Coagglomeration and Growth

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Abstract

We study the coagglomeration of domestic plants and foreign multinationals and the impact of this on domestic plant growth using data for Irish manufacturing. To this end we make use of the index developed by Ellison and Glaeser (1997) and find coagglomeration to be important for a number of industries. Foreign presence as well as foreign employment density are found to be important determinants of employment growth over the period, especially for those industries with a high degree of coagglomeration.

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1 Introduction

The idea that growth is localized is an old one and can be traced back to a number of authors, such as Perroux (1955), Myrdal (1957) and Hirschman (1958). The main argument of these authors is that proximity of heterogeneous activities favors cross-fertilization. Solutions to problems in a particular industry and geographical area can be mimicked in other areas for the same or related industries. However, as knowledge only spreads slowly through space, agglomeration of economic activity tends to foster the emergence of innovation clusters. More recently, the links between agglomeration and regional economic development have attracted growing attention. As Lucas (1988) already pointed out in his seminal paper, externalities that are at the source of endogenous growth are mostly local in nature since they concern interactions between agents. The same holds for Romer-type models where location of hi-tech firms and R&D activities may arguably matter for economic growth and development through knowledge-related externalities.

Some recent theoretical work has considered more explicitly possible linkages between agglomeration and regional growth using a dynamic approach including Walz (1996), Baldwin (1999), Martin and Ottaviano (1999, 2001), Baldwin *et al.* (2001), Fujita and Thisse (2002, chap.11), as well as Black and Henderson (1999) in an urban economics framework. Besides these theoretical contributions, a vast empirical literature relating to these issues has developed, mainly oriented towards urban economics. Empirical evidence

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has been provided in Tabuchi (1986), Glaeser *et al.* (1992), Henderson *et al.* (1995), de Lucio *et al.* (2002) and Dekle (2002). Special emphasis is generally put on identifying the nature of externalities arising in urban growth, the main question being whether such externalities are industry-specific (*à la* Marshall-Arrow-Romer) or based on cities' diversity of industries (as argued by Jacobs, 1969). Transferring the same questioning in an innovation setting, Audretsch and Feldman (1996) and Feldman and Audretsch (1999) ask whether specialization or diversity of R&D activities favor innovation, and it turns out that innovation is more prone to the local presence of diversified R&D activities.

The present paper takes a somewhat different angle. We ask the question whether agglomeration may affect regional economic growth by looking at a particular case where agglomeration and growth may go hand in hand. More specifically, we study the coagglomeration between domestic and foreign firms in Irish manufacturing industry and the way this may have fostered indigenous plants' growth. An often cited stylized fact is that the recent spectacular Irish economic boom has largely been influenced by huge foreign direct investment (FDI) inflows.[1] The empirical evidence provided here shows that FDI has been especially vigorous in some traditionally disadvantaged regions such as Galway, Limerick, and Donegal, promoting employment outside the Dublin area where manufacturing employment used to be concentrated. Relying on plant level employment, output, and wage data, we show that the rise in foreign employment has generally been accompanied by domestic employment growth giving support for the existence of positive spillovers between foreign firms and their domestic counterparts.

[1] See Barry and Bradley (1998).

Following the literature on FDI, multinationals may affect the host economy through a number of channels (see Markusen and Venables (1999) and Blomström and Kokko (1998)). More remarkably, the forces generally invoked in the economic geography related literature for economic agglomeration to take place (i.e. labor market pooling, backward-forward linkages and technological externalities) are put forward when assessing the possible impact of multinational firms on domestic plants. Multinationals are often viewed as modern firms using innovative production processes, employing skilled workers and also benefiting from R&D services from their headquarters (see Markusen, 1995). If spillovers arise between firms geographically concentrated then domestic firms may in turn benefit from R&D spillovers related to multinational activities. Domestic firms may also take advantage of backward-forward linkages with multinationals. For example, Markusen and Venables (1999) show that foreign firms may exacerbate indigenous industrial development by using local intermediate products. Domestic firms, by getting acquainted with new production techniques and benefiting from larger diversity of intermediate products, may ultimately compete with foreign firms. FDI-related backward-forward linkages are thus closely related with technological externalities and demonstration effects, since foreign firms generally use technology-intensive intermediates, pushing domestic firms to adopt new production standards (see Blomström, 1986). The existing empirical evidence on possible spillovers emanating from foreign presence points toward a potentially important impact of FDI on local industrial development, although most studies do not take the intra-national dimension of spillovers into account (see Görg and Strobl, 2001). In the present paper we do not specifically aim at identifying the mechanisms through which local positive spillovers emanate from foreign presence. Our main focus is rather to investigate the local dimension of FDI-related externalities. The first question we consider is whether there is an advantage for domestic plants to locate close to foreign multinational in order to avail of the potential externalities related to foreign presence. To this end we use exhaustive information on domestic and foreign plants' location in 27 counties of Ireland for the period 1972-1999. Our basic conjecture is that multinationals mainly aim at using Ireland as a base for exports and do not directly compete with domestic firms on their product market. Positive spillovers emanating from co-location between multinationals and domestic firms are then expected to be much more important for the latter. We use the coagglomeration index developed by Ellison and Glaeser (1997) in order to examine this hypothesis. Our results point toward substantial coagglomeration between multinationals and domestic plants for nearly half of the industrial industries examined, providing some evidence of significant FDI-related local spillovers.

The second question examined concerns the possible impact of foreign presence on regional growth. To this end we make use of a panel of Irish-owned plants over the period 1983-1998 to see whether foreign presence has had a significant impact on domestic plants' employment growth. Our basic assumption is that, for a given industry, if a domestic plant benefits from being located in a county with high foreign presence then it will grow at a faster pace than other domestic plants located elsewhere in Ireland. The results indicate a positive and significant impact of foreign presence on domestic plants' employment growth. However, this effect is not found to be equal across Irish counties. In particular, our results show that for county Dublin, congestion costs related with land price have lowered potential benefits from foreign presence. In further testing the link between coagglomeration and growth we find strong evidence for positive and significance spillovers for those plants belonging to industries where coagglomeration was significant over the period considered. Domestic and foreign plants' location choice are thus strongly correlated and, in turn, foreign presence has generally contributed to domestic employment growth at the regional level. Our results thus suggest that location matters for growth.

The rest of the paper is organized as follows. In the next section we present the data and method used to construct the measure of coagglomeration index as well as its evolution over the 1972-1999 period. In section 3 we conduct an econometric test of the impact of foreign presence on domestic employment growth for the 1983-98 period. Section 4 concludes.

2 Coagglomeration between domestic and multinational firms in Ireland

The Irish economy has experienced strong 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-1980's providing Ireland with strong competitive positions in 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.[2] In particular, some regions with traditionally low manufacturing employment in Ireland have seen their share in total Irish employment rise since 1972.

Using the data from the *Forfás Employment Survey*, an exhaustive survey of all known active manufacturing plants in Ireland since 1972. Irish

[2] Note that from now on we will use the terms county and region indistinctly.

counties are generally defined around some urban cluster, which makes them meaningful spatial economic units. Average county area in Ireland is larger than in the US (2600skm compared to about 1150skm on average for the US). However, population density is lower in Irish counties.[3] Graph 1 shows that 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, overall foreign share increased substantially. One must note however that it is only between the 1970ies and the mid-1980ies that this relative decline in county Dublin translated into a decrease in total manufacturing employment in absolute terms. In fact, during the second period the level of manufacturing employment remained practically the same in that region as shown by graph 2. The maps in appendix reveal interesting additional features by displaying the share of each county in both total domestic and foreign employment. Those 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's county while county Cork, the second county in terms of population size after Dublin came largely behind Dublin in terms of its share in total manufacturing employment (14.3% against 39.8% for Dublin). Foreign employment appeared to be relatively more concentrated in 1972 with some Western regions like Clare, Limerick and Kerry having a more than proportional (compared to domestic employment) share of foreign employment located on their territory. This is supported by the computation of Gini coefficients equal to 0.718 and 0.588 for foreign and domestic employment respectively in 1972. However, both

[3] Details of this data source are provided in the Data Appendix.

domestic and foreign employment seem to be less concentrated at the end of the period in 1999 with some Western regions like Waterford, Galway or Limerick having seen their share of in both domestic and foreign manufacturing employment to rise significantly.[4] In particular the last two counties, traditionally given "disadvantaged" status, have been successful in attracting foreign investors. In a recent paper, Barrios *et al.* (2002) show that public incentives through investment promotion in those counties have been effective in attracting foreign investors. The preceding authors also show that agglomeration economies have been an important determinant of FDI inflows into Irish counties with multinationals tending to locate where other foreign firms (with the same or different nationality) were already installed. The preliminary evidence thus tends to indicate that the higher foreign employment in a number of counties in general, and in disadvantaged areas in particular, has been accompanied by an increased share in domestic employment. Before evaluating whether higher foreign presence has also translated into higher domestic employment growth, that is, whether there where local spillovers emanating from FDI, in the next section we try to describe more accurately the patterns of foreign and multinational plants' location. The question we look at is whether domestic and foreign business units have tended to locate closer together and, more importantly, if they had advantages in doing so.

