CROSS SECTORAL FDI SPILLOVERS AND THEIR IMPACT ON MANUFACTURING PRODUCTIVITY[†]

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ABSTRACT

This paper explores the relationship between FDI spillovers and productivity in manufacturing firms in five European transition countries. The novelty of our approach lies in exploring different mechanisms of horizontal spillovers and disentangling the impact of backward and forward vertical spillovers from services and manufacturing sectors. We rely on firm level data obtained from the Amadeus database and annual input-output tables. The results from dynamic panel model estimations reveal that local manufacturing firms benefit from the presence of foreign firms in upstream services, especially in the knowledge intensive services, and in downstream manufacturing sector. Demonstration effect is found to be negatively associated with domestic firms' productivity, while worker mobility and increased competition appear to be the main channels of horizontal knowledge diffusion. The firms' productivity is also influenced positively by human capital and intangible assets. Finally, we show that the direction and intensity of both vertical and horizontal spillovers depend on the absorptive capacity of domestic firms.

Keywords: FDI, services, vertical linkages, productivity spillovers
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1. INTRODUCTION

FDI is often recognised as a catalyst for economic development; hence countries of Central and Eastern Europe have put considerable effort in attracting FDI through financial, fiscal and/or other incentives (OECD, 2005; Jindra and Rojec, 2014). The incentives offered to multinational corporations (MNCs) are based on the premise that FDI makes important contributions to economic development through either voluntary or involuntary knowledge transfer to local firms within and across industries, resulting in productivity improvements (Caves, 1974; Markusen and Venables, 1999; Blomström and Kokko, 2001; Javorcik, 2004; Hallin and Holmstrom-Lind, 2012). However, the empirical evidence has been rather inconclusive, with the estimated impact varying from positive for backward linkages to insignificant or even negative for horizontal and forward spillovers (Görg and Greenaway, 2004; Havránek and Iršová, 2011; Iršová and Havránek, 2013). Several reasons have been put forward to explain this ambiguity: the measurement of FDI spillovers (Ben Hamida and Gugler, 2009; Barbosa and Eiriz, 2009; Barrios et al., 2011; Driffield and Jindra, 2012), empirical methodologies employed (Görg and Strobl, 2001), the heterogeneity of domestic and foreign firms in terms of absorptive capacity and potential for spillovers (Blalock and Simon, 2009, Damijan et al., 2013: Javorcik and Spatareanu, 2011; Ha and Giroud, 2015), the difficulty of disentangling unintentional knowledge spillovers from intentional knowledge diffusion (Smeets, 2008), and competition effects (Garcia et al., 2013).

Although a great deal of research has been devoted to understanding of FDI spillovers, some significant knowledge gaps remain. Most of the existing empirical literature has treated FDI spillovers as a black box and has settled so far to identify an overall net effect. Therefore, implications of the existing empirical studies for policy makers are not well understood due to a plethora of different results. In this paper we aim to disentangle the role of different spillover channels. To this end, we extend the traditional empirical framework by including different channels of horizontal spillovers and by exploring the role of services that might be responsible for significant forward spillovers due to their strong orientation towards the domestic market (Javorcik, 2007). Contrary to previous studies which limited FDI spillover analysis to either backward manufacturing (Blalock and Gertler, 2008; Damijan et al., 2013; Merlevede et al., 2014) or forward services linkages (Arnold et al., 2011, Fernandes and Paunov, 2012) we consider both sectors.

FDI in services now accounts for almost 65 per cent of the total worldwide inward FDI stock (UNCTAD, 2014). Despite the broad consensus that the growth of services is crucial for economic growth and the development of other sectors (Francois, 1990; Eschenbach and Hoekman, 2006), little emphasis has been put on foreign firms in services. In addition, although the increasing role of services in economic output, employment and production processes at different levels of the value chain has been acknowledged (Hoekman and Mattoo, 2008; UNCTAD, 2008), spillovers from service sector firms to manufacturing customers and suppliers have been, with few exceptions, neglected (e.g. Miozzo and Grimshaw, 2008; Miozzo et al., 2012; Arnold et al., 2011; Fernandes and Paunov, 2012; Mariotti et al., 2013; Mariotti et al., 2015).

There are several reasons why FDI in services may have beneficial effects on domestic firms' productivity. First, given the limited scope for services trade, it is assumed that opening services to FDI brings advanced technology, know-how and other advanced inputs that may improve the performance of downstream domestic firms more directly than is the case of physical intermediate inputs which may be imported (UNCTAD, 2004; Kox and Rubalcaba, 2007). Moreover, many of the skills acquired by employees working for MNCs in services may be directly transferable to other sectors in the economy (Javorcik, 2007). Second, services are also direct inputs in the production function (Antonelli, 1999) and determine the productivity of factors of production, thus acting as a strong determinant of the competitiveness, innovation and growth (Guerrieri et al., 2005; Hoekman and Mattoo, 2008; François and Worz, 2008). Third, knowledge intensive services (KIS) may particularly have positive spillover effects on other industries if MNCs are not able to fully internalize the market for technology (Griliches, 1992; Camacho and Rodriguez, 2007; Arnold et al., 2011; Mariotti et al. 2013; Mariotti et al., 2015).

CEEC offer an interesting case for the analysis of FDI spillovers due to the massive expansion of the service sector - which played a minor role under socialism (Gabrisch and Hölscher 2006) - and the recent increase in FDI in services that is particularly relevant for increased efficiency, competition and quality of their service sector. Furthermore, governments of these countries invested significant resources in attracting MNCs (Jindra and Rojec, 2014). However, to date there has been no systematic investigation of the potential benefits of FDI in services on the productivity of manufacturing firms in these countries. Hence, this study aims to inform policy makers about productivity implications of FDI so that they can identify the industries that provide

the largest potential for technology spillovers and adjust their investment incentives accordingly. It also provides important information for the management of domestic firms – that in order to benefit from FDI spillovers, they need to invest and improve the quality of their human resources and intangible assets.

We contribute to the existing literature in several ways. First, we argue that prevailing measurement of vertical linkages does not allow proper identification of entire spillover benefits as it fails to differentiate between the channels through which spillovers occur. This is, to our best knowledge, the first study that investigates the spillover effects of foreign firms on the total factor productivity of local manufacturing firms by using four measures of vertical FDI spillovers: two related to backward linkages and two to forward linkages, each arising from manufacturing and service sectors, respectively. This enables us to shed more light on the customer-supplier relationship between domestic and foreign firms in two main sectors of the economy. Second, drawing on the notion of absorptive capacity (Cohen and Levinthal, 1990; George and Zahra, 2002; Narula and Marin, 2003), which highlights that ability of local firms to absorb the external knowledge depends on the interaction between the mechanisms by which they occur and the existing absorptive capacity (Blalock and Simon, 2009; Sanchez-Sellero et al., 2014), we evaluate the moderating role of domestic firms' investment in intangible assets and human capital. By using interaction terms between foreign presence and human capital, we explore the additional channel of horizontal spillovers related to worker mobility. Third, we investigate the heterogeneity of forward linkages in services which depends on the knowledge intensity of the service sector.

The analysis is based on firm level data in five small transition economies[1] (the Czech Republic, Estonia, Hungary, Slovakia and Slovenia) for the period between 2002 and 2010. These countries are characterised by strong penetration of foreign investment. Unlike other empirical studies, we use annual input-output tables for the calculation of spillover measures thus relaxing the restrictive assumption of fixed customer-supplier relationships at industry level. Our empirical strategy is based on a two-stage approach. In the first stage, we estimate firms' total factor productivity (TFP) using a semi-parametric method. In the second stage, we explore productivity spillovers using a dynamic model that tackles the problem of endogeneity.

[1] There are a few other small transition economies in Central and Eastern Europe, notably the Baltic states, but the unavailability of full data for these countries restricts the analysis to the five CEE countries.

The next section explains the motivation for investigating FDI spillovers in selected Central and Eastern Europe Countries (CEECs) and justifies our focus on vertical spillovers from FDI in services. In section 3, we review the current literature and relevant theoretical background, and formulate our hypotheses. Section 4 explains the variables used, the data and the empirical methodology, and presents the baseline empirical model. Section 5 details empirical findings and discusses the results of alternative model specifications. The last section contains concluding remarks including policy implications and suggestions for further research.

2. SERVICES FDI IN CEEC

At the beginning of the 1990s, the CEECs went through a process of transition from centrally planned to market oriented economies. FDI was one of the main drivers of this process, and constituted the main element of industrial policy in these countries (Myant and Drahokoupil, 2010). The reliance on FDI was especially pronounced in small CEECs (except Slovenia) where it was expected to bring the necessary capital, technology and know-how in an environment characterized by low investment and savings. Although foreign investors had to deal with political and economic instability, weak institutional framework and low quality of infrastructure, they were attracted by huge unsaturated market (e.g. Poland), skilled but cheap labour and privatization opportunities. MNCs successfully restructured the companies they acquired (Djankov and Murrell, 2002), increased their efficiency (Jindra, 2006) and international competitiveness (Rugraff, 2006). By early 2000s the increased integration of CEECs in Global Value Chains, especially into German automotive supply chain, led to increased embeddedness of foreign subsidiaries into local economies and promoted the upgrading of domestic manufacturing suppliers through the creation of backward linkages (Jindra et al., 2009) and spillovers associated with it (Damijan et al., 2013; Merlevede et al., 2014).

In the first decade of transition, foreign service providers undertook mainly horizontal demand-led investments (Hardy et al., 2011) that generally involved joint ventures or takeovers of domestic firms to draw on domestic firms' expertise and access to their clients (Dicken, 2003; Dossani and Kenney, 2007). However, with increased fragmentation and reallocation of production activities, many Western MNCs have moved their service operations to CEECs, the bulk of it going to the Czech Republic, Hungary and Poland to achieve cost efficiencies (Sass, 2008). These countries emerged as locations for outsourcing and offshoring of specific business functions (Fillipov and Kalotay, 2009).

Given the far reaching organizational changes in MNCs over the past decade, embedding domestic firms into production networks and fostering network-type linkages that are based on knowledge sharing is high on policy agenda of many governments in CEECs. In this context, services FDI offer opportunities for local firms to participate in the international division of labour, building upon their advantages such as highly skilled labour, ICT infrastructure and cultural proximity to Western Europe (i.e. the main investor). Although services constitute the majority of foreign firms in the CEECs and might be responsible for significant forward spillovers, so far, the impact of FDI in the service sector has been mainly investigated by case studies showing limited backward and forward linkages (Capik and Drahokoupil, 2011; Hardy et al., 2011) while implications for manufacturing firms' productivity have not been investigated except in very limited cases (Arnold et al., 2011). This study aims to fill this gap by differentiating between the vertical spillovers from the manufacturing and services.

3.MNCS AND POTENTIAL SPILLOVERS

3.1 INTRA- INDUSTRY SPILLOVERS

The most common assumption in FDI theory and new trade theory is that MNCs are the most productive firms and possess specific advantages that enable them to reap the benefits of operating in foreign countries and transfer technology across borders (Dunning and Lundan, 2008; Helpman et al., 2004; Antras and Yeaple, 2013). Given the technological sophistication of MNCs and their productivity advantage, a large volume of literature has developed to explain how FDI spillovers occur. Horizontal spillovers occur mainly through unintentional knowledge diffusion due to market failure (non-excludable and non-rival nature of knowledge) and therefore constitute an externality (Arrow, 1962; Hallin and Holmstrom-Lind, 2012). This unintentional knowledge diffusion could occur via different channels. One of these is the demonstration effects, which occur through imitation and reverse engineering of MNCs' ownership advantages, such as their know-how, and organizational and marketing practices (Kouizumi and Kopecky, 1977; Findlay, 1978). Worker mobility may be another source of knowledge spillovers as the MNCs are likely to provide host country workforce with more training, education and valuable work experience (Fosfuri et al., 2001; Glass and Saggi, 2002; Smeets, 2008; Markusen and Trofimenko, 2009).

