Inward investment, transactions linkages, and productivity spillovers.

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Abstract

The paper examines the extent to which foreign manufacturing firms in the UK promote productivity growth in the domestically-owned manufacturing sector through their buying and supplying relationships. The paper reveals evidence for intra- and inter-regional externalities from the presence of foreign manufacturing, and intra- and inter-industry effects. Externalities in the domestic sector are most noticeable where foreign manufacturing sells to domestic manufacturing. These externalities are, however, not wholly robust to different specifications of spatial dependence. The findings are positioned in a debate which has tended to view backward (as opposed to forward) linkages from multinationals to domestically-owned supply bases as a critical driver of indirect economic benefits.

Keywords: Productivity spillovers; Foreign manufacturing; Input-Output tables; Spatial dependence.

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1. Introduction

There has been much debate in recent years over the scale and scope of productivity spillovers that are generated by foreign manufacturing investment. One transmission mechanism for such spillovers is expected to be the extent of the buyer-supplier relationships between foreign manufacturers and their domestically-owned counterparts. This paper explores the extent to which transactions linkages between foreign and domestic firms impact on productivity growth in domestic manufacturing. This is potentially the most beneficial effect foreign capital on industrial and regional development within the host country. Extensive policy resources in the UK and elsewhere have been expended on seeking to foster linkages between foreign manufacturers and local (within-region) supply and services bases. Such linkages are seen as vital for generating the indirect multiplier impacts expected from foreign firms in their host regions, as well as potentially the most likely vehicle for technology transfer. There have, however, been few empirical attempts to assess the intra- and inter-industry productivity implications of these transaction linkages. Moreover, and a central contribution of this paper, is the fact that previously there has been only limited attention paid to the productivity externalities generated by foreign firms' sales to domestic industries (i.e. in forwardly linked sectors). This paper then assesses whether the productivity impacts of foreign manufacturing are greater where domestically-owned firms buy from, or sell to foreign manufacturing firms. The paper also adopts an inter-regional focus, examining whether production externalities from the foreign sector are restricted to host regions, or whether there is equal evidence of externalities in regions beyond the host region.

The second section of the paper examines the literature on productivity spillovers resulting from the presence of, what is assumed to be, relatively productive foreign manufacturers. The review adopts a UK focus, and goes on to demonstrate the potential role of buyer-supplier linkages as a transmission mechanism for spillovers. The third section develops some hypotheses on how transactions linkages (whether backwards or forwards) from the multinational enterprise might affect the productivity of domestic manufacturers. The fourth section describes how productivity externalities from the foreign sector might be assessed and measured, outlines the data sources used in the analysis, discusses the construction of variables and a model to test the hypotheses. The fifth section describes model estimation, and provide details of the main results. The final section concludes.

2. Foreign Manufacturing, Buyer-Supplier Linkages, and Productivity in the Domestic Sector

Connected to issues surrounding the contribution to domestic productivity growth made by manufacturing capital, is work both applied and theoretical, seeking to examine the role of multinationals in the host country's productivity growth, and role in improving allocative efficiency (Barrell and Pain, 1997). Theoretical perspectives on multinational enterprise generally suggest that foreign firms are potential agents of technological diffusion, having a series of ownership advantages over domestic firms (Dunning 1993). The multinational firms' original 'stock' of advantages may spillover or be appropriated by indigenous competing or supplier firms (Caves 1996; Markusen and Venables 1999). This type of appropriation is consistent with endogenous growth theory where non-internalised technological change and development from one industry can become an externality which is captured by other industries and individuals (Fingleton 2001).

Productivity spillovers from foreign-owned to domestic firms can arise in a number of ways. Blomstrom and Kokku (1996) demonstrate that multinational enterprises might improve allocative efficiency as they enter sectors characterised by high entry barriers, and that they can then break down domestic monopolies and improve competition. In a similar vein, a significant relationship between comparative advantage of UK manufacturing industries and new foreign direct investment into those industries was found by Driffield and Munday (2000). This, and similar studies, have demonstrated the more implicit, dynamic effects of foreign direct investment spillovers into the indigenous manufacturing sector of the UK economy.

