Using Output Spillover Variable

	Panel A Overall f	Panel A Overall i	Panel B Low-Tech f	Panel B Low-Tech i	Panel C Hi-Tech f	Panel C Hi-Tech i	Panel D Manufacturing f	Panel D Manufacturing i	Panel E Services f	Panel E Services i
SP (spillover)	1.51***	1.51***	1.35**	1.35*	1.40***	1.40***	1.40**	1.40*	1.86***	1.86***
	(0.47)	(0.44)	(0.58)	(0.78)	(0.49)	(0.44)	(0.64)	(0.78)	(0.43)	(0.44)
SP^2	-0.89**	-0.89**	-0.74	-0.74	-0.51	-0.51	-1.06**	-1.06*	-1.09***	-1.09***
	(0.40)	(0.42)	(0.50)	(0.60)	(0.45)	(0.50)	(0.53)	(0.62)	(0.39)	(0.41)
SP x Crisis	-0.06***	-0.06***	-0.08***	-0.08***	-0.03	-0.03	-0.10**	-0.10**	-0.04**	-0.04
	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.04)	(0.04)	(0.05)	(0.02)	(0.02)
lnRaD	0.05*	0.05**	0.04*	0.04**	0.04	0.04	0.00	0.00	0.05	0.05*
	(0.03)	(0.02)	(0.02)	(0.02)	(0.04)	(0.03)	(0.01)	(0.01)	(0.03)	(0.02)
SP x lnRaD	-0.07*	-0.07**	-0.05	-0.05	-0.04	-0.041	-0.01	-0.01	-0.06	-0.06
	(0.04)	(0.03)	(0.04)	(0.04)	(0.05)	(0.05)	(0.03)	(0.02)	(0.05)	(0.04)
TG	-0.31***	-0.31***	-0.34***	-0.34***	-0.37***	-0.37**	-0.20	-0.20	-0.39***	-0.39***
	(0.08)	(0.11)	(0.07)	(0.07)	(0.10)	(0.18)	(0.12)	(0.12)	(0.07)	(0.10)
TG^2	0.06	0.06	-0.00	-0.00	0.19***	0.19***	0.02	0.02	0.12***	0.12***
	(0.05)	(0.05)	(0.04)	(0.04)	(0.03)	(0.04)	(0.05)	(0.05)	(0.03)	(0.04)
SP x TG	-0.49***	-0.49***	-0.44***	-0.44***	-0.37**	-0.37	-0.60***	-0.60***	-0.34***	-0.34***
	(0.12)	(0.15)	(0.12)	(0.13)	(0.15)	(0.21)	(0.19)	(0.20)	(0.11)	(0.13)
SP x TG^2	-0.01	-0.01	0.02	0.02	-0.15**	-0.15**	0.06	0.06	-0.11**	-0.11
	(0.07)	(0.0768)	(0.07)	(0.07)	(0.06)	(0.07)	(0.09)	(0.09)	(0.05)	(0.06)
Number of observations	1191	1191	795	795	396	396	304	304	887	887
Sargan test	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hansen test	0.30	1.00	0.89	1.00	1.00	1.00	1.00	1.00	0.41	1.00
AR(1) probability	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
AR(2) probability	0.42	0.43	0.37	0.37	0.20	0.23	0.39	0.40	0.45	0.46
GMM conditions	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: GMM conditions are rejection of AR(1), non-rejection of Hansen test, non-rejection of AR(2). Yes means satisfies all GMM moment conditions, No means not all GMM moment conditions were satisfied. p-value significance, * p<0.1, **p<0.05 and *** p <0.01 (standard error in parentheses)

f: clustering at firm level. i: clustering at industry level.

