Border Regimes and Indirect Productivity Effects from Foreign Direct Investment

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Abstract

Supplying inputs to foreign affiliates is consistently found to be an important source of productivity gains for domestic firms. We analyse the impact of border regimes on the existence and size of cross-border indirect productivity effects, exploiting variation in the pace and extent of European integration of seven Central and Eastern European countries and their neighbours during the period 2000-2010. EU-membership is a necessary condition for positive cross-border indirect productivity effects through backward linkages. Schengen area participation further magnifies cross-border effects. Our results bear testimony to the successful EU integration of CEECs and warn about potential productivity costs to local firms should border restrictions be reinstated.

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1 Introduction

Multinational enterprises (MNEs) are widely considered as a potential vehicle for technology transfers to local firms. Such indirect productivity effects or 'spillovers' have been analysed in many developing and transition economies (Hanousek et al., 2011; Havránek and Irŝová, 2013). While this has typically been done in single country settings, indirect productivity effects from foreign direct investment (FDI) need not be confined within national borders, especially in economic unions comprised of a common market or customs union. In this paper we use a large firm-level dataset for seven Central and Eastern European countries (CEECs) and their neighbours to analyse cross-border indirect productivity effects. The integration of the CEECs in the European Union (EU) allows us to test how changes in border regimes due to integration have affected the existence and size of cross-border indirect productivity effects from FDI. From a broad perspective, our analysis also sheds light on whether the European integration project has been successful at eradicating borders and creating a single market in Central and Eastern Europe.

Indirect productivity effects from foreign to domestic firms have been investigated at least since Caves (1974). Initially, it proved difficult to detect clear evidence of aggregate positive effects (see Görg and Greenaway, 2004; Crespo and Fontoura, 2007). Following Javorcik (2004), the literature now distinguishes between horizontal effects within the same industry and vertical effects resulting from relationships along the supply chain. A large set of studies has used such an approach for different countries to emphasise the supply of inputs to MNEs by local firms as the main channel for positive indirect productivity effects. By means of a meta-analysis Havránek and Irŝová (2011) confirm that the average 'backward' spillover effect is both statistically and economically significant. These findings suggest that MNEs have an interest in sharing their advanced knowledge with domestic firms that are related to them through the supply chain, which involves the exchange of goods or services. Therefore, barriers to trade that increase the cost of cross-border over national supply chains will affect potential cross-border productivity spillovers.

Starting with McCallum (1995) borders have been identified as significant impediments to trade. The recent meta-analysis by Havránek and Irŝová (2017) finds that within-country regions trade around 20% more than regions from different countries with similar characteristics. Hornok and Koren (2015) and Volpe Martincus et al. (2015) show that in addition to tariffs, administrative barriers to trade have a considerable negative impact on firms' foreign sales. Since EU membership considerably reduces tariff and non-tariff barriers, it facilitates participation in cross-border supply chains among member states. Nonetheless, joining the EU might not be sufficient for optimal knowledge transfers. Key to productivity effects through backward linkages is that MNEs have an interest

in technological upgrading by their suppliers and therefore an incentive to provide them with explicit assistance (Javorcik, 2004). Successful assistance and upgrading however requires human interaction, communication, and monitoring (Giroud, 2013). Keller and Yeaple (2013) further show that more knowledge-intensive inputs call for more communication. Better connected suppliers are thus more likely to benefit from the presence of foreign clients. Therefore, border regimes that facilitate the movement of people, such as the Schengen agreement, may further increase cross-border indirect productivity effects through backward linkages.

In this paper we use a large European multi-country firm-level dataset constructed by Merlevede et al. (2015) to analyse indirect productivity effects for seven CEECs[1] over the period 2000-2010. We allow for indirect productivity effects originating both from MNEs located in the seven CEECs as well as in neighbouring countries. The CEECs are an ideal setting for this analysis for several reasons. First of all, foreign investment in the region was almost non-existent during communism, only to pick up substantially from the mid and late 1990s onwards. Second, these countries have integrated in the EU during our sample period, becoming part of the Single Market. Third, they have done so at different pace and to a different extent. Finally, most of them also have borders with non-EU-members. This allows us to employ the following empirical strategy. We start by defining a distance-limited area-of-interest around a domestic firm. We do so because Bernard et al. (2018) find distance to be an important determinant of the formation of linkages and because Giroud (2013) and Keller and Yeaple (2013) emphasise the importance of good connections for productivity effects to materialise. We then generate a measure of MNE activity within the area-of-interest which, depending on the domestic firm's location, may or may not include cross-border territory. This allows us to split the measure of MNE activity into a domestic and a cross-border component and therefore to estimate indirect productivity effects from both components separately. Due to the stepwise EU integration of the CEECs some cross-border components will be characterised by one or two border regime changes (EU membership and Schengen area participation) while others will not (borders with non-EU countries). This creates a difference-in-difference setting where we compare domestic firms close to the border that experience a border regime change with similar firms that do not experience such a regime change.

In line with earlier literature, our results confirm the existence of within-country indirect productivity effects through backward linkages. We find that cross-border effects do exist but that they depend on the type of border regime in place. EU-membership is necessary to observe significant positive cross-border productivity effects through backward linkages. Schengen area participation, however, results in larger cross-border backward indirect productivity effects and we are unable to reject that the impact of foreign pres-

[1]Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovakia, Slovenia.

ence is equal to the equivalent within-country indirect productivity effect in this case. Finally, no cross-border backward productivity effects are detected for non-EU borders. Our results thus testify to the success of European integration and re-instating more restrictive border controls, e.g. in the context of the recent refugee crisis or Brexit, entail a potential productivity cost that should be taken into account by policymakers.

The remainder of this paper is organised as follows. In section 2 we introduce an empirical framework to analyse cross-border indirect productivity effects and the impact of different border regimes. Section 3 presents our data. In section 4 we discuss the results and a present a series of robustness checks. We conclude in section 5.

2 Indirect productivity effects and borders

2.1 Definitions

The typical methodology for analysing indirect productivity effects can be viewed as an augmented production function approach where variables capturing foreign presence are added to standard independent variables in explaining total factor productivity (TFP) (Havránek and Irŝová, 2011). The size and significance of the estimated coefficients is then taken as evidence of spillover effects.[2] In this paper, we follow the methodology which Havránek and Irŝová (2011) describe as 'best practice'. More specifically, we consider a two-step procedure where, in the first step, we use firm-level data to estimate a production function in order to obtain a TFP-measure, and then, in a second step, relate TFP-growth to foreign presence and additional control variables.

In this section we define the variables used to analyse (cross-border) indirect productivity effects, in the next section we detail how we operationalise them in our dataset. We follow the literature in using the share of total output produced by foreign firms as a basis to capture foreign presence. For our specific analysis we define an 'area-of-interest' (AoI_f) around a domestic firm f active in industry j and calculate $HR_{jt}^{AoI_f}$ in (1) as the share of output produced by foreign firms in a given industry j in the area-of-interest to capture the scope for horizontal effects.

[2]The term 'spillover effects' is typically used to refer to an overall effect on productivity potentially caused by different underlying mechanisms and thus captures more than pure knowledge externalities (see e.g. Keller, 2010).

$$HR_{jt}^{AoI_f} = \frac{\sum_{i \in j, i \in AoI_f} F_{it} Y_{it}}{\sum_{i \in j, i \in AoI_f} Y_{it}} \tag{1}$$

where Y is output and F is the percentage of shares owned by foreign investors. We denote as foreign any firm with a non-domestic direct ownership of more than 50%.[3] Unlike previous literature that following Caves (1974) typically defines the area-of-interest as the entire country, we use a purely distance-based area-of-interest in our multi-country setting. $HR_{jt}^{AoI_f}$ thus measures the share of output produced by foreign firms in industry j in the area-of-interest around domestic firm f at time t. Depending on the size of the area and the location of a domestic firm, the area-of-interest may or may not cross country borders. This allows us to split HR^{AoI} into two components in (2): HR^{AoI-WC} for within country foreign activity, and HR^{AoI-CB}, for cross-border foreign activity.

$$\begin{aligned} HR_{jt}^{AoI_f} &= \frac{\sum_{i \in j, i \in AoI_f - WC} F_{it} Y_{it} + \sum_{i \in j, i \in AoI_f - CB} F_{it} Y_{it}}{\sum_{i \in j, i \in AoI_f} Y_{it}} \\ &= HR_{jt}^{AoI_f - WC} + HR_{jt}^{AoI_f - CB} \end{aligned} \tag{2}$$

Backward spillover variables can then be calculated in (3) and (4) following an approach that is by now standard in the literature and goes back to Javorcik (2004):

$$\mathrm{BK}_{jt}^{AoI_f - WC} = \sum_{k \neq j} \gamma_{jk} * HR_{kt}^{AoI_f - WC} \tag{3}$$

$$\mathrm{BK}_{jt}^{AoI_f - CB} = \sum_{k \neq j} \gamma_{jk} * HR_{kt}^{AoI_f - CB} \tag{4}$$

Here γ_{jk} is the proportion of industry j's output supplied to industry k. The γ's are calculated using the EU-27 input-output (I-O) table for consumption of intermediate goods which is available from Eurostat [4] and capture the potential for a domestic firm

[3] Results are robust to the use of a dummy variable rather than the exact share.

