

WHY IS THERE SO LITTLE EVIDENCE ON KNOWLEDGE SPILLOVERS FROM FOREIGN DIRECT INVESTMENT?*

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Abstract

Empirical analyses of knowledge spillovers from FDI offer mixed results; they find positive, neutral and negative FDI spillover effects. The lack of evidence on FDI spillovers is predominantly due to the results of the firm level panel data analysis. This is important since this approach seems to be the most appropriate for estimating FDI spillovers. The paper looks at recent substantive and methodological developments in FDI spillover analysis, which brought some more optimistic results as far as FDI spillovers is concerned, and can help in further development of the analysis. The main substantive development relates to the introduction of a broad variety of sources of firm (foreign affiliates as well as local firms) heterogeneity in the analysis. Two others are differentiation between vertical (inter-industry) and horizontal (intra-industry) spillovers, and host country absorption capacity for knowledge spillovers. Methodological developments relate to distinguishing between technological/knowledge and productivity spillovers, to the improvement of modelling and estimation methods, and to the increased amount and quality of data.

Keywords: foreign direct investment, knowledge spillovers, firm heterogeneity

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1. Introduction

When knowledge is an economic good, the possibility of ‘spillovers’ arises. The neoclassical endogenous growth models of the early 1990s (Romer, 1986, 1990; Aghion and Howitt, 1992, 1998; Grossman and Helpman, 1991) suggest that knowledge spillovers arise from two aspects of technology. The first is that the return to technological investments is partly private and partly public, and the second is the non-rival character of technology (Keller, 2004). This means that technological investments often create benefits to others than the inventor, another firm may use an innovation produced by one firm, without incurring additional cost, i.e. the marginal costs for an additional agent to use this innovation are negligible (Furman, Kyle, Cockburn and Henderson, 2006). The work of Griliches (1979, 1992) is central to the economics of spillovers. He outlined the importance of spillovers for economic growth, and the problems related to the empirical measurement of spillovers.

This paper looks at one specific type of knowledge spillovers, i.e. at knowledge spillovers from FDI. Knowledge spillovers from FDI take place when the entry or presence of foreign affiliates, which have typically better technologies and organizational skills than domestic firms, increases knowledge of domestic firms, and multinational companies (MNCs) do not fully internalize the value of these benefits (Smarzynska, 2003). The presence of a foreign subsidiary can thus increase the rate of technical change and technological learning in the host economy indirectly through knowledge spillovers to domestic firms.

FDI spillovers is probably the most extensively analyzed channel of knowledge spillovers in the literature. Academic literature, as well as policy makers increasingly treat FDI spillovers as very (if not the most) important FDI development effect for host countries. The economics of investment incentives is largely based on the possibility of positive knowledge

spillovers from foreign subsidiaries to domestic firm. Still, the empirical evidence on FDI spillovers offers mixed results. Econometric analyses find positive, neutral and negative FDI spillover effects. There can be FDI spillovers, but there is no strong consensus on the magnitudes of FDI spillovers, nor on the causality.

By the way of analysing theoretical and empirical literature on FDI spillovers, we make an attempt to find the substantive and methodological reasons for the lack of evidence on FDI spillovers in the empirical literature. Is there really a lack of knowledge spillovers from foreign subsidiaries to domestic firms, or is it more that data and methodological problems do not allow to identify them, what are the factors on the side of foreign investors, foreign subsidiaries, host country domestic firms and host country in general that affect the size of FDI spillovers etc.? The answers to these questions are not only of an academic interest but are also of relevance for policymakers. At the end of the day, as Keller (2004) puts, they need to know whether FDI spillovers are quantitatively large enough to justify the large subsidies that governments provide to attract FDI.

We find that the lack of evidence on FDI spillovers is predominantly due to the results of the firm level panel data analysis. This is important since this approach seems to be the most appropriate for estimating FDI spillovers. Recent substantive and methodological developments in FDI spillover analysis brought some more optimistic results as far as FDI spillovers is concerned, and can help in further development of the analysis. The main substantive development relates to the introduction of a broad variety of sources of firm (foreign affiliates as well as local firms) heterogeneity in the analysis. Two others are differentiation between vertical (inter-industry) and horizontal (intra-industry) spillovers, and host country absorption capacity for knowledge spillovers. Methodological developments relate to distinguishing between technological/knowledge and productivity spillovers, to the

improvement of modelling and estimation methods, and to the increased amount and quality of data.

The paper is structured as follows. Introduction is followed by a short inventory of types and channels of knowledge spillovers from FDI. Section three analyses the results of empirical studies on FDI spillovers and identify the substantive reasons for the lack of evidence on FDI spillovers. Section four analyses the data and methodological reasons for the lack of evidence on FDI spillovers. Section five concludes and summarize the proposals for further improvements of FDI spillovers' analysis.

2. Types and channels of knowledge spillovers from FDI

Kokko (1992) and Blomström and Kokko (1998) identify four ways how technology might be diffused from foreign affiliates to other firms in the host economy: demonstration-imitation effect, competition effect, foreign linkage effect and training effect. Demonstration-imitation effects occur if there are arm's length relationships between MNCs and domestic firms and domestic firms learn superior production technologies and other knowledge from MNCs. The most important forms are imitation of managerial and organizational innovation, and imitation of technology. Competition effect is when competition from MNCs force domestic rivals to update production technologies and techniques to become more productive. Foreign linkage effect relates to export spillovers. Domestic firms can learn to export from MNCs (Görg and Greenaway, 2004). Training effect is if there are movements of highly skilled personnel from MNCs to domestic firms; these employees may take with them knowledge which may be usefully applied in the domestic firm (Görg and Strobl, 2001). Not all spillovers are positive as FDI can generate negative externalities when foreign subsidiaries with superior technology force domestic firms to exit, since they attract away demand from

them. These negative externalities are an aspect of competition effect and are also called crowding-out effect or business-stealing effect. Aitken and Harrison (1999) for Colombia and Venezuela, Haddad and Harrison (1993) for Morocco, Djankov and Hoekman (2000) for the Czech Republic found evidence of such negative externalities.

A number of authors introduce new (sub)types of FDI spillovers, and/or further elaborate on specific types of FDI spillovers. Thus, Görg and Greenaway (2004) distinguish two mechanisms of the training effect; direct spillovers through complementary workers, and indirect mechanism when workers move and transfer knowledge between foreign and domestic firms. Smarzynska (2003: 4-5) distinguish between knowledge (copying technologies of foreign affiliates, observation or hiring workers trained by foreign subsidiaries) and competition spillovers (MNC entry leads to more severe competition and force domestic firms to higher efficiency and search for new technologies). According to Rodriguez-Clare (1996), spillovers may also occur because MNCs give access to new specialized intermediate inputs or because domestic firms use local intermediate goods' suppliers, whose productivity has been raised through the know-how of the MNC. Ornaghi (2004: 5-6) pleads for the differentiation between channels of technology spillovers in the case of process and product innovations. Imitation of a product innovation mainly occurs through reverse engineering, while the diffusion of process innovation may require more sophisticated channels, such as industrial espionage or recruitment of engineers and experts of rival firms.

Traditionally, empirical research of FDI spillovers dealt mainly with horizontal, intra-industry spillovers. In the recent period, however, differentiation between FDI spillovers that occur between firms being vertically integrated with the MNC (vertical, inter-industry spillovers to domestic firms in upstream and downstream industries) or in direct competition with it (horizontal, intra-industry spillovers) has been one of the most extensively studied

aspects of FDI spillovers. The economics behind this differentiation is based on the following: since MNCs have an incentive to prevent information leakages that would enhance the performance of their local competitors, but at the same time may want to transfer knowledge to their local suppliers, spillovers from FDI are more likely to be vertical rather than horizontal in nature. Vertical spillovers are of two types, backward linkages when domestic firms are suppliers of foreign affiliates, and forward linkages when domestic firms are customers of foreign affiliates. The authors, who explicitly bring the notion of vertical and horizontal spillovers in the literature, like Blalock (2001), Schoors and van der Tol (2001), Smarzynska (2001, 2003), Damijan, Knell, Majcen and Rojec (2003b) etc., all provide evidence of positive FDI spillovers through backward linkages. The most important channels of backward linkages are direct knowledge transfer, higher requirement for product quality and on-time delivery introduced by MNCs and the fact that the MNC entry can increase demand for intermediate goods (see Javorcik, 2004; Lall, 1980; Smarzynska, 2003; Markusen and Venables, 1999).

