Domestic plant productivity and marginal spillovers from foreign direct investment

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Abstract

We analyze the performance of a panel of 10,650 domestic and multinational firms operating in Romania in the period 1995-2001. Controlling for the simultaneity bias in productivity estimates through semi-parametric techniques, we find that changes in domestic firms' TFP are positively related to the first foreign investment in the specific sector and region, but get significantly weaker and become negative as the number of multinationals that enter in the considered industry/region increases.

JEL classification: F23; L10; P20

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1 Introduction

There is ongoing debate on the existence of productivity spillovers from foreign direct investment (FDI) taking place through contacts between foreign firms and domestic firms. The outcome of the debate is of high policy interest and a confirming stance is sometimes taken as to justify expensive incentive packages for the attraction of foreign investors. Nevertheless, empirical studies have not come up with a clear answer to the question whether domestic firms benefit from foreign investors or not.

Pioneering empirical studies on sector data by Caves (1974), Globerman (1979), Blomstrom and Persson (1983) and Blomstrom (1986) generally conclude that there are indeed positive productivity spillovers from FDI to domestic firms. Aitken and Harrison (1999) criticize the methodology of the sectoral studies where positive spillovers were found, by arguing that foreign investments primarily occur in sectors where domestic total factor productivity (TFP) is already high, thus leading to a critical identification problem. Using panel data on Venezuelan plants and controlling for fixed differences in productivity levels across industries, they find no significant intra-industry spillovers from foreign firms on domestic firms. Other studies with firm-level panel data also failed to identify positive spillovers from FDI, leading Gorg and Greenaway (2004), in their extensive survey of this literature, to point out the inconclusive evidence emerging from several empirical contributions on the issue[1].

More recently, Smarzynska Javorcik (2004), working on Lithuanian firm-specific data, has detected significant positive spillovers arising trough backward linkages, i.e. generated through contacts between multinational affiliates and local input suppliers. She finds instead no clear evidence in favour of neither intra-industry spillovers, nor forward linkages. Similar results have been obtained by Blalock and Gertler (2004) on a sample of Indonesian firms. In particular this latter generation of papers, in addition to the endogeneity problem, succesfully addresses a series of other methodological issues not fully taken into account by the previous literature, and namely the selection bias that might arise from the entry and exit of firms given the unbalanced panel nature of the datasets, and the simultaneity bias induced by productivity shocks correlated with firm-level input usage.

And yet the finding in the recent literature of positive vertical spillovers and no, or even negative, horizontal ones poses a puzzle, since, as argued by Alfaro and Rodriguez-Clare (2004), if multinational generate positive externalities to domestic suppliers, the increase in the quality of inputs they produce should also lead to increases in TFP of downstream domestic firms.

[1] For example the studies of Haddad and Harrison (1993) on Morocco, of Djankov and Hoekman (2000) on the Czech Republic, and of Konings (2001) on Bulgaria, Poland and Romania, either fail to find a significant positive effect or even detect a negative impact that multinational corporations generate on the performance of domestic firms in the same sector. The situation is slightly different for developed countries, where some studies have found evidence of positive intra-industry spillovers (e.g., Haskel, Pereira and Slaughter, 2002, using UK plant level data).

A possible explanation for this puzzle is related to the fact that one can distinguish two effects of foreign entry on domestic firms. First, there is the possibility of a spillover effect, which causes a reduction in marginal cost of production for domestic firms and thus an increase in TFP. If spillovers are strong, the cost advantage of foreign entrants vis-à-vis domestic firms weakens. Therefore, *ceteris paribus* the incentive for a foreign firm to invest in the host country decreases with the amount of spillovers. Second, there is a competition effect due to foreign entry that reduces output. Given a slow adjustment in inputs due to adjustment costs, or a partial usage of capital, unobserved by the econometrician, total factor productivity tends to decrease after the entry of a competitor. Hence, the competition effect predicts that foreign entry and productivity spillovers are negatively related. Since all the previous studies measure the average coefficient over time of an indicator of 'presence' of MNEs (usually the share of MNE's employment over total employment within the observational unit), it is not surprising that they typically obtain non-significant estimates.

The key issue, in other words, is that the marginal impact of MNEs on domestic TFP is likely to change over time, due to the changing market structure induced by the entry of new firms. As both the competition and the spillover effects work in the same direction, there is a very clear prediction for the relation between TFP changes for domestic firms and the number of foreign entrants. If many firms enter, the spillover effect is likely to be small and the competition effect strong, resulting in a negative effect on domestic TFP. If very few firms enter, the spillover effect is likely to be large and the competition effect weak, resulting in a positive effect on domestic TFP. So whether a domestic firm benefit from foreign entry depends on the number of foreign entrants.

This dynamic effect has not been taken into account in the literature, and could thus be at the origin of the previously quoted puzzle. Therefore, the aim of this paper is to test if there is a negative relation between the cumulate number of foreign investments and the productivity spillover on domestic firms. As the number of investors goes up, the competition effect predicts a negative effect on domestic productivity, while any positive effect of foreign investors due to technology spillovers decreases with the number of foreign investors. Hence, for a sufficiently high number of foreign investors, we may find a negative aggregate effect on TFP. The latter prediction is tested on a sample of indigenous firms in Romania during the period 1995-2001. As FDI was virtually prohibited before the fall of the Berlin wall in 1989, we were able to track all FDIs in Romania in different regions and different sectors, from the very first investment on.