Table 9: First differenced-One Step GMM of Local Firm Production Function Using Labour Spillover Variable

	Panel A Overall f	Panel A Overall i	Panel B Low-Tech f	Panel B Low-Tech i	Panel C Hi-Tech f	Panel C Hi-Tech i	Panel D Manufacturing f	Panel D Manufacturing i	Panel E Services f	Panel E Services i
SP (spillover)	0.29	0.290	0.304	0.304	-1.185	-1.19	1.37*	1.37	-0.62	-0.62
	(0.78)	(0.861)	(0.668)	(0.741)	(0.796)	(0.82)	(0.82)	(0.90)	(0.69)	(0.79)
SP^2	-0.38	-0.38	-0.14	-0.14	0.62	0.62	-0.70	-0.70	0.04	0.04
	(0.65)	(0.75)	(0.605)	(0.73)	(0.76)	(0.81)	(0.81)	(0.93)	(0.60)	(0.72)
SP x Crisis	-0.06***	-0.06*	-0.07***	-0.07**	-0.04	-0.04	-0.14***	-0.14**	-0.04	-0.04
	(0.02)	(0.03)	(0.03)	(0.03)	(0.05)	(0.06)	(0.05)	(0.06)	(0.03)	(0.04)
lnRaD	-0.04	-0.04	0.00	0.00	-0.08***	-0.08**	0.02	0.02	-0.06	-0.06
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)
SP x RaD	0.07	0.07	0.00	0.00	0.15***	0.15***	-0.04	-0.04	0.10*	0.10*
	(0.05)	(0.04)	(0.05)	(0.04	(0.05)	(0.05)	(0.04)	(0.05)	(0.05)	(0.05)
TG	-0.82***	-0.82***	-0.85***	-0.85***	-0.87***	-0.87***	-0.90***	-0.90***	-0.78***	-0.78***
	(0.10)	(0.11)	(0.10)	(0.12)	(0.09)	(0.10	(0.19)	(0.21)	(0.08)	(0.09)
TG^2	0.00	0.00	-0.09*	-0.09*	0.10**	0.10**	-0.01	-0.01	0.01	0.01
	(0.06)	(0.06)	(0.05)	(0.05)	(0.05)	(0.05)	(0.10)	(0.10)	(0.04)	(0.05)
SP x TG	0.52***	0.52***	0.52***	0.52**	0.58***	0.58**	0.78*	0.78	0.45***	0.45***
	(0.16)	(0.19)	(0.16)	(0.21)	(0.17)	(0.23)	(0.43)	(0.47)	(0.13)	(0.15)
SP x TG^2	0.03	0.03	0.10	0.10	-0.02	-0.02	0.02	0.02	0.03	0.03
	(0.09)	(0.09)	(0.09)	(0.07)	(0.08)	(0.08)	(0.21)	(0.22)	(0.08)	(0.07)
Number of observations	1189	1189	794	794	395	395	304	304	885	885
Sargan test	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hansen test	0.19	1.00	0.94	1.00	1.00	1.00	1.00	1.00	0.41	1.00
AR(1) probability	0.00	0.00	0.00	0.01	0.00	0.00	0.02	0.02	0.00	0.00
AR(2) probability	0.19	0.19	0.33	0.36	0.10	0.13	0.08	0.073	0.339	0.35
GMM conditions	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: GMM conditions are rejection of AR(1), non-rejection of Hansen test, non-rejection of AR(2). Yes means satisfies all GMM moment conditions. p-value significance, * p<0.1, **p<0.05 and *** p <0.01 (standard error in parentheses). f: clustering at firm level. i: clustering at industry level.

Table 10: First differenced-One Step GMM of Local Firm Production Function Using Capital Spillover Variable