One of the most important, but very often ignored, issues related to FDI spillovers is inability to distinguish between productivity and technological (knowledge) spillovers from FDI. 'Whereas the former occur whenever the presence of foreign firms on the national territory produces an increase in the average productivity of domestic firms, the latter requires that this increase should be associated with an improvement in the techniques used by local firms' (Perez, 1998: 22-23). Yet, the generally accepted measure of knowledge (technological) spillovers from FDI is the impact of FDI on domestic firms' productivity¹, i.e. empirical studies of knowledge spillovers from FDI as a rule regress productivity growth on

¹ One of the exceptions to this practice is Caves (1974) who uses the term spillovers of productivity but distinguishes between allocative efficiency benefits, on the one hand, and technical efficiency and technological transfer on the other. Also Blomström and Wolff (1994) draw a distinction between technological spillovers and the improvements in the average productivity of domestic firms deriving from the closure of the less competitive ones, Kokko (1992) instead gets round the problem by treating the two terms as interchangeable (see Perez, 1998: 22-23).

foreign presence. The result is then interpreted as the impact of FDI on domestic firms knowledge (technological) capacity. This is obviously only the second best measure of knowledge (technological) spillovers, which is adopted because of the unavailability of a more adequate measure, i.e. the impact of foreign subsidiaries on domestic firms' innovation activity.

Using the proxy of productivity spillovers is conceptually based on the generally accepted premise that technology plays a key role in determining productivity. The problem is that there are other factors, apart from technological externalities, that have an impact on productivity spillovers and are not controlled for in the models. In other words, technological externalities may be the most important factor of productivity spillovers, but not the only one. To the extent that productivity spillovers are also a result of other factors apart from technological externalities, the productivity spillovers are not really a good indicator of technological externalities.² There are also factors that may prevent the transformation of technological externalities into productivity spillovers, like the bankruptcy of domestic firms due to strong foreign competition, insufficient absorption capacity of domestic enterprises for technological externalities, system/institutional deficiencies, and so on.

To conclude, knowledge spillovers are difficult to measure, since, as Krugman (1991: 53) points out, 'knowledge flows ... leave no paper trail which they may be measured and tracked.' The approach to FDI spillovers adopted in the empirical literature largely avoids the question how technology spillovers actually take place, and focuses on the simpler issue of whether the presence and magnitude of MNCs affect productivity in domestic firms (Görg and Strobl, 2001).

² Ormaghi (2004) points exactly to this issue. Her results in the Spanish case suggest that knowledge spillovers play an important role in improving the quality of products and, to a lesser extent, in increasing the productivity of the firm.

3. Results of empirical studies on knowledge spillovers from FDI: Substantive reasons for the lack of evidence

The substantial body of empirical literature on FDI spillovers, which has developed in the last nearly 30 years, has produced mixed empirical results. The econometric analyses have found positive, neutral, as well as negative spillovers from foreign subsidiaries to domestic firms. The discussion on FDI spillovers mainly focuses on estimates of the magnitude of intra-industry FDI spillovers in terms of domestic productivity, which constitutes the largest and the most influential literature (Keller and Yeapl, 2003: 3-5). Overviews of literature on FDI spillovers (see, for instance, Görg and Strobl, 2001; Görg and Greenaway, 2004; Hanson, 2001; Smarzynska, 2003; Keller and Yeapl, 2003; Keller, 2004) mostly identify three types of analysis, i.e. case studies, sectoral studies and lately primarily firm level data based studies. They seem to point pretty much in the same direction. The evidence suggests that there can be FDI spillovers, but they do not occur everywhere to the same degree (Keller, 2004: 58-65). There is also no strong consensus on the associated magnitudes of FDI spillovers (Blomström, Globerman and Kokko, 2000), or on the causality (Lim, 2001). Rodrik (1999), for instance, argues that much if not most of the correlation between FDI and superior economic performance is driven by reverse causality, i.e. MNCs tend to locate in the more productive, faster growing and profitable economies.

Case study analyses. A number of case studies of recent large scale FDI projects have produced somewhat mixed results. For instance, Larrain, Lopez-Calva and Rodriguez-Clare (2000) argue that Intel's investment in Costa Rica in 1997 generated substantial benefits for the local economy, whereas Hanson's (2001) discussion of three other recent cases suggests spillovers are non-existent at all or small (Keller and Yeapl 2003: 3-5).³ The Wal-Mart

³ For case study approach to FDI spillovers see also Rhee and Belot (1990), and Moran (2001).

operation in Mexico is one of the last in the long row of case studies of FDI in developing countries. Javorcik, Keller and Tybout (2006) claim that the entry of Wal-Mart led to fundamental changes in the structure of the ‘soaps, detergents and surfactants’ sector and the retail sector in general. In interpreting the case studies results one should be careful and aware that they rarely offer quantitative information and are not easily generalized (Smarzynska, 2003: 1-2).⁴

Industry level analyses. For a long time, empirical research on FDI spillovers was dominated by industry level studies, most of which show a positive correlation between foreign presence and sectoral productivity (Smarzynska, 2003). In the first empirical study of this kind, Caves (1974) using cross-sectional data for Australian manufacturing in 1966, finds evidence of positive spillovers. His initial approach has been refined and extended subsequently by, for example, Globerman (1979) for Canadian industry, Blomström (1986), Blomström and Persson (1983), Blomström and Wolff (1994) and Kokko (1994) for Mexico, Blomström, Kokko and Zejan (1994) for Uruguay, Sjöholm (1999) for Indonesia, and Xu (2000) for US outward FDI in manufacturing in 40 countries. These studies, all of which use cross-sectional data, find statistically significant positive effects of the presence of MNCs on productivity in domestic firms (Görg and Strobl, 2001: 724-726). Xu (2000) also finds that positive relation between FDI and productivity growth is stronger in the richer than in the poorer countries (Keller, 2004). Hubert and Pain (2000), using an industry-level panel data set, find that foreign owned firms have a significant positive effect on the level of technical efficiency of domestic UK firms. On the other hand, Blomström (1996), finds that entry of new foreign producers into the Mexican market is not associated with an increase in the productivity level of local firms, and a study of U.S. firms in Europe shows that spillovers were localized and that competition forced many local competitors out of small markets

⁴ On advantages and disadvantages of case study approach to technology transfer, see more in Pack (2006). Probably his main message is that econometric and case studies are complementary.

(Cantwell, 1989). The downside of sectoral studies is the difficulty in establishing the direction of causality. A positive association may result from the tendency of MNCs to locate in high productivity industries rather than by genuine productivity spillovers. It may also be a result of FDI inflows forcing less productive domestic firms to exit and/or MNCs increasing their share of host country market, both of which would raise average productivity in the industry (Smarzynska, 2003).

Firm level analyses. Firm level panel data analysis focuses on whether the productivity of domestic firms is correlated with the extent of foreign presence in their sector or region. The main reason that FDI spillovers literature moved towards using panel data was a heterogeneity problem (Keller, 2004). Görg and Strobl (2001) argue that panels, using firm level data are the most appropriate estimation method because they look at: (i) development of domestic firms' productivity over a longer period of time, rather than relying on one data point; and (ii) spillovers, after controlling for other factors (time invariant differences in productivity across sectors which might be correlated with, but not caused by, foreign presence). Thus, firm level panel data analysis uses regressions of productivity on FDI and a number of control variables. Most firm level studies cast doubt on the existence of FDI spillovers in developing countries (Haddad and Harrison, 1993; Aitken and Harrison, 1999; Harrison, 1996; Blomström and Sjöholm, 1999; Lim, 2001 etc.); if positive they have been found to be limited to certain (types of) industries (Haddad and Harrison, 1993; Blomström and Sjöholm, 1999; Blomström, Kokko and Zejan, 1994). The picture is slightly more optimistic for industrialized countries (Girma, Greenaway and Wakelin, 2001; Haskel, Pereira and Slaughter, 2001; Barry, Görg and Strobl, 2002; Alvarez, Damijan and Knell, 2002 etc.). For transition countries, most of the firm level panel data analyses also suggest that there are few intra-industry spillovers from FDI (Konings, 2001; Djankov and Hoekman, 2000; Kinoshita, 2000; Damijan, Knell, Majcen and Rojec, 2003a, 2003b; Sabirianova, Svejnar and

Terrell, 2005 etc.). Some of more recent studies provide more optimistic results about FDI spillovers in some transition countries, at least in some sectors or categories of FDI, like in the case of firms engaged in R&D, in production of electrical equipment or in the case of export oriented FDI (Tytell and Yudaeva, 2005; Nicolini and Resmini, 2006).