Another strand of the literature emphasizes the endogenous nature of spillovers generated by competition between foreign and local firms (Wang and Blomström, 1992). The effects on local firms' behaviour are mainly pecuniary in nature. Foreign firms paying higher wages and offering other benefits may raise labour costs for local firms who want to keep their most valuable employees (Spencer, 2008). This increased competition may put downward pressure on prices leading to lower profitability and hence crowding out of local firms (Aitken and Harrison, 1999). Increased competition, however, may also have indirect knowledge effects by providing incentives to domestic firms to introduce stricter or more cost conscious management, develop new technology and encourage more efficient allocation of resources resulting in increased productivity (Blomström and Kokko, 1998). However, this cannot be considered as pure "not paid for" externality as domestic firms need to invest in their R&D, introduce organizational and managerial innovations and upgrade the skills of their employees which ultimately result in adoption and development costs (Zanfei, 2012).

Empirical studies find the effect of FDI horizontal spillovers on productivity of domestic firms in CEECs to be mostly insignificant or even negative (Djankov and Hoekman, 2000; Konings, 2001; Kolasa, 2008: Gersl et al., 2008; Damijan et al., 2013). These results are conditional on the measurement of horizontal spillovers. For example, Javorcik and Spatareanu (2008) use the share of foreign firm sales in total industry sales and find negative effects due to strong competition, while Schoors and Merlevede (2007) highlight a positive effect due to labour turnover. As emphasized by Ben Hamida and Gugler (2009), the ambiguity of empirical results is closely related to inability of theoretical and empirical models to provide a complete picture of the diverse channels and mechanisms through which technology is transmitted. In fact, the commonly used horizontal spillover effects measured by the share of foreign presence in the corresponding industry (e.g. share of foreign firms in total industry employment or sales) only capture the overall demonstration effects while it can partially contain competitive and/or worker mobility effects (Ben Hamida, 2013). To shed more light on the black box of different FDI spillovers mechanisms with potentially opposite effects, Ben Hamida and Gugler (2009) suggest to include additional control variables for each spillover mechanism.

With the above discussion in mind, this paper aims to test the following hypotheses:

H1a: The presence of MNCs in manufacturing is positively related to the productivity of domestic manufacturing firms in the same sector

H1b: The presence of MNCs in manufacturing is negatively related to the productivity of domestic manufacturing firms in the same sector

We expect *H1a* to hold if the positive demonstration and worker mobility effects prevail over the negative competition effect and *H1b* to hold when the MNCs are able to prevent the leakage of knowledge and technologies to local counterparts and exploit their superior technology and market power to force local competitors to reduce their output.

3.2 INTER-INDUSTRY SPILLOVERS

Vertical spillovers arise through customer-supplier relationship between the domestic and foreign firms. MNCs have an incentive to minimize technological leakages to their direct competitors but have a strong incentive to improve the productivity of their suppliers as improved input quality strengthens their competitive position in global markets (Alfaro and Rodriguez, 2004: Javorcik, 2004; Alcacer and Oxley, 2014). Backward spillovers occur when domestic suppliers experience productivity improvements through direct linkages and deliberate knowledge transfer from foreign customers (Giroud et al., 2012). By engaging in cooperation with MNCs, domestic suppliers are expected to benefit from inter-firm exchange of technical and managerial knowledge, assistance on product design, quality control and inventory management as well as financial and procurement assistance (Giroud, 2007; Zanfei, 2012). Even domestic firms which do not have a contractual relationship with foreign firms may benefit from spillovers through incentives to improve the quality of their products or scale economies arising from greater demand for domestic inputs (Javorcik, 2004; Newman et al., 2015). However, increased competition from abroad may result in negative backward spillovers if foreign firms rely on imported inputs.

Forward spillovers through direct linkages occur when foreign suppliers provide knowledge embodied in products, processes and technologies to domestic customers (Jindra et al., 2009). Domestic downstream firms may also benefit from indirect spillovers if the increased competition from foreign firms lead to better quality of inputs and lower prices (Rodriguez-Clare, 1996; Markusen, and Venables, 1999). However, opposite effects may also be observed if foreign firms capture a higher market share leaving domestic customers with fewer alternatives, hence higher input prices.

Spillovers from vertical linkages and corresponding productivity improvements occur either through voluntary knowledge transfer or through externalities in the form of increased demand for intermediate inputs (Giroud, 2012; Newman et al. 2015). Our dataset does not allow us to separate the effects of these two mechanisms.[2] Therefore, our estimations capture the combined effects of pure "not paid for" technological externalities that shift firm's production function and pecuniary externalities that arise from competition effects and changes in input prices. Positive spillovers will be observed if pecuniary and technological externalities outweigh negative competition effects.

The above discussion points to a further hypothesis about linkages which is tested in this paper:

H2: The presence of manufacturing MNCs creates positive backward spillovers to domestic manufacturing suppliers

H3: The presence of manufacturing MNCs creates positive forward spillovers to domestic manufacturing customers

3.3 SPILLOVERS FROM THE SERVICE SECTOR

There are several reasons why FDI in services may have beneficial effects on domestic manufacturing firms' productivity. It has been argued that the liberalization and deregulation of services has brought substantial benefits to the manufacturing sector in the form of cost reduction, increased variety, availability and better quality of inputs (Oulton, 2001; Barone and Cingano, 2011; Bourlès et al. 2013; Arnold et al., 2011; Fernandes and Paunov, 2012). Apart from increased competition which results in lower input prices, the superior technology of MNCs (Mirodout, 2006; Miozzo and Grimshaw, 2008) and the high quality of their services are expected to increase the TFP and innovative capability of domestic firms (Kox and Rubalcaba, 2007; Mas-Verdu et al. 2011; Evangelista et al., 2013). Although, theory provides compelling arguments for the importance of services inputs for manufacturing, firm level evidence on the effect of forward and backward spillovers from services are still relatively scarce.

[2] In the estimation of FDI productivity spillovers researchers, with a few exceptions (Newman et al., 2015), have been unable to separate the effects of intentional knowledge transfer from the knowledge spillovers (Smeets, 2008).

Arnold et al. (2011) analyse the impact of privatization, services liberalization, FDI penetration and the extent of competition in the services sector in the Czech Republic and find a strong positive association between services FDI and productivity of downstream manufacturing firms. Similar results are obtained by Fernandes and Paunov (2012) using Chilean data. Mariotti et al. (2013) investigate the impact of services MNCs on both upstream and downstream manufacturing firms in Italy. Their results point to both backward and forward linkage effects, the latter being the main channel for the transmission of knowledge to manufacturing firms.

The capacity of services MNCs to affect the productivity and efficiency of client firms is highly differentiated by the degree of tacit and codified knowledge (Consoli and Elche-Hortelano, 2010; Miles, 2005; Kox and Rubalcaba, 2007; Shearmur and Doloreux, 2008), and qualitative and innovative content of specific services provided to customers (Evangelista et al., 2013). Knowledge being their essential asset (Miles, 1994) - thus making spatial proximity a fundamental attribute (Landry et al., 2012; Doloreaux and Sharmour, 2012) - KIS can supply various types of inputs at varying levels of complexity, bring new knowledge, provide solutions and add or compensate for missing internal capacity by generating personalized solutions aimed at specific user's needs (den Hertog, 2000; Tether and Hipp, 2002). Hence, the interaction with KIS may support and/or improve the domestic customers' innovation and organizational processes (Ripolles-Melia et al., 2010; Shearmur et al., 2015).

Based on the discussion above, the following hypotheses will be tested in this paper:

H4: The presence of services MNCs creates positive forward spillovers to manufacturing customers

H5: The effects of forward linkages from services on downstream manufacturing firms is reinforced by the presence of MNCs in knowledge intensive services (KIS)

4. EMPIRICAL STRATEGY

4.1 ESTIMATING FIRMS' PRODUCTIVITY

The literature on the estimation of TFP at firm level has developed significantly over the past years. The original approach of estimating a Cobb-Douglas production function using OLS method was criticised for producing biased results due to the endogeneity of factor inputs and the

unobserved productivity (Marschak and Andrews, 1944). In response to this, Olley and Pakes (1996), Levinsohn-Petrin (2003) and Ackerberg et al. (2006) developed a semi-parametric estimator that imposes a certain structure on firm behaviour and timing of factor inputs. The TFP estimates in this study are obtained using Wooldridge (2009) estimator as implemented by Petrin et al. (2011) and Petrin and Levinsohn (2012)[3]. This approach is in several ways superior to Olley and Pakes (OP) and Levinsohn and Petrin (LP) estimators.[4]

Production functions are estimated for each country-industry combination identified by 2-digit NACE Rev. 1.1 classification to account for the heterogeneity arising from different production technologies, quality and intensity of inputs.[5] Output is measured by the value added, labour by the number of employees, capital by the book value of tangible fixed assets, and intermediate inputs are proxied by the cost of materials. Monetary values are deflated using industry price indices obtained from the OECD STAN database.

4.2 MEASUREMENT OF FDI SPILLOVER VARIABLES

To estimate the spillovers from the operation of foreign firms in manufacturing or services on the productivity of manufacturing firms, we define three types and measures of spillovers: horizontal, vertical backward and vertical forward. The last two are further divided into spillovers from MNCs in the manufacturing and service sectors. Horizontal spillovers for each industry-year are defined as: [6]

$$Horizontal_{jt} = \frac{\sum_{i \epsilon j}(Foreign_{it} * Y_{it})}{\sum_{i \epsilon j} Y_{it}} \quad (1)$$

where Y_{it} is the output (measured as revenue) produced by firm *i* in industry *j* in year *t* and *Foreign* is a dummy variable taking value of one if the sum of shares of foreign investors in firm *i* is at

[3] We have also employed alternative estimators (OLS, system-GMM and Levinsohn-Petrin) for robustness checks. The results of Cobb-Douglas production function estimates for each industry and country as well as correlation coefficients of TFP estimates between different approaches can be found in Tables A1 and A2 in Appendix. Results are in most cases comparable with those obtained by the Wooldridge methodology.

[4] First, it allows for simultaneous determination of factor inputs and technical efficiency. Second, it provides efficient standard errors robust to both heteroscedasticity and autocorrelation which is not the case with other structural estimators that rely on bootstrapped standard errors. Third, it is robust to Ackerberg et al. (2006) critique where labour may be unidentified in the first stage of the LP estimator.

[5] In order to satisfy the requirement of at least 50 observations per industry (Gal, 2013), some industries in each country have been merged based on the grouping used in the WIOD database.

[6] When calculating horizontal spillover measure, we included all firms in the database regardless of whether or not they were included in the TFP estimation (some firms were excluded from the latter because the data for some of the production function variables were missing).

least 10% of the firm's equity or higher and zero otherwise. The horizontal measure captures the share of foreign firms in the total output produced in industry *j* in time *t.* It is mainly a measure of demonstration effects. To differentiate between different spillover mechanisms, we additionally include two control variables: (i) interaction of foreign presence within the industry with the level of human capital; this serves as a proxy for labour mobility (ii) Herfindahl index as measurement for competition effects.