	Panel A Overall f	Panel A Overall i	Panel B Low-Tech f	Panel B Low-Tech i	Panel C Hi-Tech f	Panel C Hi-Tech i	Panel D Manufacturing f	Panel D Manufacturing i	Panel E Services f	Panel E Services i
SP (spillover)	-0.51	-0.51	-1.63**	-1.63**	-1.60*	-1.60*	0.79	0.79	-0.75	-0.75
	(0.86)	(0.85)	(0.74)	(0.79)	(0.89)	(0.82)	(0.94)	(1.11)	(0.73)	(0.73)
SP^2	0.30	0.30	0.95	0.95	1.45*	1.44*	-1.00	-1.00	0.52	0.52
	(0.72)	(0.78)	(0.68)	(0.75)	(0.76)	(0.73)	(1.11)	(1.37)	(0.63)	(0.73)
SP x Crisis	-0.05**	-0.05*	-0.064**	-0.06*	-0.05	-0.05	-0.12***	-0.12**	-0.04	-0.04
	(0.02)	(0.03)	(0.03)	(0.03)	(0.04)	(0.05)	(0.05)	(0.05)	(0.02)	(0.03)
lnRaD	-0.03	-0.03	-0.02	-0.02	-0.01	-0.01	-0.02	-0.02	-0.01	-0.01
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.04)	(0.04)
SP x RaD	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.02	0.02
	(0.05)	(0.04)	(0.05)	(0.04)	(0.06)	(0.07)	(0.05)	(0.04)	(0.05)	(0.05)
TG	-0.90***	-0.90***	-0.94***	-0.94***	-0.79***	-0.79***	-0.97***	-0.97***	-0.80***	-0.80***
	(0.08)	(0.09)	(0.08)	(0.10)	(0.08)	(0.09)	(0.12)	(0.13)	(0.07)	(0.09)
TG^2	0.03	0.03	-0.01	-0.01	0.10**	0.10**	0.10	0.10	0.00	0.00
	(0.05)	(0.05)	(0.05)	(0.05)	(0.04)	(0.04)	(0.09)	(0.09)	(0.04)	(0.04)
SP x TG	0.67***	0.67***	0.73***	0.73***	0.41***	0.41**	0.99***	0.99***	0.46***	0.46**
	(0.15)	(0.18)	(0.15)	(0.17)	(0.15)	(0.19)	(0.23)	(0.24)	(0.13)	(0.18)
SP x TG^2	-0.03	-0.03	-0.04	-0.04	-0.04	-0.04	-0.18	-0.18	0.04	0.04
	(0.09)	(0.09)	(0.09)	(0.08)	(0.09)	(0.08)	(0.15)	(0.15)	(0.07)	(0.07)
Number of observations	1191	1191	795	795	396	396	304	304	887	887
Sargan test	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hansen test	0.29	1.00	0.82	1	1.00	1	1	1	0.46	1
AR(1) probability	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AR(2) probability	0.61	0.63	0.54	0.54	0.18	0.24	0.16	0.16	0.53	0.56
GMM conditions	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: GMM conditions are rejection of AR(1), non-rejection of Hansen test, non-rejection of AR(2). Yes means satisfies all GMM moment conditions, No means not all GMM moment conditions were satisfied. p-value significance, * p<0.1, **p<0.05 and *** p <0.01 (standard error in parentheses)

f: clustering at firm level. i: clustering at industry level.

Table 11: First differenced-One Step GMM of Foreign Firm Production Function Using Output Reverse Spillover Variable

	Panel A Overall f	Panel A Overall i	Panel B Low-Tech f	Panel B Low-Tech i	Panel C Hi-Tech f	Panel C Hi-Tech i	Panel D Manufacturing f	Panel D Manufacturing i	Panel E Services f	Panel E Services i
SP	0.23	0.23	0.65	0.65	0.82	0.82	1.08	1.08	-2.19	-2.19
	(1.03)	(1.21)	(1.48)	(1.36)	(0.83)	(1.28)	(0.93)	(1.12)	(2.13)	(2.44)
SP^2	-0.58	-0.58	-0.66	-0.66	-0.60	-0.60	-1.42	-1.42	2.55	2.55
	(1.27)	(1.43)	(1.71)	(1.56)	(0.76)	(1.14)	(1.12)	(1.29)	(2.07)	(2.21)
SP x Crisis	-0.06	-0.06	-0.18***	-0.18***	-0.23***	-0.23**	-0.24***	-0.24***	-0.09	-0.09
	(0.05)	(0.05)	(0.06)	(0.07)	(0.07)	(0.10)	(0.05)	(0.06)	(0.10)	(0.09)
lnRaD	-0.07***	-0.07**	-0.03	-0.03	-0.03	-0.03	0.01	0.01	0.03	0.03
	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.03)	(0.03)	(0.05)	(0.06)
SP x lnRaD	0.04	0.04	0.08	0.08	0.07	0.07	-0.01	-0.01	-0.18	-0.18
	(0.08)	(0.09)	(0.12)	(0.12)	(0.06)	(0.06)	(0.05)	(0.06)	(0.16)	(0.18)
TG	-0.40***	-0.40***	-0.41**	-0.41**	-0.52***	-0.52***	-0.53***	-0.53***	-0.40**	-0.40**
	(0.10)	(0.13)	(0.18)	(0.19)	(0.08)	(0.14)	(0.08)	(0.14)	(0.19)	(0.19)
TG^2	-0.03	-0.03	-0.05	-0.05	-0.04**	-0.04**	-0.02	-0.02	-0.03	-0.03
	(0.03)	(0.04)	(0.08)	(0.09)	(0.02)	(0.02)	(0.04)	(0.05)	(0.07)	(0.06)
SP x TG	-0.23	-0.23	-0.26	-0.26	-0.07	-0.07	-0.06	-0.06	-0.42	-0.42
	(0.41)	(0.43)	(0.45)	(0.46)	(0.28)	(0.40)	(0.28)	(0.36)	(0.55)	(0.51)
SP x TG^2	0.32	0.32	-0.03	-0.03	0.25*	0.25	0.00	0.00	0.13	0.13
	(0.33)	(0.31)	(0.62)	(0.59)	(0.14)	(0.15)	(0.08)	(0.08)	(0.37)	(0.36)
Number of observations	1207	1207	549	549	913	913	964	964	511	511
Sargan test	0.64	0.64	0.01	0.01	0.00	0.00	0.00	0.00	0.08	0.08
Hansen test	0.23	0.72	0.29	0.79	0.94	1	0.84	1	0.20	0.54
AR(1) probability	0.00	0.01	0.02	0.03	0.00	0.00	0.00	0.00	0.01	0.01
AR(2) probability	0.94	0.95	0.06	0.07	0.12	0.12	0.22	0.23	0.95	0.95
GMM conditions	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lags dependent variable	Yes	Yes	Yes	Yes	No	No	No	No	Yes	Yes