[4] We use the 2010 EU-wide table as it best reflects the sourcing pattern of MNEs. MNEs are large and first at the technology frontier making an end-of-period table a better proxy for their sourcing pattern. Country-specific tables are available from e.g. the WIOD database, but they are less likely to reflect the sourcing pattern of MNEs (Barrios et al., 2011). The EU-level will also be less distorted by local champions, favouring the EU-wide table over national tables. WIOD tables will also underestimate the impact of backward spillovers because they are defined at a more aggregate level (Lenaerts and Merlevede, 2016).

in industry j to supply a foreign firm in downstream industries k. Some of the literature also considers indirect productivity effects that originate from buying inputs from foreign suppliers, but Havránek and Irŝová (2011) indicate that the best practice estimate of forward indirect productivity effects is small to insignificant. Given these findings and in line with other recent work such as Damijan et al. (2013) and Lenaerts and Merlevede (2018), we focus on horizontal and backward spillovers only. Furthermore, Damijan et al. (2013) indicate that foreign affiliates in Central and Eastern Europe are mainly engaged in end-user consumer goods, rendering forward effects unimportant.

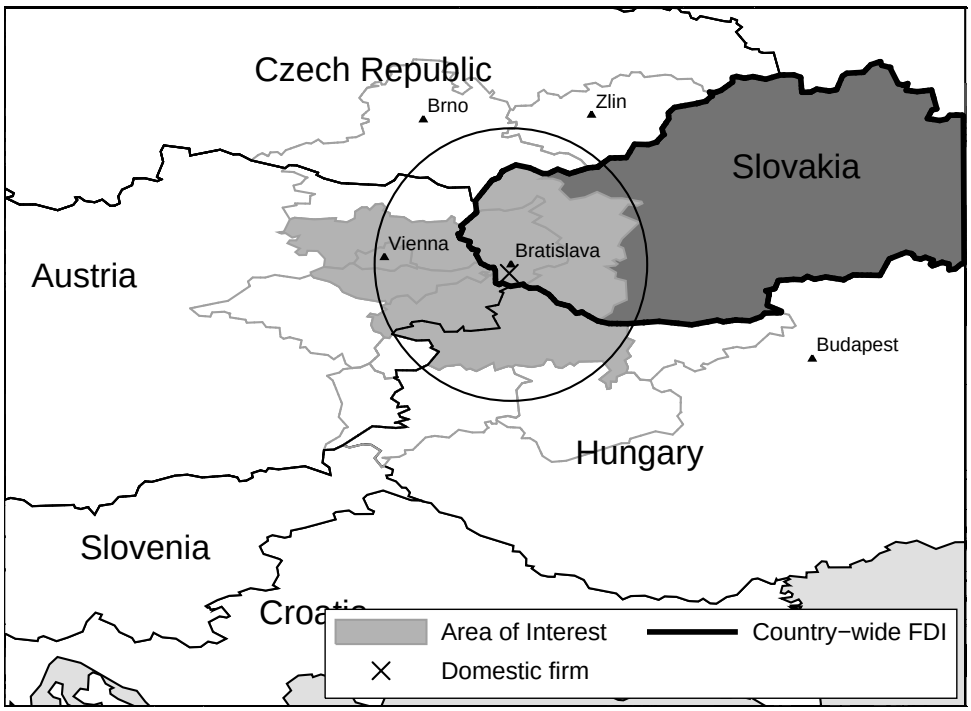
2.2 Calculation

Figure 1 illustrates how we define an area-of-interest in our data and operationalise HR^{AoI-WC} and HR^{AoI-CB}. Unfortunately our data does not contain exact addresses for most firms, but we do know the detailed NUTS 3-digit region where a firm is located.[5] We therefore use distances between regional administrative centres (retrieved from Eurostat) to determine which neighbouring regions fall within each AoI. Figure 1 illustrates this approach for a Slovakian domestic firm near Bratislava, located in the similarly named NUTS 3-digit region with the city of Bratislava as administrative centre. The area-of-interest for this firm is light grey-coloured and it encompasses all NUTS 3-digit regions whose centres are within 75 kilometres of the city of Bratislava. When calculating HR^{AoI-WC} and HR^{AoI-CB} for our domestic firm, we thus consider all foreign firms located in the light grey area. By using an absolute distance measure to determine the area of interest we make sure that existing size differences of NUTS 3-digit regions between countries do not influence the size of the area of interest. This would be the case if we only considered regions at the border (*cf. infra*).

Figure 1 shows that for our Slovakian domestic firm the area-of-interest includes both national NUTS 3-digit regions as well as regions in Austria and Hungary. Using a 75km distance, a firm in the region of Bratislava may thus benefit from indirect productivity effects both from within Slovakia itself (HR^{AoI-WC}) as well as from foreign firms in cross-border regions in Austria and Hungary (HR^{AoI-CB}). In the calculation of foreign presence we exclude MNEs originating from the home country, i.e. Slovakia, investing just across the border in Austria and Hungary. Austrian firms in Austria and Hungarian firms in Hungary are included as domestic firms in the denominator of our measures. Note that while the Czech Republic is also a neighbour of Slovakia, the distances between Bratislava and the nearest Czech NUTS 3-digit region centres of Brno and Zlin are above

[5]NUTS (Nomenclature of territorial units for statistics) 3-digit regions are defined for the EU as areas with on average between 150,000 and 800,000 inhabitants. For non-EU neighbouring countries that do not have a NUTS-classification we use an equivalent national regional division as suggested by Kolosov (2013).

Figure 1: The area-of-interest (AoI) for a domestic firm located in the Bratislava region in Slovakia



75km, therefore falling outside the area-of-interest. The robustness of our results with respect to the choice of distance is available in Subsection 4.2. Finally, assigning firms f to a region to determine their location and thus the area-of-interest further implies that the HR^{AoI-WC} and HR^{AoI-CB} variables are not firm-specific but defined for a NUTS3-region-industry-year triplet, i.e. HR^{AoI}_{rjt} rather than $HR^{AoI_f}_{jt}$.

2.3 Empirical framework

Following best practice (see Havránek and Irŝová, 2011), domestic firms' productivity is related to the variables capturing foreign presence and a set of control variables:

$$\begin{aligned} logTFP_{fjrt} = \psi_1 HR^{AoI-WC}_{rjt-1} + \psi_2 BK^{AoI-WC}_{rjt-1} + \psi_3 HR^{AoI-CB}_{rjt-1} + \psi_4 BK^{AoI-CB}_{rjt-1} \\ + \alpha_f + \Psi_1 Controls_{fjrt} + e_{fjrt} \end{aligned} \tag{5}$$

When estimating TFP, one is confronted with an endogeneity problem due to the fact that firms observe their productivity (shocks) and adjust their input choices accordingly. To account for this problem several semi-parametric techniques have been suggested, among which those of Olley and Pakes (1996) (OP) and Levinsohn and Petrin (2003)

(LP). In this analysis we use the estimator introduced by Wooldridge (2009) (WLP)[6] which combines the benefits of OP and LP, whilst applying a joint GMM estimation which both enhances efficiency and accounts for serial correlation and heteroskedasticity. As data on quantities are not available to us, our productivity estimation is based on revenue data deflated using (2-digit) industry-level price deflators ($TFPR$) rather than firm-level quantity data ($TFPQ$). Katayama et al. (2009) emphasise that the use of $TFPR$ will often confound higher productivity with higher mark-ups. Although first-differencing will help in capturing productivity changes if TFP-contaminating factors change less over time than technology (e.g. when mark-ups are more stable than technological change), results should be interpreted bearing this caveat in mind. Moreover, since the results might still be affected by faster increases in mark-ups at initially more productive domestic firms, we add initial productivity, initial market share, and changes in market share as control variables in (6) to account for these mechanisms as much as possible. Further control variables include firm size, firm age, an exit variable, and an index of demand in downstream industries[7]. Equation (5) is first-differenced to obtain (6) and is then estimated by OLS.