The results shed new light on policy recommendations for attracting foreign investors. The implication of this study is that policy should focus on sectors where there is no or little foreign presence. In these sectors the spillover effect is likely to outweigh the competition effect and a positive spillover may be expected.

The rest of the paper is organized as follows. The next section discusses the investment and

TFP data, while section 3 analyzes the empirical results and performs some robustness checks. Finally, section 4 concludes with the findings and some future lines of research.

2 The Romanian dataset

Our dataset is composed of domestic firms and affiliates of multinational enterprises operating for the period 1995-2001 in Romania, as retrieved from AMADEUS. The latter is a comprehensive, pan-European database developed by a consulting firm, Bureau van Dijck. It contains balance sheet data in time series on 7 million public and private companies in 38 European countries (2004 edition). The dataset comes as a modular product: a version including the top 250,000 companies, the top 1.5 million (employed in this paper) or all 7 million companies in the considered countries. In the case of Romania, the dataset reports information retrieved by the Romanian Chamber of Commerce and Industry, the institution to which all firms have to be legally registered and report their balance sheet data. In particular, the 'intermediate' version of AMADEUS employed in this paper includes, in the case of Romania, data on 30,148 firms (2004 edition).

For every firm we have seeked information on its location within each of the eight Romanian regions and the industry in which these firms operate (at the NACE-2 and 3 level, as reported in the Statistical Annex), as well as yearly balance sheet data on tangible and intangible fixed assets, total assets, number of employees, material costs and revenues (turnover). Moreover, we have gathered information on the year of incorporation, in order to distinguish between firms which have always been operating in the considered time span and firms which have entered over the period, thus controlling for a possible sample selection bias resulting from unbalanced panel data, in line with the previous literature. Exiting firms are also considered, recording as exiters those firms which do not report any information after a given year. Finally, we have included in the sample only those firms for which detailed information on the ownership structure is available: in particular, we have considered a firm as foreign if more than 10 per cent of its capital belongs to a MNE, and domestic otherwise.

This has yielded a total of 10,650 employable firms, 30 per cent of which are MNEs in year 2001. The entry and exit dynamics of our sample are reported in Table 1: as it can be seen, the entry rates of our sample match very closely the official entry rates recorded by the Romanian Chamber of Commerce in the considered period. The lower exit rates reported in our sample are likely due to the large-firm bias of the dataset, since larger firms on average tend to benefit from softer budget constraints and display higher survival rates than small firms. The distribution over time and across industries of MNEs is reported in Table 2[2].

[2]Information on the FDI stock up to 1994 has been retrieved from the PECODB dataset, a firm-specific collection of 4,200 FDI operations undertaken in the countries of Central and Eastern Europe in the period

In terms of validation, we have retrieved from our sample an yearly measure of regional output, summing the individual firms' revenues operating in each region. We have then correlated these figures so obtained with the official regional figures for Romania, obtaining a significant positive correlation of 0.83[3]. As a result our firm-level data seem to belong to an unbiased sample, being able to reproduce the actual evolution of output in Romania.

[Table 1 and 2 about here]

3 Methodology

To calculate firm-specific productivity estimates, we have first deflated our balance sheet data using a total of 48 NACE2 or NACE3 industry-specific price indices retrieved from the Eurostat New Cronos database, according to the classification reported in the Statistical Annex [4]. We have proxied output with deflated sales, given the better quality of these time series with respect to the ones reporting value added. The number of employees has been used as a proxy for the labour input, and the deflated value of tangible fixed assets as a proxy for capital. We have then reaggregated our initial classification of industries at the NACE2 level[5], estimating within each industry semi-parametric productivity measures at the firm level. In fact, using ordinary least squares when estimating productivity implies treating labor and other inputs as exogenous variables. However, as pointed out by Griliches and Mareisse (1995), profit-maximizing firms immediately adjust their inputs (in particular capital) each time they observe a productivity shock, which makes input levels correlated with the same shocks. Since productivity shocks are unobserved to the econometrician, they enter in the error term of the regression. Hence, inputs turn out to be correlated with the error term of the regression, and thus OLS estimates of production functions are biased. Olley and Pakes (1996) and Levinsohn and Petrin (2003) have developed two similar semi-parametric estimation procedures to overcome this problem.

The use of the latter procedure (see Annex 1 for further details) has allowed us to solve the simultaneity bias affecting standard estimates of firm-level productivity, as well as to derive

1990-2002, also based on AMADEUS data and developed by ISLA-Bocconi University. In terms of validation, the database is able to account for almost 70 per cent of the region's total FDI inward stock in the early years of transition, as registered by official statistics.

[3]Since our sample does not include all NACE industries (in particular agriculture), we have subtracted from official regional GVA data the output of those industries not present in our dataset. The correlation between our sample and the official regional data comprising all NACE industries is instead 0.73.

