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Coagglomeration and Spillovers [§]

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Abstract

We study the coagglomeration of domestic plants and foreign multinationals and the impact of this on domestic plant productivity and employment using data for Irish manufacturing. Relying on a recently developed index we find that coagglomeration has been important for a number of industries. Our econometric analysis reveals that local foreign presence has indeed resulted in productivity spillovers to domestic plants, although only in those industries where there has been coagglomeration. Further evidence suggests that these spillovers have also resulted in more jobs.

JEL classification: F23, R3, Q40

Keywords: Coagglomeration, FDI, spillovers, Ireland

Section I: Introduction

The potential positive spillovers effects of foreign direct investment (FDI) on domestic industry continues to draw a considerable amount of attention among academics and policymakers. A number of channels have been suggested in the theoretical literature regarding the way such externalities may take place; see Blomström and Kokko (1998). The standard approach used in the empirical literature to capture these spillovers has been to examine how foreign multinationals' presence, usually measured as the share of foreign affiliates in total employment or output, affects domestic firms' performance in productivity and job creation. The empirical literature on this topic has also generally looked at country-wide, intra-industry FDI spillovers, see, for instance, Haddad and Harrison (1993), Blomström and Sjöholm (1999) and Barrios et al. (2004). However, the evidence from these studies, covering a large variety of countries, thus far has remained rather mixed.[1] As argued by Görg and Strobl (2001), one reason for this may be due to differences in econometric methodology and data used.[2]

Another potential, and relatively unexplored, problem may be that most of the studies do not take the spatial dimension of spillovers into account. Indeed, a number of authors have suggested that, in general, externalities are mostly local in nature, see, for instance, Fujita and Thisse (2002) for a theoretical analysis and Jaffe et al. (1993) and Audretsch and Feldman (1996) for empirical evidence. In the present paper we try to shed further light on this issue by specifically taking into account the local dimension of FDI-related spillovers using plant level data for Ireland. In particular, we explicitly recognise that these are more likely to take place for sectors where indigenous and foreign plants are actually located near each other. To examine this we first look for evidence concerning the tendency of foreign and domestic plants within the same sector of activity to locate in

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[1] See also the comprehensive reviews of the empirical literature by Görg and Greenaway (2004) and Alfaro and Rodriguez-Clare (2003).

[2] For instance, earlier studies used mainly industry level data and cross-section econometric techniques, while more recent papers have had access to plant level data and taken advantage of advances in panel data econometrics.

the same region using the index of coagglomeration developed by Ellison and Glaeser (1997). We then examine econometrically whether FDI-spillovers are more likely to occur in sectors where domestic and foreign plants are found to be coagglomerated.[3] Ireland is arguably a particularly suitable case study for the task at hand since Irish industrial policy has constantly pursued technology influx and job creation by attracting foreign multinationals. The recent spectacular Irish economic boom has largely been influenced by huge FDI inflows, see Barry and Bradley (1997). Moreover, the regional spread of industrial activity and employment generation has constantly been a matter of concern for Irish policy makers; see Meyler and Strobl (2000). Indeed our results show that FDI has tended to modify the economic geography of Irish manufacturing in favour of the most disadvantaged counties. Furthermore, using the coagglomeration index, we show that co-location between multinationals and domestic plants has taken place in almost half of the Irish sectors. Our econometric analysis further suggests that only in sectors where such coagglomeration arises, we find that foreign presence has had a statistically and economically significant positive impact on domestic plants' productivity. Moreover, such productivity spillovers have also translated into more jobs in domestic plants, a target much pursued by Irish industrial policy.

To date, only a limited number of studies have examined the regional impact of FDI on domestic firms' productivity with contrasting evidence. In particular, using sector-level data, Driffield (1999) and Girma and Wakelin (2001, 2002) find evidence of FDI on the productivity of indigenous firms, although the overall spillover effects of FDI remains small. By contrast, Sjöholm (1999) and Aitken and Harrison (1999) find no significant regional effects from FDI for Indonesia and Venezuela, respectively. [4] Our main contributions to this literature are twofold. First, we base our study on a prior analysis of the patterns of coagglomeration between domestic and foreign plants in

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[3] Our use of plant level data also lies in contrast to what is usually found in the existing literature on local externalities, where most studies rely on more aggregate approaches, see, for instance Henderson et al. (1995) and Dekle (2002). This allows us to avoid problems such as aggregation and sample selection bias typical of more macro-level studies.

Ireland using the index developed by Ellisson and Glaeser (1997) and intended to take into account the existence of agglomeration forces between domestic and foreign plants. Second, using these results, we further investigate and find evidence for regional FDI spillovers not only for productivity but also for employment. This latter variable in particular, has, to the best of our knowledge, not been considered by the existing literature on the regional effects of FDI while it has clear policy implication for regional development.

The rest of the paper is organized as follows. In the next section we describe our data. Section III presents some trends with regard to the degree of local coagglomeration between domestic and foreign plants in Irish manufacturing. In Section IV we conduct an econometric investigation of the impact of local foreign presence on domestic total factor productivity and labour demand. Concluding remarks are provided in the final section.

Section II: Data

For the empirical analysis in this paper we mainly utilize two data sources. The first is the *Forfás Employment Survey*, which is an annual plant level survey collected by *Forfás*, the policy and advisory board for industrial development in Ireland, since 1972. According to *Forfás*, this data can be seen as including virtually the whole population of manufacturing plants in Ireland. Information at the plant level include time invariant variables such as the nationality of ownership, sector of production, and detailed regional location of each plant, as well as the level of employment in each year. *Forfás* defines foreign plants as plants where 50 per cent or more of the shares are owned by foreign shareholders. While, arguably, plants with lower foreign ownership could possibly still be considered foreign owned, this is not necessarily a problem for the case of Ireland since almost all foreign direct investment has corresponded to Greenfield investment rather than acquisition of local

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[4] In recent contributions, Barrios et al. (2005b and 2006) show that foreign presence has induced indigenous plant entry within the same regions and in neighbouring regions in Ireland.

firms (see Barry and Bradley, 1997). We use this data source to examine general employment trends and to construct our foreign presence variables.

