Knowledge Flows Through FDI: the Case of Privatisations in Central and Eastern Europe*

Christian Fons-Rosen
Universitat Pompeu Fabra

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Abstract

This paper uses data on Central and Eastern Europe (CEE) since 1990 to analyze how the pool of knowledge of entering foreign firms spreads across local firms. Using patent citations as a measure of knowledge flows, the paper analyzes whether inventors located in CEE cite patents developed by foreign firms more often *after* these companies have established themselves in CEE. First, I construct a large data set of foreign firms in CEE using firm-level information from BvD Amadeus/Orbis. Second, a smaller data set is constructed on foreign bidders of privatization cases resolved by a public tender during the 1990s. Under the identifying assumption that losing bidders form a valid counterfactual to winning bidders, the paper estimates a difference-in-difference effect of FDI on citations received. After the privatization case is resolved, winning bidders experience a 20% increase in citations received compared to losing bidders. Third, to identify the mechanism driving knowledge flows, I build a panel of patent inventors and show that foreign multinationals that reallocate inventors towards their R&D labs in CEE experience a further increase in citations received.

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1 Introduction

With the development of endogenous growth theory (Romer 1986, 1990; Lucas 1988; Grossman and Helpman 1991; Aghion and Howitt 1995), the economic profession came to accept the view that R&D, innovation, and knowledge spillovers are key factors for self-sustained, long-term economic growth and industrial development. A key condition for a country to benefit from innovation generated abroad is its absorptive capacity. It is well established that foreign direct investment (FDI) is one important way to achieve absorption and diffusion of knowledge from abroad, so that policy makers in many transition and developing economies place FDI inflows high on their agenda. But there is an important gap in the literature analysing the effects of FDI inflows on the host economy. The theoretical debate is dominated by arguments predicting positive effects, like the transfer of new technologies and management skills, apart from increasing the level of competition (Gorg and Strobl, 2001). However, there is little empirical evidence suggesting that domestic firms benefit from FDI, and the controversy is far from resolved. Rodrik (1999) concluded that *"today's policy literature is filled with extravagant claims about positive spillovers from FDI but the evidence is sobering"*, and ten years later the overall perception is still pessimistic (World Bank, 2008a).

This paper uses firm-level and inventor-level information to analyse the entry of foreign firms into Central and Eastern Europe (CEE), in particular, the effect on knowledge flows towards the host economy and its underlying transmission mechanism. Using patent citations as a measure of knowledge flows, I begin by examining whether inventors located in CEE cite the stock of patents of FDI firms more often *after* these companies have established themselves in CEE, that is, whether local CEE inventors use the accumulated knowledge of foreign multinationals with greater frequency *once* these companies are located in CEE. An important contribution is the novel identification strategy used: in our difference-in-difference estimation, we obtain a credible counterfactual group of non-FDI performing foreign firms by collecting data on foreign bidders of state-owned companies about to the privatised by a public tender in CEE during the 1990s. Under the assumption that the foreign *losing* bidder is a valid counterfactual to the foreign *winning* bidder, this strategy allows for a causal interpretation of the estimated coefficients.

The main finding is that after the privatisation case is resolved, results show that patents generated by winning bidders experience a 20% increase in citations received from CEE inventors compared to foreign losing bidders. Interestingly, starting FDI *in itself* does not generally lead to a substantial increase in citations received. Rather, the FDI firm needs to have spent enough time in the host country, thereby allowing for its ideas and knowledge to be diffused and absorbed by local inventors. Furthermore, we can explore the transmission mechanism driving these knowledge flows by using detailed inventor-level information. FDI firms

make a greater impact on the host economy when they reallocate inventors from already established R&D labs in their home country to newly developed ones in CEE. Intuitively, these reallocated inventors not only have a better knowledge of previous R&D developed by the foreign multinational, but also could play the role of managers when working together with less experienced local CEE inventors.

There are important reasons to focus on CEE as the target region. Until 1990, there was no presence at all of foreign companies, so that our framework will cleanly analyse the *first* time that a foreign multinational enters CEE. Starting in 1990, growth in FDI is among the most important structural changes these countries have undergone. As can be seen from Figure 1 for the case of the Czech Republic, Hungary, and Poland, these countries experienced substantial FDI inflows during the 1990s.[1] Additionally, the numerous privatisation cases solved by a competitive bid or a public tender allow us to obtain a better counterfactual by collecting data on both winning and losing bidders.

The empirical framework uses patent citations data as an indicator of knowledge flows using data from the European Patent Office (EPO) and U.S. Patent and Trademark Office (USPTO) to analyse whether the knowledge pool of foreign multinationals, identified by their stock of patents, is cited more frequently by local CEE inventors *after* FDI takes place.[2] I use two different samples of data. I first obtain a large benchmark sample by matching firms of Bureau Van Dijk's Amadeus and Orbis datasets to patent applicants from the EPO and the USPTO.[3] The subsample of foreign firms doing FDI in the Czech Republic, Hungary, and Poland can be identified using ownership information of Amadeus/Orbis. After constructing yearly firm-level variables, we end up with a broad sample that includes an important variety of FDI activity. This sample includes greenfield investment apart from allowing for a number of brownfield investment types: joint venture, stock market acquisition, entry through a competitive bid, and others. Furthermore, we observe an important heterogeneity in source countries and technological sectors.

This broad sample provides a good benchmark to which to compare the second dataset, in which I address the identification problems of previous literature. One of the main challenges faced by the literature on FDI firms and knowledge flows is the choice of an appropriate comparison group of non-FDI firms. FDI firms are not a random sample of foreign multinationals, and the reasons to undertake FDI are often unobserved to

[1] Source: World Bank, World Development Indicators (Internet download June 2009)

[2] For evidence that patent citations incorporate a substantial signal component reflecting patterns of knowledge flows, see Duguet and MacGarvie (2005), Jaffe et al. (1998) and Jaffe et al. (2000). See Branstetter (2006) for an approach with patent citations between Japan and the U.S.

[3] See Belenzon and Berkowitz (2010) for a paper that matches patents to Amadeus to examine the effect of business group affiliation on innovation.

the econometrician. Since it is very hard to identify a non-FDI firm that is as similar as possible to an FDI firm, the coefficient estimates obtained from a standard difference-in-difference methodology can be misleading. To address this matter, I collected data on privatisation cases in the Czech Republic, Hungary, and Poland during the 1990s. An important number of state-owned companies were privatised through an open tender or competitive bid in which foreign companies could place bids to acquire the control of the company about to be privatised. Among all the bids received, the national authority started a selection process usually consisting of a number of rounds, until only the two or three most attractive bids were considered in the final round. In the last stage of this selection process, the authorities chose the winning bidder. The identifying assumption is that losing bidders are the closest possible firms to the winning bidders, and thereby form a valid counterfactual. We rely among the revealed ranking of firms to identify a valid counterfactual.[4]

I then turn to the transmission mechanism driving these knowledge flows. I build a panel of EPO and USPTO inventors working for FDI firms and track them over time in terms of geographical location, employer, and co-authors. Descriptive statistics provide detailed evidence of the variety of ways chosen by foreign multinationals to perform R&D. The main result is in line with the theoretical literature on teams and organisations: FDI firms make a greater impact when they reallocate inventors from already established R&D labs in their home country to newly developed labs in CEE. This result is important from a policy perspective, both for the debate on capital market liberalisation versus labour market liberalisation, and for the precise strategies adopted by local governments in subsidising specific types of FDI. Previous research running firm-level productivity regressions was unable to open the *black box* of the transmission mechanism. Not going beyond firm-level information is a substantial limitation, given the apparently important role played by labour mobility in explaining knowledge flows.[5]

This paper is related to a number of streams in the literature. First, the empirical literature on FDI and knowledge spillovers runs a production function equation[6] in which the regressor of interest is the share of FDI

[4]The identification strategy is somewhat similar to Greenstone and Moretti (2004) and Greenstone et al. (2007). In these papers, U.S. counties compete for a large plant to locate within their boundaries, and the authors analyse the effect on property values, productivity, and welfare. In my approach, we rather have two firms competing for an FDI location, thereby leading to a different set of questions to be addressed.

[5]Further evidence suggests that multinationals in developing countries largely rely on expatriates from the home country for senior management positions and key technical and engineering jobs (UNCTAD, 1994).

[6]As a general benchmark, firm-level output levels or growth rates are regressed on inputs (e.g. capital, labour, materials), leading to a residual interpreted as total factor productivity. FDI spillovers are found if multinational presence are positively correlated with the productivity residual.

in a given industry or region[7]. As mentioned previously, there are a number of pitfalls in this literature that we are aiming to address in this paper. First, productivity regressions have a relatively short time dimension and it is very hard to disentangle productivity increases from price effects caused by changes in competition. Additionally, the share of FDI cannot be very precisely measured at the regional or industry level. Finally, those firm-level data approaches cannot identify the precise mechanism driving the results, and not much progress has been made on the identification. A number of survey papers have concluded that the evidence supporting positive knowledge spillovers is almost non-existent.[8] This is also true for studies that focus particularly on CEE. Djankov and Hoekman (2000) find rather a negative effect of FDI on domestic firms in the Czech Republic; Konings (2001) casts doubt on horizontal FDI spillovers in Bulgaria, Romania, and Poland; Damijan et al. (2003) look at a number of transition economies and conclude that FDI does not generate positive intra-industry spillovers for domestic firms. Bosco (2001) similarly claims that the evidence for technological spillovers in Hungary does not allow for clear-cut conclusions. More optimistic is the message of Javorcik (2004) who finds backward spillovers in Lithuania. Compared to this literature, I focus on patent citations instead of estimating a production function equation, similarly to Branstetter (2006) who does a before-after analysis of 189 Japanese multinationals in the U.S. and finds that FDI increases the flow of knowledge spillovers both from and to the investing Japanese firms.[9]

Even though the previous literature has almost unanimously rejected any positive effect of FDI on local firms in CEE, some anecdotal evidence on absorptive capacity still suggests the possibility of some positive effect that the previous literature was unable to capture. First, Kinoshita (2001) finds that the learning effect (i.e. absorptive capacity) of R&D in Czech manufacturing firms is far more important than the innovative effect in explaining the productivity growth of a firm. Second, Javorcik and Sparateanu (2005) find that in a survey of enterprises, almost a quarter of respondents in the Czech Republic and 15% in Latvia learned from multinationals about new technologies.[10]

Secondly, the literature on patent citations and geography started with the seminal paper by Jaffe et al. (1993). Inventors cite other inventors living in geographical proximity more than proportionally. As examples

[7]For an empirical paper on international trade and knowledge spillovers, see MacGarvie (2006).

[8]See Gorg and Strobl (2001), Crespo and Fontoura (2007), Gorg and Greenaway (2004).

[9]Singh (2005) uses patent citations to understand the role of multinational subsidiaries in the diffusion of knowledge. Greater subsidiary activity increases cross-border knowledge flows between host and source country.

An interesting fact to support the patent citation approach is that the contribution of multinationals' R&D to total R&D is substantial in our countries of interest, reaching more than 60 percent in Hungary (World Bank, 2008b).