For the calculation of the vertical forward and backward spillovers, we follow the standard practice in the literature (Javorcik, 2004; Arnold et al., 2011) and approximate the inter-industry linkages by using each country's input-output tables obtained from the World Input-Output Database (WIOD). Information on 2-digit inter-industry sourcing are then combined with information from the Amadeus database. WIOD provides annual input-output tables, allowing us to integrate into the analysis the most recent developments in firm behaviour, i.e. the increased splintering of the value chain as well as the intensified outsourcing and offshoring behaviour (Baldwin and Lopez-Gonzalez, 2013). This brings about a significant improvement over previous studies in measuring inter-industry sourcing behaviour.

The vertical backward and forward spillovers from the presence of foreign firms are defined as:

$$Backward_{jt} = \sum_{k=1}^{K} \alpha_{jkt} \, Horizontal_{kt} \qquad (2)$$

$$Forward_{jt} = \sum_{l=1}^{L} \gamma_{ljt} \, Horizontal_{lt} \qquad (3)$$

where $Backward_{jt}$ ($Forward_{jt}$) measures the spillover effects from the MNCs to the upstream (downstream) domestic manufacturing firms. α_{jkt} is the share of manufacturing industry *j*'s output supplied to industry *k* while γ_{ljt} is the share of total inputs sourced from sector *l* to manufacturing sector *j*. $Horizontal$ is the horizontal spillover measure given above. The technical coefficients α_{jkt} and γ_{ljt} are obtained from the annual I-O tables while the horizontal spillovers are calculated using firm level information from the Amadeus database.[7] Each of these spillover measures is

[7] Javorcik (2004) suggests to exclude the inputs supplied within the same industry while computing the technical coefficients α_{jkt} and γ_{jlt}. We depart from this approach due to relatively high aggregation of industries in WIOD; the exclusion of inputs supplied within the same 2-digit industry would cause productivity spillovers occurring at lower levels of aggregation to be captured by horizontal spillovers and lead to underestimation of vertical spillovers (Barbosa and Eiriz, 2009).

calculated for manufacturing and services separately. Equations 2 and 3 imply that the stronger the inter-industry linkages or the higher the presence of foreign firms in the industry, the higher the spillover measure will be.

4.3 EMPIRICAL MODEL

The relationship between FDI and productivity is analysed by using a system-GMM approach (Arellano and Bond 1991; Arellano and Bover 1995; Blundell and Bond 1998) where FDI spillovers measures are treated as endogenous.[8] There are two main reasons for the choice of this method. First, since FDI is more likely to go to industries or regions that exhibit higher productivity ex ante, a positive correlation between FDI and productivity of domestic firms might simply reflect the location decision by foreign investors rather than positive spillover effects (Hale and Long, 2011). In addition, large and more productive manufacturing firms may lobby for the liberalization of particular service subsectors, thus generating a reverse causality situation and an upward bias in the coefficients of vertical linkages from services (Shepotylo and Vakhitov, 2015). Also, strong productivity growth of manufacturing firms may have attracted MNCs due to strong demand. The second reason is the dynamic nature of TFP, a static specification would be inappropriate given the autoregressive structure assumed in semi-parametric estimators.

The baseline model has the following form:

$$\ln TFP_{ijt} = \beta_0 + \beta_1 \, ln\left(TFP_{ij,t-1}\right) + \beta_2 MNC_{jt} + \beta_3 DF_{it} + \beta_4 IND_{jt} + \theta_j + \theta_r + \theta_t + \varepsilon_{ijt} \qquad (4)$$

where $ln\, TFP_{ijt}$ is the logarithm of total factor productivity of firm i in industry j at time t, $MNC_{j,t}$ is a vector of spillover measures as defined above, DF_{it} is a vector of firm level determinants of TFP, and IND_{jt} is a vector of variables controlling for competition and demand effects in industry j. Finally, $\theta_j, \theta_r, \theta_t$ denote industry (NACE 1.1), region (NUTS3) and time dummies to control for the unobserved effects such as the economy-wide technological progress,

[8] The lagged dependent variable is treated as predetermined while variables measuring FDI spillovers (horizontal, backward and forward) are treated as endogenous and as such are instrumented with their own lags and lagged differences. The initial specifications included the minimum number of lags, i.e. one lag for levels and differences in case of lagged dependent variable and two lags for FDI spillover variables (Roodman, 2009). However, in certain cases model diagnostics with minimum number of lags were not satisfied and therefore the instrument matrix included higher order lags (three or four) of the regressors.

macro productivity shocks, changes in specialization of certain industries and agglomeration economies that may also affect firm productivity.

The firm level controls include two variables to capture firm's absorptive capacity. The first one is the firm's employees' skill level proxied by the average labour cost, i.e. the ratio of total labour cost to the number of employees in the firm (Wagner, 2012). The second variable is the firm's endowment of specific advantages proxied by the ratio of intangible assets to tangible fixed assets. Both variables are measured in logarithms. Additionally, we control for firm's age in years and size measured by firm's total assets in logarithms. These two variables are included in quadratic form to control for possible nonlinear effects.

As for industry controls, *Herfindahl-Hirschman concentration index* is used to account for the intensity of competition. It is defined as the sum of squares of the sales shares of all firms in industry *j* at time *t*. Hence a higher index value, i.e. a value close to 1, implies lower competition. Inclusion of the concentration index is particularly important for the measurement of horizontal and forward spillovers as it isolates the effects of increased competition from knowledge spillovers (Javorcik, 2004). A negative coefficient for this index is expected when increased competition (i.e. lower index value) is associated with productivity increases.

Demand variable, on the other hand, controls for increased demand in downstream sectors due to entry of MNCs:

$$Demand_{jt} = \sum_{k=1}^{K} \alpha_{jkt} Y_{kt} \qquad (5)$$

where α_{jkt} represents the share of industry *j's* output needed to produce one unit of industry *k*'s output at time *t* and Y_{kt} is the total real output of industry *k* derived from the input-output tables (WIOD). Increased demand may induce scale economies which may be translated into higher TFP of local supplying firms.

4.4 Data and descriptive statistics

Central to the empirical analysis is the firm level Amadeus database provided by Bureau van Dijk (BvD) which contains the balance sheet and income statement information for a very large number of firms in the countries under consideration over the period 2002-2010.[9] Amadeus also provides

[9] Eapen (2013) suggests that in incomplete datasets such as Amadeus the effects of FDI productivity spillovers may be overestimated due to selection effects if one excludes small firms from the sample. Hence, the data is taken from the "full" version of Amadeus database with no size threshold.

other firm level information relevant for our analysis such as detailed ownership information, year of incorporation, employment, location of the firm, its economic activity, etc. We use several indicators to separate foreign and domestic firms. These are shareholders' names, their percentage share in equity and their country of origin. The most recent version of Amadeus enables to track ownership changes across years. This is a significant improvement over previous studies which distinguish domestic and foreign firms according to the information for the last year of the period of analysis, assuming that a firm was domestic or foreign throughout the period of analysis – clearly ignoring the fact that the ownership of firms changed regularly in the transition period. A firm is defined as foreign if the foreign shareholders directly own at least 10 per cent of its equity (IMF, 2009).

Bartelsman et al. (2009) point out that cross-country comparison of firm dynamics is hampered by definitional problems as well as measurement problems due to differences in coverage, unit of observation, classification of activity and data quality. This caveat also applies to the Amadeus database as it relies on national data sources, which are subject to change over time. To illustrate the coverage of Amadeus database we compare the original augmented version to Eurostat Structural Business Surveys (SBS). The validation consists of calculating employment, turnover and variables used to estimate TFP averaged over industry-time level by country. The results are reported in Table A3 in Appendix. Averaged over countries, our dataset covers at least 47 per cent of employment and 63 per cent of total turnover in the economy. However, Amadeus lacks representativeness in terms of size because non-reporting firms are typically the smallest ones. The bias towards larger firms in Amadeus is also confirmed in our case, in particular for Hungary – as shown in Table A4 in Appendix. Although the sample of firms in Amadeus may not be representative of entire population of firms for which TFP can be estimated, we still obtain representativeness that is comparable to the CompNet database (CompNet Task Force 2014), which is currently the most representative dataset that allows cross-country comparison of firm productivity, but is currently publicly unavailable at firm level. The Amadeus database is the only publicly available database which allow researchers to utilize cross-country firm level data. Despite its disadvantages, it has been extensively used in estimating TFP of firms (Damijan et al., 2013; Sanfilippo, 2015; Smeets and de Vaal, 2016) and exploring the location of foreign affiliates across EU regions (Casi and Resmini, 2014).

After cleaning the dataset for productivity estimation, the final sample contains an unbalanced panel of 20,050 domestic firms during the 2002-2010 period - 95,875 firm-year observations in 23

manufacturing industries (at 2 digit NACE, Rev. 1.1 classification).[10] Table A5 in the Appendix presents the number of domestic firms' observations in each country used in the estimation of TFP classified per Eurostat classification of technology intensive industries. To construct the measures of intra and inter-industry spillovers we rely on the information presented in Table A6 which shows the total number of foreign and domestic firms before data cleaning. Between 66 and 80 percent of total number of foreign firms are in services. A closer look reveals that most foreign firms operate in less knowledge and market knowledge intensive services while a relatively smaller proportion operate in manufacturing, mainly in medium high and medium low technology industries.

Table 1 presents summary statistics of variables used in the estimation of spillovers (Section 4). As can be seen, the share of foreign firms' output in manufacturing ranges from 3 to 35 percent in Slovenia and Estonia, respectively. These shares hide significant differences across different industries (Figure A1 in the Appendix) - 55 percent of total output in transport equipment is produced by foreign firms in comparison to only 13 percent in textile industry. The foreign presence is also significant in electrical and optical equipment industry, chemical industry, production of coke and fuels, non-metallic mineral products and rubber and plastics. A more detailed analysis of vertical linkages across industries and countries is provided in Figures A2 and A3 in the Appendix. In general, backward linkages from manufacturing and forward linkages from services provide the largest potential for knowledge transfer.

	Czech Republic		Estonia		Hungary		Slovakia		Slovenia	
Variable	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
ln TFP	3.51	0.99	2.70	0.81	4.17	1.02	3.34	0.97	3.87	0.86
Horizontal	0.30	0.17	0.36	0.17	0.23	0.15	0.25	0.22	0.03	0.10
Manufacturing backward	0.13	0.08	0.10	0.06	0.12	0.07	0.13	0.09	0.05	0.04
Manufacturing forward	0.07	0.05	0.05	0.03	0.07	0.04	0.05	0.04	0.01	0.01
Services backward	0.04	0.02	0.07	0.03	0.03	0.01	0.04	0.02	0.02	0.01
Services forward	0.08	0.03	0.13	0.06	0.08	0.02	0.08	0.04	0.05	0.03
Services LKIS	0.03	0.01	0.09	0.04	0.04	0.01	0.03	0.02	0.04	0.03

[10] For the construction of TFP sample we need information on firms' sales, tangible fixed assets, number of employees and expenditure on materials. Firms with missing, negative or zero values for any of the variables of interest are dropped from the sample. We have also eliminated observations for which accounting rules are violated. In order to avoid the extreme effects of outliers and aberrant values due to typing errors during data entry we have computed output to labour ratio, value added to labour ratio, capital to output ratio, labour to output ratio and dropped firms below the 1st percentile and above 99th percentile of their respective distributions.