Our second data source serves mostly for our econometric analysis and is the *Irish Economy Expenditure Survey*, which is an annual plant level survey collected by *Forfás* from 1983 to 1998. Information is collected from larger plants, earlier in the data set of plants of at least 30 and since 1990 of plants of at least 20 employees. It must be noted, however, that a plant, once included, is generally still surveyed even if its employment level falls below the initial cut-off point. The response rate ranges on average across industries from between 60 and 80 per cent of the surveyed plants. Information provided at the plant level are, amongst other things, the time invariant identifiers as for the *Forfás Employment Survey*, output, wages, intermediate inputs and the employment level. Since 1990 there is also data available on the capital stock of each plant, defined as its replacement value. Given that we need this variable to construct a measure of total factor productivity, we limit the use of the *Irish Economy Expenditure Survey* in our econometric analysis to the data after 1989. Additionally, for our econometric analysis, we dropped all observations of plants with less than 20 employees in order to have a more straightforward selection rule and kept plants with information concerning both productivity and employment. For both the employment and productivity study we thus use the same panel of 338 Irish-owned plants.

Section III: Coagglomeration between domestic and multinational plants in Ireland

The Irish economy has experienced deep structural changes over the last 30 years, not least the effects of EU accession in 1973 on trade flows and the huge rise in foreign direct investment (FDI) especially since the mid-1980s oriented towards hi-tech industries such as pharmaceuticals and semi-conductor industries. In contrast, in earlier periods, Irish industry was strongly oriented towards the production of more traditional goods (see Barry and Bradley, 1997). Important changes have also occurred from a regional perspective. In particular, some regions with traditionally low

manufacturing employment have seen their share in total Irish employment rise since 1972. While county Dublin harbored nearly 40% of total manufacturing employment in 1972, this share has since then steadily declined to stand at less than 25 % in 1999, while at the same time, the foreign share of total manufacturing employment increased substantially from around 33% to 47%. One must note, however, that it is only between the 1970s and the middle of the 1980s that this relative decline in county Dublin translated into a decrease in total manufacturing employment in absolute terms. The maps in appendix reveal interesting additional features by displaying the share of each county in both total domestic and foreign employment. These maps show that at the beginning of the period foreign and domestic employment distributed in a relatively similar fashion across Irish counties. Domestic employment was largely concentrated in Dublin and Cork counties while foreign employment appeared to be even more concentrated in Cork and Kerry, which are located south-west of Ireland. At the end of the period in 1999, both domestic and foreign employment seem to be less concentrated, with nevertheless some Western counties having seen their share in both domestic and foreign manufacturing employment rise significantly. In particular, counties like Galway and Limerick, which have traditionally been given "disadvantaged" status, have been successful in attracting foreign investors, see Barrios et al. (2006). The preliminary evidence thus tends to indicate that higher foreign employment in a number of counties in general and in disadvantaged areas in particular, has been accompanied by an increased domestic employment.

The question we look at now is whether domestic and foreign business units have tended to locate closer together and, more importantly, if they had advantages in doing so. In order to identify the patterns of coagglomeration between foreign and domestic plants, we make use of the index of coagglomeration (CEG) developed in Ellison and Glaeser (1997), which is closely related to the authors' agglomeration index (EG) derived in the same paper. The properties of this index correspond to the behaviour of profit maximizers choosing their production locations where

spillovers and site-related natural advantages both determine the attractiveness of each potential location. When coagglomeration between plant groups is observed for a specific industry then one may interpret this result as indicating that agglomeration economies (i.e. spillovers and/or site-specific advantages) explain the tendency of these groups of plants to locate in the same regions. Here we use an extension of this index by considering the divide between foreign and domestic plants and measuring the degree of coagglomeration between these plant groups across Irish regions. When evidence for coagglomeration is found we interpret this as indicating that FDI spillovers arise between foreign and domestic plants without ruling out the possible influence of other, non spillover-related, advantages for domestic and foreign to locate in the same region. According to Ellison and Glaeser (1997), the corresponding CEG index for a given industry i can then be written as follows:

$$\gamma_i^{Co} \equiv \frac{\left[G_i /\left(1-\sum_c x_c^2\right) - H_i - \sum_k \hat{\gamma}_{i,k} w_{i,k}^2 \left(1 - H_{i,k}\right)\right]}{1 - \sum_{k=1}^{r} w_{i,k}^2} \tag{1}$$

where G_i is an approximation of the Gini index defined as the sum of square deviations of s_{ic} (the share of industry i's employment in area c) to x_c (the share of aggregate manufacturing employment in area c), i.e. $G_i = \sum_c \left(s_{ic} - x_c\right)^2$. The term $H_i = \sum_j z_{ij}^2$ represents the classical Herfindahl-Hirschman index defined as the sum of square plant employment shares by industry i, with $j=1\ldots N$ being the plant-indices. This latter index is included in order to control for the possible influence of plants' industrial concentration on their spatial concentration. The CEG index also controls for differences in the (economic) size of the geographic units, as measured by x_c. Subscripts $k=d,f$ refer to domestic or foreign plants, respectively, and w_k represents the share of domestic (foreign) employment in total employment of industry i. The term γ_i is the original agglomeration index of Ellison and Glaeser (1997), given by $\gamma_i \equiv \left[G_i - \left(1 - \sum_c x_c^2\right)H_i\right] / \left[\left(1 - \sum_c x_c^2\right)\left(1 - H_i\right)\right]$.

