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WORKING PAPER

Supply Chain Fragmentation and Spillovers from Foreign Direct Investment

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Supply Chain Fragmentation and Spillovers from Foreign Direct Investment

Karolien Lenaerts* Bruno Merlevede†

Abstract

The literature on FDI spillovers to domestic firm productivity increasingly points to supply chain linkages with multinational firms as the main channel for positive effects. To determine local and multinational firms' relative position in the supply chain, the literature relies on input-output tables. For a panel of Romanian firms we show that the level of industry aggregation in these tables and the commonly applied definitions for vertical spillovers bear an important impact on results. The use of aggregated input-output tables gives rise to significant and large horizontal spillover effects, whereas backward spillovers tend to be small and only marginally significant. Using detailed input-output tables, backward spillovers become highly significant and dominate horizontal spillover effects whose impact is considerably reduced. Assuming that the true nature of the backward spillover is to be found in a supplier-customer relationship, we show that -for the detailed IO-tables- including within-industry intermediate supply (excluded in the commonly used definition) results in a larger impact of the backward spillover, whereas the horizontal spillovers disappear.

JEL Classification: F2
Keywords: input-output tables, foreign direct investment, spillovers

1 Introduction

The last few decades have been characterized by a fragmentation of the production chain with firms specializing in specific stages of the chain. This process has often been linked with a shift in foreign direct investment (FDI) towards developing and transition economies (see e.g. UNIDO (2005), Rajan (2005), and Hanousek *et al.* (2011)). At the same time, the interest of researchers and policymakers in FDI as a source of technology transfer has been rising. Expecting a positive impact on the local economy, governments in many developing (and developed) countries have implemented a range of policies to attract foreign investment. Multinational enterprises (MNEs) are not only expected to bring resources, technology, and jobs with them, but they are also expected to generate indirect effects or FDI spillovers. The idea behind these spillover effects is that multinationals intentionally or unintentionally transfer technology and knowledge in a broad sense (e.g. managerial know-how) to domestic firms that become more productive as a result.

There is a large body of empirical research that analyzes these FDI spillovers as additional inputs explaining total factor productivity (TFP) in a production function framework. Spillovers are considered to be either of a horizontal or vertical nature. Horizontal spillovers occur between firms in similar stages in the supply chain, i.e. in competitive relationships. Vertical spillovers, on the other hand, are spillovers that arise between firms in supplier-customer relationships, i.e. in different stages of the supply chain. In this case, the literature differentiates between backward spillovers, linkages between multinationals and their local suppliers, and forward spillovers, linkages between multinationals and their local customers. Figure 1 illustrates these different spillovers in the supply chain.

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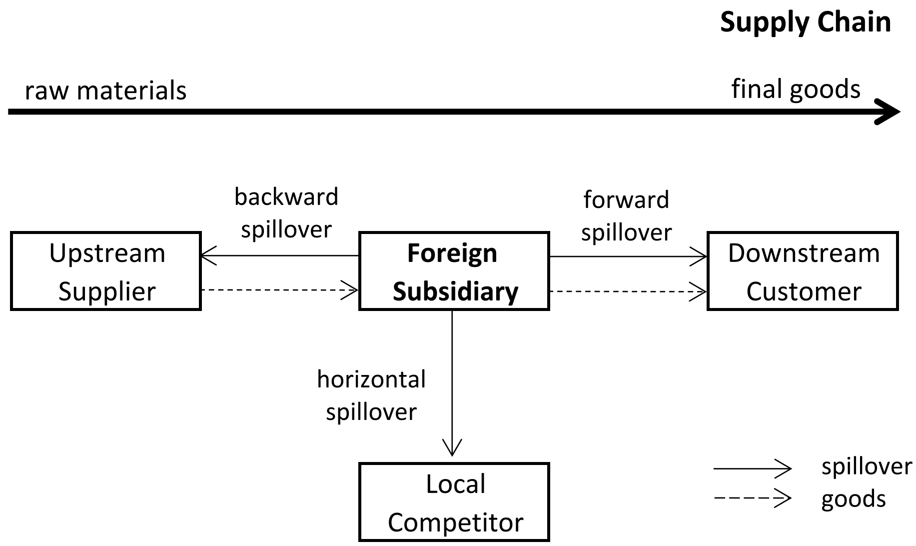

Figure 1: Horizontal, backward and forward spillovers in the supply chain.

Horizontal spillovers have received widespread attention at least since Caves (1974). Vertical spillovers were first introduced by McAleese and McDonald (1978) and Lall (1980), after which the discussion about them languished for nearly two decades before theoretical work by Rodriguez-Clare (1996) and Markusen and Venables (1999) and empirical work by Javorcik (2004) revived the interest (see also Schoors and van der Tol, 2002). Since then, vertical spillovers, and especially backward spillovers are regarded as a more likely channel for (positive) productivity spillovers because MNEs have an interest in good suppliers. The overall empirical evidence on all FDI spillovers is mixed (see the literature surveys by Görg and Greenaway, 2004; Crespo and Fontoura, 2007; Meyer and Sinani, 2009; and Havranek and Irsova, 2011a and 2011b for a detailed discussion). However, based on a meta-analysis of 3626 estimates of backward spillovers, Havranek and Irsova (2011a) do confirm that the average spillover to suppliers is economically significant.

In most empirical work, the measure to capture the horizontal spillover potential is defined as the share of output in a given industry that is produced by foreign firms (following Caves, 1974). Because firm-level data on linkages with foreign affiliates are usually unavailable, the measures to capture the vertical spillover potential are calculated as a weighted average of foreign presence (measured by the horizontal spillover variable) in industries upstream and downstream of a domestic firm in a given industry (this approach follows Javorcik, 2004). The weights are technical coefficients derived from input-output (IO) tables. For each industry, they reflect the share of input/output that is sourced from/sold to each of the other industries. Therefore, horizontal spillovers are also often labelled intra-industry spillovers and vertical spillovers inter-industry spillovers. IO-tables are thus used to put an explicit industry structure on the intuition in Figure 1. Consequently, it will be the level of industry aggregation in the IO-tables that determines which linkages are classified as vertical. Clearly, the more aggregated the IO-tables used, the more likely that supplier-customer relationships will incorrectly be classified as horizontal. Furthermore, following the standard in the literature these linkages will be excluded from the vertical spillover measures. This observation becomes even more relevant in the light of an increasingly fragmented production chain. As a result, working on a too aggregated level might result in an underestimation of backward spillover effects and complicates the interpretation of horizontal spillover effects that will partly reflect supplier-customer relationships, in addition to other horizontal channels such as labour mobility, demonstration, and competition effects (see Crespo and Fontoura, 2007).

Recent work by Alfaro and Charlton (2009) makes a similar point in a closely related matter: the classification of multinational firms' investment as horizontal or vertical. For a large sample of multinational firms, they show that due to a finer level of detail in industry classification a lot more multinational investment should be classified as vertical rather than horizontal (than previously thought).

In this paper we analyze the impact of the level of industry aggregation on horizontal and vertical spillovers by calculating spillover variables for different industry classifications (aggregated and detailed). Further, we elaborate on the standard measures for spillovers in order to link them more closely to our intuitive understanding of the channels in Figure 1. We use a panel of Romanian manufacturing firms, a time series of detailed IO-tables and a series of these tables collapsed to a higher level of industry aggregation.

We find that evidence of positive and statistically significant backward spillovers is much stronger for detailed than for aggregated input-output tables. The impact of horizontal spillovers is found to be much larger and positive for aggregated input-output tables. These results hold for both the standard methodology to calculate spillover variables and an alternative approach that consists of including within-industry intermediate supply and use in the calculation of vertical spillover variables. Surprisingly, the latter seems to have the biggest impact for the results based on the detailed input-output tables, where horizontal spillovers disappear after including within-industry intermediate supply and use. Calculating vertical spillover variables by combining aggregated IO-tables with detailed horizontal spillover variables does not affect our conclusions.

The structure of the paper is as follows. Section 2 provides a discussion of spillover measurement and the role of the supply chain and industry classification in input-output tables. In section 3, the empirical approach and data are described. Section 4 presents estimation results and section 5 concludes by summarizing our key findings.