Services KIS	0.03	0.01	0.03	0.02	0.02	0.01	0.02	0.01	0.01	0.01
ln Intangibles	-4.70	1.99	-4.20	1.99	-4.77	2.04	-5.19	1.89	-4.54	1.95
ln Human capital	2.19	0.59	1.75	0.69	2.47	0.49	2.16	0.75	2.75	0.38
Age	9.86	5.06	8.75	7.30	12.17	5.21	9.73	6.61	11.49	6.54
Age squared	122.89	143.22	129.71	445.96	175.30	221.41	138.29	319.58	174.75	225.19
ln Size	6.76	1.85	5.07	1.81	8.86	1.41	7.17	1.80	6.33	1.52
ln Size squared	49.15	26.54	29.03	20.07	80.44	26.33	54.70	26.49	42.40	20.50
HHI	0.03	0.06	0.08	0.08	0.11	0.14	0.08	0.10	0.16	0.15
ln Demand	8.14	1.01	5.75	0.97	8.60	0.82	8.56	1.29	6.98	0.89

Table 1. Summary statistics

5. EMPIRICAL FINDINGS AND DISCUSSION OF RESULTS

This section presents the results of the model estimations. [11] As system-GMM relies on internal instruments to deal with possible endogeneity, the Hansen J test of the validity of instruments together with autocorrelation test results are reported in the model diagnostics. In all models presented in the study, the Hansen J test cannot be rejected suggesting that employed instruments are satisfactory. Arellano and Bond test for autocorrelation confirms the absence of autocorrelation in second differences while rejecting the null hypothesis of no first order autocorrelation. Furthermore, the assumptions of no cross-sectional dependence and steady state are verified by the difference in Hansen C tests, respectively, for the lagged dependent variable and the equation in levels, suggesting that the models are correctly specified. The correlation coefficient matrices (reported in Table A7) together with the Variance Inflation Factors (VIF)[12] suggest that our results are not plagued by multicollinearity issues.

5.1 BASELINE MODEL

[11] Models are estimated separately for each country in the sample rather than pooling them together. This is mainly because this article aims to compare the FDI spillover effects in the selected countries rather than finding an overall average effect. Furthermore, as explained in the data section, Amadeus database relies on national sources, which may involve slight differences in the definition and measurement of variables in different countries. Besides, the estimations reveal heterogeneities among countries in the sample, supporting our preference for separate sample estimations. Finally, the effects of FDI across countries are likely to be different depending on host country characteristics. For example, across CEECs, growth and catch-up are determined by initial conditions, structural reforms, privatization and investment policies as well as the motives, structure and overall importance of FDI for economic upgrading.

[12] VIF values for all variables are less than ten.

Table 2 presents the results for the baseline model. Since we control for competition effects, we can interpret our measure of horizontal spillovers as a combination of demonstration and worker mobility effects. The estimates for the horizontal spillovers point to negative effects of foreign firms' presence in the same industry, thus rejecting H1a and supporting H1b. These results confirm some of the previous findings which suggest that foreign firms have strong incentives to prevent the leakage of embodied knowledge and technologies to their domestic competitors (Javorcik, 2004; Iršová and Havránek, 2013; Newman et al., 2015). In addition, foreign firms engage in "cherry picking" of best employees on the market. As the supply of skilled labour is inelastic, this may put upward pressure on wages of skilled workers in industries dominated by foreign firms (Jude, 2016). This may in turn raise the production costs of domestic firms and result in reduced efficiency. As for the competition effects, increase in competition induces domestic firms to become more productive in the Czech Republic while it impedes productivity improvement in Estonia; no significant evidence for either effect is found for the rest of the countries.

Table 2. System-GMM results of FDI productivity spillovers, baseline model

VARIABLES	Czech Republic	Estonia	Hungary	Slovakia	Slovenia
Lagged ln TFP	0.385***	0.267***	0.600***	0.385***	0.431***
	(0.022)	(0.027)	(0.114)	(0.043)	(0.057)
Horizontal	-0.167**	-0.635***	-0.701**	-0.383*	0.206
	(0.083)	(0.158)	(0.343)	(0.198)	(0.356)
Backward_manufacturing	1.740***	-0.597*	2.765**	1.815*	1.841**
	(0.599)	(0.339)	(1.355)	(1.100)	(0.933)
Forward_manufacturing	-2.573***	-1.331***	-3.082**	-0.257	-0.333
	(0.485)	(0.409)	(1.373)	(0.495)	(1.430)
Backward_services	-7.576***	1.286*	-20.662***	5.331*	-9.719**
	(2.158)	(0.674)	(6.324)	(2.801)	(4.698)
Forward_services	4.417***	3.110***	6.913*	6.150***	13.599***
	(1.492)	(0.710)	(4.147)	(1.752)	(5.205)
ln Human capital	0.482***	0.488***	0.295***	0.332***	0.526***
	(0.014)	(0.016)	(0.061)	(0.014)	(0.045)
ln Intangibles	0.045***	0.077***	0.008*	0.060***	0.029***
	(0.003)	(0.006)	(0.004)	(0.005)	(0.006)
Age	-0.009***	-0.015***	-0.005	-0.009***	-0.010***
	(0.002)	(0.002)	(0.004)	(0.003)	(0.002)
Age squared	0.000*	0.000***	-0.000	0.000*	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ln Size	0.213***	0.270***	0.080*	0.146***	-0.026
	(0.018)	(0.024)	(0.049)	(0.032)	(0.059)
ln Size squared	-0.004***	-0.007***	0.000	-0.003	0.011**
	(0.001)	(0.002)	(0.003)	(0.002)	(0.005)
HHI	-0.232***	0.241*	-0.142	-0.159	-0.189
	(0.062)	(0.136)	(0.116)	(0.106)	(0.132)
ln Demand	-0.033	-0.046	0.066	-0.020	0.029
	(0.024)	(0.033)	(0.047)	(0.016)	(0.100)

Model diagnostics					
No. of observations	29,263	11,451	2,499	8,140	3,584
No. of groups	9,712	2,870	1,278	3,074	1,136
No. of Instruments	55	86	107	60	81
Year effects	yes	yes	yes	yes	yes
Region effects	yes	yes	yes	yes	yes
Industry effects	yes	yes	yes	yes	yes
AR(1) p-value	0	0	0	0	0
AR(2) p-value	0.562	0.788	0.569	0.722	0.343
Hansen J Test p-value	0.106	0.107	0.682	0.755	0.353
Hansen C Test p-value (lagged dependent)	0.162	0.125	0.894	0.865	0.750
Hansen C Test p-value (equation in levels)	0.073	0.213	0.460	0.902	0.469

Notes: Robust standard errors in parenthesis. Windmeijer's finite-sample correction is applied to two-step estimations. *** significant at 1%, ** significant at 5%, and * significant at 10%.

As far as backward linkages are concerned (H2), the results suggest that, in all countries except Estonia, presence of foreign firms in manufacturing sectors benefits upstream domestic suppliers. The positive effects on local firms' productivity range from 1.7 per cent in the Czech Republic to 2.8 per cent in Hungary. These results are in line with most empirical studies (Havránek and Iršová, 2011) suggesting that countries such as the Czech Republic, Hungary and Slovakia which attracted large amount of FDI in tradable sectors are able to benefit from entering MNCs' production network.

Turning to backward linkages from services, positive effects on local manufacturing firms' productivity are evident only in Estonia and Slovakia, and are larger in magnitude in comparison to backward linkages from manufacturing. On the other hand, negative backward linkages from services are evident in manufacturing firms in the Czech Republic, Hungary and Slovenia and offset any positive effects arising from FDI in manufacturing sector. These findings are in line with those obtained by Mariotti et al. (2013) who found that four service sectors exhibit negative effects on upstream manufacturing firms unless the entry of MNCs is able to increase demand for intermediate manufacturing inputs. Ayyagari and Kosova (2010) found similar results when investigating the effects of backward linkages from services on the entry of domestic firms. They explain this by the fact that manufacturing firms usually supply only limited amount of intermediate inputs to services in form of communication and information technology and office automation equipment. Since in these industries barriers to entry may be high and foreign presence is significant, services firms may be more inclined to source from their foreign suppliers.

The findings with respect to forward spillovers (H3) suggest that inputs supplied by MNCs in manufacturing sector have detrimental effects on TFP in all countries, but are only statistically significant in the Czech Republic, Estonia and Hungary. A one percentage point increase in foreign presence in upstream manufacturing sector leads to decline in TFP levels between 1.3 (Estonia) and 3.1 (Hungary) percent. The results suggest that domestic firms may not have the capabilities to benefit from high quality inputs because of the difficulties in the integration of these into the production process. In addition, the motives of foreign manufacturing firms in CEECs are mostly efficiency-seeking, aiming to exploit low wages in production or to gain access to intermediate inputs at favourable costs. Therefore, their embeddedness into local market and the need to gain insight into the needs and requirements of potential customers in manufacturing sector is low. As evident from Figure A1 in Appendix A, an alternative explanation is that foreign firms may have gained a dominant market position in upstream sectors such as electrical and optical equipment industry, transportation and other machineries, enabling them to gain market power and better bargaining position in the sector resulting in higher priced inputs (Newman et al., 2015).

In the case of forward spillovers from the service sector (H4), the results indicate strong positive and significant effect of foreign owned services on downstream manufacturing productivity, thus confirming previous findings on the beneficial effects of FDI in services (Arnold et al., 2011; Fernandes and Paunov, 2012; Mariotti et al., 2013). The short run effects range from 3.1 per cent in Estonia to 13.6 per cent in Slovenia. Such large semi-elasticities may reflect the FDI penetration ratios in the service sector due to recent liberalisation where effects are expected to be larger for an increase in foreign presence from small levels than in sectors where levels of FDI are already saturated (Gersl et al., 2008). The evidence seems to indicate that productivity spillovers are more easily captured by manufacturing customers that buy inputs from services MNCs than through backward services linkages or forward manufacturing linkages.

For variables measuring absorptive capacity, the empirical findings suggest a positive and significant relationship between the human capital measure and TFP across all countries. One percent increase in average wage leads to 0.3 per cent increase in productivity in Hungary and up to 0.5 per cent in Slovenia. Similarly, the intensive use of intangible assets has a positive and significant effect in all countries; this is in line with other empirical studies examining the impact of intangibles on productivity (Marrocu et al., 2012; Hall et al., 2013; Battistini et al., 2015). Firm age suggests a nonlinear relationship in almost all countries except in Hungary where it is not significant and in Slovenia where there seems to be a negative linear effect of age. Firm's size has

a positive and significant effect in all countries, except Slovenia. Inverse-U shape effects can be found in the Czech Republic and Estonia suggesting that after firms achieve a certain size their effects on productivity starts to diminish. Finally, the effects of demand in downstream sectors are statistically insignificant.

5.2 EXPLORING THE MECHANISM OF HORIZONTAL SPILLOVERS

The absence of positive horizontal spillovers across countries indicates that it is important to differentiate between different mechanisms through which they occur, something we investigate next. To shed more light on three possible channels of horizontal spillovers, we augment our baseline model by including interaction terms between foreign presence in each 2-digit manufacturing industry and the level of human capital measured by the average wage in the industry. This interaction term serves as a proxy for labour mobility effects as the influence of foreign firms would be co-determined by the level of human capital of the local firms (Ben Hamida, 2013). Demonstration and competition effects are measured as before. For brevity of space, we report only the results for different horizontal channels in Table 3.[13]

Table 3. Horizontal spillovers from FDI

	Czech Republic	Estonia	Hungary	Slovakia	Slovenia
Demonstration	-3.231***	-1.515***	-2.623**	-2.324***	0.821
	0.804	0.298	1.245	0.629	2.51
Worker mobility	1.157***	0.539***	0.730*	0 .984***	-0.256
	0.308	0.143	0.443	0.265	0.867
Competition	-0.219***	0 .315***	-0.209*	-0.212*	-0.201
	0.071	0.118	0.108	0.124	0.126

Notes: Robust standard errors in parenthesis. Windmeijer's finite-sample correction is applied to two-step estimations.
*** significant at 1%, ** significant at 5%, and * significant at 10%.