In order to illustrate the way the coagglomeration index works we consider a simple numerical example. We assume a country with 10 sectors each with 100 manufacturing plants of which 80 per cent are domestic and 20 per cent are foreign, and where geographically the country is split into two regions, North and South. It is furthermore assumed that each plant employs 10 workers, so that the Herfindahl-Hirschman index is the same across all sectors and Ellison and Glaeser's story on the differential size distribution of plants is neutralized. Thus values of the CEG index are essentially driven by the share variables (s_{ic} and x_r). We first consider the case where for each sector all plants are distributed symmetrically across the two regions so that for each sector in each region the share of foreign plants relative to domestic plants is the same.[5] In this case, because the sectoral foreign-indigenous plant distribution is the same as that of the entire plant population, the coagglomeration index will be equal to zero for all sectors. Now, let us take one of these sectors and assume that all its foreign plants located in the South region migrate to the North so that only domestic plants remain in the South region, while the geographical distribution of all the other sectors remains the same as before.[6] This movement of plants causes the CEG index to increase to a value of 0.82 for this specific sector, while for the rest of the economy it remains approximately equal to zero.[7] Intuitively, the sector in question has now more indigenous and foreign plants co-locating in a particular region compared to total manufacturing. We interpret this increase in the CEG as indicating that agglomeration economies arise between domestic and foreign plants for this specific sector.

It is important to note, however, that the CEG index does not allow one to make the distinction between natural advantages due to site-specific characteristics and potential spillovers emanating from foreign plants' presence, see Ellison and Glaeser (1997 and 1999). Following the

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[5] Table A1 in Appendix provides the results of our numerical examples.

[6] We assume that workers move together with their employers.

[7] The movement in the one sector actually also changes the distribution of the location of foreign and domestic plants for all manufacturing, thus marginally changing the coagglomeration index for all other sectors as well.

previous authors, the second type of advantage has indeed little to do with the potential existence of spillovers between plant groups. For instance in industries which make intensive use of natural resources, co-location between plants of production may simply reflect the fact that resources are localized in some specific areas. One must note, however, that the case of the Irish economy considered here simplifies things since natural-advantage based industries outside of agriculture (for example, industries like mining) are of little importance. Despite this, the observed coagglomeration between domestic and foreign plants may still be influenced by other, non-observed, site-specific advantages such as access to transport facilities. It follows that we may observe positive coagglomeration for some industries, but this does not necessarily imply a causality link between domestic and foreign plants' location choice. As a first step then, in what follows we investigate the possibility that foreign and domestic plant's location pattern can be correlated without inferring whether this correlation translates into positive spillovers. Whether this correlation translates into a positive externalities for domestic plants will be investigated in section IV.

Table 1 presents results for the 18 Nace 2-digit sectors in 1972, 1985 and 1999.[8] Accordingly, overall, there seems to be positive coagglomeration though it is has been slightly decreasing on average over the years. In fact, little can be said about those average figures. First, because they are very close to zero and in this case, according to Ellison and Glaeser (1997), little can be said about their significance. Second, the standard deviation appears to be very high compared to the average values (a factor between two and four). If one examines more closely the results for the disaggregated Nace 2- digit industries one finds that between 10 and 12 of these display positive indices depending on the year considered. In addition, we find that the ranking of industries seems quite stable over the

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[8] We also examined NACE 3 digit sectors and found similar results. However, since the kind of externalities, i.e., backward-forward linkages, discussed in the introduction are more likely to occur for broader industries, we have limited our analysis in terms of the coagglomeration index and measuring spillovers to the NACE 2-digit level.

years. Spearman rank correlation coefficients were computed between 1972-1985, 1985-1999, and 1972-1999, and we obtain positive and significant correlations for all of these.

Section IV: Econometric Analysis

A. Productivity Spillover

Our first econometric task is to determine whether there is evidence of a positive impact of local foreign presence on total factor productivity of domestic plants. In order to do so we proceeded by calculating a proxy of plant level total factor productivity using the semiparametric approach of Levinshon and Petrin (2003), which is an extension of Olley and Pakes (1996) and allows one to take account of the potential endogeneity of inputs, caused by productivity shocks, in an empirical production function. The major advantage of this approach over more traditional production function estimation techniques is its ability to more effectively control for the correlation between unobservable productivity shocks and input levels. The reason why inputs may be correlated with unobserved (to the econometrician) productivity shocks is that profit-maximizing plants will respond to positive productivity shocks by expanding output, which requires additional inputs. Similarly, negative shocks will result in lower input usage. Levinsohn and Petrin (2003) suggest the use of intermediate inputs as proxies (i.e., to control for unobservable productivity shocks) under the argument that intermediate inputs are less costly to adjust, and thus may respond more fully to productivity shocks.