2.1 Measuring coagglomeration

There is now an important literature analyzing foreign multinationals' location choice, in particular in the United States (see for example Coughlin

[4]This is also supported by the Gini index which is equal to 0.482 for domestic employment and 0.628 for foreign employment in 1999.

et al. 1991, Smith and Florida 1994 and Head *et al.* (1999)).[5] Our concern here is rather different since we consider how domestic plants and foreign affiliates' location choice influence each other through the existence of positive spillovers. As a first step we are interested in analyzing whether the location of domestic plants coincides with the location of foreign plants, without, as of yet, assessing causality. Hence we need a tool to identify the patterns of coagglomeration between foreign and domestic plants.[6] To this end, we can avail of the index of coagglomeration (CEG) recently developed in Ellison and Glaeser (1997), which is closely related to the authors' agglomeration index derived in the same paper. More precisely, Ellison and Glaeser (1997) have pointed out that an important drawback of the commonly used Gini index as an agglomeration measure lies in its sensitivity to economies of scale. As a consequence, the spatial concentration of workers may be due at least partly to the existence of internal economies of scale. Ellison and Glaeser (1997) thus have proposed a model-based index of spatial concentration Glaeser which presents the desirable feature of neutralizing the possible influence of plants' size. Its expression for a particular industry i is given by:

$$\gamma_i \equiv \frac{G_i - \left(1 - \sum_c x_c^2\right) H_i}{\left(1 - \sum_c x_c^2\right)\left(1 - H_i\right)}$$

where G_i is an approximation of the Gini index defined as the sum of squared 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 Hirschman-

[5] Those papers follow more general empirical studies on plants' location choice, in particular by Carlton (1983) Bartik (1985) and Schmenner *et al.* (1987).

[6] The data appendix provides more details about the classification as foreign or domestic plant.

Herfindahl index defined as the sum of squared plant employment shares by industry i, with $j = 1...N$ the plant-indices. The Ellison Glaeser (from now on EG) index is then comparable across time and across industries regardless of plants' size distribution.[7]

A related question is to know whether the industries we make reference to represent homogenous entities. As proposed by Ellison and Glaeser (1997), a corollary to the agglomeration index then consists in computing the concentration at a finer disaggregation, and in a second step to see whether there is coagglomeration among these disaggregated units of observation. Here we are going to make a distinction between domestic and foreign employment, i.e. disaggregating industry employment into domestic and foreign. The resulting coagglomeration index (CEG) will then be a function of domestic and foreign industry indices and of the relative share of domestic and foreign employment in industries' total employment. We thus consider the way domestic and foreign firms coagglomerate for a given industry. The corresponding CEG index of Ellison and Glaeser can be written as follows:

$$\gamma_i^{Co} \equiv \frac{G_i/\left(1-\sum_c x_c^2\right) - H_i - \sum_k \gamma_{i,k} w_{i,k}^2 \left(1-H_{i,k}\right)}{1-\sum_k w_{i,k}^2}$$

where $k = d, f$ indicates whether the index refers to domestic or foreign plants, respectively, and w_k represents the employment share of domestic and foreign employment in total employment of industry i. A value of $\gamma_i^{Co} = 0$ indicates that foreign and domestic industries exhibit no coagglomeration at all (i.e. any spillovers/natural advantages found within the domestic/foreign groups are completely group-specific), whereas positive and

[7] One should note however that a major limitation of the EG index is that one cannot distinguish between spillovers and natural advantages to explain the reasons why plants agglomerate. This is simply due to the fact that in the model there is an observational equivalence between natural advantage and spillovers.

large values of γ_i^{Co} indicate that the natural advantages and spillovers that exist are industry-specific. This means that spillovers benefit foreign as well as domestic firms in an industry and/or natural advantages are perfectly correlated. In order to consider the kind of coagglomeration depicted by Ellison and Glaeser we will also consider different industry-breakdowns like Nace 2 and 3-digit. Note finally that, as for Ellison and Glaeser (1997), with our index of coagglomeration we just observe whether foreign and domestic firms tend to co-locate more than would be expected from a random process. In addition, as for the EG index, the CEG index does not allow one to make the distinction between natural advantages due to site-specific characteristic and potential spillovers emanating from foreign firms' presence. Hence, we measure coagglomeration between domestic and foreign plants without explicitly dealing with the underlying mechanisms through which spillovers occur. 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 just investigate the possibility that foreign and domestic plant's location pattern can be correlated. Whether this correlation translates into a positive advantage for domestic plants will be investigated in section 3.

2.2 Evidence for the Irish manufacturing industry

Tables 1a and 1b present results for 49 Nace 3-digit industries and 18 Nace 2-digits that were present in Ireland in 1972, 1985 and 1999.[8] Both tables show that, overall, there seems to be positive coagglomeration though it is

[8] The total number of manufacturing industries available is in fact equal to 101 though not all have experienced FDI in which case we cannot compute the coagglomeration index. In addition, some industries are not present for the whole period considered here.

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 and second because the standard deviation appears to be very high compared to the average values (a factor between two and four). If we look more closely at the results for the disaggregated Nace 3 digits industries we find that for all three years considered in Table 1a, around 30 industries out of 49 have positive coagglomeration coefficients and 18 of those have coefficients above the industry-wide average. Table 1b shows in turn that we find between 10 and 12 Nace 2 digits industries displaying positive indices depending the year considered. In addition, we find that the ranking of industries seems quite stable over the years. Spearman rank correlation coefficients were computed between 1972-1985, 1985-1999 and 1972-1999 and we obtain positive and significant correlations except for the Nace 3 digits industries over the whole period providing support for some important changes over the last 30 years or so. Some industries have seen their coagglomeration coefficient rise dramatically over this period like Nace 153 (Processing and preserving of fruit and vegetables), Nace 171 (Preparation and spinning of textile fibres) and Nace 177 (Knitted and crocheted articles), while others experienced a fall going from positive and large coefficients to become negative as, for example, Nace 175 (Other textiles), Nace 261 (Glass and glass products) and Nace 362 (Jewellry and related articles). One should note, however, that a high volatility of the CEG index may also be due to the small size of industries in total employment and/or the small number of plants in each of these industries. The evolution for Nace 2-digit industries is much more stable. Still, the general trend is rather similar to the one for the Nace 3-digit industries as can be seen through the Spearman rank correlations also reported in the lower part of table 1b.

In order to see whether we observe some trends in the changes of the coagglomeration indices by industry we have constructed transition matrices dividing up industries according to the sign of their index. Table 2 shows these for annual and 5-year changes using both 2 and 3-digit Nace classifications. One observes that the probability for a industry to experience no change in the sign of its index rises when considering annual rather than 5-year intervals. This comforts the view that there is important inertia in the short run, but that changes can occur over a longer time span. Again, from the Nace 3-digit breakdown it is hard to see any trend toward dispersion or coagglomeration since the transition probability of going from positive to negative and the one going from negative to positive are generally comparable. The same does not hold when using the Nace 2-digit classification. We now obtain a larger proportion of industries that go from negative to positive values of the index no matter which time period is being considered. This could be interpreted as coagglomeration mainly occurring within broad-industries where externalities such as backward-forward linkages, as proposed in the FDI and economic geography related literature, are more likely to take place. However, as mentioned earlier, the CEG index does not allow us to disentangle between the various possible causes of coagglomeration. As mentioned earlier, our focus is rather different in this paper since we are mainly interested by the possible impact of coagglomeration on local industry growth independently of the mechanism through which spillovers occur.

