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RESEARCH ARTICLE

Multinationals and domestic firms in France: who gains from knowledge spillovers?

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Abstract This paper aims to evaluate the direction, nature, and magnitude of spillovers between foreign-owned firms and French firms from firm-level panel data. We estimate production functions at the firm level using the recent structural techniques suggested in Ackerberg et al. (2006). From our results, three main conclusions can be drawn. First, spillovers are at work in all research-intensive sectors, although they have very weak effects in the less knowledge-based sectors. Second, foreign-owned firms belonging to high- and medium-technology manufacturing industries that are set up in France benefit from horizontal spillovers, suggesting a technology sourcing activity of foreign multinationals. Third, inward foreign investment increases the total factor productivity of French firms supplying inputs to multinationals (backward spillovers) only in high- and medium-technology manufacturing industries and after 4 years.

Keywords Productivity · FDI and reverse spillovers · Multinationals · Domestic firms · Panel data

JEL Classification F2 · O1

Introduction

An important issue for national governments is whether incentives to attract multinational firms are justified. One often-stated argument is that inward foreign direct investment (FDI) raises the performance of domestic firms by transferring new knowledge (named *FDI spillovers*) into the host country. However, a lot of empirical studies concern developing countries, emerging countries, or new members of the European Union (Aitken and Harrison1999; Görg and Greenaway 2004; Blalock and Gertler 2008). Because such countries have domestic firms exhibiting low levels of productivity, it is expected that the presence of a multinational in a low-productivity country raises the performance of local firms, especially the local input suppliers (Javorcik 2004; Javorcik and Spatareanu 2008; Blalock and Gertler 2008).

Whether FDI boosts indigenous firms' productivity is a relevant argument for FDI promotion in developing countries, but it may be difficult to extend this argument to developed countries. Indeed, the technology wedge between domestic and foreign competitors is lower. However, when the technology gap is reduced between countries, local firms have a higher absorptive capacity and consequently may benefit from international spillovers, as indicated in the meta-analyses of Havránek and Iršová (2011, 2012) and in the meta-analysis of Iršová and Havránek (2013). A way to solve this puzzle is to consider a nonlinear relationship between economic development and international spillovers. For instance, Meyer and Sinani (2009) find a U-shaped relationship. When the technology gap is important between countries, local firms can benefit from the international spillovers if they do not compete directly with foreign-owned firms. Beyond a certain threshold, the absorptive capacity is large enough for local firms to be able to benefit from international spillovers.

Furthermore, a multinational firm can invest in a foreign country to access the technology generated by host country firms (*technology sourcing*). This access is possible because of positive spillovers associated with geographic proximity to a technology leader in the foreign country. As shown by

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Fosfuri and Motta (1999) and Sanna-Randaccio and Veugelers (2007), multinationals can use FDI to source locally available external know-how, even though this investment involves (fixed) setup costs and the trade costs are zero.[1] In other words, foreign-owned firms can also benefit from spillovers. Thus, technology sourcing is an important issue because it may challenge the economic justifications for policies aimed at attracting inward FDI.

Developed countries are still the top destinations for overall FDI and the most important sources of FDI. In other words, both types of spillovers (FDI spillovers and technology sourcing) can emerge in developed countries. Despite its relevance, little attention has been devoted to both directions of spillovers between multinationals and local firms in those countries. In this paper, we assess the direction, nature, and magnitude of spillovers between foreign-owned firms and domestic firms.

The literature investigating the existence of spillovers from FDI to domestic firms has identified different types of spillovers. This literature distinguishes horizontal spillovers, the transfer of knowledge arising inside the same industry, from vertical spillovers, transfers from input suppliers or from purchasers (Blomström and Kokko 1998). Recent empirical studies on transition or new industrialized countries have revealed the presence of productivity vertical spillovers. The knowledge transfer seems to occur mainly through backward or forward linkages between foreign-owned firms and domestic firms (Konings 2001; Javorcik 2004; Javorcik and Spatareanu 2008; Blalock and Gertler 2008). The econometric studies from developed countries' data provide mixed results on vertical and horizontal spillovers. For example, Haskel et al. (2007) find a positive vertical backward spillover effect of inward FDI on the productivity of local plants from a panel of UK manufacturing plants, while Keller and Yeaple (2005) obtain only a positive horizontal effect for US manufacturing firms.

Other research related to technology sourcing studies spillovers from domestic firms to multinationals, hereafter called reverse spillovers. Kogut and Chang (1991) find evidence that the number of entries by Japanese firms (*via* joint ventures) into the US markets may be motivated by sourcing US technological advantage during the period 1976–1987. In the same vein, Co (2000) finds that inflows of acquisition or joint-venture FDI affect the R&D intensity of US industry over the period 1981–1991, which indicates the presence of technology sourcing. In these two studies, the technology sourcing is assumed to be managed inside the multinationals through the relationships between affiliates and parent firms. Driffield and Love (2003) estimate the effect of the capital investment of domestic firms (proxy for reverse spillovers) on the total factor productivity (TFP) in foreign-owned UK industries over the period 1984–1992. They show that reverse spillovers are only present in UK research-intensive industries. Multinationals can also appropriate, to a large extent, technology sourcing and spillovers from other foreign investors present in UK industries (Driffield and Love 2005).[2] However, those papers focus only on horizontal reverse spillovers and do not consider vertical reverse spillovers. Similarly to FDI spillovers, this distinction is important because it allows a better understanding of the different channels driving reverse spillovers. Moreover, most of these studies use industry data rather than firm-level panel data.

To evaluate the effects of the different forms of spillovers between host (multinational) and domestic enterprises, we use a large panel of firms that were present in the different French economic sectors over the period 1990–2003. Note that France ranks third in the world for FDI inflows behind the UK and the USA and ahead of Germany (UNCTAD 2008). Using panel data allows us to control for unobserved heterogeneity and thus to avoid overstating the spillover effects (Görg and Strobl 2001).

To determine the effects of spillovers, we must first evaluate the TFP of every firm located in France. To reach this goal, we first estimate the production function by addressing a major econometric issue surrounding the existence of factors observed by managers but unobserved by the econometricians. Thus, we use the structural techniques recently suggested in Ackerberg et al. (2006). Next, we evaluate the impact of spillovers on TFP. Following Javorcik (2004), we make a distinction between horizontal and vertical spillovers. In horizontal spillovers, the knowledge transfer is viewed as a transfer between firms belonging to the same industry, whereas vertical spillovers create positive externalities by increasing the TFP through backward or forward linkages between suppliers and customers of the intermediate product. As in Javorcik (2004), we use this distinction to test for the presence of FDI spillovers, but we extend the analysis by considering reverse spillovers.

Our results reveal knowledge interactions through spillovers between foreign-owned firms and French companies. These results are in line with the absorptive capacity argument, where domestic and foreign firms benefit from international and reverse spillovers, respectively. Moreover, spillovers arise exclusively in research-intensive sectors. Hence, a potential technology wedge must exist for spillovers to occur. However, international and reverse spillovers do not apply uniformly across sectors. There are benefits from horizontal reverse spillovers for affiliates set up in France in the high- and medium-technology manufacturing industries and in knowledge-intensive services. These results support the view

[1] This new argument also questions the widespread explanation that firms embarking on FDI must possess some specific advantages to offset the additional cost of operating in a foreign environment.

[2] From a different perspective, van Pottelsberghe de la Potterie and Lichtenberg (Van Pottelsberg de la Potterie and Lichtenberg 2001) find positive R&D spillover effects via outward FDI on the total factor productivity of the origin countries. They conclude that the outward FDI flows of 13 industrialized countries are predominantly motivated by technology sourcing.

that multinationals source technology from French firms in research-intensive sectors. On the other hand, attracting foreign firms to France can boost the productivity of French input suppliers in the high- and medium-technology manufacturing industries (backward FDI spillovers) and improve French companies' performances via horizontal FDI spillovers in knowledge-intensive services. As for reverse spillovers, FDI spillovers are very weak in the less knowledge-intensive sectors, whatever their horizontal or vertical nature.

The paper is organized as follows. In the following section, we present the empirical model. The database is described in Sect. 3, and the empirical results are analyzed in Sect. 4. The final section concludes.