[10]On theoretical literature related to FDI and absorptive capacity, see Javorcik and Saggi (2003), and Leahy and Neary (2007).

of recent interesting contributions, Griffith et al. (2007) examine the "home bias" of international knowledge spillovers measured by the speed of patent citations and find that the geographical localisation of knowledge spillovers has fallen over time. Griffith et al. (2006) analyse the relationship between U.S. and U.K. and provide evidence of knowledge spillovers associated with technology sourcing.[11]

Third, related to the approach with inventor-level data, there is a relevant literature on teams and organisations. Garicano (2000) presents a framework in which teams are formed by managers and workers, and skill heterogeneity is put at the centre of the model. Using his framework, Antras et al. (2006) show that globalisation leads to international teams with managers located in the North and workers in the South, and the idea behind it is that routine tasks are offshored, while more complex duties are solved in the North. Burstein and Monge-Naranjo (2009) extend a standard neoclassical model by introducing management know-how as an additional factor of production. They allow for firm-management to cross borders and directly control production in the foreign country, and empirically find that the South could have substantial gains in both output and welfare by allowing for Northern managers to relocate to the South.

Empirical papers in the management literature argue that ideas are partly spread by the mobility of inventors or enginners, see Almeida and Kogut (1999), Song et al. (2003), or Saxenian (1994) as examples.[12] In the economics literature, Agrawal et al. (2008) use patent citations to estimate a knowledge flow production function and find that spacial and social proximity of inventors are substitutes in their influence on access to knowledge. Agrawal et al. (2006) find that patent citations also occur disproportionately often in locations where the cited inventor was living prior to being issued the patent. Oettl and Agrawal (2008) find that international inventor mobility increases knowledge flows from the source firm to the receiving country, above and beyond flows to the receiving firm. Griffith et al. (2006) highlight the importance of the transfer of ideas from the leading country to the rest of the world and pay particular emphasis on the underlying mechanism driving this effect. They find evidence of "technology sourcing" by which U.K. firms especially benefit from R&D labs located in the U.S. in sectors in which U.S. inventive activity is especially high. Bloom et al. (2007) and Bloom and Van Reenen (2007) show that multinational firms replicate their organisational structures and management practices in foreign countries. This result is very relevant to the approach taken in this paper, since a clear mechanism by which organisational structures are replicated is by relocating managers towards foreign countries in order to teach and guide local workers.

The structure of the paper is as follows. Section 2 introduces the data and provides summary statistics.

[11] Audretsch and Feldman (1996) and Keller (2002) give evidence in favour of the fact that mobility of engineers across firms matters for localised spillovers.

[12] For earlier pioneering references on labour mobility and knowledge flows, see Gilfillan (1935) and Arrow (1962).

Section 3 explains the econometric methodology, while Section 4 shows results. Section 5 concludes.

2 Data and Summary Statistics

2.1 Data

The database on patents comes from the European Patent Office (EPO) and the U.S. Patent and Trademark Office (USPTO), and is included in the Worldwide Patent Statistical Database (PATSTAT, April 2008). The PATSTAT database contains information on all patent applications to the EPO and USPTO, including information about applicant (name and location), inventors (name and location), granted status, technology class, year of application, and citations made and received. The data dates back to 1978 for EPO (i.e. the year when EPO was launched) and much earlier for the USPTO.[13] We are able to track the number of patents awarded and citations received for each firm over time. Of particular interest for this project is the fact that for each citation we can identify both the *citing* applicant and the *cited* applicant, and the corresponding application years. In particular, I select the universe of patents developed by inventors located in either the Czech Republic, Hungary, or Poland, and identify all the citations made to patents belonging to foreign companies. Then, I construct measures of yearly citations received by each foreign company.[14]

In order to identify which foreign firms are doing FDI, we use the ownership information provided by Bureau Van Dijk (BvD)'s Amadeus and Orbis datasets.[15] For European countries, we use firm-level data from the Amadeus (Analyse MAjor Databases from EUropean Sources) database. This standardised commercial data is collected by about 50 vendors (generally the office of register of companies) across Europe. The database contains financial information on about 8 million firms from 34 countries, including all the European Union countries and Eastern Europe. Additionally, for other major foreign investors in CEE, we obtain the equivalent information from BvD's Orbis dataset, which is the extension of Amadeus to the rest of the world.[16] Amadeus/Orbis also provides information on firm ownership, including the ultimate owner. In particular, it identifies the one single firm/person/entity that ultimately owns the firm.[17] To define an ultimate owner,

[13]These DVDs are provided twice a year, and the version used for this paper is April 2008, which incorporates all the population of patents since the beginning of EPO in 1978. For the USPTO, we will also use data from 1978 onwards.

[14]We limit our sample to foreign companies that have been cited at least once by inventors located in either the Czech Republic, Hungary, or Poland.

[15]For more detailed information on the patents and ownership databases, see Appendix.

[16]While we obtain Amadeus information from a number of DVDs over time, for Orbis we used the web interface download available to LSE since 2008/2009.

[17]Variables available for the ultimate owner include: country of incorporation/origin; ID number (if the ultimate owner is present

BvD analyses the shareholding structures of companies that, according to the independence indicator, are not independent from their shareholders. BvD looks for the shareholder with the highest percentage of ownership. If this shareholder is independent, it is recognised as the ultimate owner. If the highest shareholder is not independent, the same process is repeated until the ultimate owner if found. Variables available for the ultimate owner include, among others, the country of origin and the BvD identification number.

For this particular project, it is necessary to identify the foreign companies that do FDI in CEE. We take the population of firms in the Czech Republic, Hungary, and Poland, and identify their ultimate owner, specifically by the ID number provided by BvD.[18] All the ultimate owners coming from foreign countries are, by definition, doing FDI in CEE.[19] After a matching process by which each firm is allocated the same BvD identification number in both PATSTAT and Amadeus/Orbis datasets, our group of foreign FDI firms is characterised by doing FDI in at least one of the CEE countries, apart from receiving at least one citation by inventors from this same CEE country.[20]

For the dataset on the bidders of privatisation cases in the Czech Republic, Hungary, and Poland during the 1990s, the information had to be hand-collected. It is not archived or available from any central governmental agency. Given the diverse nature of privatisation methods chosen by each country, I had to resort to a variety of procedures to gather the data. After preliminary research and investigation, I begun interviewing numerous academic scholars and national officials who played a role during the privatisations undertaken during the 1990s. The interviewees either participated in the decision making process carried out by the "Evaluation Committee" or contributed to academic literature on privatisation. I also conducted further interviews with specific company managers, and gathered valuable information from national archives, privatisation agencies, state audit departments, magazines and journals providing general privatisation information or industry-specific case-studies, or daily financial papers focusing on Central and Eastern Europe, among others.

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in the Amadeus/Orbis database); type (e.g., family, industrial firm, employees/managers, financial institution, state).

[18]Since our panel of ownership information starts in 1995 and some firms might have started their FDI activities in earlier years, we have completed the information with two datasets on changes in ownership: Thomson Financial SDC and BvD's Zephyr. Additionally, we went to the national accounts of each of these three host countries to obtain the starting year of FDI for the remaining FDI companies.

[19]For a description of how the matching was done between Patstat and Amadeus/Orbis, see Appendix A.

[20]Similarly, our group of foreign non-FDI firms receives at least one citation by CEE countries, but is not the ultimate owner of any company in the Czech Republic, Hungary, and Poland.

2.2 Summary Statistics

Table 1 provides broad descriptive features of the data. Based on Table 1A, the total number of citations in the sample is approximately 13,000.[21] While only 8% of the cited foreign firms do FDI according to our ownership information, these firms obtain 21% of the citations. This percentage rises to 33% in the case of Poland, where 11% of the firms in our sample do FDI. In Table 1B, the correlation between a firm's stock of patents and its citations received from outside the Czech Republic, Hungary, and Poland is 0.75. Interestingly, this correlation goes down to 0.31 between the stock of patents and the citations received from the three host countries analysed in this paper. The correlation between citations received from the three CEE countries and citations received from the rest of the world is only 0.39.

In Table 2 we provide separate information for FDI and non-FDI firms. A higher fraction of European firms does FDI compared to U.S. firms, which makes intuitive sense due to the fact that the barriers to FDI (e.g. geographical and cultural distance) are smaller for European companies. In terms of technology classes, six IPC classes cover the whole group of firms, each of these classes covering less than 25% of firms in our sample. Consequently, it is reassuring that our results will not be driven by a single technological category.

In Table 3, we compare FDI firms to non-FDI firms in terms of their main variables used in our empirical analysis. The variable stock of patents per firm is the cumulated number of patents awarded to this firm in every year. Citations per firm-year is the total number of citations received by a firm in each given year. In all host countries, we observe that FDI firms have a higher stock of patents and receive more citations on a yearly basis compared to non-FDI firms. These differences are especially important for Poland.

As a preview of our results, Figure 2 shows the evolution over time of the average citations received per firm, decomposed into FDI firms and non-FDI firms. Until the beginning of the 1990s, we do not observe substantial differences. It is only from the mid-1990s onwards that the gap widens substantially: FDI firms start to receive many more citations compared to non-FDI firms. The information provided by this figure will be the centre of our econometric analysis.

3 Empirical Methodology

3.1 Broad Sample

In our first specification, $\ln(c_{cit})$ is (the log of) the number of citations made by inventors located in host country c to the patent stock of firm i in year t:

[21] Self-citations, defined as a firm citing itself, have been excluded.

$$\ln(c_{cit}) = \beta_0 + \beta_1 FDI_{ci} + \beta_2 Post_{cit} + \varepsilon_{cit} \quad (1)$$

where FDI_{ci} is a dummy variable taking the value of 1 when firm i does FDI in country c at any point in time. $Post_{cit}$ is a dummy variable taking the value of 1 for FDI firm i in the subsample of years in which FDI is actually taking place in country c.[22] Our interest is on the coefficient β_2. Do inventors of country c increase the number of citations made to firm i *after* this firm started doing FDI in country c? A positive and significant value of β_2 would support this prediction.

In our second specification, we expand the formulation in the following way:

$$\ln(c_{cit}) = \beta_0 + \beta_1 FDI_{ci} + \beta_2 Post_{cit} + \beta_3 TotYears_{cit} + \varepsilon_{cit} \quad (2)$$

where $TotYears_{cit}$ is the cumulated number of years that firm i has been doing FDI in country c until time t.[23] This specification allows for additional flexibility to assess whether the increase in received citations happens right after FDI starts to take place, i.e. $\beta_2 > 0$, or whether it only increases gradually with time, i.e. $\beta_3 > 0$.[24]

From a statistical viewpoint, for both (1) and (2) one observes a large number of observations for which the dependent variable is zero, so that the log of the dependent variable remains undefined. I deal with this concern in two ways. First, when using an OLS specification, I rewrite the dependent variable as $\ln(1 + c_{cit})$.[25] Second, in our preferred econometric specification we use the Poisson estimator, which is especially suitable for count data.[26] Figure 3 illustrates the probability density function of both the observed values in the dependent variable and the predicted values obtained from the Poisson estimator. We see that the Poisson fits very well the distribution of the true data.

In terms of control variables, four types of fixed effects are incorporated: (i) year; (ii) source country; (iii) host country; (iv) technology. The PATSTAT dataset provides an IPC code identifying the technology class of each patent. By aggregating this measure to the firm level, we control for the average number of citations

[22] Therefore, $FDI_{ci} = 1$ is a necessary condition for observing $Post_{cit} = 1$.

[23] Therefore, $TotYears_{cit} > 0$ whenever $Post_{cit} = 1$. $TotYears_{cit}$ takes the value of 5 when the firm is in its fifth year of FDI, and so on.