When considering possible impact of coagglomeration on employment growth one may expect three possible outcomes. The first one is that foreign presence has no significant impact on local growth. A second possible outcome is that there is a positive impact of FDI on local growth if positive spillovers of the kind described above arise. However, one can perfectly conceive as a third alternative that domestic firms would be wiped out of the market because of a competition effect (as in Markusen and Venables, 1999). Moreover, domestic firms' employment may also decrease because of labor market poaching by multinational firms if, for example, multinationals pay higher wages and then attract workers away from domestic firms. Foreign firms may then have a positive influence on total employment growth but not necessarily on domestic employment growth. This can be observed in Table 3 showing at the county-level total and domestic employment growth over different time periods together with the level and changes of foreign presence measured by foreign share of total employment. We can see that counties like Galway or Limerick have experienced both a huge rise in total and domestic employment and also in foreign presence. This seems to support the second scenario. On the other hand counties like Dublin, Clare, Cork, Kildare or Waterford have also experienced a rise in foreign presence but also a steady decline in domestic employment providing support for the third view. If one considers the case of Dublin more carefully however, then non-reported results show that domestic manufacturing employment has started to grow steadily again from 1993 onward mitigating the apparent decline of Dublin as the Irish manufacturing base. More generally one must reckon that it is thus difficult to assess the general impact of foreign presence on local growth with the descriptive statistics at hand and we need to consider possible industry and region-specific effects as well as plant-specific characteristics.

3 Coagglomeration and growth: a panel data analysis

3.1 The Model

The tested model derives from a standard profit function, where the Solow residual is Hicks-neutral and the elasticity of substitution between our two factors of production, namely labor and capital, is assumed to be constant. Moreover, as is standard in the literature, plants are hypothesized to behave as price takers. Prices of the final goods are hence normalized to one. There is also perfect mobility on the capital market. Finally, on the labor market, we allow heterogeneity among workers affecting their productivity. Wages will hence reflect their productivity and will be plant specific.

The first order condition with respect to labor gives us the equilibrium condition on the labor market. Using natural logarithms and the difference operator, we end up with

$$\Delta \ln (A_{i,j,t}) = \Delta \ln (w_{i,j,t}) - \Delta \ln (f (l_{i,j,t}, k_{i,j,t})) \tag{1}$$

where f is the CES production function, and l and k are labor and capital stock used for production, $w_{j,t}$ and r_t are the cost of labor and capital respectively, while A is a Solow residual. Subscripts i, j, t refer to respectively industry, plant and time. We consider that the growth rate of the productivity parameter A is determined by the presence of foreign multinational in each county-sector at the base period $t-1$. Denoting i the index for the industry, c the index for the county, and assuming productivity growth to be a function of foreign presence in county c and industry i we write

$$\Delta \ln \left(A^c_{i,j,t}\right) = g\left(FP^c_{i,t-1}\right) + \gamma t + v_j \tag{2}$$

where FP is a measure of foreign presence to be explained later while v_j represents plant-specific characteristics determining plants' productive efficiency that we assume to be time-invariant, and γt captures a deterministic time trend. Equating (1) and (2) and making use of the constant elasticity of substitution hypothesis between labor and capital, we end up with a standard labor demand

$$\Delta \ln (l_{i,j,t}) = a + b \cdot \Delta \ln (y_{i,j,t}) - c \cdot \Delta \ln (w_{i,j,t}) + d \cdot g \left(FP^{c}_{i,t-1} \right) \qquad (3)$$

where a, b, c and d are parameters depending among others on the elasticity of substitution between labor and capital and on the distribution parameter. According to specification (3), domestic plants may potentially benefit from co-located near foreign plants in the same county-industry. It is worth mentioning that up to here, our interpretation on the foreign presence externality has been voluntarily broad. As can be deduced from specification (3), $g(FP)$ may refer to technological spillovers, gains from sharing labor markets, gains from interfirm trade or any other force that may increase profits of domestic firms locating close to foreign firms. This identification issue, clearly posed from a theoretical viewpoint is still staggering when it comes to the empirics (see for instance Head and Mayer (2004) and Rosenthal and Strange (2004)).

Some further refinements are added to our basic specification. First, for a given sector, if domestic plants benefit from foreign presence then plants located in a county with high foreign presence will grow *relatively more* than plants located in counties with low foreign presence, *ceteris paribus*. To test for this hypothesis, we rewrite our basic specification in terms of deviation with respect to the rest of Ireland. Second, labor growth may be affected by county and industry-specific shocks. In order to control for this possibility we also included as explanatory variable the employment growth rate of the county-industry relative to the growth rate for the same industry excluding county c. Third, at the national level, time invariant and industry invariant unobservables are accounted for through sector-specific (γ_i) and time dummies (τ_t).[9] Plant-specific time invariant unobservables are captures by the fixed effect μ_j. Finally, as we use a first difference specification, persistence effects might arise, which we do account for by adding the lagged dependent variable on the RHS of specification (3). We end up with

$$\begin{aligned}\Delta \ln \left(\frac{l^c_{i,j,t}}{l^{-c}_{i,t}} \right) &= a' + \rho \cdot \Delta \ln \left(\frac{l^c_{i,j,t-1}}{l^{-c}_{i,t-1}} \right) + b' \cdot \Delta \ln \left(\frac{y^c_{i,j,t}}{y^{-c}_{i,t}} \right) - c' \cdot \Delta \ln \left(\frac{w^c_{i,j,t}}{w^{-c}_{i,t}} \right) \\ &\quad + d' \cdot g \left(\frac{FP^c_{i,t-1}}{FP^{-c}_{i,t-1}} \right) + h' \cdot \Delta \ln \left(\frac{l^c_{i,t}}{l^{-c}_{i,t}} \right) + \mu_j + \gamma_i + \tau_t + \varepsilon_{j,t} \quad (4)\end{aligned}$$

Superscript $-c$ is used in order to represent the rest of the country, $\varepsilon_{j,t}$ is an i.i.d plant-specific effect which potential influence will be considered in the next section.

The variable of overriding importance in our empirical estimation is foreign presence. In the empirical literature on foreign direct investment, FDI is generally measured by the share of foreign affiliates in total employment by sector (Görg and Strobl, 2001). One should note that given that the Forfás Employment Survey is an exhaustive survey, our measure of foreign presence represents the *true* degree of multinational presence in terms of employment. For our econometric investigation we alter this more standard foreign presence measure to present foreign presence in a county relative to that in other counties, i.e. $g\left(FP^c_{i,t-1}/FP^{-c}_{i,t-1}\right) = \left(l^{f,c}_{i,t}/l^c_{i,t}\right) / \left(l^{f,-c}_{i,t}/l^{-c}_{i,t}\right)$,

[9] Note that as our variables are relative to national averages, a time trend is absorbed in the constant of our specification.

where superscript f refers to foreign.

One limitation of this measure is that the spatial dimension is not present since it is only based on employment data. 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. Thus, we will also use a measure of relative foreign employment density, by replacing total manufacturing employment (i.e. $l_{i,t}^{c}$ and $l_{i,t}^{-c}$) on the denominators by non-agricultural areas, ending up with a *foreign employment density* variable.

The Forfás Employment Survey only provides information on the employment level of each plant and hence we have to resort to an alternative plant level data source in order to estimate (4). In particular, we got access to the Irish Economy Expenditure Survey, which covers between 60 to 80 per cent of larger plants located in Ireland, and provides, amongst other things, the information necessary to estimate (4), namely the output, employment and wage level of each plant.[10] As a consequence, our foreign presence variable is an accurate measure of foreign presence in Irish counties while the panel of domestic firms in equation (4) is only a sub-sample of the whole Irish manufacturing sector given the data limitations on our non-labor explanatory variables.

3.2 Econometric Issues

Simple OLS estimation of (4) would yield biased estimators given that one can expect the plant specific effects μ_j to be correlated with the error terms $\varepsilon_{j,t}$, that is, there may be some unobservable plant-specific effect likely to

[10] For a detailed description of this data set see the Data Appendix.

influence employment growth at the plant level. In order to remove the influence of those plant-specific effect we then first difference the expression given in (4). Still, additional problems have to be considered. First, labor demand may be dynamic in nature so that employment growth at time t is likely to be influenced by employment growth at $t-1$ because of a non-smooth adjustment process in plants' employment policy (see, for example, Hamermesh (1993) for a description of standard labor demand functions in a dynamic context). Second, we can reasonably suspect output and wage growth to be endogenous. The problem with using a dynamic approach is that it makes the estimation more complicated especially because the lagged dependent variable used on the RHS is necessarily correlated with the disturbance term. As noted by Greene (2000, p.583) one should then rely on Generalized Method of Moments (GMM) estimators. In particular, Arellano and Bond (1991) derived a GMM estimator to be estimated using lagged levels of the dependent variable and possibly endogenous explanatory variables as instruments. Our econometric test will be based on this method. The consistency of such estimator relies on the assumption of absence of first order serial correlation. If the disturbance are not serially correlated, there should be evidence of significant negative first order serial correlation in the differenced residuals but no evidence of second order serial correlation. Furthermore, the number of instrumental variables may become very large and the use of too many instruments may result into overfitting biases. As a consequence, when instrumenting the lagged dependent variable we chose unrestricted lags of the dependent variable as instruments (that is from $t-2$ backward) while limiting the use of instruments up to four lags for the plant-specific variables. Sargan tests are conducted in order to check the validity of our instrument sets.