otes: GMM conditions are rejection of AR(1), non-rejection of Hansen test, non-rejection of AR(2). Yes means satisfies all GMM moment conditions, No means not all GMM moment conditions were satisfied. p-value significance, * p<0.1, **p<0.05 and *** p <0.01 (standard error in parentheses)

f: clustering at firm level. i: clustering at industry level.

Table 12: First differenced-One Step GMM of Foreign Firm Production Function Using Labour Reverse Spillover Variable

	Panel A Overall f	Panel A Overall i	Panel B Low-Tech f	Panel B Low-Tech i	Panel C Hi-Tech f	Panel C Hi-Tech i	Panel D Manufacturing f	Panel D Manufacturing i	Panel E Services f	Panel E Services i
SP	0.49	0.49	-0.63	-0.63	1.37	1.37	2.01	2.01	1.33	1.33
	(2.35)	(2.66)	(1.52)	(2.30)	(0.94)	(1.19)	(1.35)	(1.93)	(2.02)	(2.18)
SP^2	-0.49	-0.49	0.84	0.84	-0.78	-0.78	-1.24	-1.24	0.17	0.17
	(1.96)	(2.11)	(1.16)	(1.86)	(0.83)	(1.07)	(1.09)	(1.64)	(1.77)	(2.04)
SP x Crisis	-0.06***	-0.06***	-0.10***	-0.10***	-0.08***	-0.08***	-0.10***	-0.10***	-0.04*	-0.04
	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.03)
lnRaD	-0.00	-0.00	-0.02	-0.02	0.03	0.03	0.05	0.05	0.14	0.14
	(0.10)	(0.11)	(0.05)	(0.06)	(0.04)	(0.05)	(0.05)	(0.06)	(0.12)	(0.13)
SP x lnRaD	-0.07	-0.07	0.02	0.02	-0.07	-0.07	-0.10	-0.10	-0.28	-0.28
	(0.15)	(0.16)	(0.08)	(0.09)	(0.05)	(0.07)	(0.06)	(0.07)	(0.19)	(0.21)
TG	-0.83***	-0.83***	-0.73***	-0.73***	-0.64***	-0.64***	-0.71***	-0.71**	-0.33	-0.33
	(0.26)	(0.26)	(0.20)	(0.21)	(0.18)	(0.22)	(0.23)	(0.27)	(0.32)	(0.34)
TG^2	-0.07	-0.07	0.03	0.03	-0.01	-0.01	0.07	0.07	0.10	0.10
	(0.10)	(0.09)	(0.09)	(0.10)	(0.03)	(0.03)	(0.08)	(0.08)	(0.08)	(0.08)
SP x TG	0.80*	0.80*	0.32	0.32	0.14	0.14	0.22	0.22	-0.31	-0.31
	(0.42)	(0.43)	(0.30)	(0.33)	(0.22)	(0.32)	(0.28)	(0.38)	(0.50)	(0.55)
SP x TG^2	0.17	0.17	-0.18	-0.18	-0.06	-0.06	-0.17	-0.17*	-0.26	-0.26
	(0.20)	(0.17)	(0.17)	(0.19)	(0.07)	(0.07)	(0.11)	(0.10)	(0.19)	(0.20)
Number of observations	1186	1186	1122	1122	873	873	924	924	763	763
Sargan test	0.69	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.14
Hansen test	0.36	0.86	0.16	0.99	0.98	1	0.91	1	0.15	0.71
AR(1) probability	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
AR(2) probability	0.65	0.67	0.14	0.18	0.09	0.10	0.07	0.07	0.37	0.39
GMM conditions	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lags dependent variable	Yes	Yes	Yes	Yes	No	No	No	No	Yes	Yes