[24] One can think of β_2 as the intercept and β_3 as the slope.

[25] This solution has been widely adopted in the international economics literature when regressing a gravity-type equation.

[26] See Santos-Silva and Tenreyro (2005) in support of the Poisson estimator when the dependent variable has a large amount of zeroes. When using the Poisson estimator, our dependent variable will not appear in logarithms.

received by a firm in each technology class.[27] In addition to these four types of fixed effects, we will also have fixed effects at the firm level for each host country separately, i.e. firm-host dummies. In other words, if a company does FDI in both Hungary and Poland, this company will be allocated two different firm-level fixed effects. Since source, host, and technology dummies are constant at the firm-host level, we will rather interact them with year dummies whenever firm-host dummies are present.

An additional control variable will be the firm's (log of) the cumulated stock of patents at each given year.[28] This should control for the fact that the number of citations received by a firm might depend on how much R&D investment has been done by this firm in the past.

Even though in our most complete specification we already incorporate firm-host fixed effects, apart from source*year, host*year, and technology*year dummies, it could still be the case that a firm decides to do FDI *as a consequence* of having been very successful in their R&D activity in previous years.[29] If high success in a firm's R&D activities leads to *both* a higher firm-level productivity level *and* a greater expected profits from expanding their activities to other countries, it might be that only the most innovative and profitable firms self-select to doing FDI. In that case, an increase in citations received would partly be the consequence of great innovative success, rather than of doing FDI. In order to rule out this alternative explanation, for each firm-year observation, we control for the citations received by this firm from the rest of the world.[30]

3.2 Privatisation Cases

The number of observations in the second sample is substantially reduced. We will only use information about privatisation cases that underwent a competitive bid procedure and for which we know both the winning and the losing bidders. The benefit of this new strategy is to use a difference-in-difference econometric specification in which a comparison group (losing bidders) is carefully selected and allocated to each treatment group (winning bidders).

The econometric specifications are very similar to the ones used for the broader sample. In the simplest

[27] We allocate a technology class to each firm in the following way: first, we allocate an IPC code to each patent among eight possible codes. Second, we identify the most common IPC code for the patents belonging to a firm, and allocate this code to this firm.

[28] While the EPO was launched in 1978, the USPTO has been present for much longer, so that firms do not start with a zero stock of patents in 1978.

[29] In the framework by Helpman et al. (2004), the sunk cost of FDI is larger than the one of exporting, so that only the most productive firms will choose to do FDI.

[30] There is an additional way to separate out between the two alternatives, since under this alternative mechanism, we would not expect any gradual diffusion effect captured by a positive value of β_3.

specification, a dummy variable $Post_{cit}$ equals 1 to indicate the subset of years after the privatisation decision has taken place:

$$\ln(c_{cbit}) = \beta_0 + \beta_1 FDI_{cbi} + \beta_2 Post_{cbit} + \beta_3 (FDI_{cbi} * Post_{cbit}) + \varepsilon_{cbit}. \quad (3)$$

A positive value of the new coefficient of interest β_3 can be interpreted in the following way: after the competitive bid of case b is resolved, the winning bidder experiences a greater increase in citations received from host country c, compared to the increase in citations received by the losing bidder. Apart from this new coefficient, all the remaining coefficients keep the same interpretation as in the regressions used for the broader sample.

In our second specification, we drop the dummy variable $Post_{cbit}$ and instead use the variable $TotYears_{cbit}$, which takes the same value as the cumulated number of years passed since the privatisation tender was resolved:

$$\ln(c_{cbit}) = \beta_0 + \beta_1 FDI_{cbi} + \beta_2 TotYears_{cbit} + \beta_3 (FDI_{cbi} * TotYears_{cbit}) + \varepsilon_{cbit}. \quad (4)$$

The new interpretation of coefficient β_3 is slightly different. A positive suggests that the greater increase in citations received by the winning bidder is especially observed after the foreign company has been present in the host country long enough for its knowledge stock to be diffused.

Our final specification simply combines the previous two expressions,

$$\begin{aligned} \ln(c_{cbit}) &= \beta_0 + \beta_1 FDI_{cbi} + \beta_2 Post_{cbit} + \beta_3 TotYears_{cbit} \\ &\quad + \beta_4 (FDI_{cbi} * Post_{cbit}) + \beta_5 (FDI_{cbi} * TotYears_{cbit}) + \varepsilon_{cbit}. \end{aligned} \quad (5)$$

The goal is to assess which of the previous two effects has a stronger impact from a statistical viewpoint. A positive β_4 would suggest that the increase in citations received by the winning bidder already expresses itself shortly after the privatisation tender was resolved. Rather, a positive β_5 would provide support for the fact that it takes time for the knowledge stock of the winning bidder to diffuse across the investors located in the host country.

4 Results

4.1 Broad Sample

Focusing first on the broad and comprehensive data sample, Table 4 provides results using the Ordinary Least Squares (OLS) estimator. Equations (1)-(3) show our benchmark specification including year, technology, host and source country fixed effects. Our coefficient of interest on *"Dummy for post-FDI years"* is approximately 0.1, and statistically significant at the 1% level. This result still holds even after controlling for the firm-level fixed effects, the firm's stock of patents, and the number of citations received from the rest of the world. In terms of economic significance, it means that FDI firms experience a 10% increase in citations received from inventors located in host country after they start doing FDI in that country. The coefficient on *"Dummy for firms doing FDI"* changes sign once we add the control variables on the stock of patents and citations received in the rest of the world: even though FDI firms are cited more often than non-FDI firms at all times, it is completely driven by their greater size in terms of patents. Companies that receive more citations in the rest of the world also receive more citations in our three host countries. But the increase in citations received by FDI firms in CEE is robust to controlling for how cited these firms are in the rest of the world. It rules out the possibility that the increase in citations is a consequence of productive R&D efforts in recent years, that in turn led these firms to start FDI activities. Equations (4)-(5) additionally allow for the change in citations received to depend on the cumulated years that the FDI firm has been present in the host country. The coefficient on *"Dummy for post-FDI years"* is still positive and statistically significant, but is about half in size. This reduction in the coefficient is now captured by the coefficient *"Years since FDI started"*, which is positive and also statistically significant.

Equations (6)-(10) report results of equivalent regressions, except for additionally incorporating interactions of year dummies with the other three dummy categories (technology, host, source). Even in the most demanding specifications with firm-level fixed effects, we observe a positive and statistically significant coefficient of our two variables of interest. Each additional year of FDI leads to an increase in citations received of 0.5%. In terms of the remaining control variables, we do not observe any substantial change, neither in size nor in significance.

Table 5 presents the equivalent regressions to Table 4, but rather uses the Poisson estimator. In equations (1)-(3), our coefficient of interest is still positive and strongly statistically significant at the 1% level. Similarly to Table 4, the coefficient on *"Dummy for firms doing FDI"* changes sign once we add our two main control variables, and the coefficient on citations received by the rest of the world is positive and very statistically significant. In equations (4)-(5), where we include the variable *"Years since FDI started"*, we observe a slight

difference in results. Starting FDI in itself does not lead to an increase in citations received. Rather, what is needed is that the FDI firm has spent enough time in the host country, thereby allowing for its ideas and knowledge to be diffused and absorbed by local inventors. It is remarkable that the coefficient on *"Dummy for post-FDI years"* is always close to zero and never statistically significant. On the other hand, the coefficient on *"Years since FDI started"* is always positive and statistically significant.

Equations (6)-(10) report results that incorporate interactions of year dummies with the other three dummy categories. While the statistical significance is very similar, results are stronger once we control for firm-level fixed effects. In particular, equation (10) provides further support of the fact that knowledge is slowly diffused as the FDI firm is spending more time in the host country, controlling for firm-level fixed effects and interaction dummies.

Table 6 provides robustness checks by decomposing the dependent variable in a number of ways. In all these Poisson specifications we allow for firm-level fixed effects and dummies for year, technology, host and source countries. Equations (1) and (2) present results with citations made only by domestically-owned firms or foreign-owned firms, respectively. Interestingly, not only do both equations provide further evidence of the diffusion of knowledge over time, but the coefficient values on the variable *"Years since FDI started"* are almost identical, and statistically significant at the 5% level. Therefore, the diffusion of knowledge reaches many types of corporations operating in CEE. In equation (3) the result holds when we only keep citations between firms of different nationalities. It rules out that the increase in citations received is just driven by companies from the same foreign foreign country with a previous technological relationship citing in each other as well in CEE, simply because they knew each other from before. Finally, equation (4) presents results for the subsample of citations in which both the citing and the cited company are from the same foreign country. Again we see statistically significant results, and the coefficient value has risen.

4.2 Privatisation Cases

Before we describe the results of the main regressions with bidders, let us first get a visual idea of the data. Figures 4a and 4b show the average yearly received citations per firm decomposed into winning and losing bidders. Until the starting year of FDI, i.e. the year in which the privatisation case was resolved, both types of firms seem to receive more or less the same number of citations from inventors located in our CEE countries. Interestingly, once the winning bidder enters the host country, the number of citations it receives rises substantially, while the citations received by the losing bidder follows a much flatter trend. Figures 5 and 6 redo the same graphs by either only keeping citations *within* the same technological class, or rather only

keeping citations *across* different technology classes. The main result remains unchanged.

Table 7A provides descriptive information about the sample of firms. We have 47 winners and 89 losers, and the main represented countries are the U.S., France, and Germany. Table 7B compares both the level and the growth rate of citations received by winners and losers. The first two rows provide information about the level effect. On average, winning bidders receive more citations overall in the EPO/USPTO datasets, and also receive more citations when we limit the sample to citations made by inventors located in CEE countries. Notice that the econometric specification will already control for differences in levels, so that these differences do not undermine our identification technique. Rather, losers form a valid counterfactual if we do not observe any differences in growth rates (or trends), compared to the winning bidders.

The third and fourth rows of Table 7B provide descriptive information of the growth rate of citations *before* the privatisation case was resolved. Winning bidders seem to have a slightly higher growth rate in overall world and CEE citations received, even though these differences are not statistically significant.[31]

In the last two rows of Table 7B we show the growth rate of citations *after* the privatisation case was resolved. The comparison of world citations is not statistically significant, but once we restrict the assessment to the host CEE country, we observe a very different story. The winning bidder experiences a growth rate in the number of citations received that is substantially greater than the one of the losing bidder and statistically significant at the 1% level.

Using the sample of bidders, Table 8 shows OLS results for a variety of specifications. Equations (1)-(3) provide benchmark results in which we control for year, source, and host country fixed effects. Results are statistically significant at the 1% level, and winning bidders experience a 20% greater increase in citations received by the host country after the privatisation case was resolved, compared to losing bidders. Interestingly, most of this effect does not seem to take place right after the foreign company starts its FDI activity in the host country. Rather, every additional year of FDI seems to increase the gap between citations received by the two bidders at a rate of 2%.

Equations (4)-(6) show the same regressions after additionally including privatisation case fixed effects. The idea is to control for the possible impact that particular characteristics or circumstances of privatisation cases could have on the citations received by these companies. The coefficient values of our interaction terms of interest remain unaffected, while the R-squared has risen from 0.22 to 0.28. In terms of control variables,

[31]The growth rate is measured in the following way: we take the citations received by each firm in the first five years of our dataset, and compute the growth rate by taking the citations received by this same firm in the five years before the privatisation case is resolved.

the (log of the) stock of patents enters with a positive and statistically significant sign. The dummy variable for FDI firms enters with a negative sign, suggesting that at all times these firms are cited less than the losing bidders, after controls are included. While our descriptive statistics suggest the opposite, once we control for the stock of patents we also observed a similar result in our broader sample.