2 Spillover measurement

The methodology to calculate variables that capture FDI spillover potential draws on work by Caves (1974) and Javorcik (2004). These measures have been used by almost all work on FDI spillovers. Barrios *et al.* (2011) is the only other work we are aware of that critically analyzes the construction of spillover variables and its implications for the obtained results. In the empirical part, we get back to some of their suggestions. Our approach differs from theirs by focusing on the role of industry aggregation. In this section, we first present the 'classic' or standard spillover definitions and discus the impact of the level of industry aggregation in the IO-tables. We then present a modification to the standard definitions of spillover variables to have them better reflect our understanding of Figure 1.

Horizontal or intra-industry spillover variables are typically computed as follows:

$$Horizontal_{jt} = \frac{\sum\limits_{i \in j} ForeignShare_{it} * Y_{it}}{\sum\limits_{i \in j} Y_{it}} \tag{1}$$

where Y_{it} is output produced by firm i in industry j in year t and $ForeignShare_{it}$ is the share of foreign participation in firm i in year t. For a firm to be classified as foreign at least a single foreign investor with at least 10% of shares is required. $Horizontal_{jt}$ then captures the degree of foreign presence in industry j at time t by the share of industry j's output produced by foreign firms.

The backward spillover variable for industry j measures foreign presence in industries c supplied by industry j at time t and is typically calculated as follows:

$$Backward_{jt} = \sum_{c if c \neq j} \gamma_{jct} * Horizontal_{ct} \tag{2}$$

$Backward_{jt}$ is a weighted average of $Horizontal$ in the sourcing industries c, where the weights are the technical coefficients γ_{jct}, i.e. the share of industry j's total intermediate supply that is supplied to each industry c. These technical coefficients are derived from input-output tables for intermediate consumption (typically final uses are not taken into account, cf. *infra*). Following Javorcik (2004), inputs supplied within the same industry are commonly excluded as these are already part of the horizontal spillover (hence $c \neq j$). $Backward$ serves as a proxy for the potential linkages between MNEs and their local suppliers.

The forward spillover variable for industry j is constructed in a similar way:

$$Forward_{jt} = \sum_{r if r \neq j} \delta_{jrt} * Horizontal_{rt} \tag{3}$$

In this case, the technical coefficients δ_{jrt} correspond to the share of industry j's inputs purchased from industries r at time t. Inputs sourced within the same industry are excluded ($r \neq j$). The forward spillover is a proxy for potential linkages between multinational firms and local clients.

The above mentioned definitions thus put an explicit industry structure on the spillovers defined in Figure 1. Because these definitions rely on information from input-output tables (the γs and δs) and inputs supplied within the same industry are commonly excluded, the level of industry aggregation found in the IO-tables will determine the characterization of linkages between foreign and domestic firms as either horizontal or vertical.

Figure 2 illustrates how the level of industry aggregation affects the classification of spillovers in horizontal and vertical effects. The upper panel of Figure 2 represents a stylized IO-table with an aggregated industry classification, the lower panel shows a stylized IO-table with a more disaggregated classification. In the aggregated IO-table only three industries can be distinguished (1, 2 and 3), while in the detailed IO-table in the bottom panel, six different industries are found (1a, 1b, 2a, 2b, 3a and 3b). When input-output tables are used to construct backward and forward spillovers, within-industry supply and use are typically excluded (cf. (2) and (3)). In practice, technical coefficients on the diagonal of the input-output table (grey areas in Figure 2) are set to zero. A comparison of the two IO-tables presented in Figure 2 reveals that the diagonal is much slimmer in the detailed table than in the aggregated table. This implies that a number of linkages between firms that are regarded as horizontal (representing competitive relationships) are of a vertical nature when these linkages are studied in more detail (representing supplier-customer relationships). These linkages will be excluded from the vertical spillover variables if spillovers are calculated with the aggregated IO-table at hand. For example, the relationships between firms in industries 1a and 1b will not be taken into account at the aggregated level but are included in the backward and forward spillovers at the detailed level.

The implications are striking. Because the detailed IO-table allows for finer sourcing and supplying patterns, more linkages will be classified as vertical than on the basis of the aggregated table. In addition, the detailed IO-table also allows for a more accurate detection of sourcing from, and foreign presence in industries that are vertically linked in the aggregated IO-table. Since industry 1a cannot be distinguished from 1b in the upper table when calculating backward spillovers for industry 2 or 3, there will be an aggregated backward spillover from industry 1 that masks potential differences between industries 1a and 1b[1]. If there is a substantial variation in technical coefficients and foreign presence between the a- and b-parts of industries, the availability of a more detailed input-output table is likely to affect backward and forward spillover variables as well.

Based on the analysis of Figure 2, two major conclusions can be drawn. First, to disentangle horizontal from vertical spillovers, the level of industry aggregation in the input-output tables is essential. Second, by computing spillover effects from too aggregated input-output tables, several linkages between firms are incorrectly classified as horizontal and not taken into account although

[1]Suppose industry 2(a/b) is a big supplier of industry 1b but not of 1a, and that there is a large foreign presence in 1b but not in 1a. This type of information is likely to be largely lost in the aggregated input-output table because both the technical coefficient and the $Horizontal$-variable will refer to the entire industry 1.

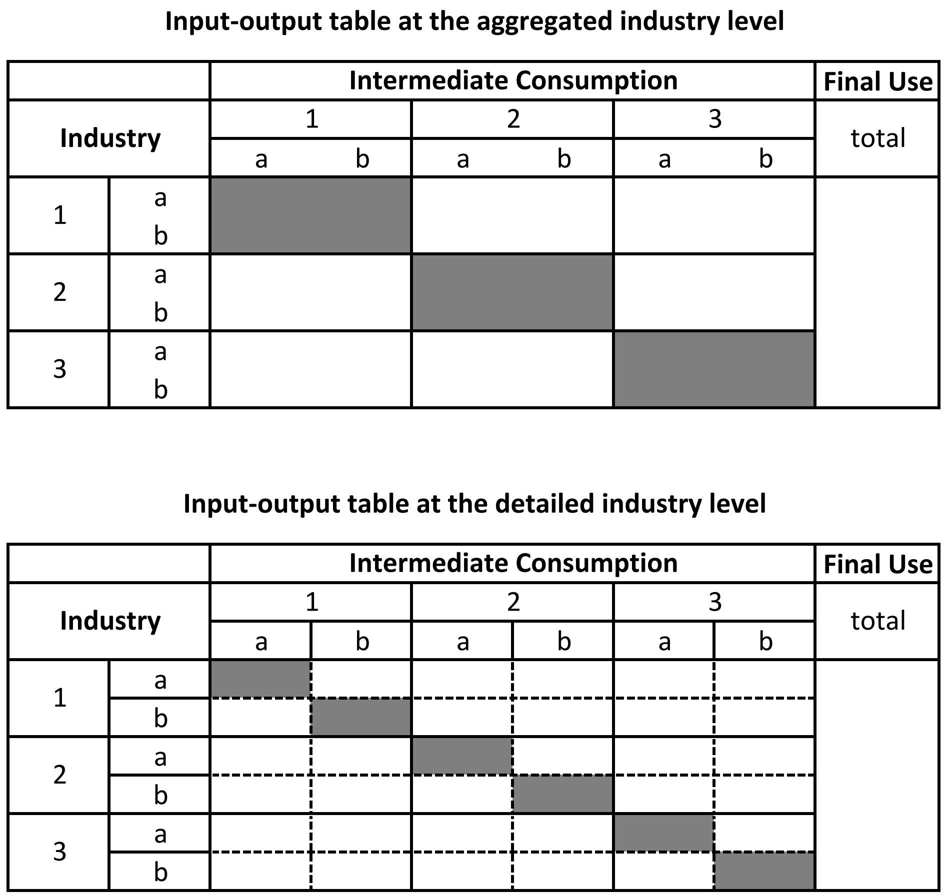

Figure 2: Stylized input-output tables at varying levels of industry aggregation.

these relationships should be included in the spillover variables. Consequently, using sufficiently detailed input-output tables in the analysis of FDI spillovers is of great importance.