[4]The classification allows to divide industries into economies of scale, traditional, high tech and specialised industries, plus services, according to Pavitt (1984). The same classification has been used by Davies and Lyons (1996) to divide industries into high, medium and low sunk costs. As such, the classification allows us to consider market structures, and hence prices, as relatively homogeneous within each industry.

[5]Firm-specific TFP estimates have been calculated for the 1995-2001 period within each NACE2 industry, in order to ensure an adequate number of observations for each productivity estimate. In a few cases (i.e. NACE16, 20 and 65) industries have displayed insufficient variation to identify the input coefficients. Accordingly, TFP measures from firms belonging to these industries have not been considered in the follow-up of our exercise.

TFP estimates from heterogeneous, industry-specific production functions. In order to check the appropriateness of our correction for simultaneity, Table 3 reports, for a sample of NACE2 industries, the clear bias that emerges when confronting the results of the semi-parametric estimates of domestic firms' productivity with standard OLS results.

[Table 3 about here]

In order to obtain a balanced panel for our estimates, we have then aggregated firm-specific TFP measures across the 48 industries and 8 regions over the years 1995-2001, using as a dependent variable the average TFP of industry i and region j at time t calculated over individual firms. The latter treatment of the dependent variable allows us to minimize potential biases deriving from the heterogeneity in the mark-ups faced by individual firms[6]. We have then related our dependent variable to the cumulated number of MNEs in the industry-region pair. More specifically, we shall estimate the following regression equation

$$\Delta \ln(TPF_{ijt}) = aD_{ijt-1} + \beta D_{ijt-1} CumFDI_{ijt-1} + \gamma_i + \gamma_j + \gamma_t + \varepsilon_{ijt} \tag{1}$$

where D_{ijt} is a dummy variable taking value 1 if there is an investment in sector i of region j in year t; $CumFDI_{ijt}$ is the (log of) cumulated number of foreign investments in sector i of region j at time t, interacted with our lagged investment dummy D_{ijt-1}. By first differencing the (log of) the dependent variable $\Delta \ln(TPF_{ijt})$, by lagging one period the MNEs-related variables and by including industry, region and time fixed effects γ_i, γ_j and γ_t, respectively, we are also able to control for endogeneity and unobserved time, region and industry-specific characteristics that might affect the correlation between firm productivity and foreign presence.

Another potential econometric concern is related to the non-stationary nature of $CumFDI$, being the cumulated number of foreign investments a variable increasing over time. Although we include time-dummies in our regression, if both the independent and the dependent variable are non-stationary we could still get a positive spurious relation between TFP and foreign presence, as well as problems with the asymptotic properties of our estimators given the resulting serial correlation of the error terms. On the other hand, the econometric literature in general acknowledges that in micro panels such as ours, characterized by a large number of cross-sectional units (48*8 in our case) with respect to time (6 years), the problem is negligible (e.g. Baltagi, 2001). Nevertheless, in order to assess the extent of the problem, for each model specification we report the modified version of the Durbin-Watson statistic for balanced panels, as proposed

[6] Katayama, Lu and Tybout (2003) argue that proxying physical inputs and outputs through nominal variables deflated by a broad price index might lead to biased productivity measures. As stated by the same authors, taking industry and region-specific averages allows to partially counter this criticism, since the cross-producer variation in productivity measures is much more problematic than the temporal variation of the population of plants.

by Bhargava et al. (1982).

A positive spillover from inward investment on domestic productivity is obtained in principle when $\alpha + \beta CumFDI_{ijt-1} > 0$. In particular, our hypothesis that spillovers are positive for a small number of foreign investors implies a positive and significant α, the parameter measuring the productivity spillover when at least one FDI drops in the considered region/industry at time $t-1$. Furthermore, our hypothesis of marginally decreasing spillovers entails that β, the parameter controlling for the number of foreign investors, should be negative and significant. Hence, the critical value of the number of foreign investors that determines the sign of the aggregate spillover can be calculated setting $\alpha + \beta CumFDI_{ijt-1} = 0$.

Therefore, $\frac{\hat{\alpha}}{\hat{\beta}}$ becomes a useful test statistic to test our assumption of marginally decreasing spillovers: if $-\frac{\alpha}{\beta} > 0$ and significant, there exists a threshold value $CumFDI^* = -\frac{\alpha}{\beta}$ of FDI under which aggregate spillovers are positive. Spillovers then become negative as soon as MNEs' entry proceeds, in line with our hypothesis.

The previous specification however imposes the threshold $CumFDI^*$ to be constant across different industries, which seems highly unlikely. In fact, in the already quoted paper by Aitken and Harrison (1999), it is claimed that one should distinguish between large and small domestic firms, since it is more likely that large firms will possess a sufficient level of absorptive capacity to benefit from the presence of FDI. To counter this criticism, we have refined our model specification so that the threshold depends also on MES_i, the minimum efficient scale of industry i[7]:

$$\Delta \ln(TPF_{ijt}) = aD_{ijt-1} + \beta D_{ijt-1} \frac{CumFDI_{ijt-1}}{MES_i} + \gamma_i + \gamma_j + \gamma_t + \varepsilon_{ijt}$$

The intuition explored in model (**??**) is that industries characterized by larger firms (i.e. a higher MES) should exhibit a higher critical threshold level of FDI after which their spillover becomes negative. Interacting $CumFDI$ and MES as reported yields in fact a critical value of the (industry-specific) threshold $CumFDI_i^* = -\frac{\alpha}{\beta} MES_i$, in line with the original intuition of Aitken and Harrison (1999)[8].