The overall impression of the lack of evidence on FDI spillovers is predominantly due to the results of the firm level panel data analysis. This is important since this approach seems to be the most appropriate method for estimating FDI spillovers. What are the reasons for the lack of evidence on FDI spillovers? The reasons are of a substantive and of a methodological nature. Substantive reasons relates to the fact that in the number of cases there are really no (or even negative) spillovers, and to the fact that often the necessary preconditions for spillovers are lacking in the host countries. Methodological reasons relate to the lack of quality and detailed enough data bases and to inadequate econometric methods used.

Let us first tackle the substantive reasons (Methodological reasons will be tackled in the next section). Görg and Greenaway (2001, 2004) list a number of factors as a reason for the failure to find unambiguously positive effects in econometric work:

- MNCs may be effective at ensuring their technology advantages and other firm specific assets, and advantages do not spill over, i.e. they may be able to prevent leakages to domestic firms and, therefore, no or only little spillovers occur.
- Foreign firms may reduce the productivity of domestic firms through competition effects. Superior foreign firms may attract demand away from domestic firms, and productivity of domestic firms fall (Aitken and Harrison, 1999; Caves, 1996; Konings, 2001; Sgard, 2001; Görg and Strobl, 2001).
- Positive spillovers may only affect a sub-set of firms and aggregate studies, therefore, underestimate the true significance of such effects. This is the firm heterogeneity problem, meaning that FDI spillovers depend on geographical distance between foreign subsidiaries

and domestic firms, on domestic firms absorptive capacity or technology gap to foreign subsidiaries (Kokko, Tansini and Zejan, 1996), industry characteristics (Keller and Yeapl, 2003), company size (Aitken and Harrison, 1999) etc.⁵

- Spillovers may not occur horizontally (intra-industry) but through vertical relationships which are missed in conventional spillover studies.
- The existence and scale of FDI spillovers depend on a number of factors in a host country, like well-functioning markets and an undistorted trade and foreign investment regime.

The newest developments in the firm level panel data analysis of FDI spillovers seem to eliminate a number of the above mentioned problems of FDI spillovers analysis. These developments go in the direction of introducing a number of new determinants of FDI spillovers in the analysis. These determinants can be classified into three groups:

- a/ Differentiation between inter-industry vertical and intra-industry horizontal FDI spillovers, and further distinction between backward and forward vertical linkages
- b/ Firm (foreign investors, foreign subsidiaries, domestic firms) heterogeneity
- c/ Host country specificities (absorption capacity)

Further on we elaborate on each of the above groups of determinants of FDI spillovers.

Table 1
Additional determinants of FDI spillovers brought in the analysis by recent literature

Study/Determinant/Analysed country	Major findings
VERTICAL VS HORIZONTAL SPILLOVERS	
Blalock, 2001 (Indonesia)	Positive backward linkages
Smarzynska, 2003 (Lithuania)	Positive backward spillovers
Schoors and van der Tool, 2001 (Hungary)	Positive vertical spillovers
Kugler, 2006 (Columbian manufacturing sector)	Knowledge spillovers from FDI exist between but not within industries
Halpern and Murakozy, 2006 (Hungary)	Positive vertical and negative horizontal FDI spillovers
Damijan, Knell, Majcen, Rojec, 2003b (Transition countries)	Direct effects the most important, vertical spillovers much more important than horizontal

⁵ Kokko, Tansini and Zejan (1996) find evidence for productivity spillovers only to domestic firms with moderate technology gaps vis a vis foreign firms. Keller and Yeapl (2003) in the case of US firms claim that FDI spillovers are much larger in the relatively high technology industries, meaning that the overall result depends on the relative importance of high technology industries in the host economy. Aitken and Harrison (1999) find that productivity in small Venezuelan firms has increased following the presence of MNCs, while there does not appear to be similar effect on large domestic firms.

Gorodnichenko, Svejnar and Terrell, 2006 (Transition countries)	Backward vertical spillovers positive, forward vertical spillovers no effect, horizontal spillovers positive for large firms
Smarzynska and Spatareanu, 2002 (Romania)	Negative vertical spillovers
FIRM HETEROGENEITY	
1. Geographical distance	
Griliches, 1979, 1992	Geographical proximity matters for spillovers
Görg and Greenaway, 2004	Domestic firms located near to MNCs and their subsidiaries may be more likely to benefit than other firms
Audretsch, 1998	Geographical proximity is necessary to facilitate knowledge spillovers
Jacobs, 1993	Geographical proximity is necessary to facilitate knowledge spillovers, especially for tacit knowledge
Branstetter, 1996	Spillovers are primarily intranational in scope
Girma and Wakelin, 2002 (UK)	Positive spillovers for firms located in the same region as foreign subsidiaries
Sgard, 2001 (Hungary)	Firms located in the most developed region, closer to EU borders, benefit most from externalities associated with FDI
Sgard, 2001 (Hungary)	Agglomeration effect: to have positive spillovers, foreign firms have to represent a substantial share of the economy
Halpern and Murakozy, 2006 (Hungary)	Distance matters for backward linkages in the Hungarian case
Sjöholm, 1999 (Indonesia)	No evidence for a regional component of spillovers
Aitken and Harrison, 1999 (Venezuela)	No evidence for a regional component of spillovers
2. Time/dynamic dimension	
Kosova, 2006 (Czech Republic)	Negative crowding-out effect is a static, short-term effect, positive spillovers need some time to appear.
Cantwell, 1989	With the passage of time foreign subsidiaries tend to intensify their vertical relations with local firms
3. Foreign investors' heterogeneity	
Abraham, Konings and Sloomackers, 2006 (China)	FDI from Western companies poses a competitive threat on domestic firms, FDI from Hong Kong, Macau or Taiwan generates positive effects on domestic counterparts
Perez, 1998 (Japan)	Japanese MNCs rather use their customary suppliers than the local ones
Graham and Krugman, 1989 (Japan) Levy and Dunning, 1993 (Japan)	Japanese MNCs encourage their usual Japanese suppliers to set up production units in countries receiving FDI
4. Foreign subsidiaries' heterogeneity	
<i>a/ Knowledge creating activities of foreign subsidiaries</i>	
Castellani and Zanfei, 2005 (Italy)	Positive spillovers to domestic firms are associated with the presence of R&D intensive foreign subsidiaries, which have long been established in Italy
Marin and Bell, 2004 (Argentina)	Substantial part of the potential for spillover is created within local subsidiaries as a result of their own knowledge-creating and accumulating activities in the host economy
<i>b/ Domestic vs export market orientation of foreign subsidiaries</i>	
Smarzynska, 2003 (Lithuania)	Larger vertical spillover effects are associated with domestic market oriented FDI
UNCTAD, 2001; Altenburg, 2000 (Developing countries); Belderbos, Campanelli and Fukao, 2001 (Japanese FDI abroad)	Domestic market oriented foreign subsidiaries tend to buy more local inputs than export oriented ones
Sgard, 2001 (Hungary)	Positive spillover effect is associated with export oriented FDI, inward looking FDI has negative side effects
Moran, 2005	Affiliates that are more integrated into MNC framework provide greater spillovers
Tytell and Yudaeva, 2005 (Poland, Romania, Russia and Ukraine)	Spillovers are positive only in the case of export oriented FDI
<i>c/ Acquisitions vs greenfield entities</i>	
UNCTAD, 2001	Acquisitions source more locally than greenfield entities