Both the OECD and Eurostat provide harmonized IO-tables that many researchers use. Unfortunately, these IO-tables are often fairly aggregated. The dimension of the OECD IO-tables is 48x48 industries. Out of these 48 industries, 22 are manufacturing. Eurostat IO-tables typically have a 59x59 dimension (i.e. NACE 2-digit classification[2]). 23 out of the 59 industries are manufacturing industries. As indicated above, we use an IO-table for the Romanian economy that consists of 105 industries (detailed IO-table henceforth) which roughly correspond to the NACE 3-digit classification. Out of these 105 industries, 61 are manufacturing industries[3]. In order to empirically study the impact of industry aggregation on spillovers, we collapse the detailed IO-tables to the NACE 2-digit level (aggregated IO-table henceforth) and compute horizontal and vertical spillover variables on the basis of both aggregated and detailed IO-tables. A time series of input-output tables (one for each year in the panel) and a conversion table to convert the Romanian industry classification into the NACE classification were obtained from the Romanian Statistical Institute (RSO). This conversion table lists the mapping of the Romanian industry classification into the NACE 2-digit and 3-digit classification schemes (Table 8 in the Appendix).

[2]Nomenclature des Activités économiques dans la Communauté Européenne.

[3]For the industries "Processing of nuclear combustibles" and "Armament and ammunition" there is no data available, reducing the number of manufacturing industries to 59.

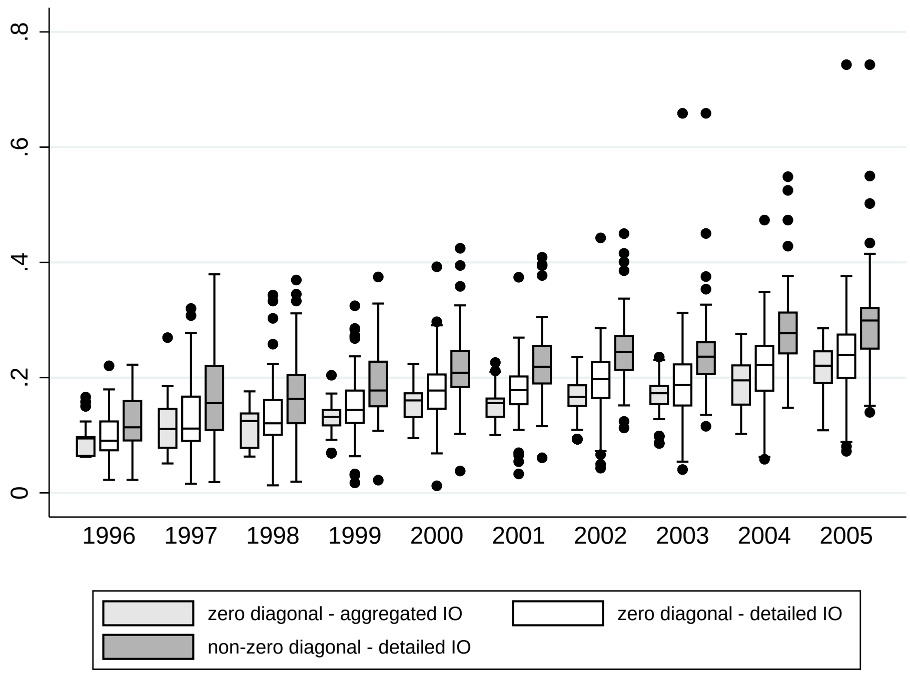

Figure 3: Boxplot of backward spillover variables calculated using aggregated and detailed input-output tables and both the zero- and non-zero-diagonal approach for the period 1996-2005.

How important are the effects discussed above? To gain some more insight, we look into some specific examples from our data on Romania. In terms of Figure 2, the detailed table for the year 2005 reveals for 2-digit industries 15 (food), 24 (chemicals), and 26 (non-metallic mineral products) -which have 9, 7, and 8 3-digit sub-industries respectively- that the off-diagonal elements within the same 2-digit industry account for 26, 47, and 37 percent of the within NACE 2-digit intermediate supply. As a share of total intermediate supply, the numbers are 12.1, 6.5, and 4.3 percent. For sub-industries, on average about 87% of firms in the same NACE 2-digit industry belongs to a different detailed NACE 3-digit sub-industry.

In order to test whether the industry classification in the input-output tables affects the estimation of FDI spillovers and in particular the backward spillover effects, we will compare estimation results using spillover variables based on aggregated and detailed IO-tables. We start by applying the methodology commonly used in the field ((1)-(3), henceforth referred to as the zero-diagonal definition for the vertical spillovers).

Based on a supply chain approach, Figure 1 illustrated our intuitive understanding of horizontal and vertical spillovers. If vertical spillovers originate from customer-supplier relationships and horizontal spillovers from competitive relationships, the standard approach of ignoring within-industry intermediate supply and use introduces another potential underestimation of backward linkages. Although within-industry supply and use refer to sales and purchases within the same sector, these linkages still refer to supplier-customer relationships. If customer-supplier relationships are more inclined to result in positive spillover effects than competitive relationships, we should measure backward spillovers as $\sum_c \gamma_{jct} * Horizontal_{ct}$ rather than $\sum_{cif c \neq j} \gamma_{jct} * Horizontal_{ct}$ as in (2) (this approach of including within-industry supply and use is labelled the non-zero-diagonal definition for the vertical spillovers henceforth). This may have important implications as even in our detailed IO-tables diagonal elements are non-negligible (in 2005 on average about 15% of intermediate supply by manufacturing industries is within the same 3-digit industry).

The boxplots presented in Figures 3 and 4 illustrate the distribution and values of various back-

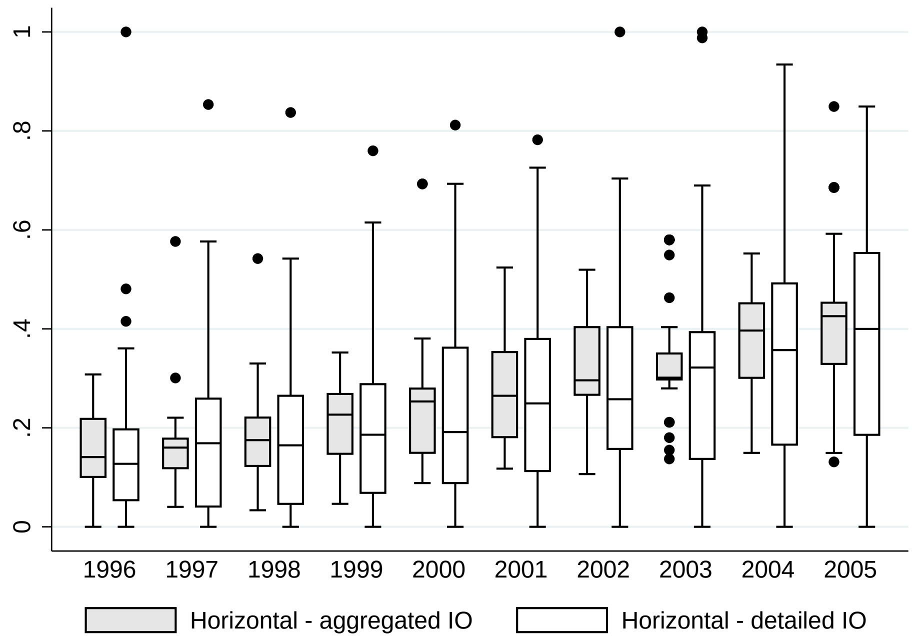

Figure 4: Boxplot of horizontal spillover variables calculated using aggregated and detailed input-output tables for the period 1996-2005.

ward and horizontal spillover variables over the sample period. The boxplots draw on industry-level data derived from the firm-level sample, covering 23 manufacturing industries at the aggregated level and 59 at the detailed level (period 1996-2005). Figure 3 shows backward spillover variables computed according to the zero-diagonal definition (following (2)) for both the aggregated and detailed input-output tables and based on the non-zero-diagonal definition for the detailed input-output tables. In the figure, the value of the spillover variables tends to increase with the different definitions. Going from the zero-diagonal aggregated IO-tables to the zero-diagonal detailed IO-tables implies an increase, because the pool of non-diagonal elements rises. Subsequently making use of the non-zero-diagonal detailed definition induces a further increase, because then the non-zero-diagonal elements are accounted for as well. Changing from aggregated to detailed coefficients also implies an increase in the dispersion of the backward variable. Figure 4 shows horizontal spillover variables, computed following equation (1), for both detailed and aggregated IO-tables. As expected, detailed input-output tables are associated with a larger dispersion than aggregated tables, but not with larger values. Both Figures 3 and 4 illustrate the rising importance of foreign firms in the Romanian economy over the sample period.