Moreover, to avoid imposing a restriction on the intercept of the latter linear relationship, assumed equal to zero in the previous model specification, we can further generalize the model design as

$$\Delta \ln(TPF_{ijt}) = aD_{ijt-1} + \beta D_{ijt-1} \frac{CumFDI_{ijt-1}}{MES_i} + \gamma D_{ijt-1} \frac{1}{MES_i} + \gamma_i + \gamma_j + \gamma_t + \varepsilon_{ijt} \quad (2)$$

so that the threshold becomes $CumFDI_i^* = -\frac{\alpha}{\beta} MES_i - \frac{\gamma}{\beta}$. We can then explicitly design a test

[7]The minimum efficient scale has been calculated as the median employment of the firms in each industry.

[8]Moreover, interacting $CumFDI$ and MES in the proposed way essentially implies to assign a greater weight to those FDI undertaken in industries characterised by lower barriers of entry (lower MES), and thus to better control for the industries in which the competition effect from MNEs should be *a priori* stronger.

statistic for both the coefficient of our functional form, $\frac{\alpha}{\beta}$, and its intercept $\frac{\gamma}{\beta}$.

4 Empirical Results

Our results are presented in Table 4. In the first column we test for our Model 1, thus only considering the (log of) cumulated FDI, without correcting for the industry's minimum efficient scale. As it can be seen, the signs are in principle correct, i.e. FDI undertaken at time $t-1$ has a positive and significant impact on the average productivity changes in a given industry/region, with the effect decreasing as the number of multinational increases (negative sign of the interaction between D_{ijt-1} and $CumFDI$). The critical value, $-\frac{\alpha}{\beta}$, is positive and significantly different from 0 at the 5% level of significance. The threshold indicates that negative spillovers arise from the 12th investment on. The estimate for α reveals that, on average, the first foreign investment in a specific sector and region increases domestic TFP by almost 3.5%. The spillover weakens when the stock of FDI in the industry and region increases, but the estimate for β is not significantly different from 0, probably due to the industry-specific nature of β. No problems of serial correlation are evident, as retrieved from the value of the modified Durbin-Watson test statistic, very close to the threshold level of 2, a finding in general true for each of our model specifications.

Interacting the cumulated number of FDI with the minimum efficient scale according to Model 2 highly reduces our industry heterogeneity and yields significant results, thus confirming our hypothesis of the existence of a threshold $CumFDI_i^* = -\frac{\alpha}{\beta}MES_i$. More specifically, in Column 2 we have divided the cumulated number of FDI by the minimum efficient scale, calculated as the firms' median employment in each industry. Both α and β are correctly signed and significant, as it is our test statistic $-\frac{\alpha}{\beta} > 0$.

In order to check whether in our expression for the threshold we have omitted an intercept term, we have also tested for our Model 3, thus including in the regression the term $\gamma D_{ijt-1}\frac{1}{MES_i}$, which implies a threshold $CumFDI_i^* = -\frac{\alpha}{\beta}MES_i - \frac{\gamma}{\beta}$ To avoid multicollinearity, we have instrumented $\frac{1}{MES_i}$, the (inverse of) the industry-specific MES, with $\frac{1}{MES_{ij}}$, i.e. the (inverse of) MES calculated for each industry i and region j. The results are reported in Column 3. Again, both α and β are correctly signed and significant, as it is our test statistic $-\frac{\alpha}{\beta} > 0$, while we cannot reject the hypothesis that the intercept, $-\frac{\gamma}{\beta}$, equals zero at conventional levels of significance.

Following the related literature (e.g. Sinani and Meyer, 2004 or Glass and Saggi, 2002), as a robustness check we have augmented Model 3 with the Herfindal index calculated for both domestic and foreign firms (Column 4a) or for domestic firms only (Column 4b), with the stock of FDI cumulated at the beginning of our observation period and with the investment in intangible assets in a given industry/region as a proxy for firms' absorptive capacity (Column

5)[9]. Our estimates of α and β are very robust to these different model specifications, as well as our hypothesis of a zero intercept term in our threshold expression.

As a further robustness check, we have recalculated our estimates removing the assumption, implicit in our model specification, that the negative impact of the MNEs' presence affects domestic firms' productivity only in the year in which the investment by the MNE has been undertaken ($CumFDI$ is multiplied by the flow dummy D). Hence, we have introduced a dummy D' that takes value 1 if an investment has dropped in the considered industry/region in any year before t, and 0 otherwise. As shown in Table 5, the results are virtually unchanged, yielding, if anything, a slightly poorer model specification.