Empirical model

Knowledge spillovers can be captured through the effects of the firm's environment on its TFP through a two-stage approach. First, we consider the following Cobb-Douglas function of firm i belonging to sector j at time t:

$$\log y_{it} = \log TFP_{it} + \alpha \log l_{it} + \beta \log k_{it} + \eta_{it}, \quad (1)$$

where k is the physical capital, l is the labor, y is the output, and ε is the error term. Parameters α and β are the coefficients to be estimated to compute log *TFP*, the TFP (in logarithms). Second, we consider that the TFP of the domestic firms (foreign-owned firms) depends on FDI (reverse) spillovers. Hence,

$$\log TFP_{it} = \rho' S_{jt} + \gamma' z_{jt} + \varphi' Year_t, \quad (2)$$

where ρ, γ, and φ are the three vectors of coefficients to be estimated; $Year_t$ is a vector of time dummies for the movements of the business cycle; and z_{jt} is a vector of the control variables discussed below. Spillovers between foreign-owned and domestic firms are captured by S_{jt}, which is sector-specific and time-specific. Following Javorcik (2004), we distinguish *horizontal* spillovers from *vertical* spillovers:

$$S_{jt} = \rho_H Horizontal_{jt}^{\overline{e}} + \rho_B Backward_{jt}^{\overline{e}} + \rho_F Forward_{jt}^{\overline{e}}, \quad (3)$$

However, contrary to Javorcik (2004), we focus on both types of spillovers. More precisely, we distinguish between FDI spillovers arising from foreign-owned affiliates ($\bar{e}=f$) and reverse spillovers from domestic firms ($\bar{e}=d$). In this pattern, $Horizontal_{jt}^{\bar{e}}$ captures spillovers between firms belonging to the same sector, *horizontal spillovers*, and is given by the following:

$$Horizontal_{jt}^{\bar{e}} = \frac{\sum_{i \in j} share_{ijt}^{\overline{e}} y_{it}}{\sum_{i \in j} y_{it}}, \quad (4)$$

where $share_{ijt}^{\overline{e}}$ is the share (in percent) of the firm's total equity controlled either by a foreign owner ($\overline{e} = f$) or by a domestic owner ($\overline{e} = d$). The variable $Horizontal_{jt}^{\overline{e}}$ increases with the share of the output in sector j produced by $\overline{e}$ -type firms. *Horizontal FDI spillovers* occur when local firms receive information from a multinational located in the same country and belonging to the same industry about new technologies, new management methods, foreign markets, and business services. Spillovers may then occur directly through the licensing of a particular technology or through subcontracting arrangements or occur indirectly as knowledge becomes public or when local firms hire workers trained by the multinational (Blomström and Kokko 1998). Such spillovers raise the productivity of the domestic firms. However, FDI can induce negative externalities in the host country. Indeed, setting up multinationals may involve a decrease in the market shares of the domestic firms and an increase in production costs due to the price competition to attract some specific factors (industry-specific skills). Hence, the net gain of an additional plant belonging to a multinational for the host country is unclear. In the case of reverse spillovers due to technology sourcing, the knowledge transfer is supported by the same arguments. Of course, reverse spillovers are not concerned with this negative effect of competitive pressures because multinationals do not enter foreign markets, where the profits are potentially negative for them.

$Backward_{jt}^{\overline{e}}$ is built as a proxy for the relationships between firm I of industry j and its $\overline{e}$ customers belonging to downstream industries l, and it is defined as follows:

$$Backward_{jt}^{\overline{e}} = \sum_{l \neq j} \mu_t^{jl} Horizontal_{lt}^{\overline{e}}, \quad (5)$$

where μ_t^{jl} is the share of sector j's output supplied to sector l with $j \neq l$. This share depends on t, and we then take into account the change in the relationships between firms belonging to different industries over time. The magnitude of the input-output relationship affects the strength of vertical spillovers. *Backward spillovers* to upstream sectors may occur for the following reasons. A rise in the demand from the multinational for intermediate products enables local suppliers to benefit from increasing returns. In addition, the relationship between a foreign affiliate and the local input suppliers may boost the productivity of these suppliers due to technical assistance or the introduction of a new organization. Spillovers emerge when the multinational is unable to extract the full value of a productivity increase. However, even when the gains in productivity benefit the multinational, backward spillovers can occur if the local suppliers are able to find new customers as a result of higher productivity. As in the previous case of horizontal linkages, the technology diffusion to upstream or downstream sectors can also be achieved through reverse spillovers from local firms to multinationals. Hence, the productivity of the foreign affiliates may be improved through their backward linkages with domestic suppliers.

For similar reasons, technology diffusion to downstream sectors may also occur (*forward spillovers*). The setup of foreign input suppliers may benefit domestic customers and vice versa. Hence, $Forward_{jt}^{\overline{e}}$ is defined as follows:

$$Forward_{jt}^{\overline{e}} = \sum_{k \neq j} \nu_t^{jk} \left[\frac{\sum_{i \in k} share_{ikt}^{\overline{e}} (y_{it} - x_{it})}{\sum_{i \in k} (y_{it} - x_{it})} \right], \qquad (6)$$

where ν_t^{jk} is the weight of industry k in the input purchases by industry j at time t. Note that we exclude the exports (x) of firms belonging to industry k in order to only consider the intermediate inputs sold in domestic markets.

Estimating (1) requires that we consider inputs as potentially correlated with the error term written as follows:

$$\varepsilon_{it} = \log TFP_{it} + \eta_{it}, \qquad (7)$$

where η_{it} is not observed (or non-predictable) by the firm and could represent measurement errors or productivity shocks. This term is not correlated with the input levels. On the contrary, $\log TFP_{it}$ is assumed to be observed by managers, but not by the econometrician, when they choose their inputs. Consequently, there is a correlation between this unobservable time-varying individual effect and the regressors.

Due to this endogeneity problem, the OLS estimator is biased and not consistent, and several solutions have been provided in the literature (see Ackerberg et al. 2007, for more details). With panel data, the first differences or the within estimator may be one way to address this problem if $\log TFP_{it}$ is constant over time which is a strong assumption. IV and GMM estimators do not suffer from such a limitation, but they require the use of instruments.[3]

In this paper, we prefer to address the endogeneity bias using the recent semi-parametric method developed by Ackerberg et al. (2006) (henceforth, ACF), an extension of the previous methods proposed by Olley and Pakes (1996) and Levinsohn and Petrin (2003) (henceforth OP and LP, respectively). Thus, we first estimate the coefficients associated with labor and capital using the ACF method. The TFP is evaluated as follows:

$$\log TFP_{it} = \log\ y_{it} - \hat{\alpha} \log l_{it} - \hat{\beta} \log k_{it}, \qquad (8)$$

Finally, we estimate the TFP Eq. (2) in the following form:

$$\log TFP_{it} = \rho' S_{jt} + \gamma' z_{jt} + \varphi' Year_t + d_i + \nu_{it}, \qquad (9)$$

where d_i captures a firm effect, and ν_{it} is an error term. Note that the estimates resulting from the OP and LP methods are also reported for comparison.

Data

We use two main databases for output and input and to identify whether a firm is an affiliate of a foreign multinational or a French company. The merging of these two micro-level databases and the discarding of outliers,[4] which is a frequent problem for this type of data, lead to an unbalanced panel over the period 1990–2003 of 90,614 firms belonging to 33 manufacturing and service sectors; we thus have 770,541 observations.[5] Our sample covers approximately 25 % of the total value added of the 33 manufacturing and service sectors.

Output and production factors (EAE surveys)

The data on output (y_{it}) and inputs (l_{it}, k_{it}) are obtained from the stacked annual surveys about firms' activities ("*Enquête annuelle d'entreprises*" (EAE)), which are the official French business-level data collected by the French Office of National Statistics (INSEE). Information is also given about the intermediate consumption (m_{it}) required by the ACF method. The French surveys are conducted for firms belonging to five macro-sectors, with one survey *per* macro-sector (the manufacturing sector, including the food industry, the energy sector, the trade sector, other services sector, and the building and transport sectors). The sampling rules differ across macro-sectors. In practice, these rules are defined in accordance with each macro-sector's characteristics and structure and are determined with respect to practical problems. Each of these surveys concerns all firms with a number of employees above a given minimum or with a turnover greater than a given threshold, whose main activity (in terms of turnover) belongs to the corresponding sector. Except for in the manufacturing sectors, the smaller firms are surveyed but not exhaustively, and the sampling scheme depends on the sector. Moreover, these smaller firms are asked to answer a simplified questionnaire (for example, the decomposition of investments into tangible and intangible assets is not requested). For the firms belonging to the manufacturing sectors and trade sectors, the minimum number of employees for the firm survey is 20 employees. The threshold value reaches 30 employees or a turnover of at least €8 million for most of services industries. However, in

[3] In practice (see Mairesse and Hall 1996), fixed effects and IV/GMM estimators do not perform well, mainly because quasi-differencing or first differencing removes much of the variation of the regressors and tends to increase the effect of measurement errors in the inputs.

[4] A value is defined as a severe outlier and is then discarded if it falls outside the interval $[Q_1 - 3 \times (Q_3 - Q_1), Q_3 + 3 \times (Q_3 - Q_1)]$. This exclusion criterion has been applied to the distributions of labour productivity and capital productivity.