A further consideration is that the technical coefficients in equations (2) and (3) are traditionally only derived from the intermediate supply and use part of the input-output table (see also Barrios *et al.*, 2011). However, from Figure 2 one can infer that industries also produce goods for final use. Clearly, the extent to which an individual industry is involved in producing other industries' intermediate supply relative to production for final use is a potential modifier of backward spillover effects. We can take this aspect into account by recalculating the backward spillover variable using a different set of technical coefficients. Generally, 'backward' technical coefficients for industry j (the γs in equation (2)) will be calculated according to equation (4), i.e. by dividing each cell of the intermediate consumption part of the IO-table in row j by the row total, the total intermediate supply by industry j. The alternative that takes final use into account is given by equation (5).

$$\gamma_{jc} = \frac{intermed_{jc}}{\sum_c intermed_{jc}} \tag{4}$$

$$\gamma'_{jc} = \frac{intermed_{jc}}{final_j + \sum_c intermed_{jc}} \tag{5}$$

The value of the backward spillover variable based on the γ's in equation (5), $Backward^{final}$, will be smaller for industries that are relatively more directed towards production for final use. The new variable can be obtained by replacing the γs in equation (2) with γ's.

3 Methodology and Data

3.1 Methodology

Following Javorcik (2004), FDI spillovers are analyzed in a production function framework where they are considered as additional 'inputs' explaining total factor productivity. Best practice is defined by Havranek and Irsova (2011a) as a study that uses firm-level data, computes TFP by a method that accounts for the endogeneity of input demand, estimates the regression in differences, and controls for sector fixed effects, sector competition, and demand in downstream sectors[4]. Following these guidelines, we specify equation (6) as our basic-level model where firm-level TFP of firm i in industry j at time t is related to FDI spillover variables, FDI_j, and a set of industry controls, Z_j. As in Javorcik (2004), the set of control variables Z_j consists of a Herfindahl index of industry concentration and a demand index.

$$TFP_{ijt} = \alpha_i + \psi_1 f(FDI_{jt-1}) + \psi_2 Z_{jt-1} + \xi_{ijt} \tag{6}$$

Equation (6) is first-differenced and region (α_r), industry (α_j), and time (α_t) dummies are added. We further include firm age, the lagged level of firm size (measured by real output) and controls for import competition, export intensity and the share of intermediate supply in total industry output as determinants of TFP growth (also in Z_j). Equation (7) is estimated by OLS. Standard errors are clustered at the industry-year level because some of the variables are at the industry-level while estimation is at the firm-level (see Moulton, 1990).

$$\begin{aligned}\Delta TFP_{ijrt} = \psi'_1 \Delta f(FDI_{jt-1}) + \psi'_2 \Delta Z_{jt-1} + \delta_1 age_{it} + \delta_2 size_{it-1} \\ + \alpha_t + \alpha_j + \alpha_r + \epsilon_{ijrt}\end{aligned} \tag{7}$$

The estimation of TFP is complicated by the endogeneity of inputs since the input choice of a firm is likely to be based on its productivity (Griliches and Mairesse, 1995). A number of authors have proposed alternative estimation methods to obtain an unbiased estimate of TFP. The dynamic panel data setup of Blundell and Bond (1998) (DPD) and the semi-parametric approaches of Olley and Pakes (1996) (OP) and Levinsohn and Petrin (2003) (LP) are commonly used. In the semi-parametric approaches, a proxy is introduced to handle the endogeneity bias. OP use investment as a proxy[5], while LP opt for material inputs, arguing that investment is not a good proxy because it is lumpy and does not respond smoothly to the productivity shock (see

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

$$demand_{jt} = \sum_k a_{jk} * Y_{kt}$$

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

[5]We apply the procedure from Amiti and Konings (2007) to compute investment from our data.

also Petrin, Poi and Levinsohn, 2004). More recently, Ackerberg, Caves and Frazer (2008) (ACF) proposed an alternative semi-parametric procedure to deal with potential collinearity issues in OP and LP. As the discussion is still ongoing[6], we check robustness with respect to a number of alternative estimators. Finally, we also check robustness of the functional form and replace the Cobb-Douglas specification with a translog specification (TL) that is estimated by OLS. Note that while TFP estimates are obtained from production functions estimated by NACE 2-digit manufacturing industry, equation (7) pools domestic firms from all manufacturing industries.

3.2 Data

We use a Romanian firm-level panel data set to analyze FDI spillover effects from firms in manufacturing and services industries on Romanian manufacturing firms. Foreign investment really started to enter Romania after several privatization and market access reforms had been conducted in the late 1990s (UNCTAD, 2003). Macroeconomic stabilization, an improved business environment and EU candidacy resulted in another sharp increases in FDI inflows from 2004 onwards, turning Romania into one of the main recipients of foreign investment in South-East Europe (OECD, 2005; UNCTAD, 2005). FDI in Romania is concentrated in the manufacturing industries and the main investors are European countries (80% of the total FDI stock) (Pauwels and Ionita, 2008). The data span the period 1996-2005 and are limited to firms with at least five employees on average. The data set was further trimmed for outliers by removing the top and bottom percentiles of the annual growth rates of real operating revenues, real capital, labour, and real material inputs[7]. The firm-level data are drawn from the Amadeus database by Bureau Van Dijk Electronic Publishing. The Amadeus database holds financial and ownership information on public and private companies across Europe (Bureau Van Dijk, 2011). The subset of Romanian firms in the Amadeus database is known for its excellent coverage (see a.o. Altomonte and Colantone, 2008). In order to get a full overview of financials and ownership through time, multiple DVDs published by Bureau Van Dijk were used to construct the database[8]. Nominal data were deflated with industry price-level data at NACE 2-digit level. Price-level data were extracted from the Statistical Yearbook of the Romanian Statistical Institute (RSO) and the Industrial Database for Eastern Europe from the Vienna Institute for International Economic Studies (WIIW). To construct real output (Y), operating revenues are deflated with producer price indices. Labour (L) equals the number of employees. Real capital (K) is tangible fixed assets deflated by the average of the following industry deflators: machinery and equipment (NACE 2-digit 29), office machinery and computing (30), electrical machinery and apparatus (31), motor vehicles, trailers and semi-trailers (34) and other transport equipment (35). Real material inputs (M) are obtained by deflating material inputs with a weighted intermediate input deflator, where weights are based on the IO-tables. IO-tables in a Romanian industry code classification (approximately NACE 3-digit) were obtained from the RSO. Since we have a time-series of input-output tables, the technical coefficients are time-varying.

Some summary statistics of the data are provided in Tables 1 and 2. Table 1 lists the annual number of firms and the entry and exit rate of all firms and of the sub-sample of foreign firms. The percentage of foreign-owned firms operating on the Romanian market in our sample increased from 16% in 1996 to 22% in 2005. The 2003 exit rate is high, but this pattern is confirmed by the pattern in the Romanian Trade Register (Trade Register data also include agriculture and services though). Table 2 lists summary statistics both for domestic and foreign firms. The stylized facts commonly found in the literature are confirmed in our data set. Foreign firms are larger in terms of employment and capital, produce more output and are more productive. The latter holds across different estimation techniques.

[6] Other recent efforts include TFP estimation based on firm-level quantity data (TFPQ) rather than deflated revenue data (TFPR). Unfortunately, we have no data on quantities. Results should therefore be interpreted with

Table 1: Overview of the number of firms, entry, exit and the penetration of foreign firms in the sample by year.