We calculate TFP estimates of Irish plants using the Levinsohn and Petrin (2003) procedure and use these to estimate an empirical version as follows:

$$tfp_{jt} = \alpha + \beta_1 FP_{c,i,t} + \beta_2 PD_{c,t} + \eta_{c,t} + \lambda_{i,t} + \tau_t + \mu_j + \varepsilon_{j,t} \tag{2}$$

where $tfp_{j,t}$ are our TFP estimates of plant j at time t, $FP_{c,i,t}$ is foreign presence of sector i in county c at time t, $PD_{c,t}$ is population density in county c at time t, $\eta_{i,t}$ are sector specific (possibly time

varying) effects, $\lambda_{c,t}$ are county specific (time varying) effects, τ_t are time specific effects, μ_j are plant specific effects, and $\varepsilon_{j,t}$ is an i.i.d. error term. The foreign presence variable (*FP*) is our main variable of interest and we assume its impact on TFP in domestic plants to be of a linear nature. It is measured as the share of employment made by foreign plants in total employment at the county/sector level. Finally, the variable *PD* represents the total population in each county *c* divided up by the respective area of each county measured in square kilometers. This variable is included in order to control for possible local externalities besides the one represented by foreign presence as generally found in the regional economics literature, see, for instance, Henderson at al. (1995). Note that this variable may either display a positive or a negative sign depending on whether urbanization economies or congestion diseconomies dominate. This variable is calculated from information taken from the Irish Central Statistics Office which provides information on population at the county level for the period considered here, i.e., 1983-1998.

It is also important to point out that we use the *Forfás Employment Survey* to calculate our foreign presence proxies in (2) given the exhaustiveness of this dataset. However, as stated in Section II, this data source only provides information on the employment level of each plant and hence we have to resort to the *Irish Economy Expenditure Survey* to calculate all our TFP estimates. As a consequence, our foreign presence variable is an accurate measure of foreign presence in Irish counties while the panel of domestic plants for which equation (2) is estimated is only a sub-sample of the total Irish indigenous manufacturing. This variable is represented by the term *FP(s)* in our estimation results. Finally, one should note that, in order to control for possible time/industry specific effects all variables are centered by taking the difference with respect to their industry-level average each year.

OLS estimates of (2) are given in the first column of Table 2. As can be seen, population density is an insignificant determinant of TFP in domestic plants. In contrast we find that the

presence of foreign multinationals in the same sector and region acts as positive stimulus to domestic plants' productivity. One should note, however, that simple OLS estimation would yield biased estimators if the (unobserved to the econometrician) plant specific effects μ_j were correlated with any of the explanatory variables. In particular it could be possible that plants that are inherently more productive locate closer to multinationals serving the same sector. To investigate this we experimented both with a fixed effects estimator and with estimating (2) in first differences, the results of which are shown in the third and second column of Table 2, respectively. Accordingly, controlling for such fixed effects produces substantially different results. For one, the population density variable is now significantly negative, indicating the possible negative effects of congestion costs on domestic plants' productivity.[9] More importantly, the presence of local multinationals in the same industry no longer influences domestic plant productivity.[10]

Arguably, however, variables such as local foreign presences or population density may themselves be endogenous in our equation. For example, foreign multinationals may tend to locate in areas with characteristics that are more advantageous for their own productivity and also for domestic plants located there, independent of any spillovers arising between the two types of plants. This could be the case, for instance, if some counties benefit from better location and access to major transport infrastructure or in presence of other site-related advantage which improves productive efficiency more or less directly. Similarly, more productive areas could attract a greater share of the population. Indeed, as pointed out in Section III, the tendency for domestic and foreign plants to coagglomerate that was observed may be due to exactly such advantages. A now popular method to take account of this potential endogeneity while also controlling for fixed effects is the GMM systems estimator developed by Blundell and Bond (1998). Accordingly, one simultaneously estimates first differenced and level versions of (2) where, for the former, appropriately lagged levels

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[9] Similar congestion effect on productivity is analysed in more detail in Ciccone (2002).
[10] We also experimented with using lagged values of foreign presence but these were in no cases significant.

of the dependent variable as well as of other explanatory variables and, for the latter, appropriately lagged differences of the endogenous variables, can serve as valid instruments. The validity of these instruments can be tested using Arellano and Bond's (1991) Sargan test.[11] The results of using GMM system estimator are shown in the fourth column of Table 2. However, as can be seen, there is little qualitative difference in the results compared to the first difference estimator.

One possible explanation of this result could be that foreign presence-related spillovers only take place in industries where there is actual coagglomeration between domestic and foreign plants. In other words, potential externalities may exist only in specific industries and such industries are also those in which foreign and domestic plants tend to locate near each other. To investigate this we take advantage of the results derived in Section III, and isolate those industries for which the coagglomeration index was positive. The results of applying our GMM systems estimator to this subset are shown in the fifth column of Table 2. Importantly, one finds that for such positive coagglomeration sectors, the presence multinationals operating in the same sector and located in the same county positively increases domestic plant productivity as the coefficient obtained (0.148) is statistically significant at the 5% significance level. This estimate is also economically significant as, for instance, a 20 percentage point increase in foreign presence (which roughly corresponds to a one standard deviation change) increases average productivity by around 3%. This suggests the existence of positive within-sector local spillovers for domestic plants arising from foreign direct investment, and thus provides supportive evidence of spillovers for this subset of industries. In addition, since potential bias are controlled by instrumenting and first differencing our explanatory variables, our results provide some support for the fact that in sectors where we observed coagglomeration there is also evidence for positive productivity spillovers between domestic and foreign plants. Thus, our econometric results tend to suggest that at least part of the coagglomeration observed in Section III

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[11] One should note that there is support for the instruments used in all specifications.

corresponds to the existence of productive spillovers benefiting domestic plants rather than just site specific advantages common to both plant types.