$$\begin{aligned}\Delta tfp_{fjrt} = {} & \psi_1' \Delta HR_{rjt-1}^{AoI-WC} + \psi_2' \Delta BK_{rjt-1}^{AoI-WC} + \psi_3' \Delta HR_{rjt-1}^{AoI-CB} + \psi_4' \Delta BK_{rjt-1}^{AoI-CB} \\ & + \Psi_1' \Delta controls_{fjrt} + \alpha_t + \alpha_j + \alpha_c + \epsilon_{fjrt} \end{aligned} \tag{6}$$

After first-differencing we also add time (α_t), industry (α_j), and country (α_c) fixed effects to the specification. This accounts for shocks that have simultaneously affected the productivity growth of local firms and the attractiveness of specific industries and countries of the Central and Eastern Europe to foreign firms. Since the estimation is performed at the firm-level while the explanatory variables are defined at the industry-region-level, standard errors are clustered for all observations in the same region and industry (see Moulton, 1990).

[6]We use production function estimates from Merlevede et al. (2015) who estimate industry-specific pan-European production functions.

[7]Downstream foreign entry could increase demand for intermediate products which may result in scale economies. To separate this effect, the regression includes demand for intermediates following Javorcik (2004) calculated as:

$$demand_{jrt} = \sum_k a_{jk} * Y_{krt}$$

where α_{jk} is the IO-matrix coefficient which indicates that in order to produce one unit of good k, α_{jk} units of good j are needed. Y_{kt} is the output of industry k deflated by an industry-specific deflator.

Table 1: Overview of border regimes in 2001-2010

Country	Partner	EU	Schengen	Country	Partner	EU	Schengen
Bulgaria	Greece	2007	-	Poland	Belarus	-	-
Bulgaria	Macedonia	-	-	Poland	Germany	2004	2008
Bulgaria	Romania	2007	-	Poland	Lithuania	2004	2008
Bulgaria	Serbia	-	-	Poland	Russia*	-	-
				Poland	Slovakia	2004	2008
Czech Rep.	Austria	2004	2008	Poland	Ukraine	-	-
Czech Rep.	Germany	2004	2008				
Czech Rep.	Poland	2004	2008	Romania	Moldova	-	-
Czech Rep.	Slovakia	2004	2008	Romania	Serbia	-	-
				Romania	Ukraine	-	-
Hungary	Austria	2004	2008				
Hungary	Croatia	-	-	Slovakia	Austria	2004	2008
Hungary	Romania	2007	-	Slovakia	Ukraine	-	-
Hungary	Slovakia	2004	2008				
Hungary	Slovenia	2004	2008	Slovenia	Austria	2004	2008
Hungary	Serbia	-	-	Slovenia	Croatia	-	-
Hungary	Ukraine	-	-	Slovenia	Italy	2004	2008

* Kaliningrad; *EU* indicates whether and when a border becomes an internal EU border; *Schengen* indicates a border between members of the Schengen area. All Schengen borders in our sample enter into force on December 21 2007. This holds for overland borders and seaports, for airports the exact date is March 30 2008. Because our data are annual, we consider 2008 as the first year these borders are classified as 'Schengen' borders. As we do not have data for Turkish firms, we do not consider the Bulgaria-Turkey border.

2.4 Border regimes and identification

We have now defined variables that distinguish cross-border from within-country foreign presence. However, the CEECs have experienced substantial changes in their border regimes in the last two decades. More specifically, in our sample period which ranges from 2000 to 2010, several bilateral borders have switched from initially very 'thick' borders with substantial administrative barriers to trade, rigorous checks of transported merchandise, and strict visa regimes to 'thin' borders where almost all obstacles to moving goods (and persons) in a fast and cost-effective way have been removed. Table 1 provides an overview of the bilateral borders status changes relevant to our sample. The Czech Republic, Hungary, Poland, Slovakia, and Slovenia first joined the EU on May 1 2004 and then, on December 21 2007, the Schengen area. Bulgaria and Romania became members of the EU on January 1 2007 and, although legally obliged to do so at some point, are not yet part of the Schengen area.

Both EU accession and Schengen membership have prompted significant changes in the institutional framework of the CEECs. They have had to align their national law to EU

law by implementing the Acquis Communautaire, a set of EU legislations and court decisions. This entailed substantial judicial, economic, and administrative reform. The new framework not only ensures the free movement of capital, goods, people, and services, but also compliance with EU competition policy, industrial policy, and regulation pertaining to the customs union. The Single Market also implies that goods that are legally sold in one country can circulate freely within the EU, with no duties being due when goods are shipped between EU-members. Hornok and Koren (2015) show that administrative barriers translate into large bilateral ad-valorem trade costs. Therefore the reduction in administrative barriers due to EU integration may foster cross-border supply chains. Volpe Martincus et al. (2015) confirm that custom-driven delays have a significant negative impact on firms' foreign sales. The CEECs were, however, in a special situation when joining the EU as earlier asymmetric FTAs (Europe Agreements) had allowed them to export duty-free into the EU already since the mid to late 1990s. Nonetheless, Handley and Limão (2015) show that reduced trade policy uncertainty is an important driver of trade. They show that the 1986 accession of Portugal was an important driver in the subsequent growth spurt of Portuguese exports into the Community, despite the fact that it did not affect applied tariffs (industrial goods had been exported into the Community duty-free since 1977). Handley and Limão (2015) attribute the large impact of formal membership to the fact that it did secure the low tariffs applied. Their findings suggest that formal EU accession in 2004/2007 may still have affected CEEC firms' cross-border customer-supplier relationships through similar reduced uncertainty, increasing the potential for indirect productivity effects along the supply chain. Whereas joining the EU implied less 'thick' inner EU borders with other members, outer EU borders did not change.[8]

For the Czech Republic, Hungary, Poland, Slovakia, and Slovenia subsequent accession to the Schengen Area has resulted in a further reduction of the thickness of borders with other Schengen Area-members. An inner Schengen border reduces to a mere road sign indicating exit from and entry to a country, allowing free and unhindered movement of both people and goods. Due to the absence of any form of checks, a shipment crossing a Schengen border is almost like a domestic shipment. Chen and Novy (2011) estimate that EU countries within the Schengen area, which are not subject to border control, enjoy 10% lower trade frictions than other EU countries. A Schengen border is in this respect potentially very different from a non-Schengen inner EU border which is not totally seamless. Although inputs can be shipped at zero tariff, potentially long and unpredictable cueing and waiting times for the border police to complete security checks

[8]In some cases they may even have hardened for the movement of people by introducing visa requirements for bordering non-EU countries and strengthening security checks at the Eastern border. E.g. Romania introduced a visa regime for Moldovan citizens, barring its largest community of Romanians abroad from easy entry to its territories. Similarly, Poland and Hungary started requiring visas from their diaspora living in Ukraine.

Table 2: Border regimes and identification

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Schengen Area	-	-	-	EU	EU	EU	EU	SCH	SCH	SCH
EU, not Schengen	-	-	-	-	-	-	EU	EU	EU	EU
Other border	-	-	-	-	-	-	-	-	-	-

and grant passage will create additional costs and uncertainty for goods and people to cross the border. Hummels and Schaur (2013) stress the importance of time as a trade barrier: the absence of key components due to late arrival can idle entire plants, the ability to ship rapidly and predictably is therefore of high value. The movement of people will also matter. Because MNEs have an interest in technological upgrading by their suppliers, they have an incentive to provide them with explicit assistance. Giroud (2013) shows that headquarters' proximity to plants increases plant-level investment and plant's productivity. Proximity facilitates human interaction, communication, and monitoring, all necessary components of successful assistance and upgrading. Keller and Yeaple (2013) further show that more knowledge-intensive inputs call for more communication. Well-connected suppliers are thus more likely to experience positive spillover effects. We therefore expect Schengen area membership to carry important potential beyond EU-membership for cross-border indirect productivity effects to materialise.