[5] Note that we select domestic and foreign firms that are present over a minimum period of five consecutive years in order to take into account the dynamic effects induced by spillovers.

some subsectors devoted to business services, the minimum number of employees may increase substantially, as in the "cleaning" sector or the "hiring of temporary workers" sector, where the threshold value is fixed at 100 and 200 employees, respectively.

The output of firm *i* operating in sector *j* at time *t* is its value-added deflated by the Annual Price Index of value added in sector *j*. The capital used by firm *i* is the value of fixed assets at the end of the year, deflated by the Annual Price Index of the capital in sector *j*. Investment and intermediate consumption, both proxies needed for estimates, are deflated by the Annual Price Index of gross fixed capital formation and the Annual Price Index of intermediate consumption, respectively. Output, inputs, and proxies are all deflated using price indexes at the two-digit NACE sector level, the most detailed level available. Labor input in firm *i* at time *t* is the number of employees at the end of year. The investment is used to build the capital series when the fixed asset value is only available either at the beginning or at the end of the period.

The domestic or foreign origin of firms (LIFI survey)

We distinguish domestic firms from foreign firms with respect to the share of firm's total equity owned by foreign investors. According to the International Monetary Fund (IMF) definition of FDI, a company is defined as foreign-owned if a non-resident investor controls 10 % or more of the ordinary shares or voting power.

The information about the foreign control of a firm can be drawn from the annual survey about financial links ("*Enquête sur les liaisons financières*" (LIFI)). In the survey, firms are asked about the owners of their capital to identify which firm possibly has control of them. They are also asked about their share *portfolio* to identify which firms they control. From this database, which is also almost exhaustive for large firms, we obtain information about which firms belong to a corporate group and the domestic or foreign origin of the corporate group's head. More precisely, firms are surveyed as long as they satisfied one of the following conditions the year before: they employed more than 500 people, their turnover was more than €60 million, they owned shares of more than €1.2 million, they were the head of a corporate group, or they were majority controlled (more than 50 % of the ordinary shares) by a foreign group.

Finally, all coefficients associated with the vertical relationship (μ_t^{jl} and ν_t^{kj}) are calculated from the French annual input-output matrices at a two-digit *Nomenclature Economique de Synthèse* (NES) level.[6] Note that μ_t^{jl} is calculated by excluding the self-consumption inside each industry. As mentioned by Barrios et al. (2011), the use of the French/local input-output matrix to measure vertical linkages may be a restrictive approach. For example, in this case, multinationals are assumed to have the same input sourcing behavior as domestic firms, irrespective of their country of origin. However, with our approach, we can consider that the vertical linkages vary over time, which is not the case in the empirical analysis of Barrios et al. (2011).

[6] The NES is the French economic summary classification used by the French Office of National Statistics (INSEE) to create input-output matrices.

Some summary statistics

Table 1 provides some descriptive statistics on the dependent variable and the explanatory variables. The proxies for FDI spillovers from foreign-owned firms to French firms located in France (*Horizontal*^{f}, *Backward*^{f}, and *Forward*^{f}) are lower, on average, than the proxies for reverse spillovers (*Horizontal*^{d}, *Backward*^{d}, and *Forward*^{d}). This is explained by the number of foreign affiliates that is low compared to the number of French firms. The mean of the *Share*^{f} variable is 5.56 %. However, the weight of foreign-owned firms in the French economy varies across sectors. As shown in Table 8 (in Appendix A), the production of these foreign-owned firms represents a high share in the manufacturing and food sectors (more than 40 % for 12 sectors) and a low share in consumer services or in some distribution and business services.

Table 2 shows that labor productivity is greater for the foreign-owned firms, while capital productivity is higher for the French firms. However, the wedges in labor and capital productivities between foreign-owned firms and French firms are low. These results are confirmed by other recent studies (see, for example, Chanut and Kremp 2006). When we distinguish between the manufacturing industries from the services and building sectors, the results change to some extent (see

Table 1 Summary statistics

Variables	Mean	St. dev.	Median	Min	Max	Q3-Q1
y^a	5.0	89.0	1.3	3×10^{-5}	17,779	1.93
k^a	10.8	622.7	0.8	3×10^{-5}	142,141	2.18
l	126.8	1346.3	40.0	1	181,617	51.50
i^a	0.9	26.7	0.1	0	6,103	0.23
m^a	15.3	172.1	2.6	5×10^{-5}	41,637	6.42
Herfindahl	19.0	37.7	8.4	0.99	1000	10.72
Horizontal^{f} [a,b]	16.5	12.8	13.6	0	54	19.81
Backward^f	14.1	6.7	13.5	0.09	32	9.81
Forward^f	15.3	6.8	15.3	0	32	9.95
Horizontal^{d} [ab]	83.5	12.8	86.4	46.02	100	19.82
Backward^d	67.2	17.4	70.9	4.18	100	11.20
Forward^d	65.4	17.1	68.8	3.01	100	11.88
Share^f	6.4	23.6	0	0	100	0.00

[a] In million Euros at constant price 2000

[b] Spillovers indexed by *f* (*d*) correspond to FDI (reverse) spillovers

Table 2 Factor productivity distribution of domestic- and foreign-owned firms

	Type of firm	P01	P10	Q1	Median	Mean	Q3	P90	P99
Labor productivity	French	0.001	0.008	0.023	0.033	0.034	0.044	0.057	0.098
	Foreign	0.001	0.011	0.030	0.044	0.046	0.060	0.080	0.130
Capital productivity	French	0.045	0.411	0.775	1.458	2.610	2.892	5.660	19.88
	Foreign	0.035	0.317	0.542	0.973	2.051	2.121	4.816	15.91

Table 3). The hierarchy in factor productivity between foreign-owned firms and French firm holds in the manufacturing industries, while a large proportion of foreign-owned firms supplying services exhibits higher levels of labor and capital productivity.

Empirical analysis

Estimating input coefficients and TFP

To evaluate each firm's TFP, we have estimated input coefficients. The estimates are produced by sector to capture technology differences and are summarized in Table 4 by distinguishing between the manufacturing and service sectors. To address the constraints imposed by using the ACF (LP and OP) estimator(s), we build two subsamples for this step. We create one subsample by selecting the observations in which investment is strictly positive (689,328 observations), as required by OP method, and a second subsample by selecting observations in which intermediate consumption is strictly positive (618,208 observations), as required by the LP method (618,208 observations). In line with the LP approach, the estimates from the ACF method are obtained using the subsample with positive intermediate consumption. We check that the estimation results are not affected when we use investment instead of intermediate consumption for the ACF method.

If the ACF method successfully corrects for biases, one would expect to find a change in the values of coefficients associated with capital and labor relative to the results from the OP and LP regressions. As shown in Table 4, the estimation results seem relatively similar between the three methods (see also Table 9 and Table 10 in Appendix B). Hence, α has, on average in all sectors, a value of approximately 0.70, and β has a value of approximately 0.20 (see columns (1), (4), and (7)). It appears that the ACF estimator provides the most robust results. For example, using the LP method, we get a lower estimate for α for all sectors and decreasing returns to scale.[7] Differences are more pronounced with the OLS estimates, mainly in the services sectors. To a certain extent, this finding confirms the validity of the hypotheses addressed by Ackerberg et al. (2006) about the relationships between inputs and the timing of firm decisions and justifies our focus on the estimates drawn from the ACF method to calculate the TFP.

Finally, by using Eq. (8), we can evaluate $\log TFP_{it}$, the TFP expressed in logarithms for each firm. In Table 5, we report the punctual estimates of the TFP and their confidence intervals per year. The TFP of foreign-owned firms reaches very similar values to those obtained for domestic firms, regardless of the sector type. Indeed, the confidence intervals are very similar in both cases, although the punctual estimates display the best productive performances for domestic firms with a higher TFP wedge in the service and building sectors. The estimates by confidence interval clearly show that the TFP is always significantly positive over the study period, but its evolution is not so obvious. From punctual estimates, we observe a rise in the TFP of French and foreign firms belonging to the service and building sectors, while the TFP has a U-shaped pattern for manufacturing and food firms.[8] However, the lower bounds of the confidence interval are very stable over time, and a systematic increase of the upper bounds is just verified for foreign firms in the manufacturing and food industries. At this stage, there is no clear evidence of a relationship between openness to FDI and French firms' productivities and of a technology sourcing strategy used by foreign multinationals.

Are FDI spillovers and/or reverse spillovers at work?

We are now equipped to determine the direction and nature of spillovers. We first create two subsamples; the first subsample selects only French firms to test the presence of FDI spillovers, while the second one consists of foreign-owned firms to evaluate the effects of reverse spillovers. For each subsample, we distinguish firms belonging to service and building sectors (construction, civil engineering, distribution, business, and consumers services) from the other firms in the manufacturing and food sectors. Indeed, the estimates of the input coefficients clearly show that technologies used in both sector types are different. In addition, the TFP difference between French firms and foreign-owned firms is lower in the

[7] At a less aggregated level (see Tables 9 and 10 in Appendix B), the LP method also gives implausible results for some sectors.