3.3 Empirical Results

As noted earlier, our main goal is to see whether there are advantages for domestic firms to co-locate with multinationals firms and whether these advantages translate into higher employment growth. Given that the results documented in the previous section showed that at least for half of the industries in Irish manufacturing there was coagglomeration there seems to be at least indirect evidence for this. In Table 4 we report some descriptive statistics on employment growth and the explanatory variables of the model described by equation (4) together with the average of the CEG index over the period under scrutiny. We consider Nace 2-digit industries for two reasons mainly. First because the previous evidence showed that co-location was more significant within broader categories of industries. As explained later, when trying to link the advantage of coagglomeration with employment growth of Irish domestic firms we will make use of these indices in order to study high and low coagglomeration industries separately. The second reason is given by the restriction on the sample data. Since we only use a reduced (albeit representative) sample of Irish plants, many 3-digit industries are likely to be underrepresented or even omitted if we use Nace 3-digit industries in order to define foreign presence. For all these reasons, we then chose to work with Nace 2-digit industries only.

3.3.1 General results

A first noticeable result from Table 4 is that employment growth has been largely positive on average for domestic firms over the period considered here. Apart from a few traditional industries like Drink and Tobacco, Textiles and Clothing, Footwear and Leather, all industries display positive growth rates that are especially high in some hi-tech industries like Medical and Precision Instruments, Other Electrical Machinery and Apparatus Machinery and Equipment, Office Machinery and Computers, and Transport Equipment. For the last three industries we also observe a positive CEG index on average over the period. Wage growth has been important as well as output growth (except for the industry Drink and Tobacco) denoting a period of high activity for the domestic Irish manufacturing industry over the 1983-1999 period. Overall, this evolution is strikingly different from the experience of other OECD countries. Except for a few hi-tech industries like the Computer or Pharmaceutical Industries, the manufacturing industries and manufacturing employment in particular have been shrinking over the last three decades in OECD countries. The Irish case is very special since it is now well-known that Irish manufacturing boom has largely been fostered by FDI (see for example, Barry and Bradley (1997), and Görg and Strobl (2002)). The question we tackle in what follows is to what extent agglomeration economies have played an active role in the dynamics of Irish manufacturing growth. To this end, in column 1 of Table 5 we present the results of our estimation by testing equation (4). Results indicate that all explanatory variables except the lagged endogenous variable display the expected signs and are highly significant. More importantly, the relative foreign share displays a positive coefficient equal to 0.160 and is significant at the 5% confidence level which provides support for strong positive impact of coagglomeration on employment growth for domestic firms. That is, even after controlling for plant-level variables determining employment growth and for the general employment growth dynamics by manufacturing industry, co-location between foreign and domestic plants has played a major role in explaining employment growth of the latter. The preceding result means that there are specific advantages for domestic firms to locate close to foreign affiliates. From an econometric point of view, the general assumption lying behind the use of a dynamic panel data approach are validated by the different test statistics: the Wald test on the joint significance of non-dummy variables shows that our explanatory variables are highly significant, the Sargan test does not allow us to reject the hypothesis of validity of the set of instruments used while the AR (auto-correlation) provides evidence for first but not second order serial correlation. Results including foreign employment density measure instead of foreign presence are depicted in column (2) of Table 5. Despite displaying positive coefficient our measure is now no longer significant.

3.3.2 Checking for robustness

The previous results call for further robustness checks. First, the plant-specific variables of our model are measured in relative terms using country-level averages as reference. In order to check the robustness of our results we also took as reference the median firms for our non-foreign employment variables. Those estimates are reported in columns (3)-(4) of Table 5. We obtain similar results: relative foreign employment share still display a positive and significant coefficient (at 10% significance level) but the result still does not hold for the foreign employment density variable.

Second, up to now we assumed that potential spillovers were essentially industry-specific. That is naturally due to our previous discussion based on the Ellison and Glaeser index where such hypothesis may be partially relaxed using the CEG index in order to capture within-broad industries externalities. However, following Jacobs' view, externalities may arise from the diversity of industries present in a given region. Our measure of FDI-related spillovers does not take into account this kind of effect. In order to do so, we also included as explanatory variable the relative foreign presence in the rest of industries in the county, that is, industries to which each plant j does not belong. Results of such estimations are reported in columns (5) and (6) of Table 5 and remain broadly similar to the previous ones. In addition, there is no evidence of inter-industry externalities.

Third, our model does not consider possible congestion effects linked to the growth experienced by Ireland during the 1980ies and the 1990ies. In particular, evidence shows that the Irish spectacular economic growth has been accompanied by a huge rise in land prices and congestion in transport infrastructure in county Dublin (see for example Roche (2001) and Dascher (2001)). As a matter of fact, land prices in Ireland display major differences across the country and notably between Dublin and the rest of the Republic. This could have well hampered potential benefits from FDI related spillovers if, for example, domestic firms located in Dublin were constrained by those congestion costs. In fact the preliminary evidence presented earlier (se graphs 1 and 2) shows that, despite a strong an persistent foreign presence, Dublin has experienced a negative growth rate in manufacturing employment over the whole period although during the 1990ies the level of employment further stabilized and even grew slightly. This could suggest that possible congestion costs may have hampered the expected benefits of foreign presence in that particular county. However, since we do not have information on industrial land prices we have to rely on an indirect measure of congestion, namely population density. By doing this, we follow a number of previous works including Bartik (1985) and Guimarães *et al.* (2000) who use this variable in order to measure possible congestion costs related with urban concentration. In the case of Ireland, population density between Dublin and the rest of Ireland is huge with population density being more than 16 times larger in Dublin compared to the rest of Ireland over the 1983-98 period. In order to see whether congestion costs may have influenced the positive impact of FDI on Irish regions we first included population density in equation (4).[11] Results are being reported in columns (1) and (4) of Table 6 when using foreign share of employment and foreign employment density as proxies for foreign presence respectively. The inclusion of population density does not significantly modify the estimated coefficients for those variables. However, when interacting our foreign presence variables we obtain a negative and significant (at 10% level) coefficient. This tends to indicate that the positive effect of foreign presence has been lower where population density was larger which appeared to be the case for county Dublin essentially. As expected as well, the coefficient on the foreign share variable is now much larger than before and it is also significant for foreign density contrasting to our general results presented before. Keeping only the interaction term and dropping the (non-significant on its own) population density does not change the results greatly. This evidence thus tends to mitigate the result presented in Table 5 by showing that, albeit FDI has had a positive impact on regional employment growth in Ireland, for some counties and in particular for Dublin county, the high level of foreign presence has had a significantly lower impact on employment growth due to congestion costs.

Fourth, it must be recognized that the nature of our results may be influenced by possible selection bias. One could, for example, have negative instead of positive spillovers that dominate and push domestic firms to exit

[11] As for the rest of explanatory variable, population density if measured in deviation with respect to the rest of the country.

the market. Those domestic firms that remain on the market may hire part of the labor made available, the result being a positive correlation between foreign presence or density and local firms employment growth. In order to, at least partially, control for this possibility, we also tested our equation keeping those firms that were continuously present over the 1983-1998 period in Ireland. Non-reported results were very similar to those presented in Table 5, that is, relative foreign employment share displayed a positive and significant coefficient (0.136***) while foreign employment density coefficient is also positive but not significant (0.113).

Fifth, we have assumed so far that externalities occurred within a year since foreign presence is measured with a lag $t-1$. This can be too restrictive. In order to check whether there may exist persistent effects of foreign presence through time we also include further lags of this variable in a way similar to de Lucio *et al.* (2002). Only results for the coefficients of the four foreign presence variables are reported in Table 7.[12] In addition, we had to restrict the number of lags used up to five years in order to maintain a feasible sample size. We observe that the significant effect of foreign presence mainly occur within a year and vanishes afterwards. However, we now obtain a significant coefficient on foreign employment density while no inter-industry spillovers seem to take place.