	All firms			Of which foreign firms			
	#firms	entry	exit	#firms	entry	exit	penetration
1996	14390			2240			0.16
1997	15610	1054	91	2608	312	32	0.17
1998	16759	995	190	2997	327	59	0.18
1999	18040	1197	761	3451	370	169	0.19
2000	19464	1845	301	3926	472	72	0.20
2001	20891	1374	506	4443	445	118	0.21
2002	21896	1224	988	4778	332	305	0.22
2003	22561	1335	2444	4881	297	490	0.21
2004	21508	1065	562	4817	313	168	0.22
2005	20946			4651			0.22

Table 2: Summary statistics of firm-level variables for the period 1996-2005 (all variables in logs).

	All firms		Domestic firms		Foreign firms	
	mean	sd	mean	sd	mean	sd
real output	13.63	2.08	13.46	2.02	14.32	2.15
employment	2.93	1.48	2.80	1.42	3.46	1.61
real capital	12.06	2.42	11.83	2.37	12.98	2.40
real materials	12.91	2.34	12.80	2.27	13.33	2.57
tfp OP	1.97	0.94	1.94	0.92	2.09	1.02
tfp LPva	7.00	1.85	6.49	1.87	7.22	1.75
tfp ACFva	5.74	1.52	5.69	1.52	5.95	1.47
tfp DPD	2.13	1.38	2.09	1.37	2.28	1.41
tfp FE	1.90	0.99	1.85	0.94	2.10	1.16
tfp TL	6.12	2.26	6.08	2.25	6.30	2.11

4 Results and Discussion

This section presents results of the estimation of specification (7) using different definitions of horizontal and vertical spillovers. In all tables, second step OLS estimates are shown for a panel of domestic Romanian manufacturing firms with on average more than five employees over the 1996-2005 period. Following (7), we relate first-differenced firm-level *TFP* to a set of FDI spillovers (horizontal, backward and forward), a set of control variables and a set of dummy variables. The dependent variable, *TFP*, is based on first-step production function estimates by NACE 2-digit industries. Column headings indicate alternative estimation methodologies and functional forms of the production function. We show results for TFP measures based on Cobb Douglas specifications applying the OP, LP, ACF, DPD and fixed effects (FE) estimators in columns 1-5. In column 6, the *TFP* measure is obtained from a translog specification (TL) estimated by OLS. The LP and ACF estimations are value-added based, the other estimations are output based. All

this caveat in mind.

[7]If the 'outlier' is the first or last observation for a specific firm and other data points are normal, the other firm-year data are kept. If not, all observations for this firm are dropped from the data set.

[8]A single issue of the database is a snapshot in terms of the ownership information and firms that exit are dropped from the next issue of the database.

Table 3: FDI spillovers from all firms on Romanian manufacturing firms with at least five employees in 1996-2005. The vertical spillovers are calculated using the zero-diagonal definition.

	(1)	(2)	(3)	(4)	(5)	(6)
	OP	LPva	ACFva	DPD	FE	TL
	Aggregated - NACE 2-digit					
horizontal	0.546**	1.785**	1.801**	0.516**	0.524**	0.552**
	[0.245]	[0.733]	[0.728]	[0.245]	[0.242]	[0.248]
backward	1.178*	1.991	2.102	1.133*	1.166*	1.050
	[0.696]	[1.692]	[1.674]	[0.679]	[0.689]	[0.691]
forward	-1.411*	-3.404	-3.372	-1.362*	-1.404*	-1.344*
	[0.790]	[2.129]	[2.117]	[0.786]	[0.782]	[0.791]
n	96,681	78,710	73,255	96,728	96,728	96,728
R^2	0.067	0.081	0.082	0.063	0.062	0.072
	Detailed - Romanian NACE 3-digit equivalent					
horizontal	0.352**	1.162**	1.175***	0.334**	0.335**	0.354**
	[0.167]	[0.452]	[0.448]	[0.168]	[0.168]	[0.167]
backward	1.010***	2.063**	2.072**	1.027***	1.006***	0.982***
	[0.318]	[0.946]	[0.931]	[0.314]	[0.314]	[0.315]
forward	-0.756	-1.475	-1.440	-0.731	-0.765	-0.730
	[0.565]	[1.526]	[1.518]	[0.565]	[0.564]	[0.564]
n	96,681	78,710	73,255	96,728	96,728	96,728
R^2	0.066	0.077	0.078	0.063	0.062	0.072

Second step OLS estimates for domestic manufacturing firms with at least five employees for the years 1996-2005. The vertical spillovers are calculated using the zero-diagonal definition. Regressions include time, industry and region dummies; control variables included are downstream demand, industry competition, firm age, firm size, import competition, export intensity and the share of intermediate supply in total industry output. Standard errors in brackets are clustered at the industry-year level. ***/**/* denotes significance at 1/5/10 percent.

regressions include time, region and industry dummies. Further control variables included are firm age, firm size, a downstream demand index, a Herfindahl index of industry competition, import competition, export intensity and the share of intermediate supply in total industry output. These industry-level controls are defined according to the industry-level in the IO-tables used to calculate spillover variables. For the sake of clarity and in order to keep the tables manageable, we do not present results for the control variables and dummies.

Table 3 presents results using 'standard' spillovers definitions (1) to (3). The upper panel of the table contains results for spillovers calculated at the aggregated industry-level (NACE 2-digit), the lower panel for spillovers calculated at the detailed industry-level (Romanian classification mapping into NACE 3-digit).

At the aggregated level, in the upper panel of Table 3, we observe significant and important positive horizontal spillovers and significant negative forward spillovers. There is also limited

Table 4: FDI spillovers from all firms on Romanian manufacturing firms with at least five employees in 1996-2005. The vertical spillovers are calculated using the non-zero-diagonal definition.

	(1) OP	(2) LPva	(3) ACFva	(4) DPD	(5) FE	(6) TL
	Aggregated - NACE 2-digit					
horizontal	0.677*	1.905*	1.881*	0.600	0.628	0.653*
	[0.398]	[1.000]	[0.994]	[0.392]	[0.394]	[0.393]
backward	0.882	2.029	2.116	0.916	0.914	0.852
	[0.665]	[1.926]	[1.917]	[0.656]	[0.669]	[0.664]
forward	-1.276*	-2.352	-2.310	-1.177*	-1.233*	-1.162*
	[0.695]	[1.844]	[1.848]	[0.690]	[0.683]	[0.695]
n	96,681	78,710	73,255	96,728	96,728	96,728
R^2	0.066	0.080	0.081	0.062	0.062	0.072
	Detailed - Romanian NACE 3-digit equivalent					
horizontal	0.226	0.628	0.633	0.200	0.205	0.212
	[0.184]	[0.491]	[0.486]	[0.184]	[0.184]	[0.181]
backward	0.913***	2.399**	2.416**	0.935***	0.928***	0.924***
	[0.316]	[0.993]	[0.987]	[0.314]	[0.318]	[0.314]
forward	-0.583	-0.580	-0.549	-0.570	-0.583	-0.533
	[0.422]	[1.175]	[1.173]	[0.420]	[0.417]	[0.420]
n	96,681	78,710	73,255	96,728	96,728	96,728
R^2	0.066	0.078	0.078	0.062	0.061	0.072

Second step OLS estimates for domestic manufacturing firms with at least five employees for the years 1996-2005. The vertical spillovers are calculated using the non-zero-diagonal definition. Regressions include time, industry and region dummies; control variables included are downstream demand, industry competition, firm age, firm size, import competition, export intensity and the share of intermediate supply in total industry output. Standard errors in brackets are clustered at the industry-year level. ***/**/* denotes significance at 1/5/10 percent.

evidence of significant positive backward spillover effects. From the table it is obvious that results are not driven by a specific methodology to obtain *TFP*. The lower panel presents results for spillover variables based on the detailed input-output tables. Switching to this more detailed industry classification has considerable implications. Forward spillovers are still negative, but no longer statistically significant. The horizontal effects remain positive and significant, but point estimates decrease by about 40%. The most important impact of switching from aggregated to detailed IO-tables is on the backward spillovers. Point estimates are somewhat smaller, but the effects are now highly significant (at the 1 percent level). Estimation results therefore clearly vary with industry aggregation in the IO-tables and results seem to suggest that the use of too aggregated IO-tables tends to increase the impact of horizontal spillovers at the detriment of backward spillovers. This is likely to be driven by our observation in section 2 that a detailed IO-table allows for finer sourcing and supplying patterns. In the lower panel of Table 3, more linkages are considered as vertical than in the upper part with spillovers based on the aggregated IO-table.