Finally, equations (7)-(9) incorporate firm-level fixed effects. The R-squared reaches 0.32 and our interaction term between the FDI firms and the variable capturing the cumulated number of years of FDI presence in the host country is still statistically significant at the 1% level.

Tables 9 presents results for the identical specifications as in Table 8 using the Poisson estimator. Equations (1)-(3) include dummies for years, host countries, and source countries, and provide a familiar result. When included separately, the interaction terms for both of our variables of interest are positive and strongly statistically significant. Once the two interaction terms are included in the same regression, the main driver of our result is again the interaction term including the cumulated stock of years that the winning bidder has been present in the host country. In the remaining equations (4)-(9) we obtain similar results, and our R-squared reaches 0.41. Overall, these results provide the familiar conclusion that winning bidders experience a relatively greater increase in citations received, and that it takes time for knowledge to be diffused.

4.3 Inventor-level Analysis

In Table 10 we focus on the broad sample and use the Poisson estimator to address the heterogeneity of FDI activity. We exploit the rich inventor-level information to better understand whether the way in which R&D is undertaken has any impact on the intensity of knowledge flows. After aggregating inventor-level data to the firm level, we still use the same econometric framework as in the previous sections of the paper. First, we test whether foreign multinationals that perform R&D activity in CEE experience a greater increase in citations received, compared to the ones that only perform production activities. Equation (2) says that foreign firms doing R&D receive more citations than non-R&D performing firms at all times, but we do not observe any statistically significant increase *after* the FDI starts to take place. While the dummy variable for post-FDI years that includes the whole sample of FDI firms is still positive and statistically significant, we do not find any additional effect of the same variable limited to the subsample of R&D-performing firms. Intuitively, new R&D is not necessarily linked to previous R&D of the firm. This new R&D is developed in a new country and partly with new inventors, so that there do not have to be important linkages towards the stock of R&D that the FDI company has accumulated up to that point in time.

In the next step, we go a step further and analyse whether relocating inventors from the rest of the world to

CEE has any impact on the intensity of knowledge flows. In the simplest intuitive case, a within-firm relocation of inventors from Western Europe or the U.S. to CEE leads to closer cooperation with local CEE inventors, thereby making the stock of the firm's knowledge more accesible to the new host countries. In equation (3) we find that this is indeed the case. Accounting for all inventors who ever worked in CEE for a given firm, we compute the fraction that previously were working for the same company in any non-CEE country. This share of inventors reallocated from the home country to CEE within the same firm has a strong positive and statistically significant impact on the citations received by this company. This suggests that a company's pool of knowledge is of easier access to local CEE inventors if non-CEE inventors are partly in charge of developing research in CEE. It is quite plausible that these inventors have been more exposed to the main development of the company's previous R&D and are more able to increase the awareness of this research in CEE. In a way, these reallocated inventors act as the bridge between the firm's stock of knowledge (mainly developed in Western countries) and inventors located in CEE.

5 Conclusion

This paper has used patent citations data to evaluate whether foreign direct investment is a channel by which knowledge flows are transmitted from the foreign multinational to the host country. Apart from presenting results for a broad and comprehensive sample of FDI multinationals in CEE countries, this paper also uses a novel identification technique with hand-collected data from the privatisation processes that took place during the 1990s. In particular, we gathered data on foreign winning and losing bidders of the privatisation cases that we resolved by a public tender or a competitive bid, whereby the losing bidder is assumed to be a valid counterfactual for the winning bidder. Both sets of results support the conclusion that patents developed by local inventors in CEE cite the stock of patents of FDI multinationals more often after these companies have established themselves in CEE. This result is particularly important given the difficulties of previous literature to find any positive effect of FDI activity on the productivity of local firms.

The literature on knowledge flows and FDI is almost completely silent about the transmission mechanism by which host inventors benefit from the presence of foreign multinationals.[32] Furthermore, FDI can take many different forms with potentially very different implications for the host economy, even though this aspect is not fully understood yet. For this reason, we construct a panel dataset of inventors working for the FDI firms

[32] An exception is Veugelers and Cassiman (2004) who use Belgian survey data and find that foreign subsidiaries are not more likely to transfer technology to the local economy as compared to local firms. See also Griffith et al. (2006) for a case of variation in the exposure of U.K. firms to U.S. global best practices.

of my sample and track their evolution over time in terms of geographical location, employer, and co-authors. FDI firms perform R&D in CEE in a number of different ways, leading to different implications on knowledge flows and absorptive capacity. In particular, companies relocating inventors from Western countries to work together with their inventors in the new R&D labs in CEE experience an increase in citations received by inventors working in CEE. Intuitively, along the lines of theoretical frameworks on teams like Garicano (2000) or Burstein and Monge-Naranjo (2009), these relocated inventors take the role of managers by teaching and guiding the new research undertaken in CEE. In this way, the previous pool of knowledge of the FDI company becomes of easier access to inventors located in CEE. This new approach is interesting from a policy perspective: it not only adds to the debate on capital market liberalisation versus labour market liberalisation, but it also shed light on how national authorities should focus on subsidising the FDI firms with greater potential to impact the local economy.

The goal of future work is to assess whether this evidence related to increased knowledge flows towards FDI corporations also has an impact on the real economy, either in terms of productivity increases of local firms or overall increases in R&D activities in CEE countries. As opposed to previous literature, the approach taken in this paper will allow a more careful definition of FDI at the firm-level, in addition to exploiting relevant interactions between patenting activity and productivity increases.

6 Appendix: Matching between Amadeus/Orbis and PATSTAT

The appendix has three sections. The first section gives general information on the Amadeus and Orbis databases of financial accounts provided by Bureau Van Dijk (BvD). While Amadeus is limited to Europe, from Orbis we additionally gather information on other parts of the world. Particularly for this paper, we have added information on the United States, Japan, Canada, South Korea, and China, given their important role as foreign investors in Central and Eastern Europe (CEE).

The second section describes the Amadeus/Orbis ownership database. In our context, the ownership structure is crucially to identify foreign firms doing FDI in CEE.

The third section describes the matching process between Amadeus/Orbis and PATSTAT. That is, we explain how we aim to allocate a BvD identification number to each company that applies for a patent.

6.1 General information on Amadeus/Orbis

For European countries, we use firm-level data from the Amadeus (Analyse MAjor Databases from EUropean Sources) database, created by Bureau Van Dijk (BvD). This standardised commercial data is collected by about 50 vendors (generally the office of register of companies) across Europe. The database contains financial information on about 8 million firms from 34 countries, including all the European Union countries and Eastern Europe. Additionally, for other major foreign investors in CEE, we obtain the equivalent information from BvD's Orbis dataset, which is the straightforward extension of Amadeus to other parts of the world.[33]

Among the key advantages of Amadeus/Orbis over other data sources are its large coverage of small and medium sized firms and its unique accounting information on private firms. It covers both listed and unlisted firms of a wide variety of size and age categories, all industries, and ownership types. Coverage varies by country and generally improves over time. The firm and industry coverage of Amadeus is an order of magnitude better compared to other existing firm samples as argued by Gomez-Salvador et al. (2004).

The accounting database includes items from the balance sheet (22 items) and income statement (22 items). No information is available from the cash flow report (i.e., investment or capital expenditure data is not available). The accounting data is harmonized by BvD to enhance comparison across countries. This comparison becomes easier over time due to the improvement in the European Union harmonization of accounting standards. The main descriptive items are country of incorporation, legal form (public vs. private), listing and activity status, date of incorporation, types of accounts (consolidated vs. unconsolidated), product market

[33]While we obtain Amadeus information from a number of DVDs over time, for Orbis we used the web interface download available to LSE since 2008/2009.

activity codes (primary and secondary). In addition, for a relatively large number of firms, we observe the number of employees.

The Amadeus information comes from a number of DVDs that we have been collecting. An important feature of Amadeus is the criteria for dropping firms from the database over time. First, the firm's accounts data are followed for up to ten years; each Amadeus DVD contains only the latest 10 years (if available) of financial data. Second, as long as a firm continues to file its financial statements, it continues to appear in Amadeus. In case a firm stops filling its financial statements, it is kept in the database for four extra years. For example, a firm that stops filling its reports in 2003 (i.e., 2002 is the last year for which a financial statement was reported) remains in the database until 2006 included. In 2007 the firm is dropped from the sample (all observations of the specific firm are taken out from the Amadeus database in the 2007 update).

6.2 Amadeus/Orbis ownership database

Amadeus/Orbis also provides information on firm ownership. BvD processes the raw data to give information along three dimensions:

(i) Independence indicator: Qualifies the degree of independence of a company with regard to its shareholders.

(ii) Ultimate owner: Identifies the one single firm/person/entity that ultimately owns the firm. Variables available for the ultimate owner include: country of incorporation/origin; ID number (if the ultimate owner is present in the Amadeus/Orbis database); type (e.g., family, industrial firm, employees/managers, financial institution, state). To define an ultimate owner, BvD analyses the shareholding structures of companies that, according to the independence indicator, are not independent from their shareholders.[34] BvD looks for the shareholder with the highest percentage of ownership. If this shareholder is independent, it is recognised as the ultimate owner. If the highest shareholder is not independent, the same process is repeated until the ultimate owner if found.

(iii) Shareholders: Lists shareholders of a given company. In addition to variables available for the ultimate owner, we observe shareholder's direct and total percentage stakes in the firm. Control relationships are followed rather than patrimonial relationships. When there are two categories of shares voting/non-voting, the percentages recorded are those attached to the category voting shares.

[34]To be independent, the shareholder must be independent by itself (i.e., having one of the following type: Individuals and families, Public authorities, Employees/Managers) or must be an entity with an independence indicator A+, A, or A- (i.e., an entity with no shareholder in control of more than 25%).

A monthly DVD issue of Amadeus contains, for each company, only the last ownership data available with the date (month and year) at which BvD verified this information as valid. In order to construct the panel of ownership, we use 7 different DVD updates from 7 consecutive years to extract ownership data: May 2001 (update 80); May 2002 (92); July 2003 (106); May 2004 (116); October 2005 (133); September 2006 (144); and May 2007 (152). The resulting ownership records dataset spans the period 1995-2007 and gives unique breadth of cross-sectional coverage over time.

6.3 The matching process between Amadeus/Orbis and PATSTAT

In this section we describe the matching between each EPO/USPTO patent applicant and an Amadeus/Orbis firm. The match is done by a coincidence both in company name and country of location. We do not consider patent applicants that are individuals or other legal entities like foundations or hospitals, because these will not receive any ID number by the BvD datasets Amadeus and Orbis.