3.3.3 Coagglomeration and growth

Up to now we have not related our econometric results with the observation that in Ireland, domestic firms have largely been coagglomerating with foreign firms. The results presented in the previous section provide evidence in

[12] The other variables displayed coefficients similar to the ones presented earlier. Results are available from the authors.

this direction. Our approach, following Ellison and Glaeser (1997) mainly relies on the assumption that the potential externalities related to the co-agglomeration of domestic and foreign plants are mainly industry-specific. One can then reasonably expect that the positive link between coagglomeration and growth to be especially important for those industries where the CEG index is positive. Put differently, if there is an advantage for domestic plants to co-locate with foreign firms then this advantage must translate into higher growth rates. We then re-estimated equation (4) splitting our sample of domestic firms into two groups according to the average of their CEG index displayed in Table 4.[13] The results of this exercise are included in Table 8. The results are now strikingly different between the two groups of industries. As shown in columns (1) and (3) of Table 8, for highly co-agglomerated industries we obtain a positive and significant coefficient that is equal to 0.106 and significant at 10% for the foreign employment share variable, which is in line with our previous evidence but, moreover, the foreign density coefficient turns out to be positive and significant (0.154**) which gives support to the results obtained in Table 6. Including now foreign presence in the rest of industries as in columns (2) and (4) we obtain a positive and significant coefficient for foreign share (0.460*) but not for foreign density (−0.059). For non-coagglomerated industries, none of these variable were significant.

[13] Alternatively, industries were classified according to the frequence of the sign of the coagglomeration index. Results were identical to the ones presented here.

4 Summary and 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 toward the 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 employment growth equations allowing for potential foreign presence spillovers. Our results support the existence of positive local spillovers from multinationals on indigenous employment growth. However, these effects have not been equal across Irish counties and especially for county Dublin where congestion costs are shown to have constrained the positive spillovers related with foreign presence. In addition, dividing our sample into industries with different coagglomeration experiences we find that such spillovers only take place for industries where there has been considerable coagglomeration of domestic and foreign plants over the 1983-1998 period.

References

[1] 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.

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

[3] Baldwin, R.E., 1999. "Agglomeration and Endogenous Capital", *European Economic Review,* 43: 253-280

[4] Baldwin, R.E., Ph. Martin, and G.I.P. Ottaviano, 2001. "Global income divergence, trade and industrialization: the geography of growth take-offs", *Journal of Economic Growth*, 6: 5-37.

[5] Barrios, S., H. Görg and E. Strobl, 2002. "Multinationals' location choice, agglomeration economies and public incentives", *CORE discussion paper* 2003-17.

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

[7] Bartik, T.J., 1985. "Business Location Decisions in the United States: Estimates of the Effects of Unionization, Taxes, and Other Characteristics of States", *Journal of Business & Economic Statistics,* 3 (1): 14-22.

[8] Black, D. and J.V. Henderson, 1999. "Urban Growth Theory", *Journal of Political Economy,* 107: 252-282

[9] Blomström, M., 1986. "Foreign investment and Productive efficiency: the case of Mexico", *Journal of Industrial Economics,* 15: 97-110.

[10] Blomström, M. and A. Kokko, 1998. "Multinational Corporations and Spillovers", *Journal of Economic Surveys,* 12: 247-277.

[11] Carlton, D.W., 1983, "The Location and Employment Choices of New Firms: An econometric Model with Discrete and Continuous Endogenous Variables", *Review of Economics and Statistics,* 65 (3): 440-449.

[12] Ciccone, A. and Hall, R., 1996. "Productivity and the density of economic activity", *American Economic Review,* 86: 54-70.

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

[14] Coughlin, C.C., J.V. Terza and V. Arromdee, 1991. "State Characteritics and the Location of Foreign Direct Investment within the United States", *Review of Econmics and Statistics,* 73 (4): 675-683.

[15] Dascher, K., 2001. "Land prices, Urban sprawl and affordable housing: Dublin and the open city", *Economic and Social Review,* 32(1): 69-79.

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

[17] De Lucio, J.J., A. Goicolea and J.A. Herce, 2002, "The Effects of Externalities on Productivity Growth in Spanish Industry", *Regional Science and Urban Economics,* 32 (2): 241-58.

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

[19] Feldman, M.P. and Audretesch, D.B., 1999. "Innovations in cities: science-based diversity, specialization and localised competition", *European Economic Review,* 43: 409-429.

[20] Fujita, M., P. Krugman and A.J. Venables, 1999. *The Spatial Economy: Cities, Regions and International Trade.* Cambridge, M.A., MIT Press.

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

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

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

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

[25] Glaeser, E.L., H.D. Kallal, J.A. Scheinkman and A. Shleifer, 1992. "Growth in cities". *Journal of Political Economy,* 100 (6): 1126-1152.

[26] Guimarães, P., O. Figueiredo and D. Woodward, 2000. "Agglomeration and the Location of Foreign Direct Investment in Portugal", *Journal of Urban Economics,* 47(1): 115-35.

[27] Hamermesh, D.S., 1993. *Labor Demand*. Princeton University Press, Princeton, N-J.

[28] Head, K.C., J.C. Ries and D.L. Swenson, 1999. "Attracting foreign manufacturing: Investment promotion and agglomeration", *Regional Science and Urban Economics,* 29: 197-218.

[29] Head, K. and T. Mayer (forthcoming), The Empirics of Agglomeration and Trade, in JF. Thisse and JV. Henderson, *Handbook of Urban And Regional Economics*, Volume 4.

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

[31] Hirschman, A.O., 1958. *The Strategy of Development*, New Haven, CN: Yale University Press.

[32] Jacobs, J., 1969, *The Economy of Cities*. Vintage, New-York.

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

[34] Lucas, R.E. Jr., 1988. "On the mechanics of Economic Development", *Journal of Monetary Economics,* 22: 3-42.

[35] Markusen, J.R., 1995. "The boundaries of Multinational Enterprises and the Theory of International Trade", *Journal of Economic Perspectives,* 9 (2): 169-189.

[36] Markusen, J.R., and A.J. Venables, 1999. "Foreign Direct Investment as a catalyst for industrial development", *European Economic Review,* 43: 335-356.

[37] Martin, Ph. and G.I.P. Ottaviano, 1999. "Growing locations: industry location in a model of endogenous growth", *European Economic Review,* 43: 281-302.

[38] Martin, Ph. and G.I.P. Ottaviano, 2001. "Growth and agglomeration", *International Economic Review*, 42(4): 947-68.

[39] Myrdal, G., 1957. *Economic Theory and Underdeveloped Regions*. London : Duckworth

[40] Perroux, F., 1955. "Note sur la notion de pôle de croissance", *Economie Appliquée*, 7: 307-20.

[41] Roche, M.J., 2001. The Rise in House Prices in Dublin: Bubble, Fad or Just Fundamentals, *Economic Modelling,* 18 (2): 281-95.

[42] Rosenthal, S. and W. Strange (forthcoming), Evidence on the Nature and Sources of Agglomeration Economies, in JF. Thisse and JV. Henderson, *Handbook of Urban And Regional Economics*, Volume 4.

[43] Schmenner, R.W., J.C. Huber and R. L.Cook, 1987. "Geographic differences and the Location of New Manufacturing Facilities", *Journal of Urban Economics,* 21: 83-104.

[44] Smith D.F., and R. Florida, 1994. "Agglomeration and Industrial location: An econometric analysis of Japanese-affiliated manufacturing establishments in Automotive-related Industries", *Journal of Urban Economics,* 36: 23-41.

[45] Tabuchi, T., 1986. "Urban Agglomeration, Capital Augmenting Technology, and Labor Market Equilibrium", *Journal of Urban Economics,* 20: 221-228.

[46] Waltz, U., 1996. "Transport costs, intermediate goods and localized growth", *Regional Science and Urban Economics*, 26: 671-95.

Data appendix

Forfás Employment Survey

This is an annual plant level survey collected by Forfás, the policy and advisory board for industrial development in Ireland, since 1972, and we have access to this data up until and including the year 2000. The response rate to this survey is argued by Forfás to essentially be nearly 100 per cent, i.e., our 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 which are majority-owned by foreign shareholders, i.e., where 50 per cent or more of the shares are owned by foreign shareholders. While arguably, plants with lower foreign ownership should possibly still be considered foreign owned, this is not necessarily a problem for the case of Ireland since almost all foreign direct investment in Ireland has been Greenfield investment rather than acquisition of local firms (see Barry and Bradley, 1997). We use this data source to examine general employment trends and to construct our foreign presence variables.