Backward spillovers have received widespread attention because of the expectation that supplier-client relationships are more inclined to result in positive spillover effects than competitive relationships (horizontal spillovers). Clearly, if one defines backward spillovers as effects that originate from supplier-customer relationships, it is sensible not to exclude the diagonal elements from the backward calculation because these elements do refer to intermediate supply and use of goods. Table 4 presents results for vertical spillover variables that do include within-industry supply and use (non-zero-diagonal definition). The table is again split in an upper and lower panel, referring to results based on aggregated and detailed IO-tables respectively. Comparing the results in the upper panel with those in the upper panel of Table 3 reveals only a limited impact of using the non-zero-diagonal definition instead of the standard zero-diagonal definition. The horizontal spillover coefficients are still significant, but only at the 10 percent level in contrast to the 5 percent level as in Table 3. Results on the forward spillover are comparable to those in Table 3. Point estimates for both types of spillovers tend to decrease in absolute value. Surprisingly and contrary to what one might expect, backward spillovers no longer affect total factor productivity. Although including within-industry supply into the definition enlarges the 'scope' for backward spillovers, point estimates are no longer statistically significant. This suggests that including within-industry supply does not help to resolve the differences between the upper and lower panels in Table 3. Interestingly, the lower panel of Table 4 shows important implications of including within-industry supply (and use) when spillovers are computed using our detailed IO-tables. The horizontal effect now disappears completely. Contrary to results in the upper part of Table 4 and both the upper and lower parts of Table 3 (zero-diagonal definition), we do not detect any horizontal spillovers. Coefficients are still positive but become insignificant and point estimates have fallen by about 70% compared to the aggregated results. Additionally, as in Table 3 we find positive and highly significant backward spillovers (at the 1 percent level). Therefore, also when applying non-zero-diagonal definitions to the vertical spillovers, significant and positive backward spillovers are only detected when detailed IO-tables are used.

Figures 5 and 5 illustrate the contribution to firm-level OP *TFP* of the mean horizontal and backward spillover variables for NACE 2-digit industries 15 (food) and 24 (chemicals and chemical products) and their 3-digit sub-industries. The numbers in these figures are obtained as the average of the level of the horizontal and backward spillover variables multiplied by the estimated coefficients taken from the upper panel of Table 3 for the aggregated results (NACE 2-digit, left bar) and the lower panel of Table 4 for the detailed results (NACE 3-digit, bars on the right). Both figures clearly show that the use of aggregated IO-tables implies a horizontal spillover that is considerably larger than the horizontal spillover found for any of the sub-industries using the detailed IO-tables. We obtain the opposite result for the backward spillovers in industry 15, i.e. the contribution to firm-level OP *TFP* is larger when using the detailed rather than the aggregated IO-tables. As the share of the diagonal elements in total intermediate supply is much larger for industry 15 than 24, size-differences of backward spillover effects in industry 24 between aggregated and detailed IO-tables are less univocal. Overall, the total spillover effect (horizontal-backward-forward combined) is about 15% larger (OP *TFP*) when using detailed IO-tables. If we only take into account significant spillover variables, the difference augments to 73%.

Table 5 presents results where final use has been taken into account in the calculation of the technical coefficients. The upper and lower panel in Table 5 show the results for the zero-diagonal-aggregated and the non-zero-diagonal-detailed approach respectively. Results in the upper panel are qualitatively comparable to those in the upper panel of Table 3 in the sense that positive horizontal spillovers are clearly present whereas vertical spillovers are absent. The lower panel confirms our earlier result that horizontal spillovers tend to disappear and backward spillovers become statistically significant, though the evidence is somewhat less clear. In terms of the size of the coefficients we observe similar changes as before when going from upper to lower panel.

In a recent contribution, Barrios *et al.* (2011) suggest to use the IO-tables from the MNEs' home countries to measure backward spillover variables because the new incoming technology will

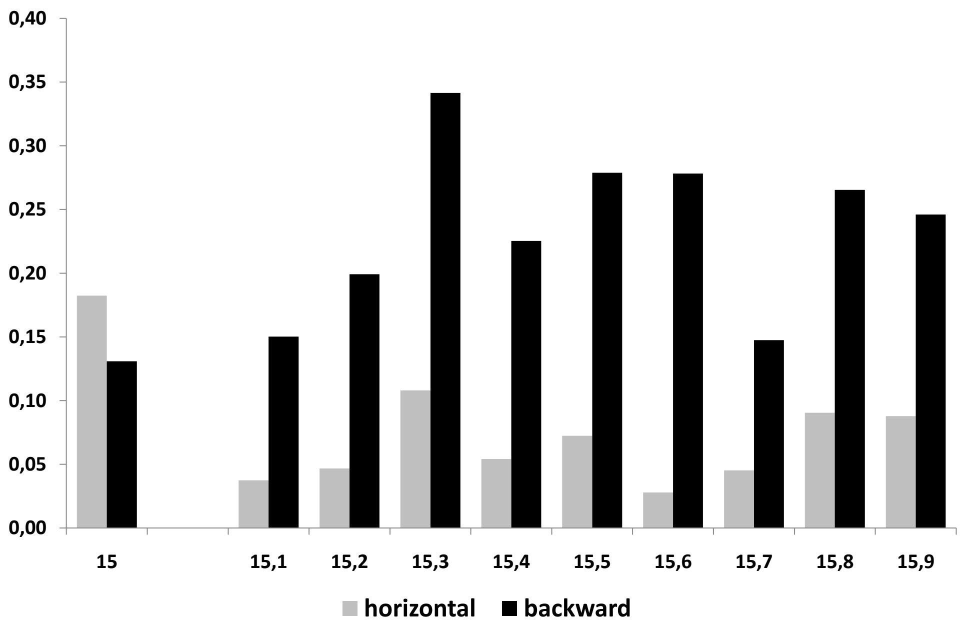

Figure 5: Contribution of 1996-2005 mean horizontal and backward spillovers to OP *TFP* of domestic firms for NACE 2-digit industry 15 "Manufacturing of food products and beverages" (based on the OP specification in Table 3) and its 3-digit sub-industries (based on the OP specification in Table 4).

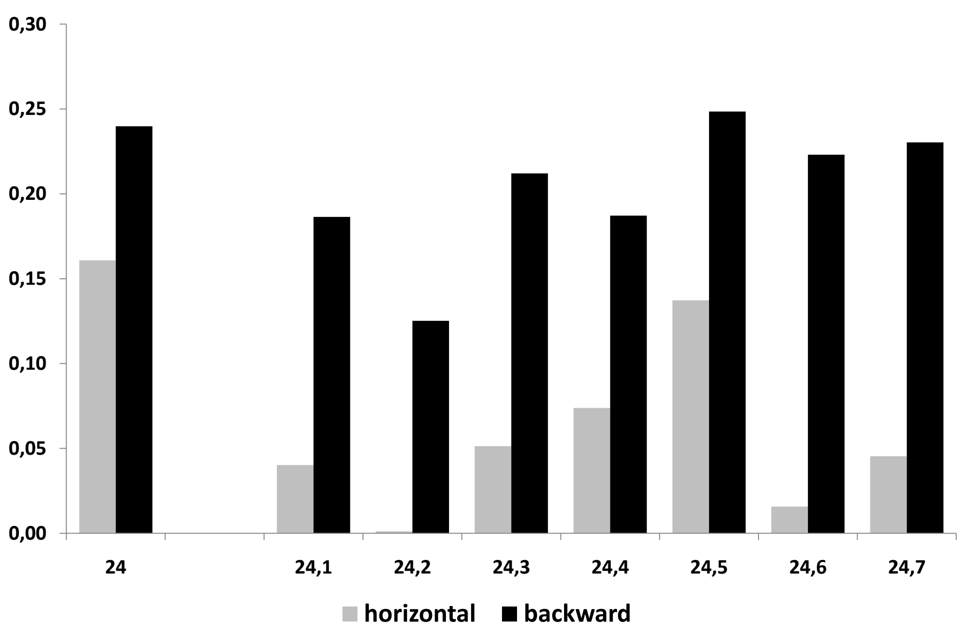

Figure 6: Contribution of 1996-2005 mean horizontal and backward spillovers to OP *TFP* of domestic firms for NACE 2-digit industry 24 "Manufacture of chemicals and chemical products" (based on the OP specification in Table 3) and its 3-digit sub-industries (based on the OP specification in Table 4).