Results indicate that our proxy for labour mobility and increased competition are associated with higher levels of productivity of domestic firms, while demonstration effects remain negative and significant. Our findings suggest that although domestic firms need to offer high wage premium to attract skilled and experienced employees from MNCs it is less costly to provide training internally. In line with theoretical model of Fosfuri et al. (2001) it seems that the productivity premium is higher than the wage premium.

[13] In an augmented model we have also interacted vertical spillovers with the levels of human capital, however the results are fairly similar to those obtained when exploring the role of absorptive capacity (reported below).

5.3 MODERATING ROLE OF ABSORPTIVE CAPACITY

The occurrence of FDI spillovers is not an automatic process and does not benefit all firms equally. In line with the literature emphasising that domestic firm heterogeneity play an important role in explaining FDI spillovers (Damijan et al., 2013; Jude, 2016) we exploit the concept of absorptive capacity in more detail. As noted by Cohen and Levinthal (1990) and George and Zahra (2002), absorptive capacity helps firms to identify, assimilate, transform and apply knowledge from the external environment. Therefore, benefits from FDI spillovers are more likely to occur in firms that are better able to absorb the technology that comes with MNCs. In this section, we test whether the intensity of a firm's intangible assets has a moderating effect on FDI spillovers. The use of intangible assets has potentially several advantages over other measures of absorptive capacity. First, intangible capital is a broader measure of absorptive capacity as it includes both innovation inputs and outputs developed in house or in arms-length transactions which leads to improvements in production process. Second, as suggested by Teece (2011) intangible assets consist of mostly non-codified knowledge and thus contribute to firm specific assets which in turn sustain firm competitiveness.[14] Third, intangible capital has been found to be a strong determinant of firm productivity in many studies (Syverson, 2011). Unlike other studies which use technological gap vis-a-vis foreign firms as proxy for absorptive capacity our measure considers innovation efforts undertaken to be able to use foreign knowledge productively.

Based on the above discussion, we test an additional hypothesis:

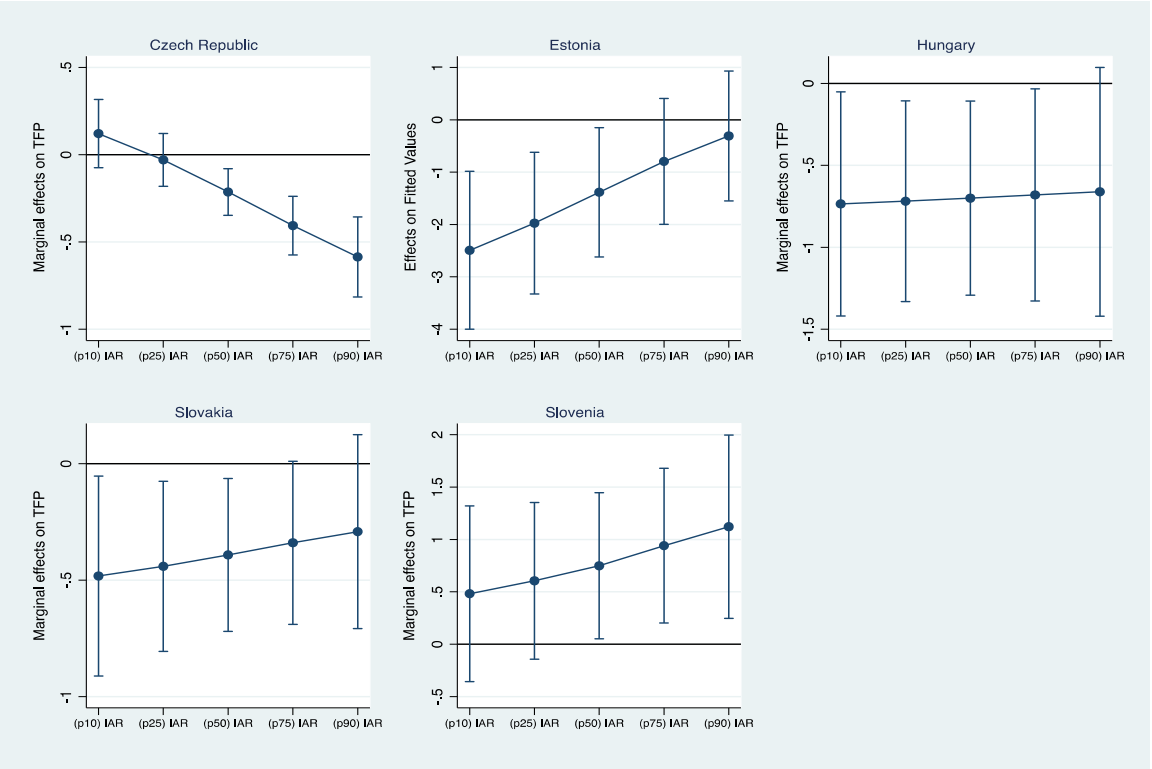
H6: The magnitude of horizontal spillovers and vertical linkages is greater for domestic firms with higher intangible assets ratio.

The model presented by equation (4) is now augmented by adding interaction terms between each FDI spillover measure and the logarithm of intangible to tangible fixed assets ratio. Since the interaction terms include two continuous variables we present the marginal effects of FDI spillovers on TFP conditional on the values of intangible asset ratio at the 10^{th}, 25^{th}, 50^{th}, 75^{th}, and 90^{th} percentiles. We find that the higher intensity of intangibles attenuates the negative horizontal spillover effects in Estonia and Slovakia while in Slovenia a statistically insignificant spillover effect at lower levels of intangible asset ratio becomes positive and significant at higher values

[14] For example, knowledge capital of the firm incorporated in intangible assets include R&D expenditure, software, patents, licences, designs, trademarks, organizational processes and firm specific skills that provide competitive advantages (Ragoussis, 2014).

(Figure 1). Results for the Czech Republic are contrary to expectations as the negative horizontal spillover effects get stronger with increases in intangible assets.

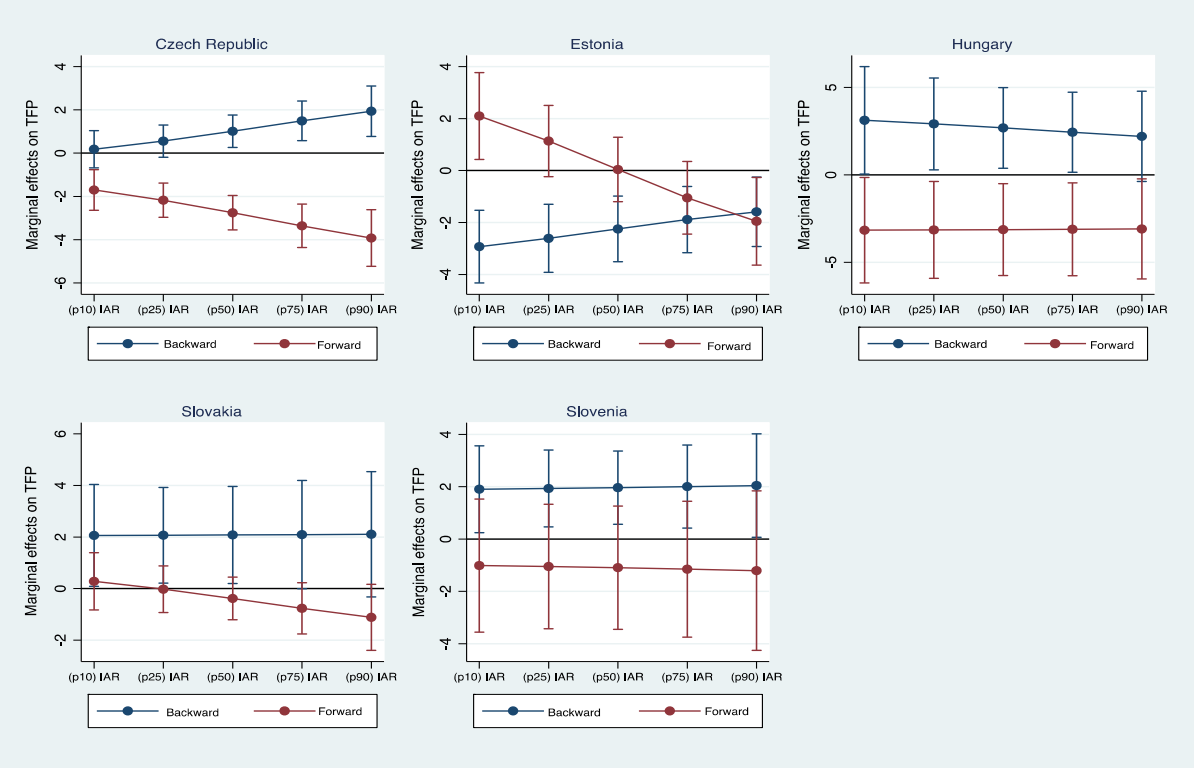
Figure 1. Average marginal effects of horizontal spillovers across intangible assets ratio percentiles



Turning to vertical linkages arising from manufacturing sectors, presented in Figure 2, findings suggest that domestic suppliers with higher absorptive capacity benefit from backward linkages only in the Czech Republic. In line with other studies, this result confirms the role of firm's

absorptive capacity as an enabling factor for FDI spillovers (Crespo and Fontoura, 2007; Blalock and Gertler, 2008; Damijan et al., 2013). However, in other countries increases in absorptive capacity do not appear to lead to changes in the marginal effects on TFP. In case of forward linkages, the point estimates for the Czech Republic, Estonia, Slovakia suggest a declining impact with higher levels of intangible asset ratio, though the difference across different percentiles is not statistically significant, except in Estonia.