[8] Note that the TFP of firms belonging to the manufacturing and food sectors, regardless of their nationality, reached, on average, a lower value in 1993, when the French economy experienced an economic crisis.

Table 3 Factor productivity distribution of domestic and foreign firms by macro-sector

	Type of firm	Manufacturing and food industries				Service and building sectors			
		Q1	Median	Mean	Q3	Q1	Median	Mean	Q3
Labor productivity	French	0.028	0.036	0.040	0.048	0.013	0.030	0.029	0.040
	Foreign	0.036	0.048	0.053	0.064	0.011	0.032	0.035	0.050
Capital productivity	French	0.708	1.211	1.720	2.165	0.852	1.710	3.242	3.641
	Foreign	0.486	0.769	1.175	1.136	0.815	1.823	3.479	4.295

manufacturing and food sectors than in the service and building sectors. Thus, we may expect that differences also exist for spillover effects. For each type of subsample and each type of industry, Eq. (9) is estimated by the within estimator and in first difference to control for a potential individual firm effect. Furthermore, as it is likely that spillover effects take time to operate inside or between sectors, models in second, third, and fourth differences are also estimated. Because some firms in the sample are only observed for 5 years, we cannot use longer differences over time.

The direction of spillovers In accordance with the literature, we first test whether the presence of foreign-owned firms raises the productivity of domestic firms. We must control for a well-known factor affecting the firm's performance: the strength of competition in the product markets. As a proxy for the strength of competition, we introduce a Herfindahl index (*Herfindahl*), which is calculated for each two-digit NES industry. An increasing Herfindahl index is expected to capture an industry that is becoming less competitive, but the effect of this factor on the TFP is ambiguous. Indeed, new entrants may improve the productivity of incumbents. On the other hand, new entrants may cause the exit of incumbents exhibiting low levels of productivity (Bartelsman et al. 2013).

The main results are reported in Table 6, while the details are given in Table 12 (see Appendix C). The estimates in differences (or by the within estimator) indicate that the TFP of French firms belonging to the manufacturing and food sectors is not affected by the degree of competition on the product market or by the different types of FDI spillovers. The presence of foreign firms in the manufacturing and food sectors does not create positive externalities. This result is not consistent with the conclusions of Keller and Yeaple (2005) for US manufacturing firms.[9] Our estimates also show some weak effects of horizontal and forward FDI spillovers in the service and building sectors. The coefficients are only significant in the first difference regression, which is inconsistent with the expectation that spillovers take time. In contrast, the degree of competition in the French markets influences the productivity levels. Indeed, whatever the magnitude of the differences, stronger competition increases the performance of French firms, other things being equal (Table 7).

Turning to reverse spillovers, the dependent variable is now the TFP of foreign-owned firms. To control for the fact that the difference in productivity between foreign affiliates is related to the weight of foreign capital in the affiliate, we also introduce a new variable to the model: the share (percentage) of a firm's total equity owned by foreign multinationals, $Share^f$. Table 6 shows that a higher share of capital owned by a multinational induces higher levels of TFP. Concerning spillover effects, the results are very similar to those obtained previously. Very few coefficients of reverse spillovers are significant.

No spillover from multinationals to French firms, and vice versa, seems to occur at the same time in the manufacturing and food sectors and in the service and building sectors (see also Table 11 in Appendix C). These results seem to contradict previous studies that highlight a negative relationship between the inter-country technology gap and spillovers (Havránek and Iršová 2011; Iršová and Havránek 2013). However, our results may simply reflect some substantial differences across sectors. Hence, from a technology-sourcing perspective, multinationals target research-intensive sectors. It is also in these sectors that the need for the positive effects of spillovers is higher, as is the firms' absorptive capacities for new knowledge (Cohen and Levinthal 1989). We then choose to make a distinction based on the technology level of the sectors.

Technology level of the sectors Here, we use the most recent taxonomy developed by the OECD in the 1990s, which enables the manufacturing industries and the service sectors to be aggregated into four groups ("high technology," "medium-high technology," "medium-low technology," and "low technology") and into three groups ("knowledge intensive," "high knowledge," and "less knowledge intensive"), respectively. To have sufficiently large subsamples and to not reduce the precision of our estimates, we choose a more aggregate classification with the high-medium-technology and low-technology sectors for the manufacturing industries and the knowledge-intensive and less knowledge-intensive sectors for the services and building sectors.

[9] Note that the literature fails to find a positive intra-industry effect in developing and transition countries.

Table 4 Estimate summary of input coefficients

		ACF method			LP method			OP method		
		(1) Mean	(2) Min	(3) Max	(4) Mean	(5) Min	(6) Max	(7) Mean	(8) Min	(9) Max
Manufacturing and food industries (17 sectors)	α	0.79	0.61	0.89	0.66	0.55	0.74	0.76	0.58	0.91
	β	0.20	0.12	0.43	0.21	0.13	0.42	0.20	0.09	0.43
	Sum	0.99	0.92	1.07	0.87	0.79	1.02	0.96	0.80	1.05
Building and services (16 sectors)	α	0.60	0.16	0.89	0.63	0.43	0.90	0.65	0.18	0.93
	β	0.23	0.01	0.48	0.24	0.01	0.70	0.18	0.02	0.55
	Sum	0.83	0.17	1.27	0.86	0.50	1.31	0.84	0.27	1.39
All (33 sectors)	α	0.70	0.16	0.89	0.64	0.43	0.90	0.71	0.18	0.93
	β	0.21	0.01	0.48	0.22	0.01	0.70	0.19	0.02	0.55
	Sum	0.91	0.17	1.27	0.87	0.50	1.31	0.90	0.27	1.39

Table 5 Changes in total factor productivity of domestic- and foreign-owned firms

Year	*Share*[f] All firms[a]	TFP[b] of French firms			TFP[b] of foreign firms		
		Average	Confidence interval		Average	Confidence interval	
Manufacturing and food industries							
1990	4.9	0.071	0.03	0.20	0.091	0.03	0.36
1991	5.2	0.070	0.03	0.19	0.086	0.03	0.35
1992	5.1	0.062	0.02	0.18	0.078	0.02	0.33
1993	5.7	0.063	0.02	0.16	0.075	0.02	0.32
1994	6.7	0.067	0.03	0.17	0.078	0.03	0.33
1995	7.1	0.070	0.03	0.17	0.082	0.03	0.37
1996	7.6	0.070	0.03	0.17	0.082	0.03	0.36
1997	8.1	0.073	0.03	0.17	0.084	0.03	0.38
1998	9.1	0.074	0.03	0.18	0.086	0.03	0.39
1999	12.3	0.077	0.03	0.18	0.086	0.03	0.39
2000	12.6	0.078	0.03	0.18	0.086	0.03	0.38
2001	13.3	0.078	0.03	0.18	0.085	0.03	0.38
2002	13.8	0.079	0.03	0.18	0.088	0.03	0.39
2003	14.1	0.081	0.04	0.19	0.090	0.03	0.41
Service and building sectors							
1990	1.4	0.098	0.02	0.45	0.097	0.01	1.34
1991	1.3	0.096	0.02	0.46	0.096	0.01	1.10
1992	1.6	0.097	0.02	0.48	0.089	0.01	1.32
1993	2.1	0.100	0.02	0.52	0.107	0.01	1.83
1994	2.9	0.099	0.02	0.55	0.111	0.01	1.55
1995	3.5	0.097	0.02	0.60	0.111	0.01	1.59
1996	3.3	0.098	0.02	0.50	0.111	0.01	1.07
1997	3.4	0.099	0.02	0.48	0.123	0.01	1.14
1998	3.4	0.105	0.02	0.50	0.137	0.02	1.18
1999	4.9	0.108	0.02	0.52	0.149	0.02	1.19
2000	5.0	0.111	0.02	0.52	0.152	0.02	1.24
2001	5.6	0.106	0.02	0.51	0.139	0.02	1.23
2002	6.0	0.105	0.02	0.51	0.141	0.02	1.16
2003	5.9	0.106	0.02	0.49	0.147	0.02	1.13

[a] In %

[b] In thousands of Euros

Table 6 FDI and reverse spillovers in manufacturing and food industries and in services and building