UNCTAD, 2000 (Swedish affiliates in transition countries)	Acquisitions source more locally than greenfield entities
Belderbos, Campanelli and Fukao, 2001 (Japanese investors abroad)	Acquisitions source more locally than greenfield entities
Toth and Semjen, 1999 (Hungary)	Acquisitions source more locally than greenfield entities
Smarzynska, 2003 (Lithuania)	No evidence that acquisitions source more locally than greenfield entities
<i>d/ Local equity participation/joint ventures vs wholly foreign-owned entities</i>	
Smeets and de Vaal, 2006 (22 transition countries)	Concave and not linear relationship exists between the level of foreign ownership and knowledge spillovers
Smarzynska Javorcik and Spatareanu, 2006 (Romania)	Spillovers are associated with shared domestic-foreign ownership rather than with wholly foreign-owned subsidiaries
Abraham, Konings and Sloommaekers, 2006 (Chinese manufacturing industry)	Spillovers are associated with shared domestic-foreign ownership rather than with wholly foreign-owned subsidiaries
Almeida and Fernandes, 2006 (Developing countries)	Spillovers are associated with shared domestic-foreign ownership rather than with wholly foreign-owned subsidiaries
Gorodnichenko, Svejnar and Terrell, 2006 (European transition countries)	Wholly owned foreign firms do not provide greater spillovers than joint ventures
5. Domestic firm heterogeneity	
<i>a/ Level of technological development/technological capacity</i>	
Cantwell, 1987, 1989	There exists a J-shaped relation between spillovers and the pre-existing level of local technological development
Perez, 1998 (UK and Italy)	Firms with lower technological gap to competitors experience positive effects of increased foreign presence and vice versa firms with higher technological gap
Halpern and Murakozy, 2006 (Hungary)	Firms with more advanced technology or R&D spending are likely to benefit more from the presence of foreign firms.
Abraham, Konings and Sloommaekers, 2006 (Chinese manufacturing industry)	Firms being far away from technological frontier do not benefit from the presence of foreign firms, while firms operating close to the frontier enjoy positive spillovers.
Girma, Gong and G6rg, 2006 (Chinese SOEs)	Firms that invest in R&D, or have prior innovation experience experience positive FDI spillovers.
Findlay, 1978	Bigger technological gap offers more room for technological spillovers
<i>b/ Human capital</i>	
Girma, Gong and G6rg, 2006 (Chinese SOEs)	Firms that invest in human capital experience positive FDI spillovers.
Gorodnichenko, Svejnar and Terrell, 2006 (Transition countries)	Firms with a higher educated workforce gain from the presence of foreign firms in their industry
<i>c/ Export propensity</i>	
Girma, Gong and G6rg, 2006 (Chinese SOEs)	Firms that export experience positive FDI spillovers.
Castellani and Zanfei, 2005 (Italy)	Exporters benefit more from foreign presence than other firms
<i>d/ Productivity level</i>	
Keller and Yeapl, 2003 (U.S.)	Relatively high productivity is required for a firm to acquire FDI related spillovers
Nicolini and Resmini, 2006 (Bulgaria, Romania and Poland)	Only more productive firms are able to reap technological externalities emanating from FDI
Haskel, Pereira and Slaughter, 2001 (UK)	Less productive (and smaller) plants receive on average stronger FDI spillovers than more productive (and larger) ones
Castellani and Zanfei, 2003 (France, Italy and Spain)	High productivity gaps tend to favour positive effects of FDI
HOST COUNTRY SPECIFITIES	
<i>a/ Level of development</i>	
Blomstr6m, Lipsey and Zejan, 1994 (Developing countries)	Positive influence of FDI on growth rates is confined to higher-income
Xu, 2000 (US outward FDI)	Positive relation between US outward FDI and productivity growth is stronger in the richer than in the poorer host counties
<i>b/ Level of human capital</i>	

Borenstein, De Gregorio and Lee, 1998 (Developing countries)	Positive contribution of FDI to economic growth is greater the higher the level of human capital stock in the host economy
<i>c/ Investment and business climate</i>	
Moran, 1998	Liberal investment and business climate tend to generate stronger FDI spillovers
Keller, 2004	Well-functioning markets and an undistorted trade and foreign investment regime are conducive to the spillover effects
Balasubramayam, Salisu and Sapsford, 1996, 1999	FDI growth contribution is greater in outward oriented or neutral trade regimes
Ernst, 1998	Domestic content-restricted FDI are characterised by the lags in the utilization of advanced management systems
Haddad and Harrison, 1993 (Morocco)	Negative correlation between the presence of trade barriers and the productive efficiency of domestic firms
Blomström and Persson, 1983 (Mexico)	No evidence for correlation between protectionist policies and the productivity of domestic firms
<i>d/ Level of infrastructure</i>	
Kinoshita and Lu, 2006 (Developing countries)	Technology spillovers via FDI take place only when the host country has the sufficient level of infrastructure.
<i>e/ Cluster development</i>	
De Propris and Driffield, 2006	Existence of clusters in a host country may promote FDI spillovers
<i>f/ Local financial market development</i>	
Alfaro, Chanda, Kalemli-Ozcan and Sayek, 2006	Development of host country financial markets has positive impact on FDI spillovers
<i>g/ Host country size</i>	
Knell and Rojec, 2007	Host economy should have a certain critical size to enable foreign subsidiaries to engage local suppliers
HOME COUNTRY SPECIFITIES	
Abraham, Konings and Sloomackers, 2006 (China)	There are differences in spillover effects in terms of foreign investors home countries

3.1. Vertical and horizontal FDI spillovers

The fact that entry of a MNC may stimulate the development of host country upstream industries supplying parts or components has been recognised long ago (Markusen and Venables, 1999). However, only relatively recently, empirical studies of FDI spillovers take explicit account of the differentiation between vertical and horizontal spillovers. The overwhelming conclusion of these studies is that horizontal intra-industry spillovers are less likely to take place than vertical spillovers. With rare exceptions - Smarzynska and Spatareanu (2002) for Romania - these studies mostly suggest positive vertical spillovers for host countries. Thus, Blalock (2001) finds positive productivity spillovers from FDI in upstream industries in Indonesia; Schoors and van der Tool (2001) find positive vertical spillovers in Hungary; Kugler (2006) finds FDI knowledge spillovers between but not within

industries of the Colombian manufacturing sector; Smarzynska (2003) finds positive backward FDI spillovers but no horizontal spillovers in Lithuania; for ten advanced transition countries, Damijan, Knell, Majcen and Rojec (2003b) find that vertical spillovers are much more important than horizontal spillovers, Halpern and Murakozy (2006) find positive vertical and negative horizontal FDI spillovers in Hungary. The results of Gorodnichenko, Svejnar and Terrell (2006) do not go fully in the same direction. Testing for FDI spillovers in a number of transition countries, they find that horizontal spillovers are consistently positive for large firms and negative (but not significant) for small firms. Supplying a foreign firm (backward FDI linkages), whether in the host country or outside of the country through exports, has positive productivity spillovers whereas purchasing from foreign firms (forward FDI linkages) has no such effect.⁶ The message of the above research is more than clear; empirical studies on technology spillovers should differentiate between horizontal and vertical spillovers, while the analysis of vertical spillovers should further differentiate between backward and forward linkages induced by foreign affiliates.

3.2. Firm heterogeneity

FDI spillovers seem to be quite different, depending on specific characteristics of MNCs, subsidiaries and domestic firms involved. Studies that further disaggregate data into more homogenous groups of firms and plants, find more encouraging results (Görg and Greenaway, 2004). Therefore, the introduction of firm heterogeneity in the analysis is a very important development in empirical studies of FDI spillovers. Firm heterogeneity has many aspects. It basically relates to the heterogeneity of foreign investors, of foreign subsidiaries and of domestic firms, or a combination of them. Castellani and Zanfei (2005) put this in the

⁶ Other sources dealing with vertical versus horizontal FDI spillovers include Kugler (2001, 2002), Blalock and Gertler (2003), Damijan, Knell, Majcen and Rojec (2003a), Driffield, Munday and Roberts (2002),

following words: ‘not every MNC is a good source of externality and not every domestic firm is equally well placed to benefit from multinational activity’.