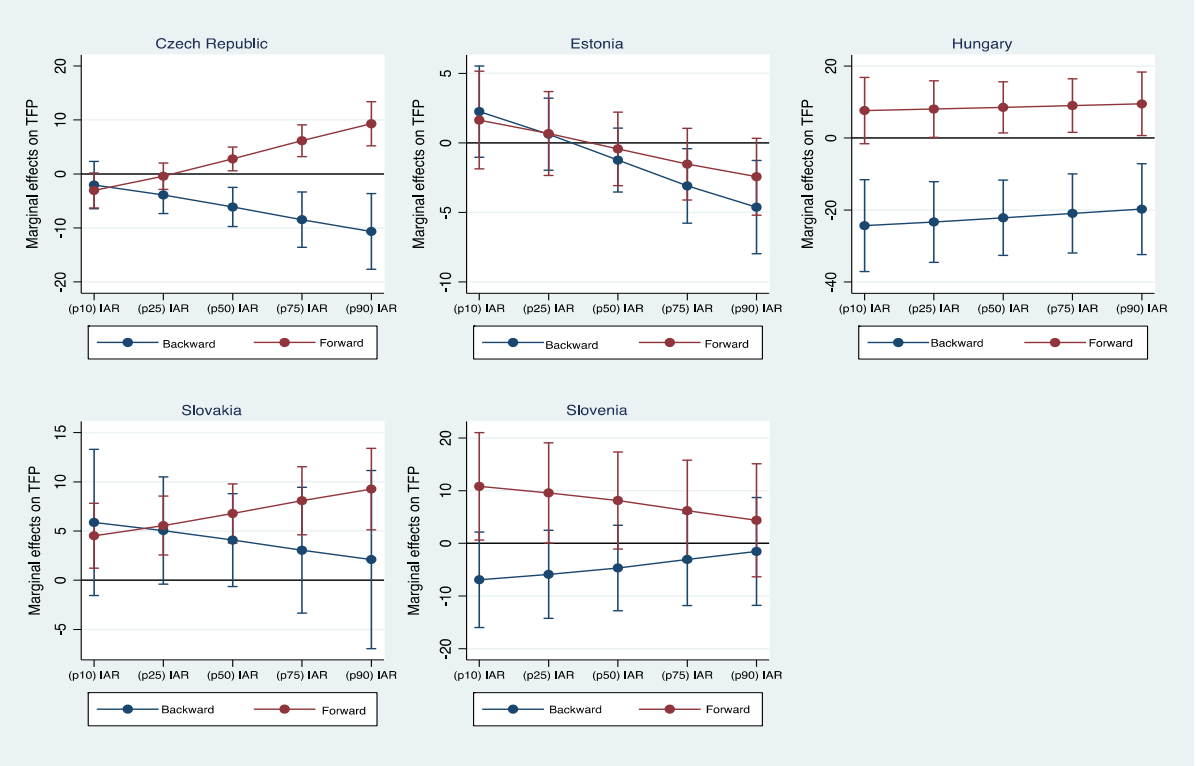
Figure 2. Average marginal effects of manufacturing vertical linkages across intangible assets ratio percentiles



Turning to linkages arising from the service sector, presented in Figure 3, the statistically insignificant effects of forward linkages becomes positive and significant for higher levels of intangible asset ratio in the Czech Republic while the moderating effects are insignificant in the

rest of the countries. Finally, none of the countries examined appear to benefit from backward vertical linkages with increased levels of absorptive capacity.

Figure 3. Average marginal effects of services vertical linkages across intangible assets ratio percentiles



There may be a few potential reasons for these largely unexpected results for most countries. The proxy used for measuring absorptive capacity may not distinguish between different types of

intangible capital; only externally acquired assets can be capitalized and therefore recognized as intangible asset while those assets generated internally is often expensed (Ragoussis, 2014). Even if intangible asset is bought on the market it requires specific dynamic capabilities to be accumulated and managed. Given rapid technological changes, the existence of organizational capabilities evident in routines and processes is required to refine and transform the knowledge (Nelson and Winter, 1982; Grant, 1996; Dosi et al., 2000; George and Zahra, 2002). Another critical resource in the process of intangible asset accumulation and exploitation is related to human capital (Abramovitz and David, 2000). Since the creation of specific competence in human capital requires hiring staff with higher education as well as formal and informal on-the-job training the costs may become too high causing firms to minimize investment in intangible asset (Cuervo-Cazurra and Un, 2009) and lead to heterogeneous patterns of investment in, and management of, intangible assets (Arrighetti et al., 2015).[15]

5.4 THE IMPORTANCE OF KNOWLEDGE INTENSIVE SERVICES

This section aims to shed more light on the role of knowledge intensity by separating forward linkages from services to those coming from less and more knowledge intensive industries. We employ standard Eurostat definition of knowledge intensive (KIS) and less knowledge intensive services (LKIS) as in Masso and Vahter (2012).[16] The results of the augmented model where services forward linkages are now separated according to KIS and LKIS are presented in Table 3.

The results show that KIS drive the positive effects of services forward linkages reported in the baseline model in Table 3, thus supporting H5. The largest effects are experienced by domestic firms in Hungary, Slovenia and the Czech Republic where a one percentage point increase in foreign firms' presence in KIS results in an increase in TFP between 8.93 and 19.75 percent. The only country in which LKIS have any positive and significant effect is Slovenia. Since FDI is industry specific (Buckley et al., 2007; Wang et al., 2009) and technology characteristics as well

[15] Economic competencies (e.g. human capital and organizational structure) are regarded as the most important part of intangible asset which are most difficult to measure and therefore are not included in the balance sheet. Given that they are important for the assimilation and exploitation of external knowledge, a limited set of capabilities included in our measure may hamper the complementarities between different types intangible asset and result in insignificant or in some cases negative moderating effects.

[16] Within the NACE 1.1 classification system the following industries are defined as knowledge intensive service sectors: water transport (NACE code 61), air transport (62), post and telecommunications (64), financial intermediation (65), insurance (66), activities auxiliary to financial intermediation (67), real estate activities (70), renting of machinery and equipment (71), computer and related activities (72), research and development (73) and other business activities (74). On the other hand, less knowledge intensive services sectors are: wholesale and retail trade (50-52), hotels and restaurants (55), land transport (60), and supporting and auxiliary transport activities (63).

as potential for knowledge absorption differ across industries (Spencer, 2008; Wang et al., 2012), we have further split manufacturing sector into high-tech and low-tech industries according to R&D intensity as defined by the OECD (2007). The results suggest significant positive effects of forward KIS on manufacturing firms in high-tech industries across all countries, except in Slovenia.[17] In addition, the beneficial effects of forward KIS on low-tech manufacturing firms are found in Hungary, Slovenia and Slovakia. In contrast, forward linkages from LKIS have mostly negative and significant effects on their downstream manufacturing customers in both types of industries in all countries except Slovenia. Overall, these results complement previous studies which found KIS to have a positive impact on downstream customers (Camacho and Rodriguez, 2007; Evangelista et al., 2013; Mariotti et al., 2013).

VARIABLES	Czech Republic	Estonia	Hungary	Slovakia	Slovenia
Lagged ln TFP	0.473***	0.285***	0.621***	0.374***	0.436***
	(0.042)	(0.027)	(0.087)	(0.042)	(0.054)
Horizontal	-0.233***	-0.417**	-0.603*	-0.533**	0.136
	(0.072)	(0.178)	(0.321)	(0.231)	(0.315)
Backward_manufacturing	0.944***	-0.926**	1.178	2.469*	1.458*
	(0.294)	(0.405)	(1.377)	(1.357)	(0.775)
Forward_manufacturing	-0.719	-0.739	-2.808*	-4.376**	0.152
	(1.853)	(0.553)	(1.470)	(2.024)	(1.251)
Backward_services	-8.240***	1.230*	-16.014***	1.945	-8.713*
	(1.657)	(0.740)	(5.581)	(3.710)	(4.573)
ForwardKIS	8.932***	2.229*	19.748**	3.432*	13.212*
	(3.092)	(1.283)	(8.586)	(2.029)	(7.732)
ForwardLKIS	-1.102	0.200	2.615	0.465	12.652***
	(1.680)	(1.919)	(7.858)	(0.340)	(4.806)
ln Human capital	0.435***	0.481***	0.278***	0.335***	0.509***
	(0.024)	(0.016)	(0.049)	(0.015)	(0.043)
ln Intangibles	0.038***	0.073***	0.007*	0.060***	0.028***
	(0.004)	(0.006)	(0.004)	(0.005)	(0.005)
Age	-0.007***	-0.015***	-0.005	-0.009***	-0.011***
	(0.002)	(0.002)	(0.004)	(0.003)	(0.003)
Age squared	0.000**	0.000***	-0.000	0.000*	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ln Size	0.161***	0.251***	0.064	0.151***	-0.001
	(0.029)	(0.030)	(0.049)	(0.032)	(0.056)

[17] Estimation results are not reported here for brevity of space. Full estimation results could be obtained from the authors on request.

ln Size squared	-0.003***	-0.006**	0.001	-0.003	0.008*
	(0.001)	(0.003)	(0.003)	(0.002)	(0.004)
HHI	-0.295***	0.306	-0.208**	-0.114	-0.215*
	(0.063)	(0.244)	(0.099)	(0.109)	(0.124)
ln Demand	-0.000	-0.022	0.103*	-0.009	-0.003
	(0.019)	(0.038)	(0.058)	(0.018)	(0.062)
Model diagnostics					
No. of observations	29,263	11,451	2,499	8,140	3,584
No. of groups	9,712	2,870	1,278	3,074	1,136
No. of instruments	60	68	95	66	90
Year effects	yes	yes	yes	yes	yes
Region effects	yes	yes	yes	yes	yes
Industry effects	yes	yes	yes	yes	yes
AR(1) p-value	0	0	0	0	0
AR(2) p-value	0.578	0.589	0.578	0.781	0.330
Hansen J Test p-value	0.262	0.261	0.796	0.677	0.449
Hansen C Test p-value (lagged dependent)	0.480	0.880	0.877	0.905	0.262
Hansen C tests p-value (levels equation)	0.218	0.318	0.900	0.880	0.266

Table 4. System-GMM results of FDI productivity spillovers, forward KIS vs. LKIS linkages

Notes: Robust standard errors in parenthesis. Windmeijer's finite-sample correction is applied to two-step estimations. *** significant at 1%, ** significant at 5%, and * significant at 10%.

6. CONCLUSION AND POLICY RECOMMENDATIONS

This article explores the effects of FDI spillovers on productivity of domestic firms in the manufacturing sectors of five CEE countries (the Czech Republic, Estonia, Hungary, Slovakia and Slovenia) between 2002 and 2010. It contributes to the existing scarce literature on productivity spillovers arising from FDI in the service sector (Arnold et al., 2011; Fernandes and Paunov, 2012; Mariotti et al., 2013) by examining whether the increased presence of MNCs encouraged by the recent liberalization of services leads to productivity improvements of domestic manufacturing firms. In addition, it sheds more light on different mechanisms through which foreign firms influence their direct competitors. This is an advancement compared with the existing literature which pools the different horizontal spillovers channels into a single aggregate coefficient. To the best of our knowledge, this is the first empirical study using firm level data and annual input-output tables for CEE countries that also disentangles vertical spillovers per industry source.

The results suggest that local manufacturing firms benefit from the backward spillovers in manufacturing and forward spillover effects of FDI in services. This confirms previous empirical findings that MNCs have a strong incentive to share knowledge with their suppliers (Javorcik,

2004; Damijan et al., 2013; Jude, 2016). They are also consistent with the view that the liberalization of services and the subsequent increased entry of MNCs is associated with improved availability, range and quality of services resulting in improved performance of downstream manufacturing firms (Arnold et al, 2011; Mariotti et al., 2013). Additionally, we found that the positive spillovers of FDI in services to manufacturing customers is driven by the presence of foreign firms in KIS. Despite positive forward spillovers from services, we confirm the previous literature highlighting negative manufacturing forward linkages that outweigh positive effects on their suppliers in the Czech Republic, Estonia and Hungary. It thus seems that domestic firms in downstream sectors are less fitted to benefit from technology spillovers then their domestic counterpart in upstream industries. In addition, local manufacturing supplier firms do not benefit from increased presence of MNCs in services except in Slovakia and Hungary.

We further contribute to the literature by investigating the different mechanisms of horizontal spillovers and explore the moderating effects of absorptive capacity. We find that knowledge diffusion within sectors mostly occur through worker mobility, while demonstration and competition effects exhibit negative effects on domestic firms' productivity. Additionally, gains from the presence of MNCs do not accrue equally to all firms. Those firms in the Czech Republic that have higher intensity of intangible asset ratio as a proxy for absorptive capacity are more likely to benefit from manufacturing backward and services forward linkages while the negative effects of intra industry spillovers are attenuated in Estonia and Slovakia.