In order to check for the robustness of this result we also experimented with an alternative proxy for foreign presence. One limitation of the foreign presence measure used up to now is that it does not take into account of the spatial dimension. As noted by Ciccone and Hall (1996) and Ciccone (2002), the *density* of economic activity may be more suitable to capture possible externalities related to the agglomeration of economic activities through space. If space and location matter then we need to consider these in our measure of foreign presence related externalities. As a consequence, we also employ a measure of relative foreign employment density represented by the total foreign employment in a sector/county divided up by the surface area of the corresponding county expressed in square kilometers. This variable is represented by the term *FP(d)* in our estimation results. Since this variable is highly correlated with population density, we have dropped the latter from the specification although it must be noted that its inclusion, not surprisingly insignificant, did not alter our results. As can be seen, one similarly finds that in sectors in which there is coagglomeration of domestic and foreign plants, there are also positive local spillovers in productivity. Here the coefficient on foreign density is significant at the 1% level. The economic interpretation differs from the foreign share variable, however, given that the variable *FP(d)* is not directly interpretable in terms of elasticity as it was the case for the *FP(s)* variable. Using a simple transformation into percentage points and considering a one standard deviation change from the average value of the *FP(d)* variable, one finds in fact that the economic impact for the foreign density variable translates into an increase of domestic plant-level productivity by approximately 4%, which is indeed very close to the impact found for the foreign share variable.[12]

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[12] One can see this by calculating the following expression $(\beta/100)\Delta FP(d)$ with β being the estimated coefficient and $\Delta FP(d)$ being the standard deviation percentage change from the average value of *FP(d)* which, in this case, is approximately equal to 3.97.

Since Dublin represents an important share of Irish manufacturing employment but a low share of FDI, we also investigated whether our results are robust to excluding this county in the last two columns of Table 2 using our two local foreign presence proxies. Accordingly, qualitatively our results are invariant to the exclusion of this county. However, in comparing results it becomes apparent that whether the exclusion of Dublin county translates into larger spillover effects depends on the choice of local foreign presence proxy. [13] If we consider the result concerning the *FP(s)* variable then we find that a one standard deviation rise in foreign presence now increases the average plant productivity by approximately 6% which doubles our previous estimate when including county Dublin while when considering the *FP(d)* variable the estimated change from one standard deviation of this variable equals 3%.

B. Labour Demand

The results just described show that at least for sectors where there was positive coagglomeration there have been positive productivity spillovers for domestic plants arising from local foreign presence. However, whether such productivity spillovers translate into greater demand of labour in domestic plants is a priori not clear. More precisely, this will crucially depend on the elasticity of substitution of labour relative to other inputs; see Hamermesh (1994). Accordingly, the effect of spillovers on the level of domestic plants' employment ends up being an empirical issue. In order to investigate this we consider the following standard expression for labour demand:

$$ l_{jt} = \alpha + \beta_1 l_{j,t-1} + \beta_2 w_{j,t} + \beta_3 y_{j,t} + \beta_4 FP_{c,i,t} + \beta_5 PD_{c,t} + \eta_{c,t} + \lambda_{i,t} + \tau_t + \mu_j + \varepsilon_{j,t} \qquad (3) $$

where *l*, *w*, and *y* are logged values of employment, wages per head and output respectively and the other variables are defined as in (2). One should note that we have also included a lagged value of the dependent variable in (3). This is standard in labour demand estimation as, arguably, labor demand may be dynamic in nature because of a non-smooth adjustment process in plants'

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[13] We also experiment with using lagged levels of the foreign share proxies, but in all cases these turned out to be

employment policy (see, for example, Hamermesh (1993) for a description of standard labor demand functions in a dynamic context).

OLS estimations of (3) are provided in the first column of Table 3. Accordingly, while output and wages significantly affect employment and are of the expected sign, there is no evidence that local foreign presence affects domestic plants' labour demand. Also, population density appears to be of little relevance. Purging unobserved time invariant plant specific effects that may be correlated with any of the regressors from (3) via a first difference estimator, as depicted in second column, produces similar results to using OLS, except that the lagged dependent variable is no longer significant. However, as the third column of Table 3 demonstrates, the way such effects are purged can influence the conclusions drawn since, when using the fixed effects estimator, the negative and significant coefficient on local foreign presence is now statistically significant.

One has to keep in mind, however, that for both the first difference and fixed effects specification, if such unobserved time invariant plant specific effects are correlated with the regressors then the inclusion of a lagged dependent will produce biased estimates.[14] Also, wages and output are likely to be endogenous regressors as these are likely to be simultaneously determined with employment. Moreover, one could similarly, as with productivity, argue that variables such as local foreign presence and population density may be endogenous with regard to employment choice of domestic plants. Hence we re-estimated (3) using the GMM systems estimator. One should note that with a lagged dependent variable the consistency of estimates crucially depends on a lack of second order serial correlation and we verify this using the test developed by Arellano and Bond (1991).[15]

The results from the fourth column of Table 3 indicate little difference compared to the OLS and first difference estimations, i.e., for the overall sample there is little evidence that local foreign

insignificant.
[14] See Greene (2000).

presence has affected domestic plant employment choice. However, since our previous results showed significant productivity spillovers only for sectors in which there was evidence of coagglomeration between foreign and domestic plants, we also re-estimated (3) for this sub-sample only. Importantly, we now find that, as shown in the fifth column, local foreign presence has acted to increase labour employed in domestic plants. This result also holds when we consider our alternative proxy of local foreign presence as indicated in the subsequent column. In all cases the influence of foreign presence is significant at the 1% level. Here again, results are very similar independently of the measure of foreign presence being used. If we consider the *FP(s)* variable we now find that a 20 percentage point increase (i.e. one standard deviation change for this variable) of foreign presence increases domestic plants' employment by around 1.8%. When considering a one standard deviation change for the *FP(d)* variable we find that the corresponding change in employment lies around 1.7%. Moreover, excluding Dublin county in the last two columns does not affect this result qualitatively.[16] Furthermore, the positive effect of local foreign presence on labour demand is quantitatively larger for non-Dublin areas and this result holds for our two measures of foreign presence: when considering the *FP(s)* variable, results in column (7) of Table 3 show that the impact of a one standard deviation change of this variable increases employment by 2.7% while when using the *FP(d)* variable we obtain a corresponding increase of domestic employment of 4.3%. One should note moreover that for counties other than Dublin the population density variable is no longer significant, suggesting that these regions do not benefit from agglomeration economies apart from FDI related externalities. This result can also be put in parallel with the evidence put forward in Section III showing the relative decline of Dublin's share in total manufacturing employment together with the increase in FDI in Ireland. The econometric evidence presented here tends to suggest that the effects of FDI-related spillovers on domestic employment were greater outside

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[15] As can be seen from the AR(2) test statistic given in the table, there is no evidence of second order serial autocorrelation in any of our specifications using the GMM estimator.

rather than inside county Dublin, thus promoting economic development outside the capital of Ireland.