	Manufacturing and food industries				Services and building			
	First diff.	Second diff.	Third diff.	Fourth diff.	First diff.	Second diff.	Third diff.	Fourth diff.
FDI spillovers								
Herfindahl	ns	ns	ns	ns	−0.000***	−0.001***	−0.001***	−0.001***
Backward^d	ns	ns	ns	ns	−0.011***	ns	ns	ns
Forward^d	ns	ns	ns	ns	0.010***	ns	ns	ns
Horizontal^d	ns	ns	ns	ns	0.002***	ns	ns	ns
NT obs.	211.092	184.296	157.943	131.981	282.571	238.861	195.692	152.986
Reverse spillovers								
Share	ns	ns	0.000***	0.001***	0.001***	0.001***	0.001***	ns
Herfindahl	−0.000***	ns	ns	ns	−0.002***	ns	−0.003***	−0.003***
Backward^d	ns	ns	ns	ns	ns	ns	ns	ns
Forward^d	ns	ns	ns	ns	ns	0.011***	ns	ns
Horizontal^d	0.004***	ns	ns	ns	ns	ns	ns	ns
NT obs.	22.030	17.756	13.965	10.636	12.383	9.172	6.545	4.399

The dependent variable is Δ log (TFP). estimated in a first step from the Ackerberg-Caves-Frazer method. All regressions include year dummies. The *t* statistics in parentheses have been corrected for clustering for each industry in each year. FDI (reverse) spillover effects have been estimated from the subsample of domestic (foreign-owned) firms

*Significant at the 10 % level. **Significant at the 5 % level. ***Significant at the 1 % level

Table 7 reports our main findings, while more detailed results for estimates are presented in Tables 12 and 13 in Appendix C. As shown in the second part of Table 7, horizontal spillovers from domestic firms to foreign-owned firms operate in the manufacturing sectors, while vertical spillovers do not seem to be at work. This result confirms the theoretical argument that multinationals use FDI to source locally available knowledge from their domestic rivals (Fosfuri and Motta 1999; Sanna-Randaccio and Veugelers 2007). The coefficients related to the reverse horizontal spillovers have higher values for a larger temporal difference. This result supports the fact that spillovers take time to materialize, especially for multinationals, which must learn about a new foreign environment. Furthermore, whatever their type, reverse spillovers are never present in the low-technology manufacturing industries (see Table 12). This last result confirms evidence of technology sourcing in France and is supported by the findings obtained by Driffield and Love (2003) from UK manufacturing data.

Concerning knowledge spillovers from inward FDI to French firms, the results clearly confirm the importance of distinguishing the sectors' technology levels. As reported in

Table 7 FDI and reverse spillovers in knowledge-intensive services and medium- and high-technology manufacturing industries

	High- and medium-technology manufacturing industries				Knowledge-intensive services			
	First diff.	Second diff.	Third diff.	Fourth diff.	First diff.	Second diff.	Third diff.	Fourth diff.
FDI spillovers								
Backward^f	ns	ns	0.015*	0.018***	ns	ns	ns	ns
Forward^f	ns	ns	−0.009***	ns	ns	ns	ns	ns
Horizontal^f	ns	ns	−0.006*	−0.008*	0.001*	0.002*	0.006***	0.008***
Reverse spillovers								
Backward^d	ns	ns	ns	ns	−0.043***	−0.060***	−0.129***	−0.136*
Forward^d	ns	ns	ns	ns	ns	0.025***	0.030***	0.035***
Horizontal^d	0.006**	0.007***	0.007***	0.010***	ns	0.004***	0.005***	0.003*

The dependent variable is Δ log (TFP), estimated in a first step from the Ackerberg-Caves-Frazer method. All regressions include year dummies. The *t* statistics in parentheses have been corrected for clustering for each industry in each year. FDI (reverse) spillover effects have been estimated from the subsample of domestic (foreign-owned) firms

*Significant at the 10 % level. **Significant at the 5 % level. ***Significant at the 1 % level

Table 6, with no distinction, no FDI spillovers emerge. When we now focus on French firms producing manufactured goods with high or medium technology, some FDI spillover effects appear. Indeed, in the high- and medium-technology manufacturing industries, the estimates produce coefficients associated with the FDI backward spillovers, which are significantly positive, while the coefficients associated with the FDI horizontal spillovers are significantly negative but at only a 10 % significance level. In fact, the competition effects due to the presence of multinationals may work through two channels: concentration and horizontal spillovers. It may be interesting to determine whether these two channels are distinct or not. The estimates of Eq. (9) without the Herfindahl index as a regressor indicate no significant changes in the amplitude of the spillover effects, especially for horizontal spillovers (see Table 12). This finding suggests that concentration and horizontal spillovers are two distinct channels through which the competition of the multinationals operates. Finally, there is no evidence of spillovers using the forward channels. These results are in accordance with the findings of Javorcik (2004), even though the backward FDI spillovers need a longer period in France than in Lithuania and have a weaker impact on the TFP of domestic firms. One possible interpretation of this difference is that, in developed countries, firms seem able to control for the diffusion of their firm-specific knowledge. From a Romanian firm-level data set, Javorcik and Spatareanu (2008) note that vertical spillovers arise from partially owned subsidiaries but not from fully owned subsidiaries. The argument is that affiliates with joint domestic and foreign ownership may encounter lower costs in finding local suppliers of intermediates and thus may be more likely to engage in local sourcing than are wholly owned foreign subsidiaries. The results of both authors also suggest that the negative competition effect due to horizontal spillovers is greater in the case of fully owned foreign investments. To test whether the ownership structure of foreign subsidiaries may affect our results, we consider a non-linear specification from Eq. (9) by introducing squared terms of horizontal and vertical FDI spillovers (see Table 12 in Appendix C). The estimates still indicate a positive relationship (in the last column) between the domestic firms' performances and backward spillovers. Consequently, in the French case, partially owned subsidiaries do not seem have lower costs in finding local suppliers. Furthermore, horizontal spillovers continue to have positive effects on French firms' performances.

If we now focus on the knowledge-intensive services, the reverse horizontal spillovers have a significant and positive effect on the TFP of affiliates. Therefore, the affiliates of multinationals located in France and belonging to the research-intensive sectors seem to benefit from technology sourcing. In knowledge-intensive services, this result is magnified by the fact that affiliates also improve their TFP from linkages with their domestic customers (forward spillovers). However, the technology-sourcing practices appear to be largely challenged by the magnitude of the negative effect of backward spillovers. The value of the coefficient associated with this type of spillovers reaches −0.136 in fourth differences, while it is largely lower for horizontal spillovers (0.035) or for forward spillovers (0.003). Hence, in French knowledge-intensive services, these practices will only be profitable for multinationals with a high degree of the upward integration of affiliates with their foreign headquarters. For the FDI spillovers, only the horizontal dimension prevails. The effect on the TFP of French firms is significantly positive, whatever the length of the differences, while vertical spillovers seem to have no effect.

FDI spillovers have very weak effects in the less knowledge-based sectors (see Table 12 in Appendix C). This result holds whatever the direction of spillovers and their nature. Hence, few coefficients are significant, and they appear systematically not significant in the third and fourth differences. This result could be a sign of firms' limited absorptive capacities for new knowledge. On the other hand, the coefficient associated with the Herfindahl index is significant in the less knowledge-intensive services. Thus, in these sectors, firms improve their performances mainly as a result of more competition.

Conclusion

In contrast to the literature focusing on FDI spillovers, we also test the magnitude of reverse spillovers in a developed country such as France by considering that spillovers can occur through vertical or horizontal linkages. The analysis, based on firm-level panel data, addresses some important econometric issues, such as the endogeneity of input demand or spillovers.

From our econometric analysis, three main conclusions can be drawn. First, spillovers are at work in all research-intensive sectors, while they have very weak effects in the less knowledge-based sectors. Second, foreign multinationals located in France obtain access to the technology of domestic firms. However, technology sourcing seems to be more frequent in the manufacturing sectors than in the service sectors, where backward spillovers have a negative effect on the TFP of affiliates. Third, the productivity of French firms benefits from their downstream linkages with foreign-owned firms in the high- and medium-technology manufacturing industries, but only after 4 years and from horizontal linkages in knowledge-intensive services. From a policy viewpoint, our findings could reveal that subsidies that attract and keep foreign capital are justified in intensive research sectors. Indeed, the presence of foreign-owned firms in France raises the productivity of French firms. However, the full benefit of the technology transfer could be internalized by the foreign and domestic parties (Blalock and Gertler 2008). More empirical investigations are needed to appreciate the collective benefit of technology transfers in a developed country such as France.

Additional analysis is needed to better understand the knowledge linkages between multinationals and domestic firms. More precisely, we must gain a better understanding of the content of knowledge spillovers, such as the nature of knowledge transfers and the relationships between firms. To (partially) open the "black box," in our future analyses, we would like to consider R&D expenditures as a proxy for the technology transfer between foreign and domestic firms.