[Table 4 and 5 about here]

Based on the estimates of α and β reported in Column 2 of Table 4, we have calculated in Table 6 the industry-specific thresholds of FDI for which the competition effects induced by multinational firms are on aggregate lower than the positive spillovers they generate on the local economy. Technically, given our model design, one should compare the thresholds so obtained with the industry and region-specific cumulated number of FDI, in order to assess the sign of the spillovers to the local economy. As it can be seen in Table 6, while for some industries more than one FDI in a given industry/region seems to be enough to generate a negative spillover, for other industries the marginal negative effect induced by the entry of further MNEs is still lower than the benefits the latter generate on the local economy.

[Table 6 about here]

5 Conclusion and further lines of research

Our analysis confirms that it exists a (industry-specific) threshold of MNEs driving the results of aggregate spillovers. If spillovers measures are combined in a unique coefficient measuring the average impact over time of MNEs' presence on the productivity of domestic firms, as the current literature has been doing, it is very likely that the same coefficient is not significant, essentially due to a serious misspecification in the model, which fails to take into account the changes in the market structure induced by the continuous entry of MNEs.

The policy implication of this study is therefore that policy should focus on sectors where the marginal (negative) impact of foreign entry is still low, as reported in our Table 6. In sectors where the number of cumulated FDI is still below the calculated threshold, in fact, the spillover

[9]In their study of MNEs' spillovers on domestic firms in transition economies, Damijan et al. (2003) find significantly different results when controlling for domestic firms' absorptive capacity as proxied here. However, they employ a different measure of productivity, i.e. output per employee rather than TFP.

effect is likely to outweigh the competition effect and benefits for the productivity of local firms might be expected. In industries characterized by lower critical FDI thresholds, instead, any new FDI entering the market aggravates negative spillovers to domestic firms.

More in general, however, it still remains to be assessed the nature of what we have called a competition effect induced by the entry of MNEs. In other words, we do not know the channel through which total factor productivity tends to progressively decrease after the entry of a competitor[10]. We have offered in our introduction a tentative explanation: foreign entry might reduce output of domestic firms and hence, given a slow adjustment in inputs due to adjustment costs, reduce TFP. However this adjustment should be progressively incorporated over time by local firms, especially if the rate of entry of FDI decreases in some industries, as it is often the case in our sample; thus the marginal negative effect of FDI on productivity should display different dynamics than those we have found in our estimates. Alternatively, a lower TFP might be induced by the lower economies of scale accruing to domestic firms given their smaller market sizes, progressively compressed by the presence of the foreign competitors. But the latter explanation will be true only for sectors characterized by increasing returns, a restriction that we have clearly not imposed in our calculation of production functions and TFP.

Thus, we find more interesting as a possible explanation the line of research which looks at the strategic decisions of technology transfers of MNEs once they enter a foreign market.

According to one hypothesis, the primary motivation for multinationals to transfer technology is to enable suppliers to provide higher quality inputs at lower prices: evidence of aggregate vertical spillovers over time has in fact been found by the literature (e.g. the already quoted works of Smarzynska Javorcik, 2004 and Blalock and Gertler, 2004). Then a trade-off opens up for the MNE: if the enabling technology is only transferred to one upstream vendor, the multinational is vulnerable to hold-up. If instead the technology is diffused widely, the hold-up risk is mitigated, but the multinational cannot prevent the upstream suppliers from also selling to the multinational's competitors in the downstream market. The latter effect will induce an indirect spillover in the same industry of the MNEs, which will be positive as long as the MNEs does not start to face too much competition, in which case it will start to strategically reduce its degree of technology transfers.

Alternative hypotheses instead look at the transfer by MNEs of R&D activities in their affiliates, in order to take advantage of host country characteristics. Technology transfers implicitely generate marshallian spillovers to the local economy. In this case, it could well be the case that the entry of multinational rivals in the same industry of the MNEs is such to alter the pay-off conditions, since the incumbent MNEs face the risk of dissipation of their know-how to rivals

[10]We recall that our measure of TFP already takes into account compositional changes in inputs due to possible changes in their prices induced by the MNEs'use of local resources. Many papers who do not adequately measure TFP might just pick up this effect.

(Belderbos et al., 2004). As a result, the technological transfer will be interrupted after a certain number of rivals' entries.

Clearly, a thorough examination of all these possible channels is left to a future research agenda.

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Annex 1: Levinsohn and Petrin (2003) productivity estimates

Let y_t denote (the log of) a firm's output in a Cobb-Douglas production function of the form

$$y_t = \beta_0 + \beta_l l_t + \beta_k k_t + \beta_m m_t + \omega_t + \eta_t \tag{A1.1}$$

where l_t and m_t denote the (freely available) labour and intermediates inputs in logs, respectively, and k_t is the logarithm of the state variable capital. The error term has two components: η_t, which is uncorrelated with input choices, and ω_t, a productivity shock unobserved to the econometrician, but observed by the firm. Since the firm adapts its input choice as soon as she observes ω_t, inputs turn out to be correlated with the error term of the regression, and thus OLS estimates of production functions yield inconsistent results.