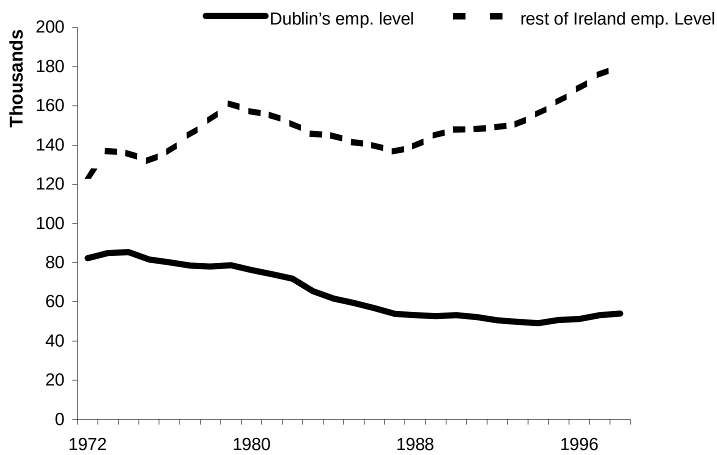
Irish Economy Expenditure Survey

This is an annual plant level survey collected by Forfás since 1983, and we have access to this data up until and including the year 1998. Information is collected from larger plants, earlier in the data set of plants of at least 30 and since 1990 of firms of at least 20 employees, although it must be noted 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 from between 60 and 80 per cent. Information provided at the plant level, are amongst other things, the time invariant identifiers as for the Forfás Employment Survey, output, wages, and the employment level. We use these data for our econometric analysis, except for construction of the foreign presence variable.

Graphs, Maps and Tables

Graph 1: Share of total employment in county Dublin and by foreign plants

Graph 2: Level of total employment in county Dublin and the rest of Ireland



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

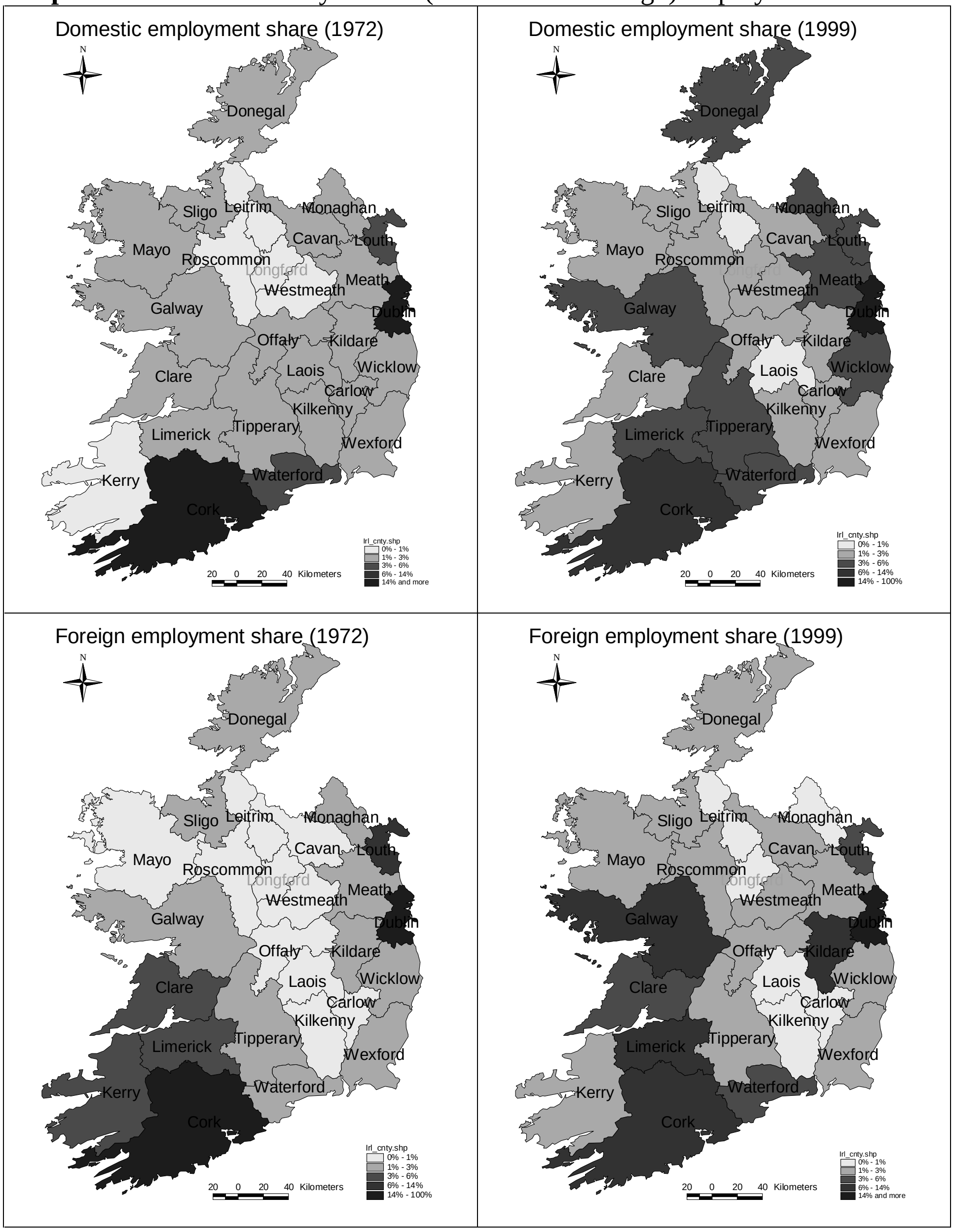


Table 1a: Coagglomeration index for Irish manufacturing industries—Nace 3 digits, 1972-1999

Industry Nace 3-digit	**CEG1972**	**CEG1985**	**CEG1999**	**var.72-85**	**var.85-99**
151.Production processing and meat products	0.047	0.058	0.027	+	-
152.Processing and preserving of fish and fish products	0.091	0.099	0.040	+	-
153.Processing and preserving of fruit and vegetables	-0.123	-0.039	0.117	+	+
155.Dairy products	0.106	0.071	0.044	-	-
157.Prepared animal feeds	-0.237	0.049	0.014	+	-
158.Other food products	0.007	-0.009	0.015	-	+
159.Beverages	-0.077	-0.045	-0.030	+	+
160.Tobacco products	-0.270	0.000	-0.126	+	+
171.Preparation and spinning of textile fibres	0.027	0.019	0.238	-	+
174.Made-up textile articles except apparel	-0.004	0.010	-0.005	+	-
175.Other textiles	0.264	0.076	-0.005	-	-
177.Knitted and crocheted articles	0.008	0.101	0.174	+	+
182.Other wearing apparel and accessories	-0.024	0.044	0.005	+	-
191.Tanning and dressing of leather	0.024	0.014	0.023	-	+
201.Sawmilling and planing of wood; impregnation of wood	0.092	0.101	0.040	+	-
211.Pulp paper and paperboard	0.105	0.173	0.218	+	+
222.Printing and service activities related to printing	0.151	0.199	0.189	+	-
241.Basic chemicals	-0.105	0.012	-0.034	+	-
243.Paints varnishes and similar coatings printing ink and mastics	0.174	0.098	0.120	-	+
244.Pharmaceuticals medicinal chemicals and botanical products	-0.011	-0.034	-0.014	-	+
245.Soap and detergents cleaning and perfumes	0.308	0.015	0.005	-	-
246.Other chemical products	0.078	0.077	0.021	-	-
251.Rubber products	0.096	0.001	0.008	-	+
252.Plastic products	-0.015	0.006	0.006	+	+
261.Glass and glass products	0.129	0.160	-0.007	+	-
262.Non-refractory ceramic goods other than for construction purposes;	0.193	0.085	0.092	-	+
264.Bricks tiles and construction products in baked clay	0.015	0.043	0.047	+	+
266.Articles of concrete plaster and cement	0.005	0.038	0.034	+	-
268.Other non-metallic mineral products	0.011	0.186	-0.048	+	-
281.Structural metal products	-0.087	-0.018	-0.019	+	-
282.Tanks reservoirs and containers of metal; central heating radiators	0.135	-0.029	-0.010	-	+
287.Other fabricated metal products	-0.002	-0.009	0.002	-	+
292.Other general purpose machinery	-0.206	-0.017	0.021	+	+
295.Other special purpose machinery	-0.004	-0.016	-0.002	-	+
297.Domestic appliances n.e.c.	0.023	-0.001	0.012	-	+
300.Office machinery and computers	0.099	0.023	-0.014	-	-
311.Electric motors generators and transformers	-0.025	-0.066	-0.023	-	+
313.Insulated wire and cable	0.132	-0.052	-0.050	-	+
315.Lighting equipment and electric lamps	0.022	-0.101	-0.015	-	+
316.Electrical equipment n.e.c.	-0.154	0.099	0.018	+	-
322.Television and radio transmitters and apparatus	0.258	-0.012	0.018	-	+
331.Medical and surgical equipment and orthopaedic appliances	0.063	-0.034	-0.049	-	-
332.Instruments and appliances for measuring checking testing navigating	0.281	0.016	-0.029	-	-
334.Optical instruments and photographic equipment	-0.097	-0.144	-0.155	-	-
343.Parts and accessories for motor vehicles and their engines	-0.012	0.015	0.031	+	+
361.Furniture	-0.053	-0.087	0.012	-	+
362.Jewellery and related articles	0.129	-0.108	-0.111	-	-
365.Games and toys	-0.016	-0.045	0.090	-	+
366.Miscellaneous manufacturing n.e.c.	-0.015	-0.007	0.007	+	+
Averages for all industries	*0.031*	*0.021*	*0.019*	-	-
Standard deviation	*0.124*	*0.074*	*0.076*		