This variation in bilateral borders over time allows us to analyse the impact of different border regimes on the existence and size of cross-border indirect productivity effects in a difference-in-difference setting. More specifically, we observe three types of border time paths in our sample as indicated in Table 2. The first is a border-time path that ends in Schengen Area membership. These are bilateral borders that become EU-borders in 2004 and Schengen area borders in 2008 (see Table 1). Because the Czech Republic, Hungary, Poland, Slovakia, and Slovenia entered the EU and the Schengen Area at the same moment, there is only a single Schengen border time path for borders among these countries and their borders with the old EU15-members. Bulgaria and Romania on the other hand entered the EU later and did not yet join the Schengen Area. Borders of these two CEECs with other EU-countries are characterised by a single regime switch in 2007 and constitute a second border-time path. Finally, our sample also contains borders with non-EU third countries that never switch regime. Identification of the impact of border regimes on cross-border indirect productivity effects stems from comparing 'border-firms' experiencing different 'border regime treatments' during our sample period. We define border regime dummies that identify an EU non-Schengen border, a Schengen border, and an 'other' border and insert interaction terms of these dummies with HR_{rjt}^{AoI-CB} and

BK_{rjt}^{AoI-CB} in (6). For a given distance, an area-of-interest may include borders with more than one country. Such a region could face different border regimes at the same time because of the different status of its neighbouring countries (e.g. regions in Slovenia bordering both Austria and Croatia). We exclude these 'fuzzy' border regions from the analysis to obtain a clean identification.

3 Data

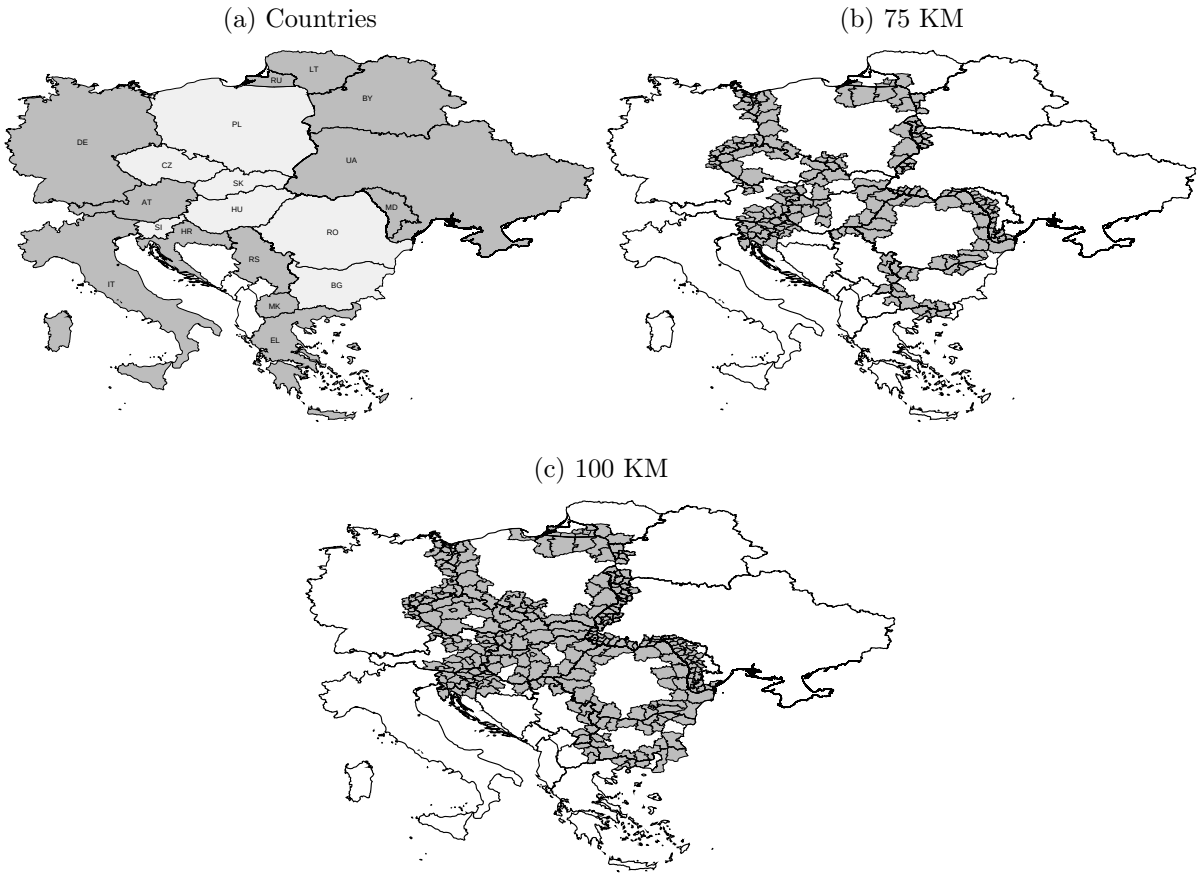
Our basic data source is the AMADEUS database issued by Bureau Van Dijk Electronic Publishing, which consists of financial and ownership information on public and private companies across Europe. From this large database, we construct a sample covering the period 2000-2010 that allows us to study FDI spillover effects on domestic manufacturing firms in the seven Central and Eastern European countries (CEECs) indicated above. For a detailed account of how the data was constructed and cleaned, we refer to Merlevede et al. (2015).[9] We limit the sample to firms with at least 10 employees for which we have an unconsolidated account. We focus on the aforementioned CEECs because their border regions present a mix of regions experiencing considerable changes in the border regime and regions with stable border regimes. The CEECs have also benefited from the entry of foreign companies (see e.g. Hanousek et al., 2011; Damijan et al., 2013). Finally, we also consider eleven countries that border our focal seven CEEC countries to analyse cross-border spillovers effects.[10]

Panel (a) in Figure 2 shows the countries used in the analysis. The core countries are highlighted in light-grey, the relevant neighbouring countries in dark grey. Figure 2 also illustrates that the surface of NUTS 3-digit regions varies considerably across countries (e.g. Poland and Germany). This motivates us to apply a distance based definition to the data rather than to focus purely on regions located at the border. Figure 2 further provides an overview of regions identified as border regions based on a 75km definition in panel (b) and a 100km definition in panel (c). For smaller countries the 100km definition defines nearly all domestic regions as border regions. Since the 75 km definition provides a better balance between border and non-border regions, we use it as our base case. An overview of how distance choice impacts our main results is presented in Subsection 4.2. From panel (b) one can also infer that the ratio between border and non-border regions varies across countries. As to be expected, for larger countries such as Romania and Poland this ratio is smallest; medium-sized countries, Hungary and Czech Republic, have

[9] We use multiple issues (published on DVDs) of the database because a single issue is only a snapshot of the ownership information and firms that exit are dropped from the next issue released. In order to get a full overview of ownership and financials through time, multiple issues are required.

[10] Austria, Belarus, Germany, Greece, Croatia, Italy, Moldova, Macedonia, Serbia, Russia, and Ukraine.

Figure 2: Sample countries and border regions at 75 and 100 km distance



The map in panel (a) shows the countries used in the analysis: core countries are in light-grey, relevant neighbouring countries are in dark grey. Panels (b) and (c) show the regions identified as 'border' regions on the basis of the 75km and 100km distance definitions respectively. See the main text for the exact definition.

a balanced mix between the two types of regions, while smaller countries such as Slovenia and Slovakia primarily consist of border regions. Table 10 in Appendix shows how the number of regions considered to be border regions varies with distance between 70 and 110km at 5km intervals.

We use the ownership information from Amadeus to distinguish between foreign firms and domestic firms. We define a firm as foreign when foreign ownership is at least 50%. Whilst other studies often use a lower boundary of 10% (*cf.* the IMF definition), we employ the higher share in order to be able to uniquely determine the nationality of the owner.[11]

Table 3 shows for each country the total number of firm-year observations (manufacturing firms with at least 10 employees that report output) in column two. Column three

[11] A simple count of firms suggests that while we do lose some firms by applying the higher cut-off, foreign firms are overwhelmingly majority foreign-owned. Further, the distribution across countries of foreign firms is very similar between the two definitions.