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Appendix A

Table 8 The weight of foreign-owned firms by sector (2003)

Industries	Code	No. of obs.	No. of foreign-owned firms	No. of firms	*Horizontal*[d]	*Backward*[d]	*Forward*[f]
Meat and milk	[1]	12,432	53	1.164	42.31	30.93	29.62
Other agricultural and food industries	[2]	20,949	232	1.603	37.52	17.59	17.24
Clothing and leather	[3]	19,365	54	1.011	44.87	27.97	29.89
Publishing, printing, and repro	[4]	18,930	151	1.434	53.94	22.99	24.82
Pharmacy, perfumery, and cleaning	[5]	5.651	153	463	44.87	27.97	29.89
Household equipment	[6]	15,866	120	1.073	44.87	27.97	29.89
Automobile	[7]	5.487	126	452	44.87	27.97	29.89
Other transport equipment industries	[8]	3.168	50	257	39.47	3.03	3.50
Metal products, machinery, and equipment industries	[9]	38,613	547	3.128	44.87	27.97	29.89
Electric and electronic equipment industries	[10]	12,102	195	899	43.42	19.94	20.62
Mining	[11]	14,272	178	1.038	33.95	15.17	14.37
Textile	[12]	14,625	101	1.001	28.76	20.83	21.20
Wood and paper industries	[13]	14,313	224	1.081	53.94	22.99	24.82
Chemistry, rubber, and plastics	[14]	22,737	511	1.852	44.87	27.97	29.89
Metallurgy	[15]	39,035	437	3.238	44.87	27.97	29.89
Industry of electric and electronic components	[16]	8.896	158	739	43.42	19.94	20.62
Coal, petroleum, gas, and uranium industries	[17]	679	19	63	42.31	30.93	29.62
Electricity, gas, and water industries	[18]	1.857	2	157	0.11	24.50	25.55
Building	[19]	14,565	15	1.945	28.76	20.83	21.20
Civil engineering	[20]	50,055	64	6.240	42.31	30.93	29.62
Sale, maintenance, and repair of motor vehicles and motorcycles	[21]	34,909	195	3.194	28.76	20.83	21.20
Wholesale trade	[22]	85,848	1,148	7.662	28.76	20.83	21.20
Retail trade, repair of personal, and household goods	[23]	83,866	218	7.037	41.23	22.92	21.87
Transport	[24]	67,865	513	8.127	29.93	17.85	20.58
Insurance and pension funding	[25]	478	15	111	22.64	18.49	20.16
Real estate activities	[26]	4.238	25	422	29.93	17.85	20.58
Letting of own property	[27]	5.545	5	450	6.95	18.20	21.18
Post and telecommunications	[28]	6.107	22	104	29.93	17.85	20.58
Consultancy and assistance activities	[29]	44,816	574	4.310	43.42	19.94	20.62
Renting and other business activities	[30]	27,736	255	2.726	29.93	17.85	20.58
Hotels and restaurants	[31]	20,499	160	2.071	37.52	17.59	17.24
Recreational, cultural, and sporting activities	[32]	4.431	58	480	14.23	17.84	17.27
Other personal and domestic services	[33]	2.776	7	272	16.92	19.29	21.44

Appendix B

Table 9 Comparison of estimates in manufacturing and food industries using four methods

Sector	ACF			LP			OP			OLS		
	α	β	Sum	α	β	Sum	α	β	Sum	α	β	Sum
[1]	0.75	0.27	1.02	0.73	0.20	0.93	0.74	0.23	0.97	0.76	0.22	0.98
[2]	0.61	0.43	1.04	0.60	0.42	1.02	0.62	0.43	1.05	0.66	0.37	1.03
[3]	0.79	0.13	0.92	0.68	0.18	0.86	0.58	0.22	0.80	0.64	0.27	0.91
[4]	0.85	0.12	0.97	0.70	0.13	0.83	0.91	0.09	1.00	0.94	0.11	0.05
[5]	0.72	0.20	0.92	0.55	0.24	0.79	0.81	0.18	0.99	0.85	0.23	1.08
[6]	0.86	0.14	1.00	0.67	0.14	0.81	0.82	0.13	0.96	0.87	0.17	1.04
[7]	0.83	0.19	1.02	0.65	0.19	0.84	0.79	0.16	0.95	0.83	0.18	1.01
[8]	0.89	0.18	1.07	0.74	0.21	0.95	0.83	0.21	1.04	0.89	0.16	1.05
[9]	0.87	0.13	1.00	0.72	0.13	0.85	0.88	0.10	0.98	0.91	0.13	1.04
[10]	0.85	0.16	1.01	0.65	0.17	0.81	0.85	0.13	0.97	0.88	0.16	1.04
[11]	0.69	0.23	0.92	0.56	0.32	0.88	0.64	0.28	0.91	0.69	0.32	1.01
[12]	0.80	0.14	0.94	0.72	0.20	0.92	0.78	0.15	0.93	0.83	0.16	0.99
[13]	0.86	0.18	1.04	0.65	0.18	0.83	0.78	0.19	0.97	0.82	0.23	1.05
[14]	0.79	0.22	1.01	0.62	0.22	0.85	0.75	0.23	0.97	0.78	0.26	1.04
[15]	0.81	0.16	0.97	0.67	0.19	0.86	0.77	0.17	0.94	0.81	0.19	1.00
[16]	0.80	0.20	1.00	0.61	0.20	0.80	0.77	0.17	0.94	0.82	0.19	1.01
[17]	0.66	0.35	1.01	0.67	0.33	1.00	0.64	0.32	0.96	0.66	0.27	0.93
Mean	0.79	0.20	0.99	0.66	0.21	0.87	0.76	0.20	0.96	0.80	0.21	1.01

For the manufacturing sectors, all coefficients are significant at a 1 % confidence level, except in the ACF case, where the standard error of coefficients will be derived from bootstrap estimation

Table 10 Comparison of estimates in service and building sectors using four methods

Sector	ACF			LP			OP			OLS		
	α	β	Sum	α	β	Sum	α	β	Sum	α	β	Sum
[18]	0.70	0.25	0.95	0.75	0.12	0.87	0.81	0.16	0.97	0.80	0.21	1.01
[19]	0.87	0.14	1.01	0.76	0.14	0.90	0.91	0.11	1.02	0.94	0.11	1.05
[20]	0.89	0.13	1.02	0.79	0.14	0.93	0.93	0.09	1.02	0.95	0.10	1.05
[21]	0.65	0.48	1.13	0.68	0.63	1.31	0.84	0.55	1.39	0.81	0.22	1.03
[22]	0.70	0.28	0.98	0.70	0.30	1.00	0.77	0.30	1.07	0.82	0.17	0.99
[23]	0.64	0.40	1.04	0.63	0.46	1.09	0.73	0.42	1.16	0.72	0.26	0.98
[24]	0.68	0.25	0.93	0.54	0.21	0.75	0.73	0.19	0.92	0.73	0.21	0.94
[25]	0.83	0.44	1.27	0.61	0.12[a]	0.72	0.75	0.21	0.96	0.82	0.22	1.04
[26]	0.56	0.01	0.57	0.82	0.01[b]	0.80	0.75	0.06	0.82	0.83	0.03	0.86
[27]	0.45	0.01	0.46	0.43	0.70	1.13	0.18	0.09[a]	0.27	0.49	0.04	0.53
[28]	0.16	0.01	0.17	0.49	0.00[b]	0.50	0.63	0.28	0.91	0.42	0.02[a]	0.44
[29]	0.39	0.31	0.70	0.47	0.22	0.68	0.45	0.15	0.61	0.57	0.18	0.75
[30]	0.37	0.25	0.62	0.48	0.21	0.69	0.47	0.13	0.60	0.53	0.21	0.74
[31]	0.44	0.39	0.83	0.47	0.17	0.64	0.33	0.09	0.41	0.42	0.21	0.63
[32]	0.40	0.13	0.53	0.51	0.10	0.61	0.41	0.09	0.50	0.48	0.11	0.59
[33]	0.85	0.16	1.01	0.90	0.27	1.17	0.78	0.02[b]	0.80	0.94	0.06	1.00
Mean	0.60	0.23	0.83	0.63	0.24	0.86	0.65	0.18	0.84	0.70	0.15	0.85

All coefficients associated with labor are significant at the 1 % confidence level, regardless of the method. The capital coefficients are significant except for a few coefficients which are significant at a ten percent confidence level (a) or not significant at all (b). Note that in the ACF case, the standard error of coefficients will be derived from bootstrap estimation

[a] The capital coefficients are significant except for a few coefficients which are significant at a 10 % confidence level

[b] The capital coefficients are significant except for a few coefficients which are not significant at all

Appendix C

Table 11 FDI and reverse spillovers in manufacturing and food industries and in service and building industries (estimated coefficients)