To correct for this problem, Levinsohn and Petrin (2003), from now on LP, assume the demand for intermediate inputs m_t (e.g. material costs) to depend on the firm's capital k_t and productivity ω_t, and show that the same demand is monotonically increasing in ω_t. Thus, it is possible for them to write ω_t as $\omega_t = \omega_t(k_t, m_t)$, expressing the unobserved productivity shock ω_t as a function of two observables, k_t and m_t.

To allow for identification of ω_t, LP follow Olley and Pakes (1996) and assume ω_t to follow a Markov process of the form $\omega_t = E[\omega_t|\omega_{t-1}] + \xi_t$, where ξ_t is a change in productivity uncorrelated with k_t. Through these assumptions it is then possible to rewrite Equation (A1.1) as

$$y_t = \beta_l l_t + \phi_t(k_{t,} m_t) + \eta_t \tag{A1.2}$$

where $\phi_t(k_{t,} m_t) = \beta_0 + \beta_k k_t + \beta_m m_t + \omega_t(k_t, m_t)$. By substituting a third-order polynomial approximation in k_t and m_t in place of $\phi_t(k_{t,} m_t)$, LP show that it is possible to consistently estimate the parameter $\widehat{\beta}_l$ and $\widehat{\phi}_t$ in Equation A1.2. For any candidate value β_k^* and β_m^* one can then compute a prediction for ω_t for all periods t, since $\widehat{\omega}_t = \widehat{\phi}_t - \beta_k^* k_t - \beta_m^* m_t$ and hence, using these predicted values, estimate $E[\omega_t|\widehat{\omega_{t-1}}]$. It then follows that the residual generated by β_k^* and β_m^* with respect to y_t can be written as

$$\widehat{\eta_t + \xi_t} = y_t - \widehat{\beta}_l l_t - \beta_k^* k_t - \beta_m^* m_t - E[\omega_t|\widehat{\omega_{t-1}}] \tag{A1.3}$$

Equation (A1.3) can then be used to identify β_k^* and β_m^* using the following two instruments: if the capital stock k_t is determined by the previous period's investment decisions, it then does not respond to shocks to productivity at time t, and hence $E[\eta_t + \xi_t|k_t] = 0$; also, if the last period's level of intermediate inputs m_t is uncorrelated with the error period at time t (which is plausible, e.g. in the case of material costs), then $E[\eta_t + \xi_t|m_{t-1}] = 0$.

Through these two moment conditions, it is then possible to write a consistent and unbiased estimator for β_k^* and β_m^* simply by solving

$$\min_{(\beta_k^*, \beta_m^*)} \sum_h [\sum_t (\widehat{\eta_t + \xi_t}) Z_{ht}]^2 \tag{A1.4}$$

with $Z_t \equiv (k_t, m_{t-1})$ and h indexing the elements of Z_t.

Table 1. The evolution of the panel of Romanian firms. Sample vs. official data

Year	Number of firms			MNEs penetration	Entry Rate		Exit Rate	
	Dom	MNEs	Total		Sample	Official	Sample	Official
1995	4764	1217	5981	0.20				
1996	5449	1504	6953	0.22	0.19	0.11	0.01	0.09
1997	5898	1653	7551	0.22	0.11	0.08	0.01	0.07
1998	6389	1896	8285	0.23	0.10	0.07	0.01	0.07
1999	6957	2121	9078	0.23	0.10	0.06	0.01	0.06
2000	7331	2603	9934	0.26	0.10	0.06	0.00	0.09
2001	7605	3045	10650	0.29	0.08	0.11	0.02	0.10

Source: authors' elaboration on the basis of AMADEUS dataset and Romanian Chamber of Commerce for official data.

Table 2. Cumulative FDI in Romania, 1990-2001.

NACE	Stock 1994	1995	1996	1997	1998	1999	2000	2001
10,14	2	13	24	31	36	42	48	49
151,152	0	6	11	19	21	24	27	29
153,155	0	10	17	26	30	39	44	49
156	0	4	12	19	20	21	21	30
157	0	0	0	1	2	3	4	4
158	0	27	42	61	87	94	106	112
159	6	10	21	24	32	35	39	40
16	0	0	1	2	5	6	7	7
17	1	9	28	54	77	97	109	124
18	4	17	49	80	122	153	180	204
19	0	9	22	39	57	66	83	97
20	1	17	43	80	113	142	172	192
21	0	3	11	14	22	27	33	34
22	0	14	27	39	52	64	70	71
241,242	2	5	13	15	22	27	28	29
243,245	2	6	10	16	22	26	31	35
246,247	1	1	2	2	5	7	7	8
251	0	3	4	6	7	8	8	9
252,262	0	6	16	32	45	53	68	77
26	1	7	14	21	29	34	41	46
27	3	4	7	10	21	26	30	33
28	1	8	18	43	55	70	85	101
291	0	1	2	4	5	7	9	10
292	0	1	2	5	8	10	11	12
293	0	1	2	2	5	5	5	5
294,295	2	4	9	13	15	17	21	27
297	0	0	2	3	3	3	4	4
30	0	3	6	12	14	15	18	21
31	2	6	10	14	21	29	33	47
321	0	0	1	3	5	5	7	10
322,323	1	3	3	5	7	8	11	12
331,332	0	1	2	4	4	6	6	9
334,335	0	0	1	2	2	2	3	3
341	0	0	1	1	1	1	1	1
343	0	0	0	0	0	0	0	0
351	0	0	0	1	1	1	1	1
352,354	1	1	2	2	2	2	2	2
361,362	1	5	16	31	43	48	59	74
363,365	1	2	2	3	7	9	9	10
366	0	1	3	10	15	18	25	30
40	0	0	3	5	7	7	8	10
45	2	19	47	91	144	171	202	224
55	6	7	7	7	7	7	7	7
642	2	2	2	6	6	6	6	6
65,66	2	7	7	7	7	7	7	7
92	0	1	2	2	2	2	2	2