Table 3: Total and foreign activity in border regions (Area-of-interest 75/100km) as share of total country activity for core CEEC countries

	# firm-year in country		share of firms in border region (75km)		share of firms in border region (100km)	
	total	foreign	domestic	foreign	domestic	foreign
Bulgaria (BG)	17,824	985	27.7	32.6	50.2	45.7
Czech Rep. (CZ)	97,225	2,977	47.0	45.8	94.2	95.3
Hungary (HU)	146,907	2,093	39.3	46.4	92.3	91.8
Poland (PL)	118,933	9,312	22.2	21.6	33.9	32.2
Romania (RO)	131,993	11,056	41.6	43.3	60.3	62.3
Slovenia (SI)	21,413	222	100	100	100	100
Slovak Rep. (SK)	24,192	676	63.5	71.2	100	100
Total	558,487	27,321	40.5	37.2	71.9	68.5

Manufacturing firms that report output needed to calculate measures of foreign presence; Foreign firms are firms owned by third country owners (i.e. countries contained by the area-of-interest are excluded) for at least 50%

presents the subset of foreign firms. In total 4.9% of our observations refer to foreign firms. Column four reports domestic firms located in border regions as a share of the total number of domestic firms for the 75km definition; column five also reports this share but now for foreign firms. A comparison of both columns shows that the numbers are very similar for both types of firms. A substantial share of domestic and foreign activity does take place in border regions: on average about 40% of both types of firms are active in border regions. Therefore there is no indication of large differences in agglomeration patterns between foreign and domestic firms. A similar observation holds for the 100km definition for the area-of-interest in the last two columns of table 3 (with obviously a bigger share of activity in border regions). Table 11 in Appendix shows the number of observations in the countries that border our core CEECs. Note that only firms in regions close to the border (shaded regions in these countries in panels (b) or (c) of figure 2) are included for the calculation of HR^{AoI-CB} and BK^{AoI-CB}. While we do detect foreign presence in all neighbour countries, foreign presence tends to be bigger in western than in eastern neighbouring countries.

Table 4 presents firm-level summary statistics for four types of firms: domestic and foreign firms in border and non-border regions. The biggest differences between firms are due to foreign ownership. Location in border or non-border regions does not seem to be associated with differences in average output, employment, TFP, nor their distributions. Foreign firms, however, are bigger and more productive than domestic firms in our sample. This confirms earlier literature that has found MNEs to be more produc-

Table 4: Summary statistics for manufacturing firms

	n	mean	st.dev.	p10	p50	p90
domestic firms in non-border regions						
ln(output)	114,905	13.76	2.24	10.87	13.98	16.37
# employees	92,403	125.8	303.1	15	49	275
ln(TFP)	80,738	8.81	1.58	6.59	9.00	10.72
domestic firms in border regions						
ln(output)	80,462	13.82	2.25	10.88	14.02	16.49
# employees	69,635	132.9	337.8	15	45	300
ln(TFP)	65,234	8.93	1.55	6.65	9.23	10.72
foreign firms in non-border regions						
ln(output)	12,068	15.04	2.41	11.71	15.34	18.00
# employees	10,873	278.8	647.6	19	109	658
ln(TFP)	9,483	9.33	1.72	6.97	9.57	11.43
foreign firms in border regions						
ln(output)	6,565	14.87	2.48	11.55	15.11	17.92
# employees	6,194	320.6	739.7	21	125	750
ln(TFP)	5,873	9.18	1.69	6.95	9.31	11.27

Only firms with at least 10 employees on average. A 75km radius is used to distinguish between border and non-border firms.

tive than their domestic counterparts and posses superior technologies and knowledge in terms of operational or management techniques (see e.g. Helpman et al., 2004; Bloom and Van Reenen, 2007; Guadalupe et al., 2012; Javorcik and Poelhekke, 2017).

Table 5 shows summary statistics for the different variables capturing foreign firms' output share (i.e. the different variations of HR_{rjt}). Summary statistics are based on an area-of-interest-industry-year observations rather than firm-year observations as HR varies at area-of-interest-industry-year level rather than firm-level. Foreign presence in border and non-border regions is fairly comparable. In most countries, border regions show on average larger foreign shares of economic activity at home than across the border. This is however not always the case: Slovenia and Slovakia, two smaller countries neighboured by Austria and Italy have on average more foreign activity in the cross-border part. Taking into account standard deviations, there is significant heterogeneity across area-of-interest-industry combinations, both in non-border and border regions, as well as within-country and cross-border for border regions.

Finally, in Table 6 we present summary statistics for the HR and BK-variables taking into account border regimes as well. Cross-border foreign activity in customer industries is larger for (future) EU and Schengen-borders compared to non-EU borders. Large standard deviations of these variables suggest substantial heterogeneity in spillover potential. Average values for BK are smaller than for HR because diagonal elements from

Table 5: Output share produced by foreign firms in Area-of-interest-Industry-Year triplets (HR_{rjt}^{AoI})

	Non-border region			Border region						
				Total AoI			Within-country		Cross-border	
	#regs (n)	mean	st.dev.	# regs (n)	mean	st.dev.	mean	st.dev.	mean	st.dev.
BG	17 (1,992)	0.14	0.24	11 (970)	0.15	0.23	0.11	0.22	0.04	0.12
CZ	6 (1,189)	0.16	0.20	8 (1,553)	0.15	0.20	0.09	0.17	0.05	0.13
HU	8 (1,214)	0.09	0.16	12 (1,741)	0.13	0.20	0.09	0.18	0.03	0.10
PL	45 (6,791)	0.17	0.23	21 (2,740)	0.16	0.22	0.12	0.20	0.04	0.10
RO	25 (4,065)	0.19	0.23	17 (2,624)	0.16	0.23	0.16	0.22	0.01	0.05
SI	0 (0)			11 (1,818)	0.08	0.14	0.03	0.11	0.04	0.08
SK	3 (555)	0.07	0.18	5 (898)	0.12	0.19	0.04	0.11	0.07	0.16

There are 275 NUTS 3-digit regions and accompanying Areas-of-Interest (AoI) in our sample. A 75km radius is used to determine the AoI.

Table 6: Summary statistics for different spillover variables for non-fuzzy border regions on the basis of Industry-Area-of-interest-Year data

	horizontal		*backward*	
	mean	st.dev.	mean	st.dev.
AoI-Within Country	0.119	0.191	0.037	0.048
AoI-Cross-border, EU border, before EU	0.038	0.098	0.014	0.026
AoI-Cross-border, EU border, after EU, before Schengen	0.050	0.118	0.016	0.028
AoI-Cross-border, EU border, after Schengen	0.069	0.131	0.026	0.042
AoI-Cross-border, non-EU border	0.027	0.077	0.007	0.017

Only observations that fit the border type mentioned are used to calculate the summary statistics. Fuzzy regions are excluded. A 75km radius is used to determine the Area-of-Interest. The share of within-industry supply is set to zero in calculating the backward spillover variable, resulting in smaller values in comparison to the horizontal spillover variable.

the IO-table are set to zero when calculating the different types of BK (see (3) and (4)).

4 Results

4.1 Main results

Table 7 presents the results of our analysis of the impact of border regimes on cross-border indirect productivity effects from FDI. The estimation sample consists of domestic manufacturing firms with at least 10 employees located in border regions in the seven aforementioned CEECs. We calculate cross-border spillover variables using an area-of-interest with a 75km radius. Firms located in regions simultaneously facing two or more distinct border regimes (i.e. fuzzy regions) are excluded from the sample.

Before considering the size and significance of cross-border indirect productivity effects,

Table 7: Indirect productivity effects and border regimes (Area-of-interest 75km)

	(1)	(2)	(3)	(4)
BACKWARD				
AoI - Within Country	0.774***	0.781***	0.774***	0.774***
	[0.255]	[0.253]	[0.254]	[0.254]
AoI - Cross-border				
before EU entry				0.089
				[0.328]
after EU entry	0.904***			
	[0.202]			
after EU, before Schengen			0.708***	0.694***
			[0.189]	[0.190]
after Schengen		1.305***	1.431***	1.420***
		[0.348]	[0.337]	[0.335]
other	0.230	0.487**	0.110	1.861
	[0.333]	[0.217]	[0.325]	[1.160]
HORIZONTAL				
AoI - Within Country	0.000	-0.003	-0.002	-0.002
	[0.035]	[0.035]	[0.035]	[0.035]
AoI - Cross-border				
before EU entry				0.087
				[0.066]
after EU entry	0.022			
	[0.053]			
after EU, before Schengen			-0.022	-0.028
			[0.051]	[0.050]
after Schengen		0.225**	0.205*	0.201*
		[0.105]	[0.105]	[0.105]
other	0.136*	0.025	0.118	0.305
	[0.082]	[0.051]	[0.081]	[0.397]
Observations	46,478	46,478	46,478	46,478
R-squared	0.108	0.109	0.109	0.109
F-tests for equality of coefficients (BACKWARD)				
EU = other	5.37**		4.07**	0.98
	(0.020)		(0.044)	(0.322)
Schengen = other		7.25***	9.75***	0.13
		(0.007)	(0.002)	(0.715)
EU = Schengen			5.78**	5.79**
			(0.017)	(0.016)
EU = within	0.16		0.04	0.06
	(0.689)		(0.839)	(0.80)
Schengen = within		1.56	2.58	2.51
		(0.212)	(0.108)	(0.11)
EU = Schengen = within			2.87**	2.90**
			(0.057)	(0.055)