FDI spillovers	Manufacturing and food industries					Services and building				
	Within	First diff.	Second diff.	Third diff.	Fourth diff.	Within	First diff.	Second diff.	Third diff.	Fourth diff.
Herfindahl	−0.000	−0.000	−0.000	−0.000	−0.000	−0.001	−0.000	−0.001	−0.001	−0.001
	(−1.03[a])	(−0.48)	(−0.41)	(−0.25)	(−0.65)	(−1.45)	(−5.27)	(−2.52)	(−2.42)	(−1.57)
Backward[d]	0.004	0.001	−0.000	0.000	0.001	−0.019	−0.011	−0.002	−0.019	−0.022
	(0.77)	(0.83)	(−0.08)	(0.03)	(0.17)	(−0.89)	(−1.94)	(−0.27)	(−0.93)	(−0.94)
Forward[d]	−0.002	−0.002	−0.001	0.002	0.001	0.009	0.010	0.002	0.011	0.010
	(−0.55)	(−1.86)	(−0.47)	(0.61)	(0.61)	(0.44)	(2.11)	(0.26)	(0.60)	(0.45)
Horizontal[d]	0.000	−0.002	−0.001	−0.001	−0.000	0.004	0.002	0.001	0.002	0.003
	(0.13)	(−1.42)	(−0.80)	(−0.48)	(−0.19)	(0.80)	(1.94)	(0.72)	(0.43)	(0.62)
Constant	–	−0.008	−0.027	0.031	−0.001	–	−0.008	−0.023	−0.043	−0.016
		(−0.69)	(−1.12)	(1.65)	(−0.02)		(−0.90)	(−1.05)	(−1.45)	(−0.38)
NT obs.	238,299	211,092	184,296	157,943	131,981	326,574	282,571	238,861	195,692	152,986
R^2	0.067	0.01	0.01	0.02	0.01	0.030	0.01	0.02	0.03	0.03
Reverse spillovers	Manufacturing and food industries					Services and building				
	Within	First diff.	Second diff.	Third diff.	Fourth diff.	Within	First diff.	Second diff.	Third diff.	Fourth diff.
ForeignShare	0.00	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001
	(0.21)	(0.19)	(0.74)	(2.40)	(2.27)	(2.25)	(4.47)	(4.08)	(2.56)	(1.13)
Herfindahl	−0.000	−0.000	−0.000	−0.000	−0.000	−0.002	−0.002	−0.001	−0.003	−0.003
	(−1.31)	(−3.16)	(−0.69)	(−0.98)	(−0.50)	(−3.26)	(−4.11)	(−1.71)	(−2.92)	(−2.21)
Backward[d]	0.001	0.002	0.002	−0.003	−0.001	−0.002	−0.002	−0.010	0.003	0.008
	(0.25)	(1.39)	(0.59)	(−0.57)	(−0.21)	(−0.48)	(−0.32)	(−1.92)	(0.31)	(0.80)
Forward[d]	−0.001	−0.000	−0.001	0.000	0.000	0.001	0.002	0.011	−0.005	−0.012
	(−0.87)	(−0.43)	(−0.43)	(0.20)	(0.16)	(0.11)	(0.44)	(2.01)	(−0.44)	(−1.03)
Horizontal[d]	0.003	0.004	0.003	0.004	−0.005	−0.003	0.005	−0.003	−0.000	−0.003
	(1.41)	(2.69)	(1.81)	(1.74)	(−0.94)	(−0.55)	(1.60)	(−1.18)	(−0.09)	(−0.54)
Constant	–	−0.046	−0.014	−0.080	−0.371	–	0.123	−0.140	−0.162	−0.244
		(−4.94)	(−0.55)	(−2.27)	(−1.56)		(2.62)	(−1.16)	(−1.67)	(−1.89)
NT obs.	26,748	22,030	17,756	13,965	4399	16,026	10,636	12,383	9172	6545
R^2	0.054	0.01	0.01	0.02	0.03	0.025	0.02	0.02	0.02	0.03

[a] The *t* statistics in parentheses have been corrected for clustering for each industry in each year

Table 12 FDI spillovers from multinationals to domestic firms (estimated coefficients)

A

Manufacturing and food industries	High and medium technology				Low technology			
	First diff.	Second diff.	Third diff.	Fourth diff.	First diff.	Second diff.	Third diff.	Fourth diff.
Herfindahl	0.000	0.000	0.000	0.001	−0.000	−0.001	−0.001	−0.002
	(0.07[a])	(0.20)	(0.35)	(0.60)	(−0.83)	(−0.97)	(−0.85)	(−2.44)
Backward[f]	−0.002	0.007	0.015	0.018	0.001	−0.002	−0.003	−0.001
	(−0.38)	(1.35)	(1.78)	(2.73)	(0.74)	(−0.55)	(−0.53)	(−0.30)
Forward[f]	0.000	−0.004	−0.009	−0.004	−0.002	0.000	0.004	0.002
	(0.00)	(−1.27)	(−3.47)	(−1.29)	(−1.63)	(0.02)	(1.26)	(1.11)
Horizontal[f]	−0.004	−0.004	−0.006	−0.008	−0.001	0.000	0.001	0.002
	(−1.41)	(−1.37)	(−1.66)	(−1.90)	(−0.67)	(0.26)	(0.83)	(1.18)

Table 12 (continued)

A								
Constant	−0.016	0.022	0.042	0.047	−0.015	−0.030	0.015	−0.005
	(−0.58)	(0.61)	(0.67)	(0.70)	(−0.90)	(−1.17)	(0.68)	(−0.16)
NT obs.	49,725	43,138	36,719	30,450	161,367	141,158	121,224	101,531
R^2	0.01	0.03	0.04	0.05	0.01	0.01	0.01	0.01
Services and building	Knowledge intensive				Less knowledge intensive			
	First diff.	Second diff.	Third diff.	Fourth diff.	First diff.	Second diff.	Third diff.	Fourth diff.
Herfindahl	−0.000	−0.001	−0.001	−0.001	−0.000	−0.001	−0.001	−0.001
	(−17.52)	(−13.47)	(−7.50)	(−10.09)	(−0.55)	(−1.55)	(−2.66)	(−2.18)
Backward[f]	0.015	0.041	0.097	0.101	−0.014	−0.003	−0.027	−0.018
	(1.01)	(0.84)	(1.61)	(1.24)	(−2.28)	(−0.50)	(−2.37)	(−1.29)
Forward[f]	−0.002	−0.017	−0.024	−0.012	0.012	0.002	0.018	0.006
	(−0.31)	(−0.79)	(−1.00)	(−0.25)	(2.36)	(0.40)	(1.65)	(0.48)
Horizontal[f]	0.001	0.002	0.006	0.008	0.006	0.002	0.001	0.003
	(1.66)	(1.88)	(2.74)	(4.77)	(1.75)	(0.65)	(0.22)	(0.71)
Constant	0.024	0.093	0.135	0.171	−0.036	−0.064	−0.070	−0.066
	(1.92)	(2.78)	(2.20)	(1.93)	(−5.50)	(−3.08)	(−2.65)	(−2.46)
NT obs.	65,782	56,873	48,066	39,386	216,789	181,988	147,626	113,600
R^2	0.01	0.02	0.03	0.02	0.01	0.02	0.03	0.03
B								
Manufacturing and food industries	High and medium technology				Low technology			
	First diff.	Second diff.	Third diff.	Fourth diff.	First diff.	Second diff.	Third diff.	Fourth diff.
Backward[f]	−0.002	0.008	0.017	0.019	0.001	−0.001	−0.002	−0.001
	(−0.35)	(1.08)	(1.47)	(2.31)	(0.84)	(−0.55)	(−0.44)	(−0.16)
Forward[f]	0.000	−0.005	−0.011	−0.006	−0.002	−0.000	0.004	0.002
	(0.00)	(−1.06)	(−1.85)	(−2.13)	(−1.65)	(−0.06)	(1.23)	(1.11)
Horizontal[f]	−0.004	−0.004	−0.005	−0.006	−0.001	0.001	0.001	0.003
	(−1.59)	(−1.58)	(−1.67)	(−1.68)	(−0.62)	(0.32)	(0.88)	(1.40)
Constant	−0.006	0.019	0.030	0.034	−0.009	−0.029	0.011	−0.003
	(−0.52)	(0.47)	(0.39)	(0.46)	(−0.59)	(−1.12)	(0.56)	(−0.08)
NT obs.	49,725	43,138	36,719	30,450	161,367	141,158	121,224	101,531
R^2	0.01	0.03	0.04	0.04	0.01	0.01	0.01	0.01
Services and building	Knowledge intensive				Less knowledge intensive			
	First diff.	Second diff.	Third diff.	Fourth diff.	First diff.	Second diff.	Third diff.	Fourth diff.
Herfindahl	–	–	–	–	–	–	–	–
Backward[f]	0.011	0.033	0.099	0.085	−0.014	−0.005	−0.029	−0.018
	(0.70)	(0.65)	(1.61)	(0.91)	(−2.57)	(−1.00)	(−2.80)	(−1.14)
Forward[f]	0.002	−0.010	−0.010	−0.002	0.012	0.004	0.019	0.006
	(0.26)	(−0.40)	(−0.32)	(−0.03)	(2.72)	(0.91)	(1.93)	(0.39)
Horizontal[f]	0.001	0.001	0.006	0.007	0.007	0.004	0.004	0.006
	(2.55)	(0.83)	(2.91)	(3.08)	(1.85)	(1.17)	(1.21)	(2.00)
Constant	0.028	0.095	0.125	0.165	−0.014	−0.046	−0.051	−0.037
	(1.89)	(2.74)	(2.06)	(1.59)	(−1.68)	(−2.67)	(−1.66)	(−1.10)
NT obs.	65782	56873	48066	39386	216789	181988	147626	113600
R^2	0.01	0.02	0.03	0.02	0.02	0.02	0.03	0.02
C								
Manufacturing and food industries—high and medium technology								
	First diff.	First diff.	Second diff.	Second diff.	Third diff.	Third diff.	Fourth diff.	Fourth diff.
Herfindahl	−0.000	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001
	(−1.43[a])	(−2.37)	(−2.78)	(−2.42)	(−5.29)	(−2.48)	(−1.35)	(−2.65)