6.1 POLICY RECOMMENDATIONS

Given the positive impact of foreign entry in services, particularly the KIS, on the performance of downstream manufacturing firms, policy makers should make every effort to encourage the greater presence of MNCs in services. However, more attention should be paid to the type and skill content of FDI in services. So far, CEE suppliers have been successful in integrating production network of MNCs in manufacturing sector, but the bulk of recent FDI in services characterised by vertical cost driven investment has still not been able to create backward spillovers.

Governments should provide information about any industry specific requirements needed by MNCs to facilitate the creation of vertical linkages and entry of indigenous firms into global value chains. Policy makers should encourage the entry of knowledge intensive services firms, thus contributing to the development of knowledge-based economy. Increased interaction within these group of services would facilitate the exchange of tacit and codified knowledge and increase the

local embeddedness of foreign firms. Since CEE already possess certain comparative advantages evident in low cost high skilled labour, cultural similarity, favourable geographical location and relatively developed infrastructure, host countries at national and regional level should develop their innovation capabilities and invest in intangible asset building upon their existing education and skills. By fostering linkages with MNCs and matching domestic capacities with dynamics of global value chains, especially in those characterised by modular or relational governance favourable to an open-ended upgrading through knowledge sharing, domestic firms with sufficient absorptive capability are more likely to benefit from technological spillovers and functionally upgrade to activities with higher value added. Therefore, investment incentives already in place should promote interaction with foreign firms, and be accompanied by innovation and knowledge promotion policies.

Regarding the managerial implications, our findings suggest that domestic suppliers to MNCs in manufacturing sector and manufacturing customers of MNCs in services should extend their linkages as they provide wider benefits to the economy in terms of indirect productivity spillovers. By contrast, domestic customers of manufacturing MNCs and suppliers to services MNCs should aim to establish closer relationships with MNCs. One possibility is to ensure that local standards, certification and accreditation meet international standards and best practice which would potentially result in more extensive backward linkages with services customers and knowledge diffusion. Given the somewhat limited role of intangible asset to moderate the capacity to absorb FDI spillovers, more effort should be put in developing capacities of domestic firms by reducing technical and managerial skills gap with foreign investors. One approach would be for managers to actively engage in cooperation with local universities and research centres and to invest in innovation activities. Given the increased internationalization of R&D and knowledge services managers of domestic firms should seek cooperation with foreign firms and encourage worker mobility by offering higher wages. In addition, given that manufacturing customers in high-tech sectors benefit more from services inputs, especially those coming from knowledge intensive services, managers of local manufacturing firms should ensure the assimilation and exploitation of the existing knowledge to increase their technological capabilities that would result in new processes, products and services and enable them to move up the value chain.

6.2 LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

As with previous studies, our paper is not without limitations. First, although we tried to disentangle different mechanisms of horizontal spillovers, our proxies for worker mobility and

competition are not without drawbacks. Standard measure of horizontal spillovers based on foreign firms output in total industry output is only capturing net effects of demonstration and competition effects without disentangling pecuniary from technological spillovers. Future research should try to disentangle different mechanisms through which foreign firms affect their direct domestic competitors by using better data and methodology. With this aim, collecting data on worker mobility from MNCs to domestic firms would be a first step. Since competition effects are mostly pecuniary in nature, investigating the survival of domestic firms and their reaction upon MNC entry is a promising research avenue as it may shed more light on the effects of pecuniary versus technological spillovers.

Second, due to reliance on secondary databases, the availability of data limits the empirical boundaries of the research. For example, our measure of vertical linkages is based on industry level data, and thus assumes that sourcing behaviour of foreign firms is homogenous within industries. In addition, we are not able to differentiate between the extent and intensity of linkages and consequently between FDI spillovers arising through direct linkages and externalities accruing to all firms in downstream and upstream industries. To better advance the understanding of these issues, future research should generate and analyse firm level survey data.

Recent IB studies have started looking at technological development, strategies and internal structure of MNCs and their effects on spillovers (Ghauri and Yamin, 2009). Given the importance of foreign firms' heterogeneity in terms of nationality, mode of entry, extent of ownership, intra firm strategies such as autonomy and technological capabilities and the nature and level of embeddedness of subsidiaries in local economy (Giroud, 2012), one should explore these issues in more depth. Furthermore, the heterogeneity of domestic firms in terms of international orientation, the level of internationalization and technological capabilities, and other factors influencing the scope and magnitude of spillovers should be considered. Unfortunately, the lack of detailed data regarding such characteristics hinders current empirical investigation. Finally, following Mariotti et al. (2015), further research could explore the role of spatial proximity of domestic and foreign firms. This would provide a promising step in advancing and understanding of the mechanism underlying productivity spillovers to domestic firms.

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APPENDIX

Table A1. Output of Cobb-Douglas value added production function across countries and industries based on Wooldridge (2009) estimator

	Czech Republic				Estonia				Hungary			
NACE GROUP	labour	capital	Observations	Returns to scale	labour	capital	Observations	Returns to scale	labour	capital	Observations	Returns to scale
1516	0.518***	0.172***	3,740	0.69***	0.497***	0.140***	1,013	0.637***	0.538***	0.192*	496	0.73**
1718	0.554***	0.154***	1,964	0.708***	0.695***	0.042	1,190	0.737***	0.732***	0.18	107	0.91
19	0.652***	0.521***	274	1.173	0.596***	0.0193	123	0.615***	0.732***	0.18	107	0.91
20	0.554***	0.145***	2,547	0.699***	0.520***	0.221***	2,000	0.741***	0.413	0.288	39	0.7
2122	0.725***	0.102***	3,127	0.827***	0.556***	0.104***	1,298	0.66***	0.848***	0.109	196	0.96
2324	0.421***	0.107**	1,315	0.528***	0.776***	0.0631	122	0.839	0.535***	0.0933	156	0.63***
25	0.490***	0.166***	2,990	0.656***	0.693***	0.140***	387	0.833**	0.550***	0.283**	298	0.83
26	0.353***	0.102***	1,864	0.455***	0.565***	0.269***	353	0.835*	0.487***	0.292**	141	0.78
2728	0.570***	0.209***	9,565	0.779***	0.732***	0.154***	1,927	0.886***	0.609***	0.348***	474	0.96
29	0.550***	0.138***	6,568	0.689***	0.578***	0.178***	706	0.757***	0.541***	0.243	281	0.78
3033	0.567***	0.169***	5,080	0.736***	0.657***	0.178***	533	0.835***	0.726***	0.218	263	0.94
3435	0.482***	0.239***	1,278	0.721***	0.719***	0.114**	372	0.832	0.676***	0.385***	128	1.06
3637	0.448***	0.199***	2,556	0.647***	0.529***	0.182***	1,482	0.711***	0.789***	-0.00057	114	0.79

	Slovakia				Slovenia			
NACE GROUP	labour	capital	Observations	Returns to scale	labour	capital	Observations	Returns to scale
1516	0.366***	0.322***	967	0.69***	0.582***	0.0508	207	0.63***
1718	0.503***	0.246***	440	0.75***	0.548***	-0.0218	176	0.52***
19	0.379***	0.342*	105	0.72	0.548***	-0.0218	176	0.52***
20	0.272***	0.305***	497	0.58***	0.346***	0.169***	219	0.51***
2122	0.577***	0.177**	525	0.75**	0.928***	0.0942**	558	1.02
2324	0.160**	0.218*	249	0.38***	0.484***	-0.161***	53	0.32***
25	0.384***	0.324***	564	0.71***	0.431***	0.147*	364	0.57***
26	0.151***	0.603***	447	0.75**	0.559***	-0.0113	125	0.54***
2728	0.367***	0.403***	1,680	0.77***	0.595***	0.228***	1,163	0.82***
29	0.341***	0.322***	1,185	0.66***	0.543***	0.147***	403	0.69***
3033	0.396***	0.267***	697	0.66***	0.445***	0.149**	283	0.59***
3435	0.197***	0.308***	291	0.51***	0.400***	0.385***	69	0.78**
3637	0.381***	0.381***	521	0.76**	0.237***	0.156**	308	0.39***

Note: Due to insufficient number of observations in industry 19, the latter was combined with industry 17 and 18 in Hungary and Slovenia.

Table A2. Correlation of TFP estimates across different estimators

	Czech Republic					Estonia					Hungary			
	WLP	LP	OLS	GMM		WLP	LP	OLS	GMM		WLP	LP	OLS	GMM
WLP	1.00				WLP	1.00				WLP	1.00			
LP	1.00	1.00			LP	1.00	1.00			LP	0.94	1.00		
OLS	0.85	0.84	1.00		OLS	0.89	0.88	1.00		OLS	0.50	0.49	1.00	
GMM	0.83	0.84	0.74	1.00	GMM	0.82	0.81	0.88	1.00	GMM	0.63	0.58	0.08	1.00
	Slovakia					Slovenia								
	WLP	LP	OLS	GMM		WLP	LP	OLS	GMM					
WLP	1.00				WLP	1.00								
LP	0.99	1.00			LP	0.98	1.00							
OLS	0.88	0.87	1.00		OLS	0.79	0.80	1.00						
GMM	0.78	0.81	0.69	1.00	GMM	0.64	0.57	0.51	1.00					

Table A3. Representativeness of Amadeus database versus Eurostat SBS

	SBS 2002-2010 (average)	Amadeus as a share of SBS				
	# firms	# employees	turnover	#firms with employees	#firms with employees and turnover	#firms with employees , value added and tangible fixed assets
Czech Republic	884,842	64%	80%	7%	5.1%	3.9%
Estonia	42,463	79%	86%	60.1%	59.0%	35.5%
Hungary	556,195	28%	81%	5.5%	5.2%	0.5%
Slovakia	47,624	53%	55%	43%	20.8%	17.7%
Slovenia	98,568	12%	11%	3.9%	3.2%	3.0%

Note: Data on the number of firms and turnover in year 2010 for Czech Republic are not available for most industries in SBS, therefore the comparison is made up until 2009. Similarly, there was a large increase in the number of firms in SBS for Slovakia starting from year 2010 so in order to reduce possible misrepresentation of the data, we limit the comparison up until 2009 for shares involving the number of firms.