Clustered standard errors in brackets. */**/*** significant at 10%, 5%, and 1%. Industry, country, and year fixed effects included. Additional controls included: firm age, firm size, initial TFP, initial market share, change in market share, exit dummy, and a downstream demand indicator. P-values below

we first look at the impact of within-country foreign presence on domestic firms' productivity. We find the impact to be stable across specifications (also in the robustness checks) and in line with earlier literature, both in terms of direction and magnitude. Foreign presence within the same industry has no impact on domestic firms' productivity. This is in line with the meta-study by Havránek and Irŝová (2013) who find that horizontal spillover effects are generally weak. We do find positive and statistically significant indirect productivity effects through backward linkages, a common finding in the literature (see Havránek and Irŝová, 2011). A one standard deviation increase in the backward spillover variable results in a 3.7% higher productivity for the average domestic firm through backward linkages.

With respect to the impact of border regimes on cross-border indirect productivity effects, we first consider how EU-membership affects these spillovers. The first column presents a specification where national borders are split up in EU and non-EU borders. The former connects two EU members, while the latter does not. The analysis thus abstracts from the introduction of the Schengen regime and Schengen borders are subsumed under EU borders. In column one the coefficient for cross-border indirect productivity effects through backward linkages is not significant for non-EU borders, but the coefficient for EU-borders is. An F-test reveals that the latter is not statistically different from the within-country coefficient. A one standard deviation increase in foreign presence in client industries across the EU border results in a productivity level of domestic firms that is 3% higher. While EU accession did decrease uncertainty around tariffs (Handley and Limão, 2015) and guaranteed free circulation of goods through harmonisation of existing national rules, the Schengen agreement went a step further by wiping out all border controls between members. The second column in Table 7 therefore focuses on membership of the Schengen area agreement, abstracting from EU-membership. The coefficient for cross-border indirect productivity effects through backward linkages is statistically significant and the point estimate is large in size. The F-test reveals, however, that we cannot reject this coefficient being equal to the within-country coefficient. The point estimate implies that a one standard deviation increase results in a 5.4% higher productivity due to foreign presence in downstream industries across Schengen borders. The 'other border' backward variable now also becomes significant, but obviously this variable now lumps both non-EU and EU-non-Schengen borders together. Column three separates the effects for EU-non-Schengen, Schengen, and other (again non-EU in this specification) border regimes. Both the coefficient for EU-non-Schengen and Schengen border regimes are significant, while the other (non-EU) border coefficient is insignificant as in column one. Both the EU-non-Schengen and Schengen coefficients cannot individually be rejected to equal the within country coefficient, but they do differ from the non-EU coefficient. They are statistically different from one another and we also reject that the three coefficients

are equal to one another. This suggests that a Schengen border allows for a significantly larger cross-border indirect productivity effect through backward linkages than an EU-non-Schengen-border. On the basis of the point estimates, a one standard deviation increase in the respective variables results in a productivity level that is 3.7%, 2.0%, and 5.9% higher for within-country, cross-border EU-non-Schengen, and cross-border Schengen effects respectively. Finally, in column four we single out future EU borders to test whether these borders were different from never-EU borders already prior to entry. We find that the coefficient for this interaction is insignificant and not different from the coefficient for remaining 'never-EU' borders. Results for within-country, cross-border EU-non-Schengen, and cross-border Schengen effects are unaffected.

These findings suggest that formal EU accession which implied a cutback in administrative barriers (*cf.* Hornok and Koren, 2015) and a reduction in policy uncertainty (*cf.* Handley and Limão, 2015) is a necessary condition for cross-border indirect productivity effects through backward linkages to emerge. Schengen area participation seems to significantly increase the impact. This is likely due to the fact that in-person contact and communication are necessary for successful technology upgrading (*cf.* Giroud, 2013) and that Schengen area participation makes border crossing seamless rather than potentially long and unpredictable due to security checks.

We do not detect any horizontal indirect productivity effects for either non-EU or EU-non-Schengen borders. There is some indication however of positive cross-border horizontal effects when the border is governed by the Schengen agreement. Based on column three, a one standard deviation increase in cross-border foreign presence in the same industry results in a productivity level that is 2.6% higher. The most cited channels for horizontal spillovers are technology imitation (the demonstration effect, see Teece (1977)) and mobility of workers trained by foreign firms (Görg and Strobl, 2005). Especially the latter seems the more likely candidate to be affected by Schengen area participation. Labour mobility from cross-border foreign firms to domestic firms is more straightforward when moving across borders is seamless. The fairly short distances we consider enable commuting without moving, but passport and security checks will involve unpredictable waiting times at the border, an issue that is resolved within Schengen area. Schengen area participation may also have increased competition which could incentivise firms to use existing technologies and resources more efficiently or to adopt new technologies (see Aitken and Harrison (1999) on this competition effect).

Table 8: Cross-border spillovers and the area-of-interest radius (radius distance indicated in column headings)

	(1) 70	(2) 75	(3) 80	(4) 85	(5) 90	(6) 95	(7) 100	(8) 105	(9) 110
BACKWARD									
AoI - Within Country	0.864***	0.774***	0.696***	0.656***	0.682***	0.735***	0.742***	0.726***	0.556***
	[0.311]	[0.254]	[0.216]	[0.193]	[0.173]	[0.171]	[0.160]	[0.165]	[0.165]
AoI - Cross-border									
after EU, before Schengen	0.695***	0.708***	0.389**	0.485**	0.449**	0.459*	0.506**	0.703***	0.465*
	[0.170]	[0.189]	[0.198]	[0.212]	[0.206]	[0.235]	[0.234]	[0.229]	[0.244]
after Schengen	1.533***	1.431***	1.057***	1.130***	1.059***	1.123***	1.041***	1.058***	0.941***
	[0.387]	[0.337]	[0.266]	[0.291]	[0.279]	[0.286]	[0.301]	[0.328]	[0.299]
other	-0.138	0.110	-0.081	-0.072	-0.123	-0.155	-0.113	0.139	0.129
	[0.287]	[0.325]	[0.363]	[0.391]	[0.353]	[0.371]	[0.387]	[0.381]	[0.391]
HORIZONTAL									
AoI - Within Country	-0.031	-0.002	0.018	0.006	0.013	0.024	0.031	0.025	0.034
	[0.038]	[0.035]	[0.030]	[0.030]	[0.032]	[0.029]	[0.028]	[0.028]	[0.030]
AoI - Cross-border									
after EU, before Schengen	0.045	-0.022	-0.026	0.004	0.016	-0.031	-0.062	-0.061	-0.074
	[0.058]	[0.051]	[0.047]	[0.048]	[0.048]	[0.060]	[0.062]	[0.054]	[0.059]
after Schengen	0.260**	0.205*	0.190**	0.175*	0.180**	0.248**	0.246**	0.308***	0.261**
	[0.111]	[0.105]	[0.093]	[0.097]	[0.092]	[0.101]	[0.105]	[0.114]	[0.104]
other	0.193**	0.118	0.110	0.142	0.120	0.094	0.079	-0.003	0.025
	[0.085]	[0.081]	[0.086]	[0.088]	[0.082]	[0.102]	[0.083]	[0.079]	[0.086]
Observations	39,555	46,478	56,332	57,375	62,148	62,389	66,562	63,866	65,868
R-squared	0.105	0.109	0.101	0.100	0.093	0.096	0.091	0.092	0.089
border region share	39.2	45.0	51.3	54.0	60.3	62.4	65.6	66.7	69.8
# non-fuzzy border regions	70	79	87	90	99	100	105	102	105

Robust standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%. Industry, region, and year fixed effects included. Additional controls included: firm age, firm size, initial TFP, initial market share, change in market share, exit dummy, and a downstream demand indicator. Border region share is the share of (non-fuzzy and fuzzy) border regions in the total number of regions using the radius indicated in the column heading. The last row indicates the number of non-fuzzy regions in the estimation sample.