Notes: GMM conditions are rejection of AR(1), non-rejection of Hansen test, non-rejection of AR(2). Yes means satisfies all GMM moment conditions, No means not all GMM moment conditions were satisfied. p-value significance, * p<0.1, **p<0.05 and *** p <0.01 (standard error in parentheses)

f: clustering at firm level. i: clustering at industry level.

Table 13: First differenced-One Step GMM of Foreign Firm Production Function Using Capital Reverse Spillover Variable

	Panel A Overall f	Panel A Overall i	Panel B Low-Tech f	Panel B Low-Tech i	Panel C Hi-Tech f	Panel C Hi-Tech i	Panel D Manufacturing f	Panel D Manufacturing i	Panel E Services f	Panel E Services i
SP	-1.41	-1.411	3.270	3.27	1.04	1.04	2.07*	2.07	1.59	1.59
	(3.25)	(4.501)	(4.001)	(3.83)	(0.92)	(1.01)	(1.07)	(1.48)	(1.01)	(1.16)
SP^2	2.40	2.40	-2.07	-2.07	-0.47	-0.47	-1.90**	-1.90*	-0.25	-0.25
	(2.60)	(3.74)	(2.38)	(2.44)	(0.78)	(0.88)	(0.87)	(1.13)	(0.70)	(0.78)
SP x Crisis	-0.07***	-0.07**	-0.06**	-0.06*	-0.10***	-0.10***	-0.10***	-0.10***	-0.082***	-0.08***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.02	(0.03)	(0.02)	(0.01)	(0.02)	(0.03)
lnRaD	-0.01	-0.01	-0.01	-0.01	-0.04*	-0.04	-0.04**	-0.04	0.00	0.00
	(0.04)	(0.05	(0.06)	(0.06)	(0.02)	(0.03)	(0.02)	(0.04)	(0.02)	(0.02)
SP x lnRaD	-0.00	-0.00	0.01	0.01	0.01	0.01	0.01*	0.00	-0.01	-0.00
	(0.01)	(0.01)	(0.02)	(0.02)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)
TG	-0.99***	-0.99***	-1.11*	-1.11*	-0.77***	-0.77***	-0.78***	-0.78***	-0.98***	-0.98***
	(0.34)	(0.37)	(0.57	(0.59)	(0.13)	(0.19)	(0.18)	(0.23)	(0.13)	(0.16)
TG^2	-0.05	-0.05	-0.06	-0.06	-0.01	-0.01	0.04	0.049	0.00	0.00
	(0.09)	(0.07)	(0.22)	(0.17)	(0.03)	(0.02)	(0.06)	(0.06)	(0.02)	(0.02)
SP x TG	1.16**	1.16*	0.97	0.97	0.31*	0.31	0.31	0.31	0.66***	0.66***
	(0.54)	(0.60)	(1.08)	(1.13)	(0.18)	(0.31)	(0.23)	(0.37)	(0.18)	(0.22)
SP x TG^2	0.13	0.13	-0.18	-0.18	-0.05	-0.05	-0.10	-0.10	-0.18***	-0.18**
	(0.24)	(0.21)	(0.61)	(0.56)	(0.07)	(0.06)	(0.09)	(0.08)	(0.06)	(0.07)
Number of observations	798	798	549	549	913	913	964	964	1074	1074
Sargan test	0.76	0.76	0.95	0.95	0.00	0.00	0.00	0.00	0.00	0.00
Hansen test	0.80	0.51	0.98	0.94	0.93	1	0.86	1	0.10	1.00
AR(1) probability	0.02	0.02	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00
AR(2) probability	0.28	0.35	0.08	0.10	0.12	0.12	0.31	0.31	0.21	0.26
GMM conditions	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lags dependent variable	Yes	Yes	Yes	Yes	No	No	No	No	Yes	Yes