Section V: Conclusion

It is now widely accepted that the astonishing economic performance of the Irish economy over the last decade has in a large part been due to the considerable influx of FDI. One of the major objectives of Irish policy makers in attracting FDI has been to stimulate the development of the domestic industry through spillovers from multinationals. According to the New Economic Geography literature such spillovers are often better fostered if plants are located close to each other. In this paper we have thus investigated what role the spatial coagglomeration of domestic and foreign plants has played towards local industrial development.

Using an index recently developed by Ellison and Glaeser (1997) we have first shown that for a large number of industries, coagglomeration between domestic and foreign plants has been considerable and persistent, and has coincided with the influx of FDI since the early 1970ies. In order to verify that coagglomeration has served to stimulate indigenous industrial development we have estimated plant-level productivity equations allowing for potential foreign presence spillovers. Our results support the existence of positive local spillovers from multinationals on indigenous productivity and employment, but only in sectors where there has been actual coagglomeration of domestic and foreign plants. We found that a one standard deviation change in foreign presence translated into a rise varying between 3 and 6% in productivity and 1.7 and 4.3% in employment depending on the measure of foreign presence used and whether county Dublin was included in the

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[16] As with the productivity equations, we here also experiment with using lagged levels of the foreign share proxies, but in all cases these turned out to be insignificant.

estimations. These results in turn suggest that the coagglomeration between foreign and domestic plants observed in Ireland was at least in part due to the existence of positive spillovers.

References

Aitken, B.J. and A.E. Harrison (1999), Do Domestic Firms Benefit from Direct Foreign Investment? Evidence from Venezuela, *American Economic Review*, 89, 605-618.

Alfaro, L and A. Rodriguez-Clare (2003), "Multinationals and Linkages: An Empirical Investigation", Economia 4 (2): 113-56.

Arellano, M. and S. Bond, (1991). "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations", *Review of Economic Studies*, 58(2): 277-97.

Audretsch, D. and M. Feldman, (1996). "R&D Spillovers and the Geography of Innovation and Production", *American Economic Review*, 86(3): 630-640

Barrios, S., S. Dimelis, H. Louri and E. Strobl (2004), "Efficiency spillovers from foreign direct investment in the EU periphery: a comparative study of Greece, Ireland and Spain", *Review of World Economics* 140 (4): 688-705.

Barrios, S., L. Bertinelli, E. Strobl, (2005b). Multinationals and regional indigenous development, *Annals of Regional Science* 39 (1) 149-166.

Barrios, S., H. Görg and E. Strobl, (2006). "Multinationals' location choice, agglomeration economies and public incentives", *International Regional Science Review 29(1): 1-27.*

Barry, F. and J. Bradley, (1997). "FDI and Trade: The Irish Host-Country Experience". *Economic Journal* 107, 1798-1811.

Blomström, M. and A. Kokko, (1998). "Multinational Corporations and Spillovers", *Journal of Economic Surveys* 12, 247-277.

Blomström, M. and F. Sjöholm (1999), "Technology transfer and spillovers: does local participation with multinationals matter"? *European Economic Review* 43: 915-923.

Blundell, R. and S. Bond, (1998). "Initial Conditions and Moment Restrictions in Dynamic Panel Data Models", *Journal of Econometrics*, 87, 115-143.

Ciccone, A. and Hall, R., (1996). "Productivity and the density of economic activity". *American Economic Review* 86, 54-70.

Ciccone, A., (2002). "Agglomeration-effects in Europe", *European Economic Review* 46(2), 213-227

Dekle, R., (2002). "Industrial concentration and regional growth: evidence from the prefectures". *Review of Economics and Statistics* 84(2), 310-315.

Ellison, G. and Glaeser, E., (1997). "Geographic concentration in U.S. manufacturing industries: a dartboard approach". *Journal of Political Economy* 105 (5), 889-927.

Ellison, G. and Glaeser, E., (1999), "The Geographic Concentration of Industry: Does Natural Advantage Explain Agglomeration?" *American Economic Review Papers and Proceedings* 89 (2), 311-316.

Fujita, M. and J.F. Thisse, (2002). *Economics of Agglomeration. Cities, Industrial Location and Regional Growth.* Cambridge University Press.

Girma, S. and K. Wakelin (2001), Regional underdevelopment: Is FDI the solution? GEP Research Paper n°2000/16, Nottingham.

Girma, S. and K. Wakelin (2002), Are there Regional Spillovers from FDI in the UK? In: D. Greenaway, R. Upward and K. Wakelin (Eds.) Trade, investment, migration and labour market adjustment, IEA conference Volume n°135, International Economic Association and Palgrave Macmillan.

Görg, H. and Greenaway, D.., (2004). "Much ado about nothing? Do domestic firms really benefit from foreign direct investment?", *World Bank Research Observer*, Vol. 19, No. 2, 2004, pp. 171-197.

Görg, H. and Strobl, E., (2001). "Multinational Companies and Productivity spillovers: A Meta-Analysis", *Economic Journal*, Vol.111, pp.F723-F739.