4.2 Robustness

Because our choice of distance determines both which regions are considered when calculating the variables capturing foreign presence and which domestic firms are included in the estimation sample, it is imperative to test robustness with respect to the choice of distance. This is what we do in Table 8 where we repeat our analysis using distances from 70 to 110km in increments of 5km. Increasing the radius of the area of interest increases the share of border regions from about 40% of all CEEC-regions to about 70% of all CEEC-regions. Widening the area of interest also implies that some non-fuzzy regions, characterised by a single border regime at a time, become fuzzy. Because we drop (firms in) fuzzy regions facing several distinct border regimes simultaneously, the number of firms and regions decreases when we increase the distance from 100 to 105km. Comparing the results across different columns in Table 8 we notice that the choice of distance is not a major determinant of results. The within country and Schengen effects remain robust. Point estimates do change but given standard errors, they are not significantly

Table 9: Further robustness checks

	(1) at least 7 obs.	(2) no *WC*	(3) country wide	(4) EU only	(5) SCH vs. non-EU	(6) with fuzzy	(7) all regions no fuzzy	(8) all regions
BACKWARD								
AoI - Within Country	0.886***		0.650***	0.193	0.863***	0.728***	0.337***	0.324***
	[0.284]		[0.178]	[0.170]	[0.283]	[0.258]	[0.112]	[0.112]
AoI - Cross-border								
after EU, before Schengen	0.704***	0.730***	0.751***	0.575***	0.704***	0.557***	0.706***	0.556***
	[0.224]	[0.191]	[0.189]	[0.167]	[0.188]	[0.183]	[0.182]	[0.186]
after Schengen	1.494***	1.440***	1.290***	0.816**	1.142***	1.244***	1.284***	1.173***
	[0.399]	[0.350]	[0.342]	[0.323]	[0.328]	[0.314]	[0.293]	[0.279]
other	0.170	0.069	0.072		0.133	0.026	0.019	-0.031
	[0.306]	[0.327]	[0.321]		[0.331]	[0.310]	[0.318]	[0.306]
HORIZONTAL								
AoI - Within Country	-0.003		-0.005	-0.020	-0.009	-0.007	0.006	0.005
	[0.037]		[0.038]	[0.039]	[0.038]	[0.035]	[0.017]	[0.017]
AoI - Cross-border								
after EU, before Schengen	-0.025	-0.029	-0.019	-0.038	-0.029	-0.034	-0.027	-0.039
	[0.052]	[0.054]	[0.053]	[0.045]	[0.049]	[0.049]	[0.053]	[0.051]
after Schengen	0.282**	0.204*	0.197*	0.113	0.148	0.183*	0.184*	0.175*
	[0.121]	[0.108]	[0.103]	[0.097]	[0.101]	[0.095]	[0.103]	[0.093]
other	0.133*	0.113	0.109		0.110	0.097	0.105	0.089
	[0.079]	[0.081]	[0.083]		[0.084]	[0.074]	[0.083]	[0.076]
Observations	37,726	46,478	46,478	35,045	41,102	50,364	102,082	105,968
R-squared	0.116	0.107	0.109	0.080	0.098	0.105	0.106	0.104

Robust standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%. Industry, country, and year fixed effects included. Additional controls included: firm age, firm size, initial TFP, initial market share, change in market share, exit dummy, and a downstream demand indicator.

different across distances. The EU-membership effect drops in the level of significance for some distance choices, but remains significant at least at the 10% level throughout the table. The same observation holds for the post-Schengen horizontal effect. Overall, the choice of distance does not seem to be driving our results.

We set the radius of the area of interest again at 75km for a further set of robustness checks in Table 9. In the first column we reduce the estimation sample to firms that we observe for a sufficiently long period such that firms that experience only a single border regime change are excluded from the sample. This ensures that we are not comparing different groups of firms before and after a regime switch. Note that this does involve dropping underperforming firms and retaining survivors and decreases the sample size by about 20%. Our earlier results are confirmed for this sample. Next, we check whether excluding within country foreign presence influences cross-border coefficients e.g. because of specific correlation patterns. Dropping the within country variable from the estimation in column two does not affect the results. In column three we replace within country foreign presence in the area-of-interest with within country foreign presence in the *entire* country, i.e. the definition of foreign presence that is commonly used in the literature. Applying this standard definition for within country foreign presence leaves our cross-

border results unaffected.

In our main estimations we compare three types of regions with three types of border regime time paths for identification. In columns four and five we focus on two smaller subsets of our main sample. More specifically, in column four we restrict the sample to EU-non Schengen and Schengen borders only, i.e. the first two rows in Table 2. This explains why there is no 'other' border coefficient in column four. The Schengen effect is now identified by comparing Schengen border regions with EU-non-Schengen border regions. The EU-non-Schengen effect now reduces to a single difference setting as all regions become EU-border regions, be it at different points in time. In column five we compare the two extremes in terms of border 'thickness', i.e. the seamless EU-Schengen borders and the highly restrictive non-EU borders (the first and the last row in Table 2). Both columns qualitatively confirm our results for cross-border indirect productivity effects through backward linkages. The horizontal effect for Schengen borders disappears, however.

Finally, in the last three columns we check whether results are sensitive to the inclusion of fuzzy regions or non-border regions in the estimation sample. In column six we include fuzzy regions in the estimation sample, in columns seven and eight we extend the sample to also include non-border regions with and without fuzzy regions. Again, columns six to eight confirm earlier results with respect to backward linkages, horizontal post-Schengen effects are weakly confirmed, as coefficients are now significant at the 10%-level.

Summarising, our results with respect to indirect productivity effects through backward linkages pass a wide range of robustness checks. We confirm the existence of positive cross-border indirect productivity effects through backward linkages. EU-membership, however, is a necessary condition for cross-border effects to exist and Schengen area participation magnifies cross-border effects. We find indications of a potential positive post-Schengen cross-border within-industry indirect productivity effect. The evidence, however, is generally weaker than for effects through backward linkages and fails to pass all robustness checks.

5 Conclusion

Supplying inputs to foreign-owned firms is widely cited as a source of productivity gains for local firms. The existing literature has confirmed the existence of positive indirect productivity effects through backward linkages in many developing and transition countries. Whilst previous papers implicitly confine indirect productivity effects within national borders, this does not need to be the case, especially in higly integrated regions. In this paper we analyse indirect productivity effects through backward linkages in a

multi-country setting which allows for cross-border effects.

We use a large dataset for seven Central and Eastern European countries and their neighbours for the period 2000-2010. During our sample period all seven countries have integrated in the European Union, but at a different pace and to a different extent. Most of these countries also share borders with third countries that are not EU-members. This allows us to test the impact of different border regimes on cross-border indirect productivity effects in a difference-in-difference setting. For this purpose we define distance-limited areas-of-interest around domestic firms which may or may not include cross-border territory depending on the domestic firm's location. We distinguish three types of areas including cross-border territory (border regions) that can be used to set up a difference-in-difference analysis. There are regions with borders that switch from non-EU to EU to Schengen status; regions with borders that switch from non-EU to EU-non-Schengen status; and regions with borders that never switch non-EU status. The latter serve as a control group to test the effect of two different treatments, EU and Schengen area accession.

We find that domestic manufacturing firms with more than ten employees benefit from cross-border FDI in client industries and, importantly, they only do so when borders are not 'thick'. Specifically, we find that EU-membership on both sides of the border is a necessary condition for productivity effects to emerge. Schengen area participation increases the coefficient of cross-border effects significantly. Point estimates imply that a one standard deviation increase in FDI activity results in a productivity level that is 3.7%, 2.0%, and 5.9% higher for within-country, cross-border EU, and cross-border Schengen effects respectively. These results are not dependent on the choice of distance and pass a series of additional robustness checks. Finally, we find indications of potential positive post-Schengen cross-border within-industry productivity effects, but the evidence is less robust.

Our findings suggest that reducing administrative barriers to trade and policy uncertainty through formal EU accession have allowed positive cross-border indirect productivity effects through backward linkages to emerge. Schengen area participation, which eliminates border controls altogether, further increases this impact. Bearing in mind that MNEs have an interest in technological upgrading by their suppliers and therefore an incentive to provide them with explicit assistance, the Schengen premium is not unexpected. Schengen area participation makes border crossing seamless rather than potentially long and unpredictable due to security checks. This not only enhances the ability to ship rapidly and predictably across borders, but also facilitates in-person contact and reduces communication costs, which are important ingredients for successful technology transfer.