Notes: GMM conditions are rejection of AR(1), non-rejection of Hansen test, non-rejection of AR(2). Yes means satisfies all GMM moment conditions. p-value significance, * p<0.1, **p<0.05 and *** p <0.01 (standard error in parentheses). f: clustering at firm level. i: clustering at industry level.
f: clustering at firm level. i: clustering at industry level.

Table 1: Overview Literature on Traditional Productivity Spillovers in Transition Economies

Author	Country [a]	Period	Data	Aggregation Level	Type of Spillovers	Results and method [b]
Djankov and Hoekman (2000)	CZ	1992-1996	Panel	Firm	Horizontal	- (FDI+JV); n.s. (only FDI) OLS, random effects
Bosco (2001)	HU	1993-1997	Panel	Firm	Horizontal	n.s. Cluster analysis, robust regression
Konings (2001)	BG, RO, PL	1993-1997	Panel	Firm	Horizontal	- (Bulgaria and Romania); n.s. (Poland) OLS and GMM IV
Li, Liu and Parker (2001)	CN	1995	Cross-Section	Industry	Horizontal	+ (labour); + (assets) OLS and 3SLS
Liu (2002)	CN	1993-1998	Panel	Industry	Horizontal + Vertical	+ (horizontal); + (vertical) 2SLS
Yudaeva, Kozlov, Melentieva and Pnomareva (2003)	RU	1993-1997	Panel	Firm	Horizontal + Vertical	+ (horizontal); - (vertical) OLS, Fixed effects

Damijan, Knell, Majcen and Rojec (2003)	BG, CZ, EE, HU, PL, RO, SI, SK	1994-1998	Panel	Firm	Horizontal	+ RO; n.s. (others) GMM (dynamic)
Javorcik (2004)	LT	1996-2000	Panel	Firm	Horizontal + Vertical	n.s. (horizontal); + (backward); n.s. (forward) OLS and Olley-Pakes regression
Lutz and Talavera (2004)	UA	1998-1999	Panel	Firm	Horizontal (regional)	+ GLS
Sinani and Meyer (2004)	EE	1994-1999	Panel	Firm	Horizontal	+ (labour); + (equity); + (sales) GLS
Pawlik (2006)	PL	1993-2002	Panel	Firm	Horizontal	- (capital, sales); n.s. (labour, investment) IV fixed effects
Wei and Liu (2006)	CN	1998-2001	Panel	Firm	Horizontal + Vertical	+ (horizontal); + (vertical) OLS?
Buckley, Clegg and Wang (2007)	CN	1995	Cross-Section	Firm	Horizontal	+ (if FDI is from Hong Kong, Macau, Taiwan); n.s. (If FDI is from other) OLS/Hausman Test
Halpern and Muraközy (2007)	HU	1996-2003	Panel	Firm	Horizontal + Vertical	n.s. (horizontal) + (vertical) Levinsohn-Petrin corrections
Wang and Yu (2007)	CN	2001	Cross-Section	Industry	Horizontal	+ (capital); + (labour) OLS/White’s correction