Görg, H. and Strobl, E., (2002). "Multinational Companies and Indigenous Development: an empirical analysis". *European Economic Review* 46(7): 1305-22

Görg, H. and Strobl, E., (2005). "Spillovers from foreign firms through worker mobility: an empirical investigation", *Scandinavian Journal of Economics*, *forthcoming.*

Greene,W.H., 2000. *Econometric Analysis.* Prentice Hall International Inc, 4th edition.

Haddad, M. and A. Harrison (1993), Are There Positive Spillovers from Direct Foreign Investment? Evidence from Panel Data for Morocco, *Journal of Development Economics* 42(1): 51-74

Hamermesh, D.S., (1993). *Labor Demand.* Princeton University Press, Princeton, N-J.

Hamermesh, D.S., (1994). "The demand for Labor in the Long run", NBER working paper 1297.

Henderson, V., A. Kuncoro and M. Turner, (1995). "Industrial development in Cities". *Journal of Political Economy* 103 (5), 1065-1090.

Jaffe, A.B., Trajtenberg, M. And Henderson, R., (1993). "Geographic localization of Knowledge Spillovers as Evidenced by Patent Citations", *Quarterly Journal of Economics* 108, 577-98.

Krugman, P.R., (1991). "Increasing Returns and Economic Geography". *Journal of Political Economy* 99(3), 483-99

Levinsohn, J. and A. Petrin, (2003). "Estimating Production Functions Using Inputs to Control for Unobservables", *Review of Economic Studies*, Vol. 70(2), 317-342

Meyler, A. and E. Strobl (2000), "Job Generation and Regional Industrial Policy in Ireland", *Economic and Social Review* 31 (2): 111-128

Olley, S. and Pakes, A. (1996), "The Dynamics of Productivity in the Telecommunications Equipment Industry", *Econometrica* 64: 1263-1297.

Sjöholm, F. (1999), Technology gap, competition, and spillovers from FDI: Evidence from establishment level data, *Journal of Development Studies* 36: 53-73.

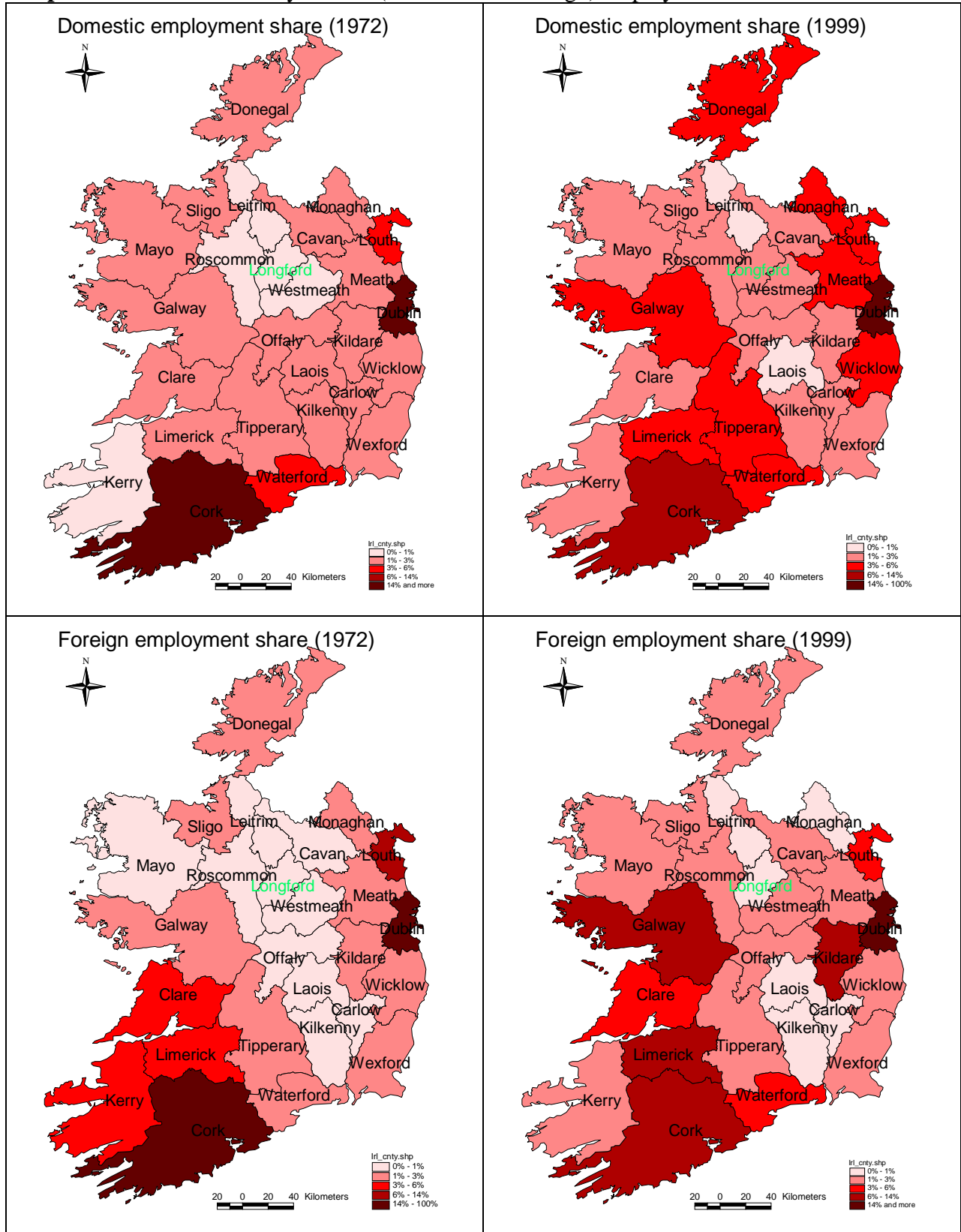**Maps** : Share of each country in total (domestic and foreign) employment