Geographical distance between foreign subsidiaries and domestic firms is probably the oldest recognised firm heterogeneity determinant of knowledge spillovers; it has been brought in the analysis already by Griliches (1979, 1992). Domestic firms that are located near to MNCs and their subsidiaries may be more likely to benefit than other firms (Görg and Greenaway, 2004). Geographical proximity is necessary to facilitate knowledge spillovers (Audretsch, 1998), because for transmitting knowledge face-to-face communication and other kinds of personal interaction are important, especially as far as tacit knowledge transfer is concerned (Jacobs, 1993). With the exception of Sjöholm (1999), and Aitken and Harrison (1999) who fail to find evidence for a regional component of FDI spillovers in Indonesia and Venezuela, empirical evidence confirms that technological spillovers are limited by distance. Branstetter (1996) claims that spillovers are primarily intranational in scope, Girma and Wakelin (2002) find positive spillovers in domestic UK firms located in the same region as foreign subsidiaries, while Sgard (2001) in domestic Hungarian firms located in the most developed region, closer to the EU borders. Halpern and Murakozy (2006) also find that distance matters for backward linkages in the Hungarian case. Externalities require that firms produce close to each other. Geographical distance has another aspect, i.e. the agglomeration effect seems to be at work. In order to have positive spillover effects, foreign firms have to represent a substantial share of the economy (Sgard, 2001).

Time/dynamic dimension of FDI spillovers has only exceptionally been present in the analysis of FDI spillovers but offers another possibility to improve the accuracy of the empirical research. Kosova (2006) tackles the problem by analyzing the effect of foreign firm presence on the growth and survival of domestic firms in the Czech Republic. She finds both

Harris and Robinson (2002), Girma, Görg and Pisu (2003).

negative crowding out effect and positive technology spillover effect. Crowding out appears to be a short-term or static phenomenon: initial foreign entry increases the exit rate of domestic firms. Subsequently, however, the growth of the foreign industry segment is accompanied by increases in both the growth rate and survival of domestic firms. All in all, firms in industries without foreign presence have higher exit rates than firms in industries with foreign presence. This seems to confirm that foreign subsidiaries tend, with the passage of time, to intensify their vertical relations with local firms and to establish more stable linkages with the local environment (Cantwell, 1989).

Heterogeneity of foreign investors. To the best of our knowledge there are no studies, which would include foreign investors' heterogeneity in the analysis of FDI spillovers. There are studies, however, which identify differences in spillovers according to the home country of foreign investors. Abraham, Konings and Slootmaekers (2006) claim that FDI from Western companies poses a competitive threat on Chinese firms, while FDI coming from Hong Kong, Macau or Taiwan generates positive effects on their Chinese counterparts. Studies of Japanese MNCs suggest that after investing abroad they tend to continue with their customary suppliers, rather than use the local ones (Perez, 1998), or encourage their usual Japanese suppliers to set up production units in countries receiving FDI (Graham and Krugman, 1989; Levy and Dunning, 1993).

Heterogeneity of foreign subsidiaries relates to the position of a subsidiary in foreign parent company's network, domestic versus export market orientation of a subsidiary, acquisition versus greenfield type of FDI, and joint venture (local equity participation) versus wholly foreign owned subsidiaries. According to Castellani and Zanfei (2005), positive spillovers to domestic firms are associated with the presence of *R&D intensive foreign subsidiaries*, which have long been established in Italy. Similarly, Marin and Bell (2004) suggest that a substantial part of the potential for spillovers to industrial firms in Argentina is

created within local subsidiaries as a result of their own knowledge-creating and accumulating activities in the host economy.

Domestic versus export market orientation of foreign affiliates also seems to have an impact on the extent of (vertical) spillovers, but the empirical findings are not unanimous in this regard. Smarzynska (2003: 6) claims that larger vertical spillover effects are associated with domestic-market rather than export-oriented foreign subsidiaries. She explains this by the tendency of domestic-market-oriented foreign affiliates to purchase more locally than export-oriented ones (UNCTAD, 2001; Altenburg, 2000; Belderbos, Campannelli and Fukao, 2001). Quality and technical requirements associated with goods targeted for the domestic market may be lower and thus local suppliers may find it easier to serve MNCs focused on the domestic market. On the other hand, MNCs serving global markets may impose more stringent cost and quality requirements, which may be difficult for local suppliers to meet. Moreover, affiliates which are part of international production systems are likely to be more dependent on global sourcing policies of their parent company and thus have less freedom to choose their own suppliers. Arguments of some other authors go in the opposite direction. According to Sgard (2001), positive spillover effect of FDI on aggregate TFP growth of domestic firms in Hungary is significant only when associated with export orientation, while inward looking FDI has negative side effects. Moran (2005) argues that foreign parent companies are more interested to transfer knowledge to subsidiaries that are well integrated into their global network. Therefore, this kind of subsidiaries has a greater positive impact on the host country, often accompanied by vertical backward linkages and externalities. Subsidiaries that cater primarily to protected local markets have a much less positive – and sometimes demonstrably negative – impact on the local economy. Findings of Tytell and Yudaeva (2005) for Poland, Romania, Russia and Ukraine are similar, i.e. spillovers are

positive only in the case of export-oriented FDI and, more generally, influenced by the more productive foreign companies.

Another determinant for the extent of vertical FDI spillovers is whether a foreign subsidiary is established as an *acquisition or as a greenfield entity*. It has been argued that the former are likely to source more locally (UNCTAD, 2001). While greenfield investments have to take time and effort to develop local linkages, foreign acquisitions can take advantages of the supplier relationships established by the acquired firm. Empirical evidence to support this view has been found for Japanese investors (Belderbos, Campannelli and Fukao, 2001) and Swedish affiliates in transition countries (UNCTAD, 2000) and for foreign affiliates in Hungary (Toth and Semjen, 1999). Smarzynska (2003) has not find any evidence in this direction.

A similar issue is the *impact of local equity participation on FDI spillovers*. In econometric modelling the relationship between FDI ownership and knowledge spillovers has been largely absent. The studies that do take account of the relationship have assumed it to be linear. Smeets and de Vaal (2006) believe that this could provide one of the possible explanations for the apparent lack of consensus in empirical results on FDI spillovers. They propose and confirm, on the sample of firms from transition countries, a concave relationship between FDI ownership and knowledge spillovers instead of a linear one. Empirical studies, which explicitly take the factor of foreign ownership into consideration, seem to be more or less in line with what Smeets and de Vaal (2006) propose. These studies suggest that partial foreign ownership in the form of joint ventures and minority foreign-owned affiliates produce better results as far as spillovers to local firms is concerned than majority or wholly foreign-owned affiliates. Smarzynska Javorcik and Spatareanu (2006) for Romania, Abraham, Konings and Sloomackers (2006) for Chinese manufacturing industries, Almeida and Fernandes (2006) for developing countries, and Gorodnichenko, Svejnar and Terrell (2006)

for European transition countries all claim that (vertical) spillovers are rather associated with projects with shared domestic and foreign ownership than with fully foreign-owned subsidiaries. The latter, in fact, find no support for the hypothesis that wholly owned foreign firms provide greater spillovers than joint ventures for either vertical or horizontal relationships. Explanation of positive impact of local equity participation on FDI spillovers arises from direct participation of a local partner in foreign subsidiary/joint venture.⁷

Heterogeneity of domestic firms as determinant of knowledge and FDI spillovers relates primarily to their productivity, technological capacity and human capital. These factors determine domestic firms' absorption capacity for knowledge and FDI spillovers.⁸ Absorption capacity for knowledge spillovers is most frequently directly 'measured' by firm's *level of technological development*. Any technology gap signals something about absorptive capacity (Glass and Saggi, 1998). Given that MNCs tend to tap into local lines of technological development and/or to import more technology to productive locations in which local competition is strongest, existing centres of excellence in the development of a certain technology will benefit most from possible technological spillovers. In these productive areas the importing of technology by foreign subsidiaries, and the absorption of foreign technology by local firms, will interact to generate virtuous circles of technological development. Conversely, locations characterised by a lower level of development will receive productions with modest technological content. Of these latter locations, those where domestic firms have

⁷ Subsidiaries with joint domestic and foreign ownership face lower costs of finding local suppliers of intermediates and thus are more likely to engage in local sourcing than wholly owned foreign subsidiaries. As far as horizontal spillovers is concerned, less sophisticated technologies transferred to partially foreign owned subsidiaries, combined with better access to knowledge by local shareholders, may facilitate more knowledge spillovers to local firms than in the case of wholly foreign-owned subsidiaries (see, for instance, Smarzynska Javorcik and Spatareanu, 2006; Abraham, Konings and Sloomackers, 2006).