Source: authors' elaboration on the basis of the AMADEUS dataset. See Annex for details on the classification of industries.

Table 3. A comparison of productivity estimates in a sample of NACE2 industries

	NACE2 Industry	**Food**	**Automotive**	**Wood products**	**Rubber and Plastics**
Lev Pet (2003)	ln (labor)	0.0257***	0.0552***	0.0578***	0.0603***
	ln (materials)	0.8436***	0.9756***	0.8547***	0.7672***
	ln (capital)	0.0858***	0.1617***	0.0803***	0.1021***
OLS	ln (labor)	0.1494***	0.2184***	0.2653***	0.2823***
	ln (materials)	0.9199***	0.9224***	0.8992***	0.8927***
	ln (capital)	0.0019	-0.0238	0.0017	-0.0261***
	OLS bias in labor coeff.	+	+	+	+
	OLS bias in material coeff.	+	-	-	+
	OLS bias in capital coeff.	not sign.	not sign.	not sign.	-
	N. of domestic firms	6880	360	3172	1276
	NACE2 Industry	**Metal Products**	**Construction**	**Hotels and Restaurants**	**Telecom**
Lev Pet (2003)	ln (labor)	0.111***	0.1270***	0.1995***	0.2124***
	ln (materials)	0.8939***	0.7120***	0.7010***	0.8772***
	ln (capital)	0.0831**	0.1382***	0.0659	0.0049
OLS	ln (labor)	0.3098***	0.3601***	0.3898***	0.5697***
	ln (materials)	0.8774***	0.8201***	0.7575***	0.7101***
	ln (capital)	-0.0392***	-0.0097**	0.0468***	0.0468***
	OLS bias in labor coeff.	+	+	+	+
	OLS bias in material coeff.	-	+	+	-
	OLS bias in capital coeff.	-	-	not sign.	not sign.
	N. of domestic firms	2821	8697	812	721

Table 4. Marginal spillover effects from FDI – Flow dummy

Dep var.: average change in ln(TFP) (Levinsohn-Petrin semi-parametric estimates)

	(1)	**(2)**	**(3)**	**(4a)**	**(4b)**	**(5)**
D_{t-1}	.034* (.02)	.035** (.02)	.056*** (.02)	.056*** (.02)	.056*** (.02)	.056*** (.02)
$D_{t-1}*Cumfdi_{t-1}$	-.014 (.01)					
$D_{t-1}*Cumfdi_{t-1}/MES$		-.25* (.15)	-.26* (.15)	-.26* (.15)	-.26* (.15)	-.26* (.15)
D_{t-1}/MES			-.22* (.13)	-.22* (.13)	-.22* (.13)	-.22* (.13)
Herfindal (all firms)				-.001 (.03)		-.003 (.03)
Herfindal (dom. firms)					.008 (.03)	
FDI Stock 1994						.016 (.02)
Absorptive capacity						.01 (.01)
48 Industry dummies	83.08***	79.85***	80.25***	79.92***	80.46***	77.55***
8 Regional dummies	4.63	4.50	4.58	4.57	4.55	4.99
6 Time dummies	46.64***	48.88***	44.67***	43.01***	44.37***	43.01***
R-sq.	.26	.27	.27	.27		.28
N. of obs.	1802	1802	1802	1802		1802
Modified Durbin-Watson serial correlation test	1.92 (ρ=0.04)	1.92 (ρ=0.04)	1.91 (ρ=0.05)	1.91 (ρ=0.05)	1.92 (ρ=0.05)	1.92 (ρ=0.05)
Spillover test statistic [a] X^2	4.38**	5.80**	5.23**	5.21**	5.28**	5.15**
Intercept test statistic [b] X^2	-	-	1.62	1.61	1.63	1.60

Note: Standard deviation in parentheses. Joint significance tests for industry, region and time dummies.
*, ** or ***: significant at the 10, 5 or 1 per cent level respectively.