A number of difficulties arise during the process, among which we emphasise:

(i) misspelling of company names (e.g. BAYER versus BAYAR)

(ii) same company name can be written in different ways (e.g. BAYER, BAYER AG, BAYER A.G., BAYER AKTIENGES., BAYER AKTIENGESELLSCHAFT)

(iii) a large number of corporate extensions have to be standardised across countries (e.g. LIMITED, CORPORATION, GMBH, AG, SA, SL)

In order to account for these matters, the company name of each first patent applicant is standardised by using an algorithm in order to come up with two different versions of the cleaned name:[35]

(i) standard name: includes the standardized corporate extension

(ii) stem name: excludes the standardized corporate extension

After the company names in Amadeus/Orbis are standardised in the same way, the matching by cleaned company name and country takes place. For each match, we provide information on whether it was matched by standard name or stem name.[36]

[35]The initial algorithm was available to me through the CEP Productivity and Innovation Group, including the Derwent (2000) industrial standard for converting corporate extensions to standard formats for many different countries, and my task has been to improve this algorithm, especially to increase the coverage of matching of Central and Eastern European countries. This meant standardising company extensions for the Czech Republic, Hungary, or Poland, among other tasks.

[36]Given that the standardisation process cannot correct spelling errors, some minor manual name matching has been done by CEP research assistants. The research assistants were allocated countries based on their language skills.

In a number of cases, multiple ID matches were found for a given patent applicant, identified by its name and country. These cases are resolved by supplementary information (e.g. ownership or address information), where available.

The match between patent applicants and company names in Amadeus/Orbis includes the following countries: all European countries, U.S., Japan, Canada, South Korea, and China. For the paper, unmatched patent applicants will be excluded from the analysis. Consequently, our new population of firms includes only patent applicants that have been allocated an ID.

Therefore, the subsample of firms that we identify as doing FDI activity in CEE are company names with an ID, and that additionally are the Ultimate Owner of a company in the Czech Republic, Hungary, or Poland.

References

[1] Aghion, P. and P. Howitt (1995). "Technical Progress in the Theory of Economic Growth." In Jean-Paul Fitoussi, ed., *Economics in a Changing World: Proceedings of the 10th World Congress of the International Economic Association*, Vol. 5. London: Macmillan.

[2] Agrawal, A., I. Cockburn, and J. McHale (2006). "Gone But Not Forgotten: Knowledge Flows, Labor Mobility, and Enduring Social Relationships". Journal of Economic Geography, vol. 6, pp. 571-591.

[3] Agrawal, A., D. Kapur, and J. McHale (2008). "How Do Spatial and Social Proximity Influence Knowledge Flows? Evidence From Patents Data". Journal of Urban Economics, vol. 64, pp. 258-269.

[4] Almeida, P. and B. Kogut (1999). "Localization of Knowledge and the Mobility of Engineers in Regional Networks". Management Science, vol. 45, no. 7; pp. 905-917

[5] Antras, P., L. Garicano, E. Rossi-Hansberg (2006). "Offshoring in a Knowledge Economy". Quarterly Journal of Economics, vol. 121, no. 1; pp. 31–77

[6] Arrow, K. J. (1962). "Economic welfare and the allocation of resources for invention" in R. R. Nelson, ed. *The Rate and Direction of Inventive Activity: Economic and Social Factors,* vol. 13, NBER Special Conference Series. Princeton University Press.

[7] Audretsch, D. and M. P. Feldman (1996). "R&D Spillovers and the Geography of Innovation and Production". The American Economic Review, vol. 86, no. 3; pp. 630-640.

[8] Belenzon, S. and T. Berkowitz (2010). "Innovation in Business Groups". Management Science, vol. 56, pp. 519-535

[9] Bloom, N., R. Sadun, J. Van Reenen (2007). "Nobody Does I.T. Better: U.S. Firms and their Multinational Productivity Miracle", mimeo, Stanford University.

[10] Bloom, N., J. Van Reenen (2007). "Measuring and Explaining Management Practices across Firms and Countries". Quarterly Journal of Economics, vol. 122, pp. 1351-1408.

[11] Bosco, M. G. (2001). "Does FDI Contribute to Technological Spillovers and Growth? A Panel Data Analysis of Hungarian Firms". Transnational Corporations, vol. 10, no. 1; pp. 43-68.

[12] Branstetter, L. (2006). "Is Foreign Direct Investment a Channel of Knowledge Spillovers? Evidence from Japan's FDI in the United States". Journal of International Economics, vol. 68, pp. 325-344.

[13] Burstein, A.T., A. Monge-Naranjo (2009). "Foreign Know-How, Firm Control, and the Income of Developing Countries". Quarterly Journal of Economics, vol. 124, no. 1; pp. 149–195.

[14] Crespo, N. and M. P. Fontoura (2007). "Determinant Factors of FDI Spillovers - What Do We Really Know?". World Development, vol. 35, no. 3; pp.410-425.

[15] Damijan, J.P., M. Knell, B. Majcen, M. Rojec (2003). "The Role of FDI, R&D Accumulation and Trade in Transferring Technology to Transition Countries: Evidence from Firm Panel Data for Eight Transition Countries". Economic Systems, vol. 27; pp. 189-204.

[16] Djankov, S. and B. Hoekman (2000). "Foreign Investment and Productivity Growth in Czech Enterprises". World Bank Economic Review, vol. 14, no. 1; pp. 49-64.

[17] Duguet, E. and M. MacGarvie (2005). "How Well Do Patent Citations Measure Flows of Technology? Evidence from French Innovation Surveys". Economics of Innovation and New Technology, vol. 14, issue 5, pp. 375-393.

[18] Garicano, L. (2000). "Hierarchies and the Organization of Knowledge in Production". Journal of Political Economy, vol. 108, no. 5, pp. 874-904.

[19] Gilfillan, S. (1935). "The Sociology of Invention". Follett Publishing Co. Chicago.

[20] Gomez-Salvador, R., Messina, J. and Vallanti, G. (2004). "Gross job flows in Europe", Labour Economics, vol. 11,pp. 469–85.

[21] Gorg, H. and D. Greenaway (2004). "Much Ado about Nothing? Do Domestic Firms Really Benefit from Foreign Direct Investment?". The World Bank Research Observer, vol. 19, no. 2; pp.171-197.

[22] Gorg, H. and E. Strobl (2001). "Multinational Companies and Productivity Spillovers: A Meta-Analysis". Economic Journal, vol. 111, pp. 723-739

[23] Greenstone, M. and E. Moretti (2004). "Bidding for Industrial Plants: Does Winning a "Million Dollar Plant" Increase Welfare?". MIT Working Paper 04-39.

[24] Greenstone, M., R. Hornbeck, and E. Moretti (2007). "Identifying Agglomeration Spillovers: Evidence from Million Dollar Plants". MIT Working Paper 07-31.

[25] Griffith, R., R. Harrison, J. Van Reenen (2006). "How Special is the Special Relationship? Using the Impact of U.S. R&D Spillovers on U.K. Firms as a Test of Technology Sourcing". The American Economic Review, vol. 96, no. 5; pp. 1859-1875.

[26] Griffith, R., S. Lee, J. Van Reenen (2007). "Is Distance Dying at Last? Home Bias in Fixed Effects Models of Patent Citations". CEP Discussion Paper No. 818.

[27] Grossman, G. and E. Helpman (1991). "Trade, Knowledge Spillovers, and Growth". Working Paper No. 3485. National Bureau of Economic Research, Cambridge, Massachusetts.

[28] Helpman, E., M. Melitz, S. Yeaple (2004). "Exports versus FDI with heterogeneous firms". American Economic Review, vol. 94; pp. 300-316.

[29] Jaffe, A., M. Trajtenberg, and M. Fogarty (2000). "The Meaning of Patent Citations: Report on the NBER/Case-Western Reserve Survey of Patentees", NBER Working Paper No. 7631.

[30] Jaffe, A., M. Trajtenberg, and R. Henderson (1993). "Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations". Quarterly Journal of Economics, vol. 108, no. 3; pp. 577-598.

[31] Jaffe, A., M. Fogarty, and B. Banks (1998). "Evidence from patents and patent citations on the impact of NASA and other federal labs on commerical innovation". Journal of Industrial Economics, vol. 46, no. 2; pp. 183-205.

[32] Javorcik, B. (2004). "Does Foreign Direct Investment Increase the Productivity of Domestic Firms? In Search of Spillovers Through Backward Linkages". American Economic Review, vol. 94, no. 3; pp. 605-627.

[33] Javorcik, B. and K. Saggi (2003). "Technological Asymmetry among Foreign Investors and Mode of Entry". World Bank Working Paper Series 3196.

[34] Javorcik, B. and M. Sparateanu (2005). "Disentangling FDI Spillovers Effects: What Do Firm Perceptions Tell Us?" In *Does Foreign Direct Investment Promote Development?* by T. Moran, E. Graham, and M. Blomstrom, eds., Institute for International Economics, Washington D.C., 2005

[35] Keller, W. (2002). "Geographic Localization of International Technology Diffusion". The American Economic Review, vol. 92, no. 1; pp.120-142.

[36] Kinoshita, Y. (2001). "R&D and Technology Spillovers via FDI: Innovation and Absorptive Capacity". CEPR Discussion Paper 2775.

[37] Konings, J. (2001). "The Effects of Foreign Direct Investment on Domestic Firms". Economics of Transition, vol. 9, no. 3; pp. 619-633.

[38] Leahy, D. and J. P. Neary (2007). "Absorptive Capacity, R&D Spillovers, and Public Policy". International Journal of Industrial Organization, vol. 25, no. 5; pp. 1089-1108.

[39] Lucas, R. (1988). "On the Mechanics of Economic Development". Journal of Monetary Economics, vol. 22, no. 1; pp. 3-42.

[40] MacGarvie, M. (2006). "Do Firms Learn From International Trade?". The Review of Economics and Statistics, vol. 88(1), pp. 46-60.

[41] Oettl, A. and A. Agrawal (2008). "International labor mobility and knowledge flow externalities". Journal of International Business Studies, vol. 39, pp. 1242-1260.

[42] Rodrik, D. (1999). "The New Global Economy and Developing Countries: Making Openness Work". Overseas Development Council (Baltimore, MD) Policy Essay No. 24.

[43] Romer, P. (1986). "Increasing Returns and Long-run Growth". Journal of Political Economy, vol. 94, no. 5; pp. 1002-1037.

[44] Romer, P. (1990). "Endogenous Technological Change". Journal of Political Economy, vol. 98, no. 5; pp. 71-102.

[45] Santos-Silva, J.M.C. and S. Tenreyro (2005). "The Log of Gravity". The Review of Economics and Statistics, vol. 88, no. 4, pp. 641-658.

[46] Saxenian, A. (1994). *Regional Advantage: Culture and Competition in Silicon Valley and Route 128.* Cambridge, MA: Harvard University Press.

[47] Singh, J. (2005). "Asymmetry of Knowledge Spillovers between MNCs and Host Country Firms". Unpublished.

[48] Song, J., P. Almeida, G. Wu (2003). "Learning-by-Hiring: When is Mobility More Likely to Facilitate Interfirm Knowledge Transfer?". Management Science, vol. 49, no. 4; pp. 351-365.