⁸ The issue of absorption capacity has attracted increasing attention of knowledge spillovers' literature, as well as of policy makers. Studies of Blomström (1986), Kokko (1994), Kokko, Tansini and Zejan (1996), Cameron (1996), Imbriani and Reganati (1997), Borensztein, De Gregorio and Lee (1998), Cameron, Proudman and Redding (1998), Perez (1998), Kinoshita (2000), Keller and Yeapl (2003), Damijan, Knell, Majcen and Rojec (2003a) Glass and Saggi (1998), Girma, Greenaway and Waklein (2001), Girma and Görg (2002), Griffith, Redding and Simpson (2004) all tend to confirm the importance of absorptive capacity for the magnitude of spillovers (Lim 2001: 4-9).

some lines of technological development but are not at the technological frontier are the ones most likely to be penalised by the presence of foreign MNCs, since the competitiveness of local firms may be affected by the expansion of the MNC brought about R&D conducted elsewhere. Locations with little (or no) productive development may instead at least benefit from the increased economic activity. There therefore exists, according to Cantwell, a J-shaped relation between spillovers and the pre-existing level of technological development of locations that receive FDI (Cantwell, 1987, 1989).

The empirical literature – Perez (1998) for UK and Italy, Halpern and Murakozy (2006) for Hungary, Abraham, Konings and Sloomakers (2006) for Chinese manufacturing sector, Girma, Gong and G6rg (2006) for Chinese SOEs - predominantly confirms that knowledge spillovers occur more frequently if technology gap between domestic and foreign firms is not too large and thus a sufficient absorptive capacity is available in domestic firms. In contrast, a handful of authors tend to claim that bigger technological gap offers more room for technological spillovers. Findlay (1978) suggests that the greater the distance between two economies in terms of development, the greater the backlog of available opportunities to exploit in the less advanced economy, the greater the pressure for change and therefore the more rapidly new technology is imitated/adopted.

Human capital capacity seems to be an alternative measure of firm's technological development. Thus, Gorodnichenko, Svejnar and Terrell (2006) put forward the importance of human capital for absorption capacity on a firm level; they find that in transition economies firms with a higher educated workforce gain from the presence of foreign firms in their industry. Girma, Gong and G6rg (2006) also claim that there is a positive effect of FDI on Chinese SOEs that invest in human capital.

Domestic firms' productivity level is also used as an alternative indicator of their absorption capacity. According to Keller and Yeapl (2003: 28), the U.S case shows that a

relatively high productivity is required for a firm to acquire FDI related spillovers. Also, in the case of Bulgaria, Romania and Poland, only more productive firms have been able to reap technological externalities emanating from FDI (Nicolini and Resmini, 2006). Quite the opposite, Haskel, Pereira and Slaughter (2001) estimate that less productive (and smaller) UK plants receive on average stronger FDI spillovers than more productive (and larger) ones. Castellani and Zanfei (2003), on the case of France, Italy and Spain, find that high productivity gaps tend to favour positive effects of FDI.

Export propensity of domestic firms also seems to have a positive influence on knowledge spillovers via FDI. Thus, Castellani and Zanfei (2005) claim that among Italian firms, exporters benefit significantly more from foreign presence than other firms, while Girma, Gong and Görg (2006) find that those Chinese SOEs that export experience positive FDI spillovers.

3.3. Host country specificities (absorption capacity)

The need to have adequate absorption capacity to be able to benefit from knowledge spillovers is not recognised only on the firm but also on the host country level. In the literature, host country's absorption capacity is defined in a rather diversified way; from very broad, as the overall development level of country's economy, technology, institutions etc., to much more specific measures, such as the level of technological development or the level of human capital.

The easiest way to proxy host country's absorption capacity is to look at its overall *level of development*. According to Blomström, Lipsey and Zejan (1994), positive influence of FDI on growth rates of developing countries seem to be confined to higher-income countries. The authors interpret this result as signifying that the host economy must be capable of absorbing

the new technology manifested in FDI. Xu (2000) claims that positive relation between US outward FDI and productivity growth is stronger in the richer than in the poorer host counties. Economists often conceive absorptive capacity as a certain *level of human capital*. Borenstein, De Gregorio and Lee (1998) find that impact of technology transfer via FDI and a positive contribution of FDI to developing countries' economic growth is greater the higher the level of human capital stock in the host economy (proxied by the level of educational attainment).

Another possible determinant of host country's absorption capacity is *investment and business climate* in a host country. Liberal investment and business climate tend to generate stronger spillovers because it is more likely to attract more dynamic FDI, which enjoys economies of scale, exhibits best management practices, is at the cutting edge technologically, while restrictive investment climate tend to attract FDI that is likely to be less efficient and exhibit older technology, as well as experiences slower rates of new technology transfer and lags in the utilization of advanced management systems (Moran, 1998; Lim, 2001: 4-9). Moran (1998) lists three types of restrictions which restrict the positive direct effects and spillovers of FDI: (i) restrictions of foreign ownership, (ii) national content requirements, and (iii) the imposition of host country mandates on the behaviour of foreign affiliates (Kokko and Blomström, 1995). Findings of Keller (2004: 60-61: well-functioning markets and an undistorted trade and foreign investment regime are conducive to the spillover effects), Balasubramayam, Salisu and Sapsford (1996, 1999: FDI growth contribution is significantly greater in outward oriented or neutral trade regimes compared to those pursuing import-substituting strategy), Ernst (1998: domestic content-restricted FDI are characterised by the lags in the utilization of advanced management systems), and Haddad and Harrison (1993: there is a negative correlation between the presence of trade barriers and the productive efficiency of Moroccan firms) confirm Moran's propositions. On the other hand, however,

Blomström and Persson (1983) fail to find evidence for significant correlation between protectionist policies and the productivity of Mexican firms.

Kinoshita and Lu (2006) show that technology spillovers via FDI in developing countries take place only when the host country has the sufficient *level of infrastructure*. If infrastructure falls short of the critical level than FDI has little effect on growth as the country is trapped in a low-growth equilibrium. Yet another possible determinant of knowledge and FDI spillovers, which has not been mentioned or analysed in the literature, is the *size of a host economy*. It seems logical that a host economy should have a certain critical size to enable foreign subsidiaries to engage local suppliers (Knell and Rojec, 2007). This seems especially relevant in the case of local suppliers, i.e. backward linkages. In the literature, one can find other host country determinants of FDI spillovers, like the impact of *cluster development* on FDI spillovers (De Propris and Driffield, 2006), the *role of local financial markets* in enabling FDI to promote growth through backward linkages (Alfaro, Chanda, Kalemli-Ozcan and Sayek, 2006).

Finally, a basic problem of spillovers analysis is the failure to better understand and to identify the exact mechanisms through which FDI facilitates knowledge spillovers (Griffith, Redding and Simpson, 2004: 16-19). Much work remains to be done until the precise process of spilling-over will be described correctly; the exact channels of embodied and disembodied spillovers remain undetermined (Hoppe, 2005: 40-42). Ornaghi (2004: 26-27) also claim that further work is needed to determine the channels that actually permit knowledge to flow and how these differ between product and process innovations.

4. Methodology and development of research on FDI spillovers

Broadly speaking one has three possible methodologies at hand when measuring technological and FDI spillovers: case studies, econometric analysis and simulation studies. All three can potentially prove to be very useful (Keller, 2004: 60-61). The issue of which methodology to use is important since there are some aspects of the empirical methods used, namely how the presence of MNCs is defined and whether cross-section or panel analysis is employed, which may have an effect on the results (Görg and Strobl, 2001). The most common approach to examining externalities to FDI in the existing empirical literature is to regress the productivity levels or growth rates of domestic-owned firms on a measure of foreign presence within an industry, such as the share of foreign affiliates in employment, sales etc. A series of more recent articles have relied upon micro-level, longitudinal data basis, which have allowed for a more precise approach than sector-level ones, which were a usual approach in 1970s and 1980s (Sgard, 2001: 9-10). Still, most studies use either the contemporaneous level of foreign penetration, or relatively short lags (most commonly a one year lag) as their explanatory variables. Therefore, these studies usually measure short run effects of foreign presence on domestic productivity (Görg and Greenaway, 2004). As argued above, this empirical literature has yielded mixed results.