Author	Country [a]	Period	Data	Aggregation Level	Type of Spillovers	Results [b]
Tian (2007)	CN	1996-1999	Panel	Firm	Horizontal	+ (capital, tangible assets, local sales, traditional products, lower level salary); n.s (labour, labour, intangible assets, newly developed products); - (exports, higher level salary) OLS/White's correction
Marcin (2008)	PL	1996-2003	Panel	Firm	Horizontal + Vertical	+ (horizontal); + (backward); n.s. (forward) FE/White's correction
Wei, Liu and Wang (2008)	CN	1998-2001	Panel	Firm	Horizontal	+ (R&D); + (capital); + (labour) GLS, 3SLS
Liu (2008)	CN	1995-1999	Panel	Firm	Horizontal + Vertical	+ (horizontal); + (vertical) OLS?
Javorcik and Spatareanu (2008)	RO	1998-2003	Panel	Firm	Horizontal + Vertical	- (Horizontal); + (backward) OLS, translog, Levinsohn-Petrin correction
Abraham, Konings, Slootmaekers (2010)	CN	2002-2004	Panel	Firm	Horizontal	+ Olley-Pakes regression
Franco and Kozovska (2011)	PL, RO	2000-2006	Panel	Firm	Horizontal	+ (PL); n.s. (RO)

						OLS
Javorcik and Spatareanu (2011)	RO	1998-2003	Panel	Firm	Horizontal + Vertical	n.s. (horizontal); + (vertical, from US firms); - (vertical, from EU firms) OLS; Ackerberg, Caves and Frazer regression
Damijan, Rojec, Majcen and Knell (2013)	BG, CZ, HR, EE, LV, LT, PL, RO, SI, UA	1995-2005	Panel	Firm	Horizontal + Vertical	+ (horizontal, 6 out of 10); + (vertical, 2/3 out of 10) Olley-Pakes method

Notes: Table 1 provides an overview of most of the studies on the existence of productivity spillovers published between 2001 and 2013. This overview does not include working papers. In addition, the papers had to be accessible by the author.

[a] Abbreviations of countries: BG, Bulgaria; CN, China; CZ, Czech Republic; EE, Estonia; HR, Croatia; HU, Hungary; LT, Lithuania; LV, Latvia; PL, Poland; RO, Romania; RU, Russian Federation; SI, Slovenia; SK, Slovakia; and UA, Ukraine.

[b] n.s. indicates non-significant spillovers, + indicates positive spillovers & - indicates negative spillovers. The spillover variables used are reported in parentheses.

Source: Authors’ adaptation

Table 5: Means, Standard Deviations and Correlations of Variables for Local Firms in the Dataset

Variables	Obs	Mean	Std. Dev.	1	2	3	4	5	6	7
1. LnTFP	9701	2.88	0.93	-						
2. lnL	12082	1.79	1.52	0.00	-					
3. lnK	12323	4.03	2.50	-0.03***	0.58***	-				
4. lnM	14525	4.27	2.99	0.15***	0.55***	0.52***	-			
5. lnRaD	2461	1.87	2.27	0.14***	0.51***	0.43***	0.27***	-		
6. Technology Gap	8755	0.42	0.94	-0.74***	-0.05***	-0.02	0.24***	-0.14***	-	
7. Spillover	14986	0.67	0.24	-0.57***	-0.13***	-0.09***	-0.09***	-0.05**	0.18***	-

Notes: Table 5 presents the pairwise correlation coefficients across the variables that were presented in Table 7. The significant levels of the correlations are given by *** p < 0.01, ** p < 0.05 and * p < 0.10

Table 6: Means, Standard Deviations and Correlations of Variables for Foreign Firms in the Dataset

Variables	Obs	Mean	Std. Dev.	1	2	3	4	5	6	7
1. LnTFP	10308	3.26	0.94	-						
2. lnL	11495	3.02	1.91	-0.10***	-					
3. lnK	12732	5.79	2.78	-0.15***	0.70***	-				
4. lnM	13322	6.63	3.02	-0.01	0.56***	0.53***	-			
5. lnRaD	6292	2.77	2.39	-0.02	0.48***	0.49***	0.38***	-		
6. Technology Gap	8457	-0.39	0.89	-0.81***	0.00	0.08***	-0.08***	-0.07***	-	
7. Reverse Spillover	12707	0.25	0.22	-0.07***	-0.27***	-0.25***	-0.22***	-0.23***	0.15***	-

Notes: Table 6 presents the pairwise correlation coefficients across the variables that were presented in Table 6. The significant levels of the correlations are given by *** p < 0.01, ** p < 0.05 and * p < 0.10