Finally, as the European integration project has aimed to create an internal market with-

out national borders, our analysis can also be seen as a test of European integration. In this sense, our finding that cross-border indirect productivity effects across EU and Schengen borders cannot be rejected to be equal to within country effects provides evidence of successful European integration. Therefore policy actions, e.g. in the context of Brexit or the refugee crisis, which go against integration and promote re-instatement of strict border controls, will among other things also entail a considerable productivity cost to local firms. Policymakers should take this additional cost into account when considering border reform.

References

Aitken, B. J. and A. E. Harrison (1999). Do domestic firms benefit from direct foreign investment? Evidence from Venezuela. *The American Economic Review 89*(3), pp. 605–618.

Barrios, S., H. Görg, and E. Strobl (2011). Spillovers through Backward Linkages from Multinationals: Measurement Matters! *European Economic Review 55*(6), pp. 862–875.

Bernard, A. B., A. Moxnes, and Y. U. Saito (2018). Production networks, geography and firm performance. *Journal of Political Economy forthcoming*.

Bloom, N. and J. Van Reenen (2007). Measuring and explaining management practices across firms and countries. *The Quarterly Journal of Economics 122*(4), pp. 1351–1408.

Caves, R. E. (1974). Multinational firms, competition, and productivity in host-country markets. *Economica 41*(162), pp. 176–193.

Chen, N. and D. Novy (2011). Gravity, trade integration, and heterogeneity across industries. *Journal of International Economics 85*(2), pp. 206 – 221.

Crespo, N. and M. P. Fontoura (2007). Determinant factors of FDI spillovers - What do we really know? *World Development 35*(3), pp. 410–425.

Damijan, J., M. Rojec, B. Majcen, and M. Knell (2013). Impact of firm heterogeneity on direct and spillover effects of FDI: Micro-evidence from ten transition countries. *Journal of Comparative Economics 41*(3), pp. 895 – 922.

Giroud, X. (2013). Proximity and investment: Evidence from plant-level data. *The Quarterly Journal of Economics 128*(2), pp. 861–915.

Görg, H. and D. Greenaway (2004). Much ado about nothing? Do domestic firms really benefit from foreign direct investment? *World Bank Research Observer 19*(2), pp. 171–197.

Görg, H. and E. Strobl (2005). Spillovers from foreign firms through worker mobility: An empirical investigation. *Scandinavian Journal of Economics 107*(4), pp. 693–709.

Guadalupe, M., O. Kuzmina, and C. Thomas (2012). Innovation and foreign ownership. *American Economic Review 102*(7), pp. 3594–3627.

Handley, K. and N. Limão (2015). Trade and investment under policy uncertainty: Theory and firm evidence. *American Economic Journal: Economic Policy 7*(4), pp. 189–222.

Hanousek, J., E. Kočenda, and M. Maurel (2011). Direct and indirect effects of FDI in emerging European markets: A survey and meta-analysis. *Economic Systems 35*(3), pp. 301–322.

Havránek, T. and Z. Irŝová (2011). Estimating vertical spillovers from FDI: Why results vary and what the true effect is. *Journal of International Economics 85*(2), pp. 234–244.

Havránek, T. and Z. Irŝová (2013). Determinants of horizontal spillovers from FDI: Evidence from a large meta-analysis. *World Development 42*, pp. 1–15.

Havránek, T. and Z. Irŝová (2017). Do borders really slash trade? a meta-analysis. *IMF Economic Review 65*(2), pp. 365–396.

Helpman, E., M. J. Melitz, and S. R. Yeaple (2004). Export versus FDI with heterogeneous firms. *American Economic Review 94*(1), pp. 300–316.

Hornok, C. and M. Koren (2015). Administrative barriers to trade. *Journal of International Economics 96*, S110–S122. 37th Annual NBER International Seminar on Macroeconomics.

Hummels, D. L. and G. Schaur (2013). Time as a trade barrier. *American Economic Review 103*(7), pp. 2935–2959.

Javorcik, B. S. (2004). Does Foreign Direct Investment increase the productivity of domestic firms? In search ofspillovers through backward linkages. *American Economic Review 94*(3), pp. 605–627.

Javorcik, B. S. and S. Poelhekke (2017). Former Foreign Affiliates: Cast Out and Outperformed? *Journal of the European Economic Association 15*(3), pp. 501–539.

Katayama, H., S. Lu, and J. R. Tybout (2009). Firm-level productivity studies: Illusions and a solution. *International Journal of Industrial Organization 27*(3), pp. 403–413.

Keller, W. (2010). Chapter 19 - International Trade, Foreign Direct Investment, and Technology Spillovers. In B. H. Hall and N. Rosenberg (Eds.), *Handbook of the Economics of Innovation*, Volume 2, pp. 793–829. North-Holland.

Keller, W. and S. R. Yeaple (2013). The gravity of knowledge. *American Economic Review 103*(4), pp. 1414–1444.

Kolosov, V. (2013). Territorial units in Russia, Ukraine, Belarus and Moldova and NUTS classification. Technical report, ESPON.

Lenaerts, K. and B. Merlevede (2016). Supply chain fragmentation, input-output tables and spillovers from foreign direct investment. *Economic Systems Research 28*(3), pp. 315–332.

Lenaerts, K. and B. Merlevede (2018). Indirect productivity effects from foreign direct investment and multinational firm heterogeneity. *Review of World Economics 154*(2), pp. 377–400.

Levinsohn, J. and A. Petrin (2003). Estimating production functions using inputs to control for unobservables. *The Review of Economic Studies 70*(2), pp. 317–341.

McCallum, J. (1995). National borders matter: Canada-U.S. regional trade patterns. *American Economic Review 85*(3), pp. 615–23.

Merlevede, B., M. de Zwaan, K. Lenaerts, and V. Purice (2015). Multinational networks, domestic,and foreign firms in Europe. Working Papers of Faculty of Economics and Business Administration, Ghent University, Belgium 15/900, Ghent University, Faculty of Economics and Business Administration.

Moulton, B. R. (1990). An Illustration of a Pitfall in Estimating the Effects of Aggregate Variables on Micro Units. *The Review of Economics and Statistics 72*(2), pp. 334–338.

Olley, G. S. and A. Pakes (1996). The dynamics of productivity in the telecommunications equipment industry. *Econometrica 64*(6), pp. 1263–1297.

Teece, D. J. (1977). Technology transfer by multinational firms: The resource cost of transferring technological know-how. *The Economic Journal 87*(346), pp. 242–261.

Volpe Martincus, C., J. Carballo, and A. Graziano (2015). Customs. *Journal of International Economics 96*(1), pp. 119–137.

Wooldridge, J. M. (2009). On estimating firm-level production functions using proxy variables to control for unobservables. *Economics Letters 104*(3), pp. 112–114.

Appendix A

Table 10: Distance and the share of border regions

	total	Distance to define Area-of-interest								
	# regions	70	75	80	85	90	95	100	105	110
BG	28	9	11	13	13	18	19	19	20	23
CZ	14	7	8	10	10	12	12	13	13	14
HU	20	8	12	15	15	16	17	17	17	19
PL	66	20	21	22	26	28	28	31	31	31
RO	42	16	17	20	20	21	23	25	26	26
SI	11	11	11	11	11	11	11	11	11	11
SK	8	3	5	6	7	8	8	8	8	8
Share	100%	39.2%	45.0%	51.3%	54.0%	60.3%	62.4%	65.6%	66.7%	69.8%

Table 11: Number of (foreign) firms in border regions in neighbouring countries that are used to calculate the share of output produced by foreign firms in the Area-of-interest (75/100km)

	border region-75km		border region-100km			border region-75km		border region-100km	
	total	foreign	total	foreign		total	foreign	total	foreign
AT	46,403	2,573	53,156	2,863	LT	556	28	2,631	98
BY	761	55	1,015	70	MD	1,747	30	1,779	30
DE	210,828	5,969	331,166	9,009	MK	6,193	251	6,835	268
GR	4,046	6	13,379	99	RS	16,937	1,488	18,997	1,632
HR	27,966	727	29,899	773	*RU**	2,638	86	5,598	163
IT	13,970	112	38,108	321	UA	7,911	66	22,569	143

Manufacturing firms that report output needed to calculate measures of foreign presence; foreign firms are firms owned by third country owners (i.e. countries contained by the area-of-intrest are excluded) for at least 50%.

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