Table 5: FDI spillovers from all firms on Romanian manufacturing firms with at least five employees in 1996-2005. The vertical spillovers are calculated using the zero-diagonal definition at the aggregated level and the non-zero-diagonal definition at the detailed level. Final uses are taken into account.

	(1)	(2)	(3)	(4)	(5)	(6)
	OP	LPva	ACFva	DPD	FE	TL
	Aggregated - NACE 2-digit					
horizontal	0.527**	1.762**	1.776**	0.499**	0.505**	0.535**
	[0.242]	[0.722]	[0.717]	[0.241]	[0.239]	[0.244]
backward final	0.303	-0.260	-0.140	0.238	0.291	0.182
	[1.385]	[3.196]	[3.183]	[1.341]	[1.372]	[1.362]
forward	-1.161	-2.867	-2.830	-1.115	-1.155	-1.111
	[0.796]	[2.152]	[2.141]	[0.793]	[0.789]	[0.795]
n	96,681	78,710	73,255	96,728	96,728	96,728
R^2	0.065	0.080	0.081	0.061	0.061	0.071
	Detailed - Romanian NACE 3-digit equivalent					
horizontal	0.330*	0.972*	0.977*	0.307	0.313	0.318*
	[0.194]	[0.521]	[0.516]	[0.194]	[0.193]	[0.191]
backward final	1.430**	2.715	2.707	1.446**	1.430**	1.427**
	[0.620]	[1.780]	[1.764]	[0.606]	[0.613]	[0.610]
forward	-0.589	-0.508	-0.470	-0.570	-0.584	-0.534
	[0.419]	[1.180]	[1.178]	[0.418]	[0.414]	[0.416]
n	96,681	78,710	73,255	96,728	96,728	96,728
R^2	0.064	0.074	0.075	0.060	0.059	0.069

Second step OLS estimates for domestic manufacturing firms with at least five employees for the years 1996-2005. The vertical spillovers are calculated using the zero-diagonal definition at the aggregated level and the non-zero-diagonal definition at the detailed level. Technical coefficients are calculated taking final use into account. Regressions include time, industry and region dummies; control variables included are downstream demand, industry competition, firm age, firm size, import competition, export intensity and the share of intermediate supply in total industry output. Standard errors in brackets are clustered at the industry-year level. ***/**/* denotes significance at 1/5/10 percent.

resemble the technology of the home country rather than that of the host country. Although we are unable to perfectly address this suggestion with our data, we try to accommodate this view by using the technical coefficients of the 2005 IO-table for the calculation of the spillover variables throughout the sample period. By 2005 the foreign involvement in most of the industries in Romania was considerable (on average just below 40%) and a considerable number of foreign firms had been present for a longer period in the Romanian economy. Therefore the industrial structure found in the 2005 IO-table is likely to be a good reflection of MNEs' production technologies (see also Merlevede *et al.*, 2011). The upper and lower panel in Table 6 again show the results for the zero-diagonal-aggregated and the non-zero-diagonal-detailed approach respectively. The results confirm our main findings: (i) (only) positive and statistically significant horizontal effects are

Table 6: FDI spillovers from all firms on Romanian manufacturing firms with at least five employees in 1996-2005. The vertical spillovers are calculated using the zero-diagonal definition at the aggregated level and the non-zero-diagonal definition at the detailed level. Only the 2005 IO-table is used.

	(1)	(2)	(3)	(4)	(5)	(6)
	OP	LPva	ACFva	DPD	FE	TL
	Aggregated - NACE 2-digit					
horizontal	0.481**	1.685**	1.697**	0.452*	0.458*	0.488**
	[0.240]	[0.734]	[0.730]	[0.240]	[0.238]	[0.242]
backward	1.374	1.921	2.105	1.232	1.369	1.358
	[0.864]	[2.282]	[2.283]	[0.861]	[0.864]	[0.862]
forward	-0.104	-0.757	-0.770	-0.002	-0.081	-0.075
	[0.818]	[2.220]	[2.226]	[0.807]	[0.810]	[0.812]
n	96,681	78,710	73,255	96,728	96,728	96,728
R^2	0.064	0.078	0.079	0.060	0.060	0.070
	Detailed - Romanian NACE 3-digit equivalent					
horizontal	-0.033	-0.017	-0.003	-0.058	-0.054	-0.043
	[0.206]	[0.533]	[0.529]	[0.204]	[0.205]	[0.201]
backward	0.764*	2.725**	2.852**	0.732*	0.766*	0.826*
	[0.445]	[1.147]	[1.157]	[0.438]	[0.441]	[0.438]
forward	0.512	1.516	1.413	0.574	0.529	0.498
	[0.530]	[1.447]	[1.434]	[0.523]	[0.524]	[0.523]
n	96,681	78,710	73,255	96,728	96,728	96,728
R^2	0.064	0.078	0.079	0.060	0.059	0.070

Second step OLS estimates for domestic manufacturing firms with at least five employees for the years 1996-2005. The vertical spillovers are calculated using the zero-diagonal definition at the aggregated level and the non-zero-diagonal definition at the detailed level. Input-output coefficients are taken from the 2005 IO-table only. Regressions include time, industry and region dummies; control variables included are downstream demand, industry competition, firm age, firm size, import competition, export intensity and the share of intermediate supply in total industry output. Standard errors in brackets are clustered at the industry-year level. ***/**/* denotes significance at 1/5/10 percent.

found when aggregated IO-tables are used, (ii) (only) positive and significant backward effects are found when detailed IO-tables are used, and therefore the industry classification affects which spillover effects can be captured and which cannot.

As detailed input-output tables are often unavailable, we conduct one further experiment by applying aggregated technical coefficients to detailed horizontal variables (firms typically have a detailed industry classification) to calculate backward and forward spillovers (cf. (2) and (3)). Specifically, we calculate the *Horizontal*-variable at the NACE 3-digit level and apply the same NACE 2-digit technical coefficients to each 3-digit *Horizontal* belonging to this 2-digit industry to obtain backward and forward spillover variables. The results are presented in Table 7. For

Table 7: FDI spillovers from all firms on Romanian manufacturing firms with at least five employees in 1996-2005. The vertical spillovers are calculated using aggregated IO-tables but detailed horizontal spillover variables (for both the zero- and non-zero-diagonal definition).

	(1)		(2)		(3)		(4)		(5)		(6)	
	OP		LPva		ACFva		DPD		FE		TL	
	zero	non-zero	zero	non-zero	zero	non-zero	zero	non-zero	zero	non-zero	zero	non-zero
horizontal	0.345**	0.312*	1.140**	0.992**	1.157**	1.014**	0.329*	0.286	0.329*	0.298*	0.346**	0.307*
	[0.169]	[0.179]	[0.461]	[0.501]	[0.458]	[0.498]	[0.170]	[0.178]	[0.170]	[0.179]	[0.169]	[0.177]
backward	-0.001	0.011	-0.525	-0.302	-0.459	-0.295	0.002	0.031	0.009	0.017	-0.038	0.019
	[0.251]	[0.136]	[0.666]	[0.371]	[0.664]	[0.369]	[0.252]	[0.135]	[0.255]	[0.136]	[0.250]	[0.134]
forward	-0.120	0.031	-0.278	0.571	-0.282	0.549	-0.132	0.021	-0.128	0.022	-0.141	0.032
	[0.236]	[0.171]	[0.600]	[0.417]	[0.595]	[0.414]	[0.239]	[0.172]	[0.239]	[0.172]	[0.239]	[0.170]
n	96,681	96,681	78,710	78,710	73,255	73,255	96,728	96,728	96,728	96,728	96,728	96,728
R^2	0.062	0.062	0.074	0.075	0.075	0.076	0.058	0.058	0.057	0.057	0.067	0.067

Second step OLS estimates for domestic manufacturing firms with at least five employees for the years 1996-2005. The vertical spillovers are calculated using both the zero-diagonal definition and the non-zero-diagonal definition. Aggregated input-output coefficients are combined with detailed data. Regressions include time, industry and region dummies; control variables included are downstream demand, industry competition, firm age, firm size, import competition, export intensity and the share of intermediate supply in total industry output. Standard errors in brackets are clustered at the industry-year level. ***/**/* denotes significance at 1/5/10 percent.

each *TFP* measure we show results for a zero- and non-zero-diagonal definition. In none of the cases, statistically significant vertical spillover effects are obtained. In contrast, there is evidence of significant and positive horizontal spillovers. As a result, simply applying aggregated technical coefficients to the detailed horizontal variables does not allow to detect significant vertical spillover effects.