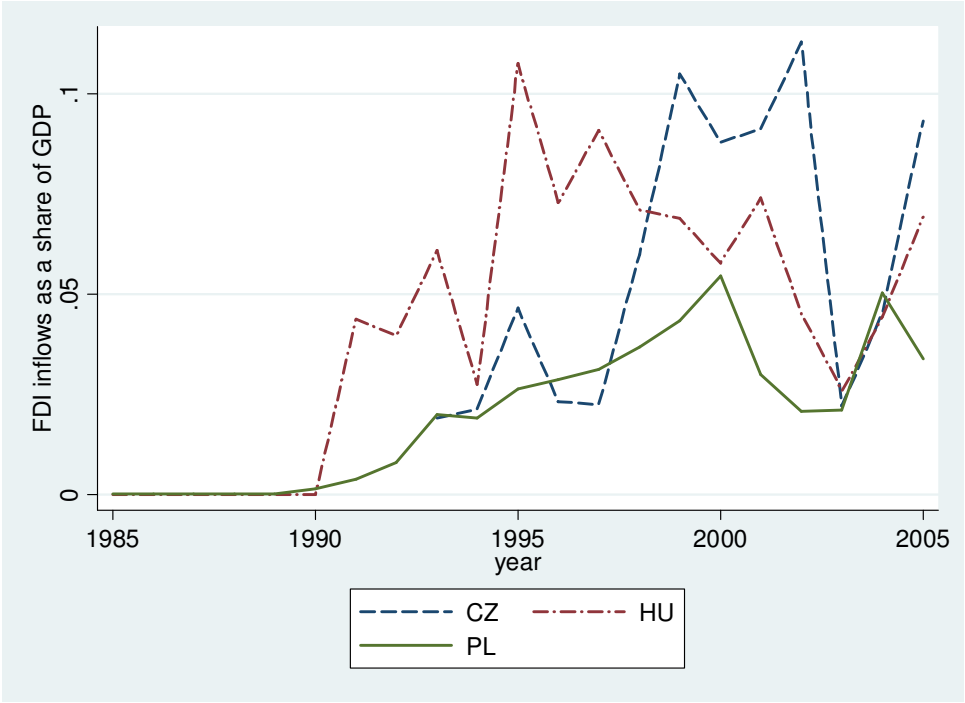
[49] United Nations Conference on Trade and Development (UNCTAD). *World Investment Report 1994: Transnational Corporations, Employment and teh Workplace* (New York, Geneva: United Nations 1994).

[50] Veugelers, R. and B. Cassiman (2004). "Foreign Subsidiaries as a Channel of International Technology Diffusion: Some Direct Firm Level Evidence from Belgium". European Economic Review, 48, pp. 455-476.

[51] World Bank (2008a). "Globalization and Technology Absorption in Europe and Central Asia" by I. Goldberg, L. Branstetter, J. G. Goddard, S. Kuriakose. World Bank Working Paper No. 150.

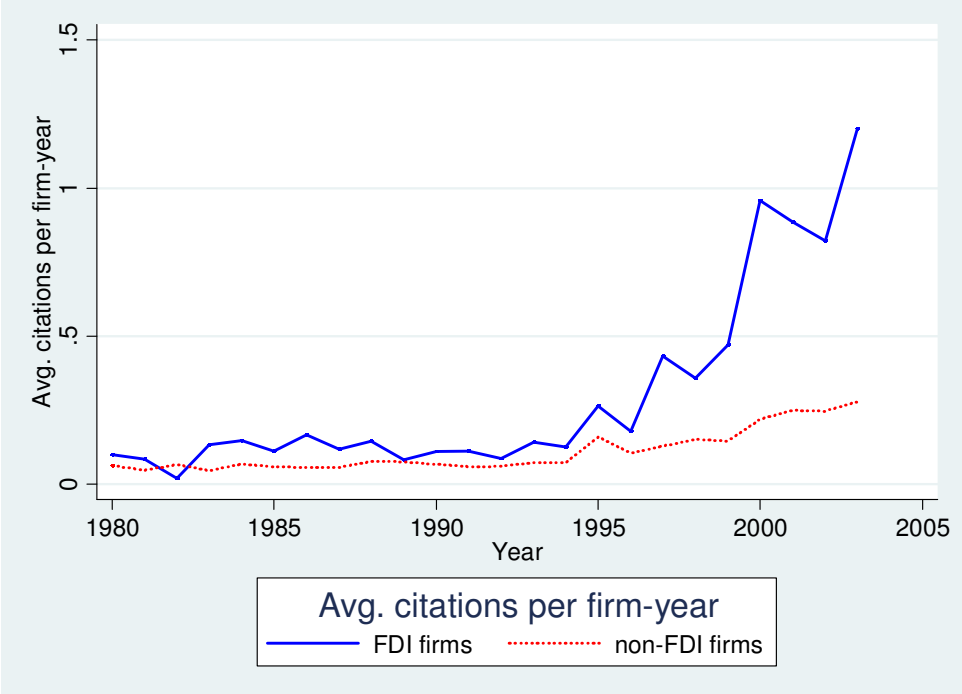
[52] World Bank (2008b). "Global Economic Prospects: Technology Diffusion in the Developing World".

Figure 1. Evolution of FDI inflows as a percentage of GDP



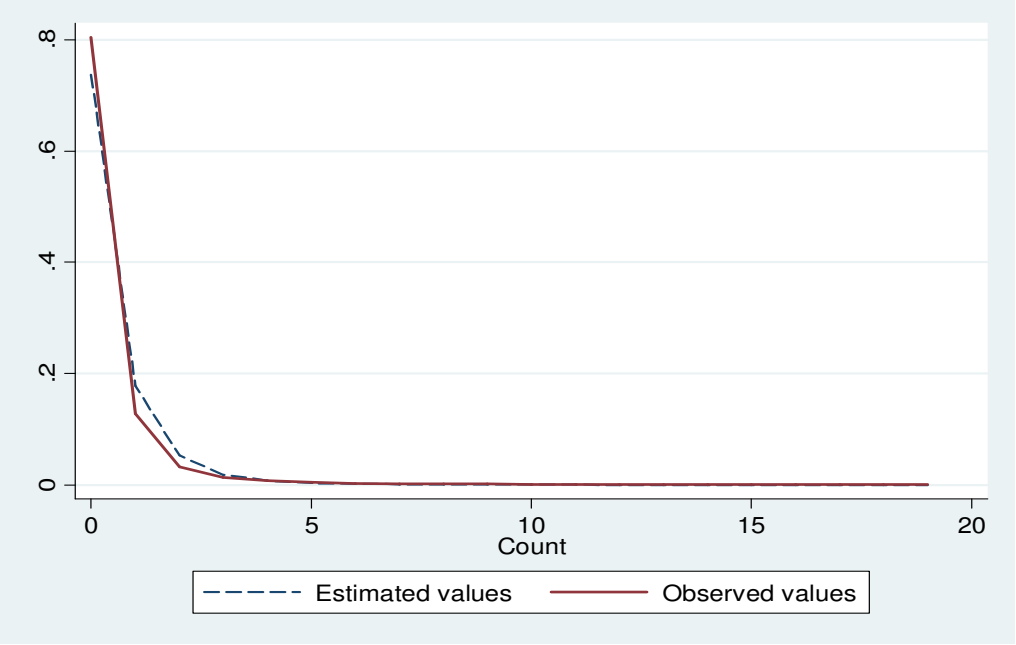
Note: Using data from the World Development Indicators, we show the evolution of FDI inflows as a percentage of GDP. Until 1990, these countries had no exposure to foreign activity. After 1990, the pace in which foreign ownership increased does vary across countries. By the year 2000, all three host countries had share of FDI inflows greater than 5%.

Figure 2. Average citations per firm-year (Broad sample)



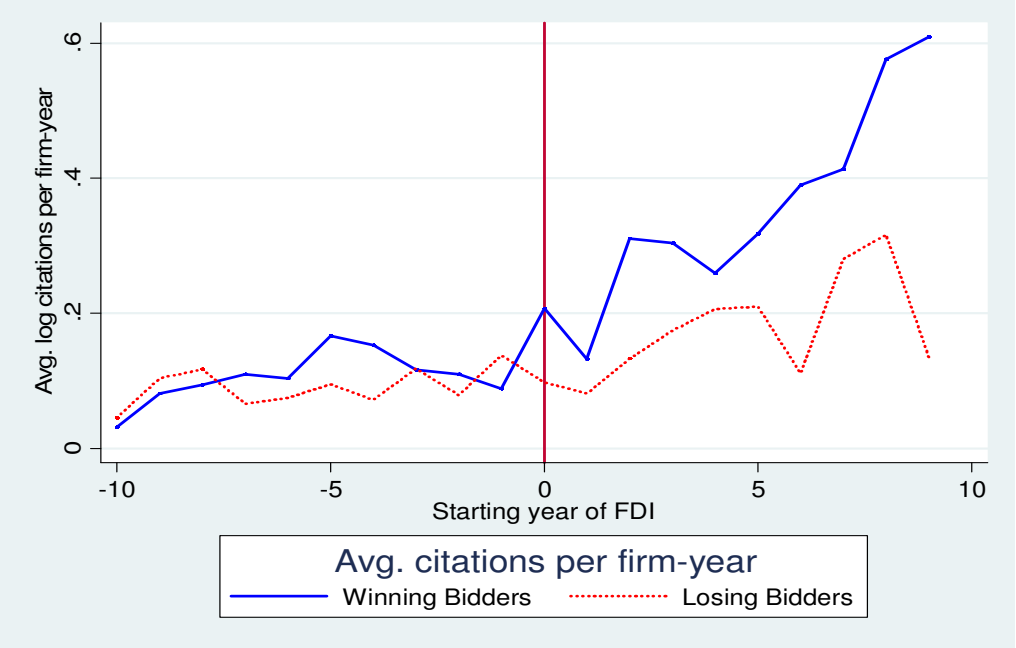
Note: This figure uses yearly average citations received per firm over time. Until the mid-1990s, both FDI and non-FDI firms received on average more or less the same number of citations from inventors located in CEE. It is only after the mid-1990s that we observe a striking difference: FDI firms start to receive substantially more citations than non-FDI firms.

Figure 3. Comparison of probability distribution functions (observed vs estimated data)



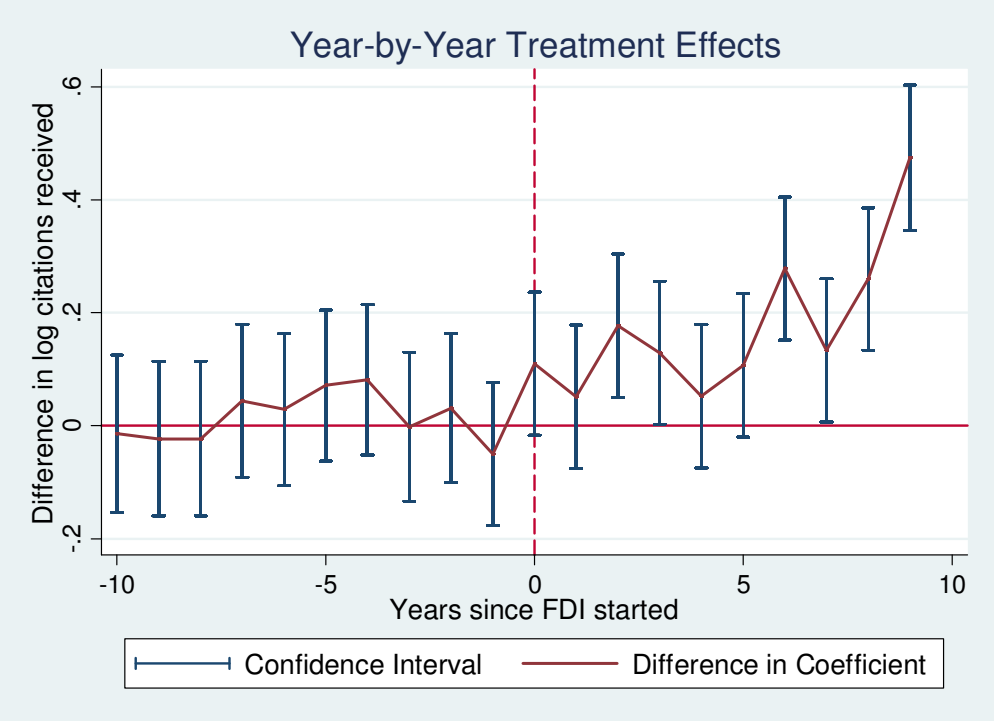
Note: This figure displays the probability distribution function of the true data and compares it to the estimated value using the Poisson estimator. For example, we observe that around 80% of our values in the dependent variable are zeroes, and that only very few firms obtain more than then citations in a given year.