Some authors try to identify technology transfers by patent citations. Branstetter (2001), e.g. shows that FDI between the US and Japan is associated with higher knowledge flows in terms of patent citations of US and Japanese firms. Globermann, Kokko and Sjöholm (2000), Branstetter (2001) and Singh (2003) tried to find econometric evidence on whether MNCs raise the rate of international technology transfers measured by patent citations. Their results are less clear and it appears that MNC affiliates learn more from the firms in their host country than vice versa, but here one faces the problem of firm heterogeneity and the endogeneity issue, the value of patent is also difficult to estimate (Keller, 2004). Griffith, Redding and Simpson (2004) adopt another empirical approach, which uses an

establishment's distance from the technological frontier as a direct measure of the potential for technology transfer. They find that foreign owned MNCs are frequently the technological leader within UK industries and that technology transfer from these technological leaders makes a substantial contribution to productivity growth in domestic owned.

Methodological reasons for the lack of evidence on FDI spillovers are no less important than the substantive ones. At the same time, recent period has brought a number of methodological and data developments, which result in a more optimistic estimates of FDI spillovers.⁹ Methodological issues of specific relevance for the analysis of FDI spillovers can be classified into three groups. The first is distinguishing between technological/knowledge and productivity spillovers, the second is improvement of modelling and estimation methods, and the third is the increased amount and quality of data.

Table 2
Methodological improvements of FDI spillovers' analysis brought in the analysis by recent literature

Study	Major findings
TECHNOLOGY/KNOWLEDGE VERSUS PRODUCTIVITY SPILLOVERS	
Perez, 1998	Productivity spillovers occur whenever the presence of foreign firms produces an increase in the productivity of domestic firms, technological spillovers require that this increase is associated with improvement in the techniques used by local firms.
Caves, 1974	Within spillovers of productivity distinguishes between allocative efficiency benefits, and technical efficiency and technological transfer on the other.
Blomström and Wolff, 1993, 1994	Draw a distinction between technological spillovers and the improvements in the average productivity of domestic firms deriving from the closure of the less competitive ones
Damijan, Jaklič and Rojec, 2006	Technological/knowledge spillovers should be measured by innovation and not productivity growth
Alvarez and Robertson, 2004	By using indicators of technological innovation one can avoid potentially controversial use of productivity measures
MODELLING AND ESTIMATION METHODS	
1. Aggregate/sectoral versus firm level studies	
Keller, 2004	The higher the level of aggregation, the stronger the evidence for externalities and learning effects. Micro data can capture heterogeneity across firms while aggregate level studies cannot control for this.
2. Simultaneity and endogeneity	
Keller, 2004	Simultaneity and endogeneity are more important issues than aggregation, and in

⁹ Keller and Yeapl (2003) analyse international technology spillovers to US manufacturing firms and find that FDI spillovers are significant and economically important. The authors claim that such result, which is much more optimistic than those of most other firm-level data based studies, is importantly due to the methodological improvements, which they introduced, and higher quality of data. Overall, Keller and Yeaple (2003) argue that their results are likely to generalize to other countries and periods once FDI activity can be properly measured.

	this respect there is little difference between micro and more aggregate studies. It is very important to identify the truly causal effect.
3. Cross-sectional versus panel data	
Görg and Strobl, 2001	Cross-sectional studies may overstate the spillover effects because they do not allow for the time-invariant firm or sector specific effects. Panel data allow to control for such factors
4. Shape of relationship between FDI spillovers and technological/productivity growth of domestic firms	
Perez, 1998	One must abandon the idea of linear relations between foreign presence and technological development of host countries.
Altomonte and Pennings, 2005	Changes in domestic firms' TFP are positively related to the first foreign investment in a specific industry and region, but get significantly weaker and become negative as the number of MNCs that enter in the considered industry/region increases.
Barrios, Görg and Strobl, 2004	There is a U-shaped relationship between foreign presence and spillovers; competition effect dominates when foreign presence is small, positive externalities appear as foreign presence increases.
5. Application of appropriate econometric technique	
Damijan, Knell, Majcen and Rojec, 2003b	Simple pooled OLS or static panel data techniques are not adequate for spillovers analysis.
Keller, 2004	Olley-Pakes' estimation method leads to a substantially greater role for FDI spillovers. Olley-Pakes results in a better estimate of in-sample productivity growth.
MORE AND BETTER DATA	
Keller and Yeapl (2003),	For econometric analysis of technological spillovers, it is of great importance that the data closely relates to the issues of technology and technology diffusion.
Alfaro and Rodriguez-Clare, 2004	Proper measure of linkages between foreign affiliates and domestic firms is the ratio of the value of inputs bought locally to the total number of workers hired by a MNC.
Keller and Yeapl (2003)	High importance of accurate measure of inward FDI in the host economy.
Görg and Strobl (2001)	It is preferable to use alternative measures of foreign presence before making conclusions on spillovers.

Technologicaly/knowledge versus productivity spillovers. In measuring the technological spillovers from FDI, most of the econometric studies resort to the second best solution, i.e. to the indirect measuring of technological spillovers as reflected in the productivity growth. In other words, what we usually measure are productivity spillovers and not technological spillovers. Thus, productivity spillovers are only an indirect indicator of technological externalities, which is often used because there is no direct indicator of 'technological growth'. Technological externalities may be the most important part of productivity spillovers, but not the only one. To the extent that productivity spillovers are also a result of other factors apart from technological externalities, the productivity spillovers are not really an accurate indicator of technological externalities (More on the issue see in section 2).

Modelling and estimation methods represent the second set of methodological factors, which offers room for further improvements of the analysis of knowledge spillovers from

FDI. Here, the issues relate to the level of aggregation, i.e. to the aggregate/sectoral versus firm level studies, to simultaneity and endogeneity, to cross-sectional versus panel data, to the shape of the relationship between FDI spillovers and technological/productivity growth of domestic firms, and to the application of appropriate econometric technique.

Level of aggregation importantly influences the results of FDI spillovers analysis. As claimed by Keller, the higher the level of aggregation, the stronger tends to be the evidence for externalities and learning effects. Micro data can capture heterogeneity across firms while aggregate level studies cannot control for this and may suffer from composition and aggregation biases that tend to lead to inflated spillovers estimates. Firm heterogeneity seems to be quite strong in the case of FDI spillovers and micro data sets provide a better estimation of micro behaviour, as the data is recorded right at the decision taking level (Keller, 2004: 60-61). In short, micro, firm level studies of FDI seem to be more accurate approach to studying FDI spillovers. Still, for Keller (2004: 60-61) *simultaneity and endogeneity* seem to be more important issues than aggregation, and in this respect there is little difference between micro and more aggregate studies. For instance, interpreting a cross-sectional correlation of foreign ownership and productivity as evidence for FDI spillovers would be just as inappropriate at the firm level as it is at the aggregate level. In this regard it is very important to identify the truly causal effect. Most strategies for doing that rely on comparing sets of firms (Keller, 2004: 60-61).

To improve the method of analysing technology and FDI spillovers, Görg and Strobl point to *the importance of panel data*. They claim that the results of spillover studies are less affected by whether the studies use sector or firm level data, than whether the data used are cross-sectional or panel data. Cross-sectional studies may overstate the spillover effects of MNCs on domestic productivity because they do not allow for the time-invariant firm or sector specific effects, which may impact on the relationship between MNCs and

productivity, but for which the researcher does not have any information. For example, high productivity sectors or firms may attract the location of MNCs in the same sector yielding a positive relationship between these even without spillovers taking place. Panel data would allow the researcher to control for such factors (Görg and Strobl, 2001: 737-738).

Another methodological issue that deserves consideration is the *shape of relationship between FDI spillovers and technological/productivity growth of domestic firms*. Perez (1998) suggests that one must abandon the idea of linear relations between foreign presence and technological development of host countries envisaged by most studies on the topic (e.g. Findlay, 1978; Blomström, 1989; Wang and Blomström, 1992). Factors that 'prevent' the linear relation and that are the most important in influencing the direction and scale of technological spillovers are the initial technological gap between domestic and foreign firms, the level and pace of the expansion of the foreign presence in the country, the strength of the market's selective mechanisms, and the existence of government policies designed to encourage the technological development of local firms and to favour technological exchange between the two groups of firms. These factors are, as a rule, not included in econometric analysis of spillovers (Perez, 1998: 4).