The above results suggest that one is likely to underestimate the total spillover effect when using aggregated IO-tables to calculate vertical spillover variables for our sample of Romanian firms. The total effect -regardless statistical significance- is smaller when using aggregated IO-tables to calculate vertical spillover effects. Taking into account statistically significant variables only, the total effect becomes considerably larger using the detailed IO-tables. This seems to be due to the fact that at the aggregated level part of the backward effect is captured by the horizontal spillover variable leading to (nearly) insignificant backward spillovers. These findings are not affected by applying a non-zero-diagonal definition to the calculation of spillover variables; on the contrary differences between detailed and aggregated levels are even widening. The idea of using a non-zero-diagonal definition is driven by our understanding of the literature that expects supplier-client relationships to be more inclined to result in positive spillover effects than competitive relationships. Comparing results for zero- and non-zero definitions using detailed IO-tables, we do observe that the horizontal spillover becomes insignificant using the non-zero definition. Therefore the use of sufficiently detailed input-output tables seems essential in the analysis of FDI spillover effects.

Clearly, these results raise the question whether linkages between companies should not be identified at an even more detailed level. At the limit, it would be informative to gain a better insight into linkages between firms at the firm-level. Unfortunately, firm-level data on these linkages is rarely available, especially for large firm-level panels[9]. Firm-level linkages are also suspect to considerable endogeneity issues since MNEs are likely to select the best local firms as their partners. In search for appropriate instruments, linkages derived from IO-tables would be a natural candidate since it is more difficult to switch industries when choosing suppliers.

5 Conclusions

Although there is an extensive empirical literature discussing the spillover effects of foreign direct investment, estimation results are mixed. The channels for spillover effects are intuitively linked to the supply chain. These channels are operationalized in empirical work through the use of input-output tables that convey technical relationships between industries. This paper contributes to the literature by exploring the relationship between the industry classification in the input-output tables and the spillover effects that can be found. As the methodology to calculate spillover variables draws heavily on input-output tables, it is the level of industry aggregation in these tables that determines the categorization of spillovers into horizontal (same stage in the supply chain) and vertical (different stages in the supply chain) effects. We show that calculating spillovers from fairly aggregated input-output tables causes linkages between foreign and domestic firms to be classified as horizontal rather than vertical. Therefore these firms are implicitly considered to be in a competitive rather than in a supplier-customer relationship. The industry classification in the input-output tables thus seems an important factor to take into account. We further present an alternative approach to calculate vertical spillovers that is more tightly linked to the supply chain interpretation of linkages between firms. This approach consists of including within-industry intermediate supply and use in the calculation of vertical spillover variables. The standard approach excludes within-industry intermediate supply and use because they are captured by horizontal spillover variables.

[9] Vacek (2010) studies firm-level FDI spillovers through backward and forward linkages using a smaller panel of Czech manufacturing firms for which data were collected from a survey. He finds positive and significant backward spillovers at the firm-level, as opposed to spillovers at the industry-level (NACE 2-digit) where no effects were found. These findings are in line with the empirical results presented in this paper.

Our results are based on both aggregated and detailed input-output tables for a panel of Romanian manufacturing firms. We show that evidence of positive and statistically significant backward spillovers is much stronger for detailed than for aggregated input-output tables. The impact of horizontal spillovers is found to be much larger and positive for aggregated input-output tables. These results hold for both the standard methodology to calculate spillover variables and an alternative approach that consists of including within-industry intermediate supply and use. Surprisingly, the latter seems to have the biggest impact for the results based on the detailed input-output tables, where horizontal spillovers disappear after including within-industry intermediate supply and use. Calculating vertical spillover variables by combining aggregated technical coefficients with detailed horizontal spillover variables does not appear to affect our results. We conclude that it is preferable to use sufficiently detailed input-output tables in the analysis of FDI spillover effects. If these are unavailable, researchers using more aggregated tables should be aware that this may result in an upward bias of horizontal effects and a bias against finding significant backward spillover effects.

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A Appendix

IO-code	Description	NACE rev. 1.1		#firms
		3-digit	2-digit	2005
18	Meat production and processing	15.1	15	603
19	Processing and preserving of fish and fish products	15.2	15	25
20	Processing and preserving of fruits and vegetables	15.3	15	123
21	Production of vegetal and animal oil and fat	15.4	15	68
22	Production of milk products	15.5	15	335
23	Production of milling products, starch and starch products	15.6	15	458
24	Manufacture of fodder	15.7	15	58
25	Processing of other food products	15.8	15	2675
26	Beverages	15.9	15	367
27	Tobacco products	16	16	17
28	Textile industry	17	17	1024
29	Textile clothing	18.2	18	2636
30	Manufacture of leather and fur clothes	18.1+18.3	18	35
31	Footwear and other leather goods	19	19	1082
32	Wood processing (excluding furniture)	20	20	1989
33	Pulp, paper and cardboard; related items	21.1+21.2	21	282
34	Publishing, printing and reproduction of recorded media	22	22	1016
35	Coking	23.1	23	1
36	Crude oil processing	23.2	23	27
37	Processing of nuclear combustibles	23.3	23	-
38	Basic chemical products	24.1	24	154
39	Pesticide and other agrochemical products	24.2	24	9
40	Dyes and varnishes	24.3	24	105
41	Medicines and pharmaceutical products	24.4	24	92
42	Soaps, detergents, up-keeping products, cosmetics, perfumery	24.5	24	88
43	Other chemical products	24.6	24	62
44	Synthetic and man-made fibres	24.7	24	7
45	Rubber processing	25.1	25	117
46	Plastic processing	25.2	25	742
47	Glass and glassware	26.1	26	212
48	Processing and refractory ceramics (excluding building items)	26.2	26	104
49	Ceramic boards and flags	26.3	26	14
50	Brick, tile and other building material processing	26.4	26	79
51	Cement, lime and plaster	26.5	26	16
52	Processing of concrete, cement and lime items	26.6	26	254
53	Cutting, shaping and finishing of stone	26.7	26	94
54	Other non-metallic mineral products	26.8	26	42
55	Metallurgy and ferroalloys processing	27.1	27	26
56	Manufacture of basic precious and non-ferrous metals	27.2	27	19
57	Other metallurgy products	27.3	27	18
58	Precious metals and other non-ferrous metals	27.4	27	35
59	Foundry	27.5	27	122
60	Metal structures and products	28	28	2101
61	Manufacture of eq. for producing/using of mechanical power	29.1	29	108
62	Machinery for general use	29.2	29	172
63	Agricultural and forestry machine	29.3	29	50
64	Machine tools	29.4	29	96
65	Other machines for special use	29.5	29	175

Table continued on the next page

IO-code	Description	NACE rev. 1.1		#firms
		3-digit	2-digit	2005
66	Armament and ammunition	29.6	29	-
67	Labour-saving devices and domestic machinery	29.7	29	39
68	Computers and office means	30	30	132
69	Electric machinery and appliances	31	31	348
70	Radio, TV-sets and communication eq. and apparatus	32	32	84
71	Medical, precision, optical, watch-making apparatus	33	33	231
72	Means of road transport	34	34	209
73	Naval engineering and repair	35.1	35	198
74	Production/repair of railway transport means and rolling eq.	35.2	35	50
75	Aircraft engineering and repair	35.3	35	13
76	Motorcycles, bicycles and other transport means	35.4	35	7
77	Furniture	36.1	36	1438
78	Other industrial activities	36.2-36.6	36	280

Table 8: Conversion table used for mapping the Romanian industry classification into NACE 3-digit and 2-digit coding. This table was provided by the Romanian Statistical Office.