Figure 4a. Average log citations received per type of bidder (Privatisation sample)



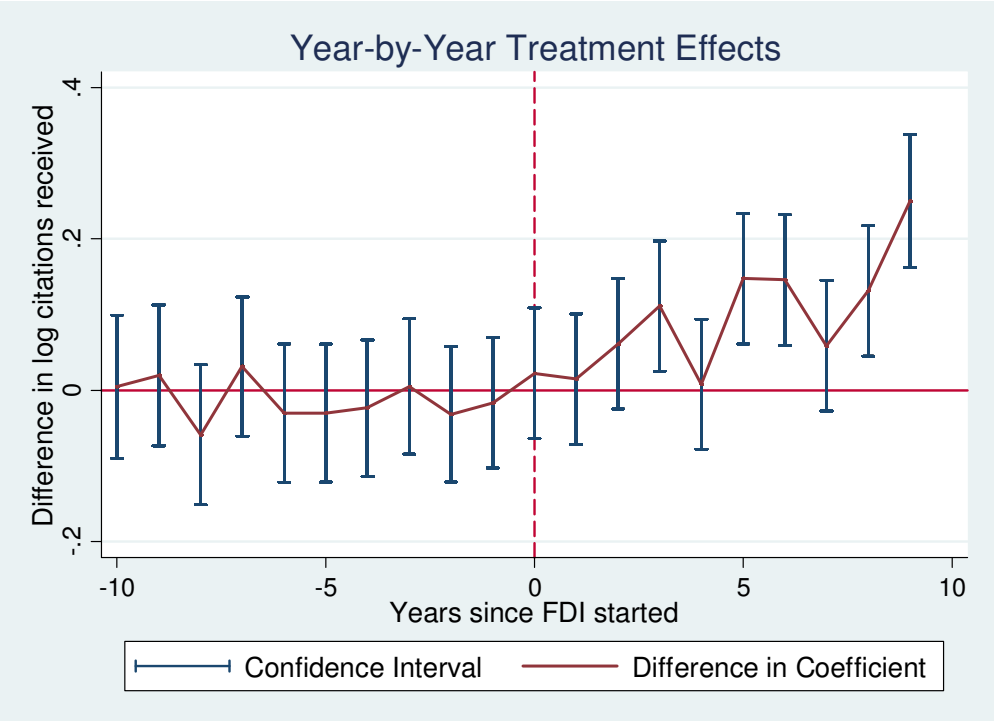
Note: This figure divides the sample between winning and losing bidders and analyses their evolution over time in terms of yearly citations received. The zero value in the horizontal axis defines the year in which the privatisation case was resolved. The vertical axis displays the average yearly citations received per firm. Until the starting year of FDI, we do not observe major differences in citations received by the two groups. After the winning bidders start to do FDI in the host country where the privatisation took place, they start to receive more citations than the losing bidders, who could not start any FDI activity.

Figure 4b. Difference in average log citations per type of bidder



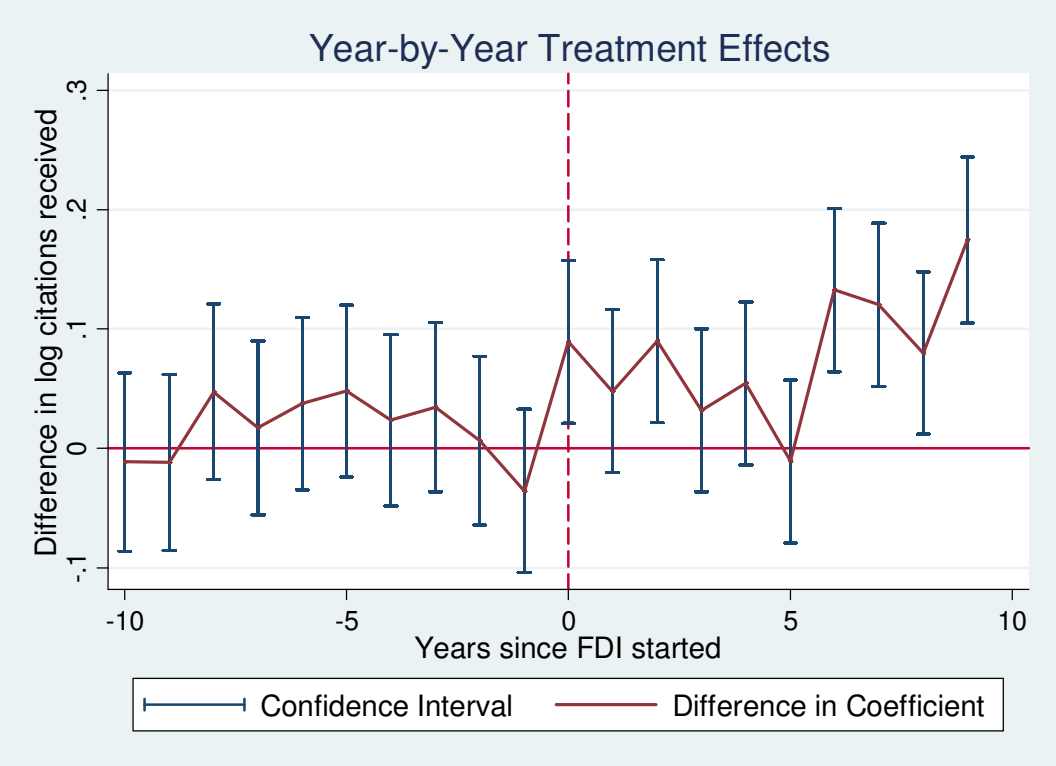
Note: This figure divides the sample between winning and losing bidders and analyses the difference in the citations they receive over time, including confidence intervals at the 90% level. The zero value in the horizontal axis defines the year in which the privatisation case was resolved. We observe a number of things: (1) before FDI, there is no statistically significant difference in citations received by winners and losers; (2) after FDI, the gap gradually increases in favour of the winning bidder, reaching statistical significance a number of years after the privatisation case was resolved.

Figure 5. Difference in average log citations per type of bidder (within IPC)



Note: This figure is similar to Figure 4b, except for the fact that here we only consider citations between firms that belong to the same technological IPC class.

Figure 6. Difference in average log citations per type of bidder (across IPC)



Note: This figure is similar to Figure 4b, except for the fact that here we only consider citations between firms that belong to different technological IPC classes.

Table 1. Descriptive Statistics

A. Summary statistics of aggregate variables

	CZ	HU	PL	Total
Citing firms	658	902	596	2156
Cited firms	1321	1499	1152	3972
...out of which doing FDI:	*97 (7.3%)*	*81 (5.5%)*	*126 (10.9%)*	*304 (7.7%)*
Citing patents	1309	2178	1055	4542
Cited patents	3337	4678	2524	10539
Citations	4134	5418	3612	13164
...out of which received by FDI firms:	*716 (17%)*	*814 (15%)*	*1218 (33%)*	*2748 (21%)*

B. Correlations:

	Stock of patents	Citations per firm-year	Citations per firm-year outside CEE
Stock of patents	1		
Citations per firm-year	0.31	1	
Citations per firm-year outside CEE	0.75	0.39	1

Table 2. Distribution of firms

A. Decomposition of firms by source country

	FDI firms		non-FDI firms	
	Total	*%*	*Total*	*%*
Europe	127	42%	979	27%
U.S.	132	43%	2100	57%
Japan	38	13%	503	14%
Rest	7	2%	86	2%
Total	*304*	*100%*	*3668*	*100%*

B. Decomposition of firms by technology sector (IPC Class):

	FDI firms		non-FDI firms		
	Total	*%*	*Total*	*%*	
A	43	14%	638	17%	Human Necessities
B	60	20%	619	17%	Performing Operations; Transporting
C	65	21%	775	21%	Chemistry; Metallurgy
D	3	1%	62	2%	Textiles; Paper
E	0	0%	85	2%	Fixed Construction
F	44	14%	331	9%	Mechanical Engineering; Lighting
G	37	12%	594	16%	Physics
H	52	17%	537	15%	Electricity
n.a.	0	0%	27	1%	
Total	*304*	*100%*	*3668*	*100%*	

Table 3. Summary statistics of key variables, divided by FDI and non-FDI firms:

Variable	Type of firm	Mean	S.D.	Min	Median	Max	Observations
Full Sample							
Stock of patents per firm	FDI firms	2948.13	6298.88	0	757	70622	8382
	non-FDI firms	532.84	1980.89	0	42	70622	86407
Citations per firm-year	FDI firms	0.33	1.78	0	0	82	8382
	non-FDI firms	0.12	0.67	0	0	56	86407
Czech Republic							
Stock of patents per firm	FDI firms	2381.52	4938.85	0	635	51038	2667
	non-FDI firms	610.78	2422.78	0	49	70622	28383
Citations per firm-year	FDI firms	0.27	0.99	0	0	16	2667
	non-FDI firms	0.12	0.73	0	0	50	28383
Hungary							
Stock of patents per firm	FDI firms	2974.02	6870.32	0	669	70622	2254
	non-FDI firms	512.11	1869.65	0	40	51957	34578
Citations per firm-year	FDI firms	0.36	1.29	0	0	25	2254
	non-FDI firms	0.13	0.71	0	0	56	34578
Poland							
Stock of patents per firm	FDI firms	3367.89	6793.45	0	914	70622	3461
	non-FDI firms	469.06	1479.26	0	39	31935	23446
Citations per firm-year	FDI firms	0.35	2.42	0	0	82	3461
	non-FDI firms	0.1	0.52	0	0	17	23446

Table 4. OLS. Broad sample.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dummy for firms doing FDI	0.033	-0.017		-0.017		0.040	-0.010		-0.010	
	[0.010]***	[0.009]*		[0.009]*		[0.010]***	[0.009]		[0.009]	
Dummy for post-FDI years	**0.108**	**0.087**	**0.105**	**0.048**	**0.057**	**0.099**	**0.079**	**0.099**	**0.046**	**0.058**
	[0.016]* **	**[0.016]*** **	**[0.016]*** **	**[0.019]** **	**[0.018]*** **	**[0.016]*** **	**[0.016]*** **	**[0.015]*** **	**[0.018]** **	**[0.017]*** **
Years since FDI started				**0.005**	**0.007**				**0.004**	**0.006**
				[0.002] **	**[0.002]*** **				**[0.002]* **	**[0.002]*** **
ln(Stock of Patents)		-0.008	0.009	-0.009	0.008		-0.005	0.010	-0.005	0.009
		[0.001]***	[0.002]***	[0.001]***	[0.002]***		[0.001]***	[0.002]***	[0.002]***	[0.002]***
ln(Citations received by non-CEE)		0.035	0.031	0.035	0.031		0.031	0.025	0.031	0.026
		[0.002]***	[0.002]***	[0.002]***	[0.002]***		[0.002]***	[0.002]***	[0.002]***	[0.002]***
Observations	84719	84718	84718	84718	84718	84719	84718	84718	84718	84718
Firm-host FE			Y		Y			Y		Y
Year FE	Y	Y	Y	Y	Y					
Host Country FE	Y	Y	Y	Y	Y					
Source Country FE	Y	Y	Y	Y	Y					
Technology Class FE	Y	Y	Y	Y	Y					
Year*Host Country FE						Y	Y	Y	Y	Y
Year*Source Country FE						Y	Y	Y	Y	Y
Year*Technology Class FE						Y	Y	Y	Y	Y

Note: The dependent variable is yearly citations received by each firm for the sample period 1978-2007. The statistical significance is as follows: * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors are clustered at the firm level; for regressions with firm FE, std. errors are robust to heteroskedasticity and serial correlation.