In an attempt to test more precisely the nature of the relationship between changes in the cumulate number of foreign investments and the changes in productivity of domestic firms, Altomonte and Pennings (2005) introduce the notion of *marginal spillovers*. The marginal impact of MNCs on the performance of domestic firms is, thus, not necessarily always positive or negative over time, due to the changing market structure induced by the entry of new firms. On the case of a panel of 10,650 domestic and foreign firms operating in Romania in 1995-2001, they find that changes in domestic firms' TFP are positively related to the first foreign investment in a specific industry and region, but get significantly weaker and become negative as the number of MNCs that enter in the considered industry/region increases. This

is opposite to the findings of Barrios, Görg and Strobl (2004) who demonstrate a *U-shaped relationship between foreign presence and spillovers*. The competition effect, which dominates when foreign presence is small, gives way to positive externalities as foreign presence increases.

Another methodological reason for the lack of evidence on FDI spillovers might lie in using *inappropriate econometric techniques* such as simple pooled OLS or static panel data techniques (Damijan, Knell, Majcen and Rojec, 2003b). Keller (2004: 60-61) suggests that employing of Olley-Pakes' estimation method instead of the more frequently used time-differencing method leads to a substantially greater role for FDI spillovers. This is primarily so because Olley-Pakes results in a better estimate of in-sample productivity growth, not because it is more strongly correlated with changes in FDI than time differencing productivity.

More and better data. The lack of good quality, comprehensive firm/plant level datasets is a serious impediment to the research of knowledge spillovers from FDI. Apart from availability of long enough time series of accurate firm level data¹⁰, the issue here is above all what kind of firm level data is to be used for best assessing FDI spillovers. As pointed by Keller and Yeapl (2003), for any kind of econometric analysis of technological spillovers, it is of great importance that the *data closely relates to the issues of technology and technology diffusion*. For instance, FDI spillovers estimated from data on foreign affiliates' and their parents' R&D should tell us much more on technology transfer than a variable like the foreign share of employment.

Alfaro and Rodriguez-Clare (2004) also point to the importance of the *measure of linkages between foreign affiliates and domestic firms*. They argue that the proper measure of the MNCs impact on linkages (as implied by theory) is not the share of inputs purchased locally

¹⁰ Short panels of firms analyzed are a problem, because there seem to be lags in domestic firms' learning from MNCs, which short run analyses do not pick up.

by MNCs but the ratio of the value of inputs bought domestically to the total number of workers hired by a MNC. The distinction between two types of measures is important, because MNCs typically source a smaller percentage of their inputs locally than their local competitors. This does not imply that their linkage effects are necessarily negative, since their production techniques may require more inputs in relation to the workers they hire. Alfaro and Rodrigues-Clare find that the linkage coefficient of MNCs is actually higher than that of local firms in Brazil, Chile and Venezuela, where it is no different in Mexico.

Another issue is the importance of the *measurement of inward FDI in the host economy*. Keller and Yeapl (2003) claim that the single biggest reason of why they estimate stronger FDI spillovers than others is due to relatively accurate measure of industry FDI. Görg and Strobl (2001) also put forward the need to take care in defining foreign presence in a sector, as different measures may yield different evidence as to whether productivity spillovers from MNCs take place. It seems to be preferable to use alternative measures of foreign presence before concluding on whether indigenous firms benefit from their foreign counterparts through spillovers.

5. Concluding remarks on how to further develop FDI spillovers' analysis

Empirical analyses of knowledge spillovers from FDI offer mixed results; they find positive, neutral and negative FDI spillover effects; there can be FDI spillovers, but there is no strong consensus on the magnitudes of FDI spillovers, nor on the causality. The lack of evidence on FDI spillovers is predominantly due to the results of the firm level panel data analysis. This is important since this approach seems to be the most appropriate for estimating FDI spillovers. By the way of analysing the existing theoretical and empirical literature, the paper looks at the reasons for the lack of evidence and for developments in FDI spillover

analysis. In a number of recent papers, these developments have brought some more optimistic results as far as FDI spillovers is concerned. The reasons for the lack of evidence and the developments are of a substantive and of a methodological nature.

The main substantive reasons relate: (i) to the fact that in a number of cases there are really no (or even negative) spillovers because MNCs are efficient in preventing leakages, (ii) to no or deficient consideration of firm heterogeneity in the econometric models, (iii) to concentration on horizontal (intra-industry) spillovers, and (iv) to the fact that often the necessary preconditions for spillovers are lacking in the host countries. Recent econometric literature has introduced a number of additional determinants of FDI spillovers, which help overcoming the above mentioned deficiencies, and have brought more accurate and often also more optimistic conclusions as far as FDI spillovers is concerned. These determinants can be classified under three headings: firm heterogeneity, differentiation between vertical (inter-industry) and horizontal (intra-industry) spillovers, and host country absorption capacity for knowledge spillovers.

Definitely, the most important development is bringing of firm heterogeneity in the analysis. As put by Castellani and Zanfei (2005), 'not every MNC is a good source of externality and not every domestic firm is equally well placed to benefit from multinational activity'. Studies that further disaggregate data into more homogenous groups of firms and plants, find more encouraging results. The literature offers the following sources of firm heterogeneity, which may explain variability in FDI (knowledge) spillovers: (i) geographical distance (proximity) between foreign subsidiaries and domestic firms; (ii) time/dynamic dimension of FDI, the issue of time lags in which spillovers realize; (iii) heterogeneity of foreign subsidiaries with issues like domestic versus export market oriented subsidiaries, acquisitions versus greenfield FDI, impact of local equity participation on FDI spillovers; (iv) heterogeneity of domestic firms, which defines their absorption capacity, reflected in the level

of technological development, R&D and innovation activity, human capital capacity, productivity level and or export propensity.

Apart from great variety of firm heterogeneity sources, the main developments in the literature are differentiation between vertical and horizontal spillovers, and bringing host country absorption capacity in the analysis. As far as the former is concerned, the overwhelming conclusion is that horizontal spillovers are less likely to take place than vertical spillovers. Therefore, empirical studies should differentiate between horizontal and vertical spillovers, and within vertical spillovers further between backward and forward linkages induced by foreign affiliates. The need to have adequate absorption capacity to be able to benefit from knowledge spillovers is not recognised only on the firm but also on the host country level. In the literature, host country's absorption capacity is defined in a rather diversified way; from very broad, as the overall development level of country's economy, technology, institutions, investment and business climate etc., to much more specific measures, such as the level of technological development, the level of human capital or the level of infrastructure.

Recent econometric literature has also introduced a number of data and methodological improvements. They relate to distinguishing between technological/knowledge and productivity spillovers, to the improvement of modelling and estimation methods, and to the increased amount and quality of data.

In measuring the technological spillovers from FDI, most of the econometric studies resort to the second best solution, i.e. to the indirect measuring of technological spillovers as reflected in the productivity growth. In other words, what we usually measure are productivity spillovers and not technological spillovers. To the extent that productivity spillovers are also a result of other factors apart from technological externalities, the productivity spillovers are

not really an accurate indicator of technological externalities. This points to the necessity of distinguishing between productivity and technology spillovers from FDI.

Modelling and estimation methods represent the second set of methodological factors, which offers room for further improvements of FDI spillovers analysis. Here, the literature speaks in favour of micro, firm level studies, which seem to be more accurate approach; to the importance of identifying the truly causal effect (simultaneity and endogeneity problem) where most strategies rely on comparing sets of firms; to the importance of panel instead of cross-sectional data because the latter may overstate spillover effects as they do not allow for the time-invariant firm or sector specific effects; to abandon the idea of a linear relationship between FDI spillovers and technological/productivity growth of domestic firms; to avoid using inappropriate econometric techniques such as simple pooled OLS or static panel data techniques; Keller (2004) suggests to use Olley-Pakes' estimation method.

The lack of good quality, comprehensive firm/plant level datasets is a serious impediment to the research of knowledge spillovers from FDI. Apart from availability of long enough time series of accurate firm level data, two issues are extremely important here. The first is that the data should closely relate to the issues of technology and technology diffusion, and the second is that the measure of inward FDI in the host economy should be properly defined and accurate.

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