Domestic employment share (1972)

Domestic employment share (1999)

Foreign employment share (1972)

Foreign employment share (1999)

Table 1: Coagglomeration index for Irish manufacturing industries—Nace 2 digits, 1972-1999

Nace code (2-digit)		1972	1985	1999	var.72-85	var. 85-99
15	Food and beverages	-0.066	-0.039	-0.028	+	+
16	Tobacco products	-0.270	-0.025	-0.126	+	-
17	Textiles and textile products	0.069	0.045	0.077	-	+
18	Clothing, footwear and leather	-0.024	0.030	0.006	+	-
20	Wood and wood products	0.104	0.047	0.014	-	-
21	Paper and paper products	0.105	0.150	0.152	+	+
22	Printing	0.197	0.178	0.140	-	-
24	Chemicals	-0.009	0.013	0.010	+	-
25	Rubber and plastic products	-0.020	0.011	0.005	+	-
26	Glass and glass products	0.013	0.010	-0.005	-	-
28	Basic and fabricated metal products	-0.001	-0.007	0.001	-	+
29	Machinery	-0.019	0.030	0.012	+	-
30	Office machinery and computers	0.099	0.023	-0.014	-	-
31	Electrical machinery and apparatus n.e.c.	0.003	-0.012	0.009	-	+
32	Television and radio	0.391	-0.015	0.006	-	+
33	Electronic equipment	0.070	-0.021	-0.039	-	-
34	Motor vehicles	0.031	0.041	0.009	+	-
36	Miscellaneous manuf. products	-0.016	0.002	-0.004	+	-
Averages for all industries		*0.037*	*0.026*	*0.013*	*-*	*-*
Standard deviation		*0.130*	*0.056*	*0.062*	*-*	*-*

	Spearman rank correlation coefficients	**1972-85**	**1985-99**	**1972-99**		
	Nace 3-digit	0.351	0.516	0.157		
		(0.013)	(0.000)	(0.281)		
	Nace 2-digit	0.444	0.833	0.479		
		(0.058)	(0.000)	(0.038)		

Note: * P-values between parentheses

Table 2: Productivity Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Method	OLS	FD	FE	GMM	GMM	GMM	GMM	GMM
Sample	Total	Total	Total	Total	Pos. Co.	Pos. Co.	Pos. Co.	Pos. Co.
Dublin	Yes	Yes	Yes	Yes	Yes	Yes	No	No
POPD	0.012	-0.414	-0.350	-0.019	0.033		0.044	
	(0.007)	(0.965)	(0.150)*	(0.027)	(0.018)		(0.018)*	
FP(s)	0.166	0.182	0.177	-0.180	0.148		0.302	
	(0.051)**	(0.285)	(0.105)	(0.182)	(0.070)*		(0.043)**	
FP(d)						1.012		0.755
						(0.202)**		(0.219)**
Constant	0.008	-0.009	-0.003	0.000	0.002	-0.006	0.035	-0.012
	(0.009)	(0.013)	(0.008)	(0.022)	(0.013)	(0.016)	(0.018)	(0.012)
Obs.	1823	1823	1823	1823	881	881	548	548
F-t. FE			28.76**					
Hansen				51.55	47.84	16.62	52.49	27.67

Table 3: Labour Demand Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Method	OLS	FD	FE	GMM	GMM	GMM	GMM	GMM
Sample	Total	Total	Total	Total	Pos. Co.	Pos. Co.	Pos. Co.	Pos. Co.
Dublin	Yes	Yes	Yes	Yes	Yes	Yes	No	No
L(-1)	0.938	0.014	0.527	0.951	0.857	0.851	0.886	0.889
	(0.007)**	(0.027)	(0.022)**	(0.014)**	(0.003)**	(0.005)**	(0.017)**	(0.005)**
W	-0.106	-0.317	-0.300	-0.100	-0.111	-0.145	-0.123	-0.118
	(0.010)**	(0.022)**	(0.020)**	(0.011)**	(0.001)**	(0.003)**	(0.020)**	(0.007)**
Y	0.071	0.142	0.163	0.081	0.167	0.195	0.101	0.087
	(0.007)**	(0.018)**	(0.017)**	(0.010)**	(0.003)**	(0.008)**	(0.014)**	(0.005)**
POPD	0.004	0.271	0.489	0.005	0.009		0.008	
	(0.003)	(0.381)	(0.141)**	(0.005)	(0.003)**		(0.025)	
FP(s)	0.015	-0.192	-0.317	-0.070	0.094		0.136	
	(0.022)	(0.116)	(0.103)**	(0.044)	(0.008)**		(0.036)**	
FS(d)						0.436		1.073
						(0.028)**		(0.062)**
Constant	0.111	-0.006	0.906	0.086	0.267	0.273	0.233	0.233
	(0.013)**	(0.005)	(0.043)**	(0.026)**	(0.003)**	(0.010)**	(0.046)**	(0.010)**
Obs.	1443	1443	1443	1443	686	686	435	435
F-t. FE			3.17**					
Hansen				151.17	119.47	114.48	70.66	75.01
AR(2)				0.71	0.36	0.31	0.90	0.88

Appendix

Table A1: Numerical simulation on the Ellison-Glaeser Coagglomeration (CEG) index

	Symmetric case	Asymmetric case
CEG index between domestic and foreign firms in sector *i*	0.00	0.82
CEG index between domestic and foreign firms in the rest of sectors	0.00	0.01