Table A4. Comparison of firm size distribution between Eeurostat SBS and Amadeus database

	SBS (2002-2010 average)					Amadeus (firms with employment) (2002-2010 average)					Amadeus (firms with TFP) (2002-2010 average)				
	1-9	10-19	20-49	50-249	>250	1-9	10-19	20-49	50-249	>250	1-9	10-19	20-49	50-249	>250
Czech Republic	95.3%	2.4%	1.4%	0.8%	0.2%	68.2%	12.9%	9.5%	7.7%	1.8%	46.2%	19.2%	16.6%	14.5%	3.5%
Estonia	84.0%	8.0%	5.1%	2.6%	0.4%	79.3%	10.2%	6.7%	3.4%	0.4%	69.5%	15.0%	10.1%	4.8%	0.6%
Hungary	94.6%	3.0%	1.5%	0.8%	0.1%	78.8%	9.6%	6.5%	4.1%	1.1%	7.0%	10.8%	24.1%	41.6%	16.5%
Slovakia	84.8%	9.4%	2.8%	2.4%	0.6%	77.8%	10.9%	4.9%	5.1%	1.4%	67.7%	14.7%	10.5%	6.1%	1.0%
Slovenia	92.9%	3.6%	2.0%	1.2%	0.3%	72.3%	13.3%	8.7%	4.9%	0.8%	41.0%	23.1%	13.3%	17.7%	5.0%

Table A5. Number of observations (domestic firms only) used in TFP estimation

	Czech Republic	Estonia	Hungary	Slovakia	Slovenia
High tech manufacturing	3,439	424	338	493	192
Medium high tech manufacturing	16,027	1,596	966	2,983	869
Medium low tech manufacturing	20,029	3,784	1,448	4,036	2,247
Low tech manufacturing	19,762	9,228	1,539	4,478	1,997
Total	**59,257**	**15,032**	**4,291**	**11,990**	**5,305**

Table A6. Number of firms per industry and country over the 2002-2010 period in the original sample

	Czech Republic		Estonia		Hungary		Slovakia		Slovenia	
	Domestic	Foreign	Domestic	Foreign	Domestic	Foreign	Domestic	Foreign	Domestic	Foreign
Construction	134,352	1,119	43,096	1,263	88,475	145	71,102	199	15,259	55
High tech manufacturing	2,032	170	241	60	2,642	27	1,231	42	280	4
Medium high tech manufacturing	9,400	733	837	145	5,929	86	3,643	212	1,086	25
Medium low tech manufacturing	14,997	838	1,914	222	9,981	118	7,605	226	2,278	22
Low tech manufacturing	21,025	635	4,420	390	20,939	99	12,865	184	3,323	28
High knowledge intensive services	7,749	482	5,456	527	26,040	68	5,372	102	3,758	66
Market knowledge intensive services	109,401	6,309	25,157	2,212	105,204	349	41,912	496	15,649	97
Less knowledge intensive services	155,220	5,540	25,872	2,323	118,056	490	90,932	1,357	20,602	386
Total	**454,176**	**15,826**	**106,993**	**7,142**	**377,266**	**1,382**	**234,662**	**2,818**	**62,235**	**683**

Table A7a. Correlation matrix – Czech Republic

	TFP	Horizontal	Manufacturing backward	Manufacturing forward	Services backward	Services forward	Demand	HHI	Age	Size	Average wage	Intangibles
TFP	1.00											
Horizontal	0.12	1.00										
Manufacturing backward	0.04	0.14	1.00									
Manufacturing forward	0.16	0.22	0.40	1.00								
Services backward	-0.02	0.19	-0.26	0.09	1.00							
Services forward	0.06	0.37	0.48	0.31	0.33	1.00						
Demand	0.06	0.28	0.43	-0.04	-0.37	-0.12	1.00					
HHI	0.02	0.17	-0.04	-0.05	-0.01	-0.01	0.04	1.00				
Age	0.07	0.12	0.05	0.11	0.08	0.19	-0.09	-0.02	1.00			
Size	0.57	0.13	-0.01	0.09	-0.01	0.02	0.02	0.08	0.23	1.00		
Average wage	0.59	0.17	0.11	0.18	0.04	0.13	0.11	-0.01	0.07	0.30	1.00	
Intangibles	-0.04	-0.04	0.00	0.04	0.01	-0.02	0.02	0.00	-0.19	-0.40	-0.03	1.00

Table A7b. Correlation matrix – Estonia

	TFP	Horizontal	Manufacturing backward	Manufacturing forward	Services backward	Services forward	Demand	HHI	Age	Size	Average wage	Intangibles
TFP	1.00											
Horizontal	0.02	1.00										
Manufacturing backward	0.02	0.41	1.00									
Manufacturing forward	0.01	0.12	0.53	1.00								
Services backward	0.12	0.42	0.41	0.26	1.00							
Services forward	0.10	0.61	0.73	0.42	0.78	1.00						
Demand	-0.09	-0.14	-0.45	-0.36	-0.14	-0.37	1.00					
HHI	0.02	0.44	0.14	-0.08	0.13	0.20	-0.14	1.00				

Age	0.14	0.13	0.07	-0.02	0.11	0.14	-0.09	0.07	1.00			
Size	0.61	0.15	0.05	-0.01	0.07	0.12	-0.03	0.15	0.32	1.00		
Average wage	0.64	0.26	0.22	0.11	0.34	0.39	0.00	0.10	0.19	0.54	1.00	
Intangibles	-0.30	-0.01	0.02	0.02	0.06	0.02	-0.05	-0.01	-0.23	-0.70	-0.29	1.00

Table A7c. Correlation matrix - Hungary

	TFP	Horizontal	Manufacturing backward	Manufacturing forward	Services backward	Services forward	Demand	HHI	Age	Size	Average wage	Intangibles
TFP	1.00											
Horizontal	-0.24	1.00										
Manufacturing backward	-0.42	0.23	1.00									
Manufacturing forward	-0.35	0.50	0.58	1.00								
Services backward	0.01	-0.06	-0.08	-0.21	1.00							
Services forward	-0.34	0.25	0.50	0.50	0.48	1.00						
Demand	-0.03	-0.08	0.20	0.01	-0.18	-0.02	1.00					
HHI	0.00	0.33	0.01	0.10	-0.11	0.06	-0.05	1.00				
Age	0.02	-0.03	0.00	0.02	0.05	0.05	0.01	-0.07	1.00			
Size	0.49	0.15	-0.13	0.01	0.00	-0.03	0.03	0.11	0.12	1.00		
Average wage	0.35	0.14	0.09	0.15	0.17	0.18	0.11	0.00	0.08	0.37	1.00	
Intangibles	0.10	0.06	0.03	0.06	0.05	0.07	0.07	0.05	-0.03	0.05	0.20	1.00

Table A7d. Correlation matrix - Slovakia

	TFP	Horizontal	Manufacturing backward	Manufacturing forward	Services backward	Services forward	Demand	HHI	Age	Size	Average wage	Intangibles
TFP	1.00											
Horizontal	0.11	1.00										
Manufacturing backward	-0.11	0.22	1.00									

Manufacturing forward	0.13	0.31	0.47	1.00								
Services backward	0.14	0.22	0.21	0.48	1.00							
Services forward	-0.05	0.29	0.47	0.42	0.58	1.00						
Demand	-0.08	0.01	0.15	0.03	-0.22	0.10	1.00					
HHI	0.09	0.17	-0.26	-0.09	0.05	-0.11	-0.32	1.00				
Age	-0.05	0.03	0.01	0.05	0.08	0.10	-0.04	0.01	1.00			
Size	0.37	0.08	-0.08	-0.02	-0.08	-0.03	-0.01	0.09	0.09	1.00		
Average wage	0.46	0.05	0.07	0.08	0.04	0.03	0.09	0.00	-0.08	0.23	1.00	
Intangibles	0.15	0.04	0.05	0.08	0.05	-0.01	0.00	0.00	-0.09	-0.28	-0.03	1.00

Table A7e. Correlation matrix - Slovenia

	TFP	Horizontal	Manufacturing backward	Manufacturing forward	Services backward	Services forward	Demand	HHI	Age	Size	Average wage	Intangibles
TFP	1.00											
Horizontal	0.04	1.00										
Manufacturing backward	-0.06	0.05	1.00									
Manufacturing forward	-0.01	0.19	0.68	1.00								
Services backward	0.05	0.43	0.21	0.38	1.00							
Services forward	0.02	0.46	0.58	0.72	0.79	1.00						
Demand	0.02	-0.36	0.19	0.14	-0.20	-0.17	1.00					
HHI	0.07	0.28	-0.24	-0.10	0.12	0.08	-0.52	1.00				
Age	0.04	0.03	0.01	0.04	0.07	0.06	-0.03	-0.01	1.00			
Size	0.55	0.10	-0.03	0.03	0.05	0.07	-0.07	0.12	0.23	1.00		
Average wage	0.56	0.14	0.14	0.17	0.21	0.25	-0.01	0.01	0.11	0.41	1.00	
Intangibles	0.07	0.05	-0.03	-0.03	0.03	0.01	-0.09	0.11	-0.13	-0.24	-0.03	1.00

Figure A1. The share of foreign firms in industry output by country and industry

Figure A2. Average size of manufacturing backward and forward linkages across countries and manufacturing industries

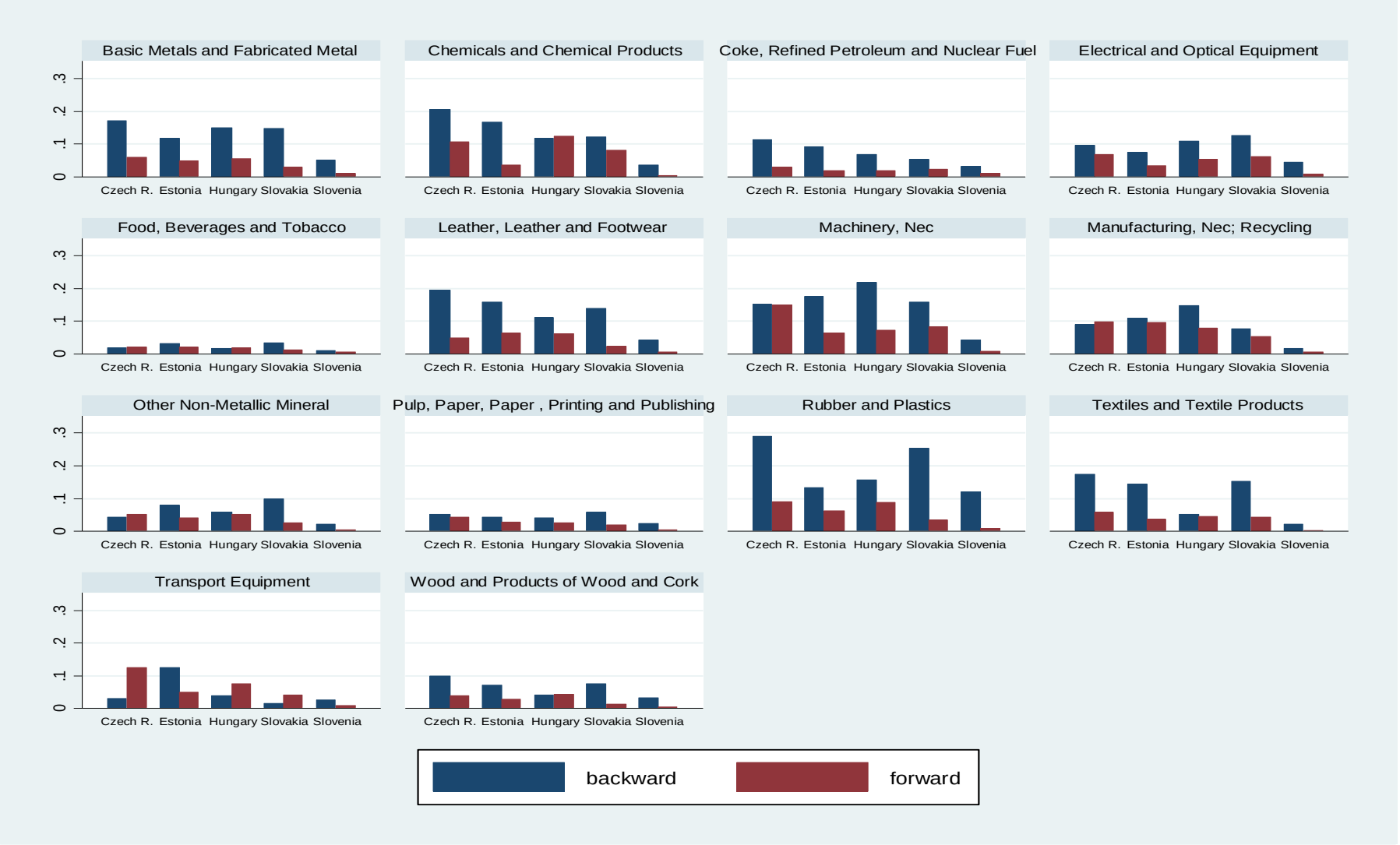

Figure A3. Average size of services backward and forward linkages across countries and manufacturing industries