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

nace_keep	Nace 2 digits	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: CEG transition matrices

1972-1999

Nace 3-digit

1-year	<0	>0	Total
<0	91.09	8.91	100
>0	7.34	92.66	100
Total	45.15	54.85	100
5-years	<0	>0	Total
<0	79.56	20.44	100
>0	19.51	80.49	100
Total	46.84	53.16	100

Nace 2-digit

1-year	<0	>0	Total
<0	90.48	9.52	100
>0	5.36	94.64	100
Total	38.1	61.9	100
5-years	<0	>0	Total
<0	70.73	29.27	100
>0	15.63	84.38	100
Total	37.14	62.86	100

1972-1983

Nace 3-digit

1-year	<0	>0	Total
<0	92.01	7.99	100
>0	7.25	92.75	100
Total	42.73	57.27	100
5-years	<0	>0	Total
<0	76	24	100
>0	20.59	79.41	100
Total	44.07	55.93	100

Nace 2-digit

1-year	<0	>0	Total
<0	91.49	8.51	100
>0	4.38	95.62	100
Total	39.83	60.17	100
5-years	<0	>0	Total
<0	73.68	26.32	100
>0	13.04	86.96	100
Total	40.48	59.52	100

1984-1999

Nace 3-digit

1-year	<0	>0	Total
<0	90.36	9.64	100
>0	7.1	92.9	100
Total	46.65	53.35	100
5-years	<0	>0	Total
<0	75.28	24.72	100
>0	17.58	82.42	100
Total	46.11	53.89	100

Nace 2-digit

1-year	<0	>0	Total
<0	90.74	9.26	100
>0	6.45	93.55	100
Total	37.41	62.59	100
5-years	<0	>0	Total
<0	71.43	28.57	100
>0	25	75	100
Total	40.48	59.52	100

Table 3: Employment growth and foreign presence by county of Ireland, 1972-1999

	Total employment		Domestic employment		Foreign share in total employment				
	growth 1972-83	growth 1983-99	growth 1972-83	growth 1983-99	1972	1983	1999	Δ72-83	Δ83-99
Carlow	0.55	-0.10	0.05	-0.09	0.03	0.34	0.33	0.31	-0.01
Cavan *	0.58	0.12	0.32	0.17	0.16	0.29	0.26	0.14	-0.03
Clare *	0.30	0.23	-0.09	-0.01	0.51	0.66	0.73	0.15	0.07
Cork *	-0.12	0.18	-0.22	-0.01	0.34	0.41	0.51	0.07	0.09
Donegal *	0.19	0.45	-0.08	0.37	0.17	0.36	0.39	0.18	0.03
Dublin	-0.20	-0.14	-0.26	-0.18	0.37	0.41	0.44	0.04	0.03
Galway *	0.58	0.80	0.18	0.59	0.33	0.50	0.56	0.17	0.06
Kerry *	0.51	0.09	2.01	0.35	0.77	0.55	0.44	-0.22	-0.11
Kildare	0.03	1.18	-0.03	-0.01	0.30	0.34	0.70	0.04	0.36
Kilkenny	0.10	0.01	0.01	0.06	0.10	0.17	0.13	0.07	-0.04
Laois	0.47	-0.39	0.10	-0.27	0.17	0.38	0.25	0.21	-0.13
Leitrim *	0.88	-0.02	0.28	-0.10	0.16	0.43	0.47	0.27	0.04
Limerick	1.07	0.54	0.82	0.19	0.50	0.56	0.66	0.06	0.10
Longford *	1.34	-0.10	0.86	0.20	0.28	0.42	0.23	0.15	-0.19
Louth	-0.23	-0.04	-0.21	-0.03	0.50	0.48	0.48	-0.01	0.00
Mayo	0.68	0.20	-0.08	0.33	0.21	0.57	0.52	0.35	-0.05
Meath	0.06	0.15	-0.06	0.26	0.20	0.29	0.23	0.09	-0.06
Monaghan *	0.13	0.26	0.23	0.28	0.21	0.13	0.12	-0.07	-0.02
Offaly	0.07	0.58	-0.26	0.19	0.04	0.33	0.50	0.30	0.16
Roscommon *	0.97	0.54	0.70	0.18	0.09	0.22	0.40	0.13	0.19
Sligo *	0.14	0.50	-0.07	0.11	0.38	0.49	0.62	0.12	0.13
Tipperary North Riding	1.48	0.25	1.75	0.28	0.36	0.29	0.28	-0.07	-0.02
Tipperary South Riding	0.22	-0.10	0.00	-0.26	0.22	0.36	0.48	0.14	0.11
Waterford	0.07	0.06	-0.05	-0.27	0.19	0.28	0.50	0.09	0.23
Westmeath	0.35	0.38	-0.12	0.35	0.31	0.55	0.56	0.24	0.01
Wexford	0.10	0.20	-0.03	0.14	0.26	0.34	0.38	0.09	0.03
Wicklow	0.03	0.21	-0.09	0.12	0.16	0.26	0.32	0.10	0.05
Total Ireland	0.02	0.13	-0.09	0.01	0.33	0.41	0.47	0.08	0.07

Note: Counties followed by * are designated areas. County Cork is only partly a designated area.

Table 4: Descriptive statistics: growth, foreign presence and coagglomeration, 1983-1998.

	Average employ. growth*	Average wage growth*	Average output growth*	# domestic firms	# foreign firms	Average foreign presence	Average CEG. index	Std. Dev CEG
15. Food	1.4	2.5	5.6	977	72	16.7	-0.039	0.006
16. Drink and Tobacco	-0.5	-5.8	-2.3	72	30	48.0	-0.032	0.007
17. Textiles	-0.1	3.1	3.9	324	52	41.4	0.055	0.018
18. Clothing, footwear and leather	-3.1	2.8	3.3	440	49	21.6	0.019	0.014
20. Wood and product of wood exc. furniture	3.8	2.5	7.0	400	8	3.9	0.024	0.017
21. Pulp, paper and paper products	2.2	4.8	7.4	92	14	18.4	0.140	0.022
22. Publishing, printing and recorded media	1.2	2.8	5.7	337	13	7.0	0.170	0.018
24. Chemicals and chemicals products	3.2	1.7	4.5	173	124	65.6	0.009	0.003
25. Rubber and plastic products	2.6	4.1	6.4	231	65	33.4	0.004	0.003
26. Other non-metallic mineral products	2.4	3.2	7.3	478	34	15.3	-0.002	0.007
28. Basic and fabricated metal products	2.7	3.6	8.7	927	95	22.5	-0.006	0.002
29. Machinery and equipment	4.1	5.7	8.5	305	52	36.9	0.027	0.006
30. Office machinery and computers	9.1	2.9	19.0	56	63	71.6	0.013	0.017
31. Electrical machinery and apparatus, nec.	5.6	2.3	11.5	178	63	51.0	-0.011	0.017
32. Electronic equipment	1.6	1.7	10.3	59	39	59.8	-0.006	0.008
33. Medical and precision instruments	6.8	0.5	11.0	107	66	60.6	-0.028	0.008
35. Transport equipment	7.4	4.2	13.6	198	43	38.2	0.012	0.033
37. Other manufacturing industries nec.	2.1	2.8	8.8	937	30	12.0	0.001	0.005

Note: * for domestic firms only

Table 5: General results. Dependent variable: employment growth by domestic plants in Ireland, 1983-1998