Table 12 (continued)

A								
Backward^{f}	−0.005		0.004		−0.011		−0.029	
	(−0.74)		(0.72)		(−0.60)		(−0.87)	
Backward^{f2}	0.001	0.000	0.000	0.000	0.002	0.001	0.003	0.001
	(0.69)	(0.90)	(0.28)	(1.48)	(1.31)	(1.95)	(1.20)	(3.11)
Forward^{f}	0.004		−0.001		−0.014		0.037	
	(0.91)		(−0.20)		(−2.70)		(1.46)	
Forward^{f2}	−0.001	−0.001	−0.000	−0.000	0.001	−0.000	−0.003	−0.001
	(−2.17)	(−3.77)	(−0.96)	(−1.61)	(1.40)	(−1.03)	(−1.80)	(−1.43)
Horizontal^{f}	−0.002		−0.001		−0.001		−0.001	
	(−2.12)		(−0.89)		(−0.46)		(−0.69)	
Horizontal^{f2}	−0.000	−0.000	−0.000	−0.000	−0.001	−0.001	−0.001	−0.001
	(−17.65)	(−11.57)	(−9.83)	(−10.34)	(−8.22)	(−11.77)	(−9.51)	(−14.40)
Constant	0.013	−0.009	0.046	−0.003	0.112	0.065	0.097	0.090
	(0.45)	(−0.75)	(3.09)	(−0.08)	(2.76)	(1.95)	(2.26)	(2.22)
NT obs.	49,725	49,725	43,138	43,138	36,719	36,719	30,450	30,450
R^2	0.018	0.018	0.040	0.039	0.063	0.061	0.069	0.068
Services and building—knowledge intensive								
	First diff.	First diff.	Second diff.	Second diff.	Third diff.	Third diff.	Fourth diff.	Fourth diff.
Herfindahl	−0.000	−0.000	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001
	(−16.27)	(−63.19)	(−8.96)	(−8.74)	(−8.22)	(−4.28)	(−9.25)	(−7.95)
Backward^{f}	0.010		0.028		0.146		0.115	
	(0.75)		(0.68)		(1.83)		(1.33)	
Backward^{f2}	0.002	0.002	0.000	0.001	−0.006	0.005	−0.001	0.005
	(0.38)	(0.66)	(0.04)	(0.20)	(−0.59)	(0.88)	(−0.15)	(0.73)
Forward^{f}	0.001		−0.021		−0.039		−0.018	
	(0.40)		(−1.03)		(−1.21)		(−0.21)	
Forward^{f2}	0.002	0.002	0.002	0.001	0.002	−0.001	0.000	−0.002
	(2.88)	(2.47)	(2.33)	(1.57)	(1.03)	(−1.30)	(0.08)	(−0.80)
Horizontal^{f}	0.002		0.001		0.006		0.008	
	(2.10)		(0.89)		(1.93)		(3.35)	
Horizontal^{f2}	−0.000	0.000	0.000	0.000	−0.000	0.000	0.000	0.000
	(−0.09)	(0.25)	(0.76)	(2.33)	(−0.14)	(0.90)	(0.05)	(2.40)
Constant	−0.007	0.002	0.101	0.009	0.093	−0.012	0.155	−0.068
	(−0.18)	(0.05)	(2.29)	(0.11)	(1.51)	(−0.15)	(1.48)	(−0.72)
NT obs.	65,782	65,782	56,873	56,873	48,066	48,066	39,386	39,386
R^2	0.015	0.014	0.025	0.024	0.028	0.026	0.023	0.022

[a] The *t* statistics in parentheses have been corrected for clustering for each industry in each year

Table 13 Reverse spillovers from domestic firms to multinationals (estimated coefficients)

Manufacturing industries	High and medium technology				Low technology			
	First diff.	Second diff.	Third diff.	Fourth diff.	First diff.	Second diff.	Third diff.	Fourth diff.
ForeignShare	0.000	0.000	0.000	0.001	−0.000	0.000	0.000	0.000
	(0.78)[a]	(0.56)	(1.31)	(1.70)	(−0.56)	(0.55)	(1.72)	(1.42)
Herfindahl	−0.000	−0.000	−0.000	−0.000	−0.001	0.001	0.001	−0.001
	(−1.59)	(−0.00)	(−0.74)	(−0.01)	(−0.49)	(0.35)	(0.75)	(−0.44)

Table 13 (continued)

Manufacturing industries	High and medium technology				Low technology			
	First diff.	Second diff.	Third diff.	Fourth diff.	First diff.	Second diff.	Third diff.	Fourth diff.
Backward^d	0.005	−0.004	−0.018	−0.022	0.003	0.008	−0.001	0.005
	(0.96)	(−0.61)	(−1.46)	(−1.63)	(2.01)	(2.08)	(−0.20)	(1.16)
Forward^d	−0.006	−0.001	0.010	0.011	−0.000	−0.002	−0.001	−0.001
	(−1.39)	(−0.14)	(1.04)	(0.97)	(−0.03)	(−0.96)	(−0.52)	(−0.86)
Horizontal^d	0.006	0.007	0.007	0.010	0.003	0.000	−0.000	−0.001
	(2.23)	(3.00)	(2.69)	(3.21)	(2.76)	(0.14)	(−0.09)	(−0.29)
Constant	0.022	−0.031	0.078	0.014	0.022	−0.005	−0.059	0.023
	(0.83)	(−0.66)	(1.51)	(0.29)	(0.70)	(−0.08)	(−0.77)	(0.36)
NT obs.	9654	7849	6229	4798	12,376	9907	7736	5838
R^2	0.02	0.03	0.05	0.06	0.01	0.01	0.01	0.01
Services and building	Knowledge intensive				Less knowledge intensive			
	First diff.	Second diff.	Third diff.	Fourth diff.	First diff.	Second diff.	Third diff.	Fourth diff.
ForeignShare	0.001	0.001	0.001	0.000	0.001	0.001	0.001	0.001
	(3.95)	(2.53)	(2.12)	(0.09)	(2.27)	(2.87)	(1.99)	(0.90)
Herfindahl	−0.001	0.000	−0.000	−0.001	−0.002	−0.003	−0.003	−0.001
	(−1.58)	(0.06)	(−0.09)	(−0.71)	(−2.84)	(−3.11)	(−3.60)	(−0.84)
Backward^d	−0.043	−0.060	−0.129	−0.136	0.003	−0.008	−0.009	−0.007
	(−4.43)	(−3.50)	(−3.91)	(−1.77)	(0.55)	(−1.45)	(−1.09)	(−1.49)
Forward^d	0.015	0.025	0.030	0.035	−0.002	0.009	0.009	0.005
	(1.49)	(4.31)	(11.39)	(2.37)	(−0.40)	(1.51)	(0.99)	(0.99)
Horizontal^d	0.003	0.004	0.005	0.003	−0.015	−0.011	−0.009	−0.018
	(0.67)	(3.21)	(2.88)	(1.72)	(−3.58)	(−2.62)	(−1.36)	(−2.01)
Constant	−0.194	0.365	0.647	0.097	−0.176	−0.069	−0.212	−0.183
	(−4.43)	(6.76)	(6.66)	(1.27)	(−4.96)	(−1.92)	(−2.06)	(−2.68)
NT obs.	4205	3185	2307	1591	8178	5987	4238	2808
R^2	0.02	0.03	0.04	0.05	0.03	0.04	0.04	0.04

[a] The *t* statistics in parentheses have been corrected for clustering for each industry in each year

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