(a) Ho: α/β=0 given α D_{t-1} + β $D_{t-1}*Cumfdi_{t-1}$ (Column 1) and α D_{t-1} + β $D_{t-1}*Cumfdi_{t-1}/MES$ (Columns 2-5)

(b) Ho: γ/β=0 given α D_{t-1} + β $D_{t-1}*Cumfdi_{t-1}/MES$ + γ D_{t-1}/MES

Table 5. Marginal spillover effects from FDI – First investment dummy

Dep var.: average change in ln(TFP) (Levinsohn-Petrin semi-parametric estimates)

	(1)	(2)	(3)	(4a)	(4b)	(5)
D'_{t-1}	.023* (.01)	.024* (.01)	.043** (.02)	.044** (.01)	.044** (.01)	.045** (.02)
$D'_{t-1}*Cumfdi_{t-1}$	-.015 (.01)					
$D'_{t-1}*Cumfdi_{t-1}/MES$		-.27* (.14)	-.29** (.14)	-.29** (.14)	-.28** (.14)	-.29** (.14)
D'_{t-1}/MES			-.22* (.13)	-.22* (.13)	-.22* (.13)	-.22* (.13)
Herfindal (all firms)				-.001 (.03)		-.003 (.03)
Herfindal (dom. firms)					.006 (.03)	
FDI Stock 1994						.018 (.02)
Absorptive capacity						.01 (.01)
48 Sector dummies	85.59***	82.93***	83.55***	82.97***	83.67***	80.44***
8 Regional dummies	4.91	4.89	5.00	4.98	4.99	5.41
6 Time dummies	43.55***	47.61***	44.41***	42.83***	44.17***	43.05***
R-sq.	.27	.27	.27	.27		.28
N. of obs.	1802	1802	1802	1802		1802
Modified Durbin-Watson serial correlation test	1.92 (ρ=0.04)	1.92 (ρ=0.04)	1.92 (ρ=0.04)	1.92 (ρ=0.04)	1.92 (ρ=0.04)	1.92 (ρ=0.04)
Spillover test [a] X^2	2.50	2.82*	3.53*	3.52*	3.52*	3.69*
Intercept test statistic [b] X^2	-	-	1.75	1.74	1.75	1.78

Note: Standard deviation in parentheses. Joint significance tests for sector, region and time dummies.
*, ** or ***: significant at the 10, 5 or 1 per cent level respectively.

(a) Ho: α/β=0 given $\alpha\, D'_{t-1} + \beta\, D'_{t-1}*Cumfdi_{t-1}$ (Column 1) and $\alpha\, D'_{t-1} + \beta\, D'_{t-1}*Cumfdi_{t-1}/MES$ (Columns 2-5)

(b) Ho: γ/β=0 given $\alpha\, D'_{t-1} + \beta\, D'_{t-1}*Cumfdi_{t-1}/MES + \gamma\, D'_{t-1}/MES$

Table 6. Industry-specific FDI thresholds for positive spillovers

Nace	CumFDI*	*Nace*	CumFDI*
10,14	1	*292*	3
151,152	2	*293*	3
153,155	2	*294,295*	4
156	2	*297*	2
157	7	*30*	3
158	2	*31*	24
159	2	*321*	11
16	2	*322,323*	69
17	2	*331,332*	81
18	2	*334,335*	18
19	3	*341*	1
20	2	*343*	2
21	2	*351*	72
22	1	*352,354*	30
241,242	3	*361,362*	2
243,245	43	*363,365*	3
246,247	16	*366*	3
251	14	*40*	3
252,262	2	*45*	1
26	3	*55*	1
27	11	*642*	3
28	2	*65,66*	13
291	2	*92*	3

Note: CumFDI* = $-\alpha * MES/\beta - \gamma/\beta$ as retrieved from Column 2, Table 4.

See the Statistical Annex for the definition of the NACE codes.

Statistical Annex – Classification of industries

The model includes a total of 48 NACE 2 and 3 digits industries, grouped as follows:

Economies of scale industries: 10-11-12-13 and 14 (mining of coal, metals and stone; extraction of petroleum and natural gas); 21 (paper and pulp); 22 (publishing and press); 241 and 242 (basic chemicals and agro-chemicals); 246 and 247 (other chemical products and synthetic fibres); 251 (rubber products); 26 (other non-metallic products); 27 (metallurgy); 297 (domestic appliances); 31 (electrical appliances, excluding domestic); 321 (electronics); 322 and 323 (communication equipment); 341 (car production); 343 (car components); 351 (ship building); 352 and 354 (railways; motorcycles); 40 (energy)

Traditional industries: 151 and 152 (production and transformation of meat and fish); 153 and 155 (vegetables, milk and dairy products); 156 (grains); 157 (pet food); 158 (fabrication of bread, tea, coffee); 159 (drink and beverages); 16 (tobacco); 17 (textiles); 18 (clothing); 19 (leather); 20 (wood); 28 (metals); 361 and 362 (furniture); 363 and 365 (musical instruments and toys); 366 (other general manufacturing)

Specialized industries; 252 and 262 (plastic products); 291 (mechanical machinery); 292 (general machinery); 293 (agricultural machines); 294 and 295 (machine tools); 334 and 335 (optics, photography, clocks); 45 (construction)

High-tech industries: 243-245 (paintings and pharmaceuticals); 244 (pharmaceuticals); 30 (office machines and computers); 331 and 332 (medical and precision instruments); 642 (telecommunication)

Services: 55 (hotels and restaurants); 65 and 66 (financial intermediation and insurance); 72 (computer and related activities); 73 (research and development); 92 (cultural and sporting activities)