	(1)	(2)	(3)	(4)	(5)	(6)
Employment growth (t-1)	-0.010 (0.028)	-0.000 (0.030)	-0.005 (0.029)	0.003 (0.030)	-0.013 (0.029)	-0.008 (0.031)
Output growth (t)	0.257*** (0.067)	0.264*** (0.067)	0.259*** (0.066)	0.267*** (0.066)	0.250*** (0.067)	0.260*** (0.066)
Wage growth (t)	-0.360*** (0.090)	-0.368*** (0.095)	-0.368*** (0.088)	-0.393*** (0.096)	-0.353*** (0.091)	-0.371*** (0.096)
Growth industrie (t)	0.401*** (0.150)	0.398** (0.160)	0.381*** (0.136)	0.367** (0.151)	0.424*** (0.162)	0.400** (0.159)
Foreign share industry (t-1)	0.160** (0.081)	-	0.142* (0.086)	-	0.168** (0.084)	-
Foreign density industry (t-1)	-	0.102 (0.106)	-	0.053 (0.130)	-	0.090 (0.111)
Foreign share manuf. (t-1)	-	-	-	-	0.255 (0.332)	-
Foreign density manuf. (t-1)	-	-	-	-	-	0.052 (0.720)
# obs.	5192	5192	5192	5192	5192	5192
Wald (joint) *p-value*	50.05** [0.000]	43.90** [0.000]	52.20** [0.000]	47.90** [0.000]	53.43** [0.000]	44.83** [0.000]
Sargan *p-value*	177.1 [0.142]	182.8 [0.086]	176.7 [0.147]	182.7 [0.087]	175.5 [0.148]	175.0 [0.154]
AR(1) test *p-value*	-10.07** [0.000]	-10.58** [0.000]	-10.03** [0.000]	-10.62** [0.000]	-9.892** [0.000]	-10.45** [0.000]
AR(2) test *p-value*	-1.424 [0.154]	-1.436 [0.151]	-1.665 [0.096]	-1.565 [0.117]	-1.431 [0.152]	-1.427 [0.154]

Notes:
Equations (1)-(2) and (5)-(6) use deviation with respect to the mean-values of the variables in the rest of the country. Equations (3)-(4) use deviations with respect to the medians. All specifications include a constant term together with time and industry dummies. Two-steps, heteroskedasticity-consistent standard error in parentheses. The Wald test is performed on the explanatory variables, excluding the time and industry dummies. Wald, Sargan and AR tests are based on two-step heteroskedastic estimate. Probability-values are in parentheses for those tests.

Table 6: Considering congestion effects. Dependent variable: employment growth by domestic plants in Ireland, 1983-1998

	(1)	(2)	(3)	(4)	(5)	(6)
Employment growth (t-1)	-0.017 (0.028)	-0.010 (0.029)	-0.004 (0.029)	-0.015 (0.031)	-0.017 (0.030)	-0.012 (0.030)
Output growth (t)	0.262*** (0.067)	0.266*** (0.066)	0.261*** (0.067)	0.269*** (0.067)	0.261*** (0.064)	0.255*** (0.065)
Wage growth (t)	-0.359*** (0.091)	-0.365*** (0.096)	-0.368*** (0.095)	-0.368*** (0.095)	-0.360*** (0.093)	-0.360*** (0.093)
Growth industry (t)	0.419*** (0.144)	0.406*** (0.154)	0.382** (0.154)	0.409*** (0.154)	0.487*** (0.170)	0.466*** (0.173)
Foreign share industry (t-1)	0.183** (0.083)	0.467** (0.193)	0.464** (0.190)	-	-	-
Foreign density industry (t-1)	-	-	-	0.112 (0.111)	3.103* (1.753)	2.975* (1.791)
Pop. density (t-1)	-6.928 (5.593)	-5.953 (5.499)	-	-3.970 (5.108)	-5.621 (5.741)	-
For. share sec. * Pop. density	-	-0.233* (0.141)	-0.245* (0.132)	-	-	-
For. den. sec. * Pop. density	-	-	-	-	-1.392* (0.801)	-1.135* (0.823)
# obs.	5192	5192	5192	5192	5192	5192
Wald (joint) *p-value*	53.0** [0.000]	52.4** [0.000]	49.42** [0.000]	46.55** [0.000]	47.18** [0.000]	42.17** [0.000]
Sargan *p-value*	165.2 [0.312]	162.4 [0.347]	172.6 [0.187]	174.2 [0.165]	163.4 [0.326]	172.2 [0.192]
AR(1) test *p-value*	-9.723** [0.000]	-9.452** [0.000]	-9.777** [0.000]	-10.43** [0.000]	-9.980** [0.000]	-10.08** [0.000]
AR(2) test *p-value*	-1.379 [0.168]	-1.288 [0.198]	-1.330 [0.184]	-1.475 [0.140]	-1.395 [0.163]	-1.452 [0.146]

Notes:
Two-steps, heteroskedasticity-consistent standard error in parentheses. The Wald test is performed on the explanatory variables, excluding the time and industry dummies. Wald, Sargan and AR tests are based on two-step heteroskedastic estimate. Probability-values are in parentheses for those tests.

Table 7: Introducing dynamics. Dependent variable: employment growth by domestic plants in Ireland, 1983-1998

	Lag (t-1)	Lag (t-2)	Lag (t-3)	Lag (t-4)
Foreign share industry	0.270**	0.075	0.050	0.102
	(0.103)	(0.098)	(0.091)	(0.063)
Foreign share manuf.	0.491	0.238	-0.261	0.554
	(0.457)	(0.534)	(0.457)	(0.500)
Foreign density industry	0.283**	0.065	0.039	0.040
	(0.112)	(0.114)	(0.108)	(0.109)
Foreign density manuf.	-0.637	1.328	-1.309	-0.332
	(1.269)	(1.298)	(1.243)	(1.114)

Notes:
Only foreign share and foreign density variables are presented. Other explanatory variables were also used as in table 4 but are not reported for clarity. The same applies to different statistical tests. Regressions were run using continuing plants only.

Table 8: Coagglomeration and growth. Dependent variable: employment growth by domestic plants in Ireland, 1983-1998

	positive coagglomeration industries				*negative coagglomeration industries*			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
employment growth (t-1)	-0.01	-0.015	-0.019	-0.02	-0.009	-0.001	-0.013	-0.17
	(0.041)	(0.042)	(0.041)	(0.042)	(0.032)	(0.033)	(0.032)	(0.035)
output growth (t)	0.135**	0.138**	0.143**	0.144**	0.319***	0.322***	0.317**	0.318***
	(0.065)	(0.652)	(0.06)	(0.062)	(0.090)	(0.088)	(0.087)	(0.085)
wage growth (t)	-0.341***	-0.327***	-0.358***	-0.359***	-0.345***	-0.350***	-0.345***	-0.347***
	(0.074)	(0.080)	(0.072)	(0.072)	(0.093)	(0.090)	(0.096)	(0.094)
growth industry (t)	0.387**	0.433***	0.380***	0.375***	0.688***	0.688***	0.665***	0.664***
	(0.126)	(0.122)	(0.130)	(0.126)	(0.207)	(0.204)	(0.201)	(0.202)
foreign share industry (t-1)	0.106*	0.111*	-	-	-0.078	-0.055	-	-
	(0.060)	(0.06)			(0.087)	(0.096)		
foreign density industry (t-1)	-	-	0.154**	0.155**	-	-	-0.279	-0.191
			(0.062)	(0.07)			(0.354)	(0.35)
foreign share manuf. (t-1)	-	0.460*	-	-		0.539		-
		(0.263)				(0.537)		
foreign density manuf. (t-1)	-	-	-	-0.059		-		-0.499
				(0.642)				(0.914)
# obs.	2511	2511	2511	2511	2681	2681	2681	2681
Wald	62.69**	73.31**	66.09**	66.62**	44.95**	50.63**	45.94**	46.48**
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Sargan	170.1	164.4	172.4	172.0	175.5	171.3	173.0	171.3
	[0.241]	[0.327]	[0.205]	[0.196]	[0.161]	[0.206]	[0.197]	[0.207]
AR(1) test	-6.870**	-7.062**	-7.109**	-7.058**	-8.219**	-8.046**	-8.307**	-8.382**
	[0.000]	[0.00]	[0.000]	[0.00]	[0.000]	[0.000]	[0.000]	[0.000]
AR(2) test	-0.970	-0.988	-1.155	-1.161	-1.198	-1.171	-1.275	-1.287
	[0.332]	[0.323]	[0.248]	[0.246]	[0.231]	[0.242]	[0.202]	[0.198]

Notes:
All specifications include a constant term together with time and industry dummies. Two-steps, heteroskedasticity-consistent standard error in parentheses. The Wald test is performed on the explanatory variables, excluding the time and industry dummies. Wald, Sargan and AR tests are based on two-step heteroskedastic estimates. Probability-values are in parentheses for those tests.