Table 5. Poisson. Broad Sample.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dummy for firms doing FDI	0.559	-0.224		-0.229		0.728	-0.012		-0.016	
	[0.146]***	[0.131]*		[0.131]*		[0.143]***	[0.121]		[0.122]	
Dummy for post-FDI years	**0.715**	**0.494**	**0.440**	**0.259**	**0.100**	**0.518**	**0.255**	**0.182**	**0.074**	**-0.117**
	[0.193]* **	**[0.170]*** **	**[0.147]*** **	**[0.189]**	**[0.151]**	**[0.191]*** **	**[0.157]**	**[0.108]***	**[0.177]**	**[0.124]**
Years since FDI started				**0.030**	**0.052**				**0.023**	**0.046**
				[0.014] **	**[0.018]*** **				**[0.015]**	**[0.015]*** **
ln(Stock of Patents)		-0.145	0.664	-0.147	0.644		-0.082	0.753	-0.084	0.740
		[0.035]***	[0.075]***	[0.035]***	[0.075]***		[0.035]**	[0.075]***	[0.035]**	[0.074]***
ln(Citations received by non-CEE)		0.569	0.592	0.570	0.600		0.498	0.490	0.499	0.497
		[0.039]***	[0.048]***	[0.039]***	[0.049]***		[0.036]***	[0.046]***	[0.037]***	[0.046]***
Observations	84719	84718	84718	84718	84718	84719	84718	84715	84718	84715
Firm-host FE			Y		Y			Y		Y
Year FE	Y	Y	Y	Y	Y					
Host Country FE	Y	Y	Y	Y	Y					
Source Country FE	Y	Y	Y	Y	Y					
Technology Class FE	Y	Y	Y	Y	Y					
Year*Host Country FE						Y	Y	Y	Y	Y
Year*Source Country FE						Y	Y	Y	Y	Y
Year*Technology Class FE						Y	Y	Y	Y	Y

Note: The dependent variable is yearly citations received by each firm for the sample period 1978-2007. The statistical significance is as follows: * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors are clustered at the firm level; for regressions with firm FE, std. errors are robust to heteroskedasticity and serial correlation.

Table 6. Broad sample. Poisson. Alternative dependent variables

Dependent Variable:	*Citing: Only domestic firms*	*Citing: Only foreign firms*	*Different home countries*	*Same home countries*
	(1)	(2)	(3)	(4)
Dummy for post-FDI years	-0.187	-0.122	0.047	-0.227
	[0.161]	[0.170]	[0.144]	[0.242]
Years since FDI started	**0.044**	**0.043**	**0.033**	**0.080**
	[0.021]**	**[0.022]****	**[0.014]****	**[0.036]****
ln(Stock of Patents)	0.708	0.549	0.774	0.396
	[0.097]***	[0.110]***	[0.079]***	[0.179]**
ln(Citations received by non-CEE)	0.354	0.705	0.448	0.877
	[0.060]***	[0.065]***	[0.046]***	[0.110]***
Observations	46001	53956	71433	24322
Firm- host FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Host Country FE	Y	Y	Y	Y
Source Country FE	Y	Y	Y	Y
Technology Class FE	Y	Y	Y	Y

Note: The dependent variable is yearly citations received by each firm for the sample period 1978-2007. The statistical significance is as follows: * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors are clustered at the firm level; for regressions with firm RE and FE, std. errors are robust to heteroskedasticity and serial correlation.

Table 7A. The Bidders' Sample

Number of Companies:

Winning bidders:	47
Losing bidders:	89

Decomposition by FDI starting year:

1990	2
1991	12
1992	6
1993	9
1994	1
1995	7
1996	4
1997	1
1998	3
1999	2

Decomposition of winners and losers by home country:

Winners:		*Losers:*	
AT	1	ARG	1
CH	2	AT	2
DE	9	CA	3
FR	6	CH	4
GB	3	DE	16
HU	3	DK	1
KR	2	FI	2
NL	2	FR	19
SE	2	GB	8
US	17	IT	4
Total:	47	JP	3
		KR	1
		NL	1
		SE	2
		US	22
		Total:	89

Table 7B. The Bidders' Characteristics by Winner Status

	Winners (1)	Losers (2)	(1)-(2) t-stat [p-value]
(1) Levels of Variables:			
Total world citations received	11569.6	2748.3	4.3
	(18058.9)	(4901.4)	[0.00]***
Total CEE citations received	3.1	2.5	0.4
	(6.1)	(7.5)	[0.71]
(2) Growth rates **before FDI**:			
Total world citations received	15.1	10.2	0.81
	(29.3)	(32.2)	[0.42]
Total CEE citations received	0.5	0.3	1.35
	(1.1)	(1.1)	[0.18]
(3) Growth rates **after FDI**:			
Total world citations received	3.9	8.2	1.43
	(11.4)	(24.5)	[0.16]
Total CEE citations received	3.4	0.6	3.35
	(3.4)	(1.4)	[0.00]***

Table 8. Privatisation sample. OLS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
D(FDI firms)	-0.067	-0.059	-0.068	-0.048	-0.041	-0.049			
	[0.033]**	[0.033]*	[0.033]**	[0.030]	[0.027]	[0.031]			
D(post-FDI years)	-0.050		0.009	-0.030		0.019	-0.044		0.010
	[0.042]		[0.039]	[0.037]		[0.036]	[0.038]		[0.038]
D(FDI firms)*D(post-FDI years)	**0.191**		**0.045**	**0.185**		**0.045**	**0.194**		**0.043**
	[0.062]* **		**[0.070]**	**[0.065]*** **		**[0.071]**	**[0.066]*** **		**[0.072]**
Years since FDI started		-0.009	-0.009		-0.002	-0.002		-0.008	-0.007
		[0.009]	[0.008]		[0.009]	[0.008]		[0.009]	[0.009]
D(FDI firms)*Years since FDI started		**0.022**	**0.018**		**0.021**	**0.018**		**0.023**	**0.019**
		[0.006]* **	**[0.007]** **		**[0.006]*** **	**[0.007]** **		**[0.006]*** **	**[0.007]*** **
ln(Stock of Patents)	0.061	0.062	0.061	0.050	0.051	0.050	0.047	0.049	0.049
	[0.010]***	[0.010]***	[0.010]***	[0.008]***	[0.008]***	[0.008]***	[0.014]***	[0.014]***	[0.013]***
Observations	4098	4098	4098	4098	4098	4098	4098	4098	4098
R-squared	0.21	0.22	0.22	0.28	0.28	0.28	0.31	0.32	0.32
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Host Country FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Source Country FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Case dummies				Y	Y	Y			
Firm dummies							Y	Y	Y

Note: The dependent variable is yearly citations received by each firm for the sample period 1978-2007. The statistical significance is as follows: * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors are clustered at the firm level.

Table 9. Privatisation sample. Poisson

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
D(FDI firms)	-0.472	-0.403	-0.479	0.183	0.171	0.189			
	[0.328]	[0.300]	[0.322]	[0.281]	[0.258]	[0.282]			
D(post-FDI years)	-0.334		0.029	-0.173		0.268	-0.088		0.187
	[0.337]		[0.313]	[0.309]		[0.322]	[0.302]		[0.295]
D(FDI firms)*D(post-FDI years)	**0.747**		**0.199**	**0.574**		**-0.069**	**0.392**		**-0.126**
	[0.280]* **		**[0.459]**	**[0.265]** **		**[0.372]**	**[0.284]**		**[0.373]**
Years since FDI started		-0.062	-0.058		0.100	0.101		0.036	0.030
		[0.059]	[0.050]		[0.065]	[0.064]		[0.057]	[0.056]
D(FDI firms)*Years since FDI started		**0.080**	**0.068**		**0.066**	**0.071**		**0.059**	**0.068**
		[0.023]* **	**[0.037]***		**[0.027]** **	**[0.038]***		**[0.030]** **	**[0.040]***
ln(Stock of Patents)	0.713	0.706	0.705	0.738	0.735	0.733	1.278	1.211	1.210
	[0.062]***	[0.061]***	[0.061]***	[0.091]***	[0.089]***	[0.089]***	[0.234]***	[0.215]***	[0.215]***
Observations	4098	4098	4098	4098	4098	4098	4098	4098	4098
R-squared	0.29	0.29	0.30	0.41	0.41	0.41	0.41	0.41	0.41
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Host Country FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Source Country FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Case dummies				Y	Y	Y			
Firm dummies							Y	Y	Y

Note: The dependent variable is yearly citations received by each firm for the sample period 1978-2007. The statistical significance is as follows: * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors are clustered at the firm level.

Table 10. Broad Sample. Poisson. Inventor-level analysis

	(1)	(2)	(3)	(4)	(5)	(6)
D(FDI firms)	-0.035	-0.312	-0.297			
	[0.122]	[0.154]**	[0.152]*			
D(FDI+R&D firms)		0.710	0.694			
		[0.187]***	[0.186]***			
D(post-FDI years)	0.374	0.384	0.382	0.350	0.372	0.374
	[0.157]**	[0.156]**	[0.156]**	[0.131]***	[0.139]***	[0.138]***
D(post-FDI+R&D years)		0.132	-0.197		-0.046	-0.339
		[0.315]	[0.232]		[0.271]	[0.240]
Share inventors reallocated from West to CEE			**1.437**			**1.266**
			[0.473]* **			**[0.513]** **
ln(Stock of Patents)	-0.152	-0.161	-0.169	0.668	0.668	0.669
	[0.035]***	[0.036]***	[0.036]***	[0.075]***	[0.075]***	[0.075]***
ln(Citations received by non-CEE)	0.567	0.564	0.567	0.591	0.591	0.584
	[0.039]***	[0.038]***	[0.036]***	[0.048]***	[0.049]***	[0.048]***
Observations	84718	84718	84718	85282	85282	85282
Firm-host FE				Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Host Country FE	Y	Y	Y	Y	Y	Y
Source Country FE	Y	Y	Y	Y	Y	Y
Technology Class FE	Y	Y	Y	Y	Y	Y

Note: The dependent variable is yearly citations received by each firm for the sample period 1978-2007. The statistical significance is as follows: * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors are clustered at the firm level; for regressions with firm RE and FE, std. errors are robust to heteroskedasticity and serial correlation.