A range of studies have suggested that buyer-supplier partnerships involving foreign firms are a mechanism for productivity spillovers, technology diffusion (Morris et al. 1993; Gorg and Ruane 1998), and more fundamental value chain restructuring (O'hUallachain and Wasserman 1999). In a wider review, Crone and Roper (1999) examined the specific literature on knowledge transfers from multinationals, and concluded that the supply chain is the main route through which knowledge is transferred from multinational plants to indigenous firms, and that such transfers lead to important improvements in supplier performance. The more system-wide efficiency effects of growth in FDI were also demonstrated by Gillespie et al., (2000) for Scotland.

Despite its importance, examining the significance of production externalities generated by FDI in the supply chain has hitherto been problematic, largely due to data constraints. Nevertheless, there is some case evidence of the importance of such effects (see Oliver and Wilkinson 1992; Morris et al. 1993). Moreover, there is an apparent consensus that low levels of input-output linkages between the foreign and domestic sectors are an impediment to cluster development, a theme which is increasing in importance in several UK regional development agency strategy documents. Indeed there is more general evidence purporting to demonstrate that those foreign investors with the lowest rates of local linkages contribute least to regional growth prospects and competitiveness (Crone and Roper 1999; see also Brand *et al*. 2000). There is then an underlying assumption that higher levels of transactions linkages between foreign and domestic firms are beneficial to the domestic sector, with an implicit recognition that the intensity of input-output linkages encourage knowledge and technology spillovers to indigenous sectors.

The focus of previous analysis has been on the level of backward linkage from multinationals to the indigenous supply base, on the assumption that those firms with the highest backward linkage contribute most to economic development prospects (Hirschman 1958, see also Scott 1982). This perspective can be linked to growth pole theory which focused attention on technological input-output linkages as a key generator of regional growth, particularly as a result of expansion in a relatively productive lead firm (see Erickson 1974). Backward linkages then have the potential to generate greater indirect employment impacts than forward linkages in the regional economy. There is also some expectation that backward linkages are more important than forward linkages in creating productivity spillovers into the indigenous sector (Munday and Roberts 2001). However, as discussed below, there is some concern over who appropriates the derived gain.

In this paper forward linkage effects (i.e. foreign industries selling to domestic industries) are investigated with some expectation that these connections also impact on domestic firms in terms of production externalities. For example, Erickson (1974) demonstrated the potential for externally generated economies in forwardly linked sectors. These resulted from lead firms generating cost reductions for customer groups because of their greater efficiency, and with other benefits deriving from the production of technologically superior intermediate goods. However, it is likely that technology-related spillovers will result from within-region technical change, and/or result from extra regional technical change (see Fingleton 2001). For example, in the latter case an adjacent region with a high concentration of relatively productive foreign firms could, through purchasing links, create spillover effects in domestically-owned supplier industries in another region. In this paper the presence of both inter- and intra-regional effects from the presence of foreign manufacturing investment are investigated.

3. Input-Output Linkages with Foreign Manufacturers and Domestic Industry Performance

The potential for domestically-owned suppliers to benefit from linkages with foreign manufacturers may be seen to have increased in the context of modern manufacturing environments. Flexible production systems form a key component of cultures of continuous manufacturing improvement. Central to the 'new' manufacturing ethos has been the need to redefine relationships with suppliers and subcontractors. At one extreme, O'hUllachain and Wasserman (1999) show in the Brazilian case, how the demands placed by foreign car assemblers on their first tier suppliers to produce more complex sub-systems and partake in design, led through to some of these same first tier suppliers (often foreign-owned themselves) internalising activities that were previously undertaken by a very large number of their smaller subcontractors. Basically tier one suppliers with greater responsibilities had valid concerns about the quality of production in the second tier and below. This combined with normal contractual hazards led to greater vertical integration in the value chain. In the UK, foreign manufacturers, particularly the Japanese, have led the way in a rather different redefinitional process. Within this redefinition has been a trend away from short-term 'arms-length' contractual relationships emphasising 'exit' in the case of problems, towards co-makership, and the establishment of longer term relationships based on 'voice'[1](Helper 1991). More predominant 'voice' relationships which are at the heart of continuous improvement manufacturing systems provide the potential for a wider range of production externalities between buyer and supplier, particularly where the buyer is a multinational enterprise in possession of a set of ownership advantages embodied in physical and intangible assets, technology and knowledge.

3.1 Backward linkages from multinational firms and spillovers.

Case evidence reveals that in the above circumstances, foreign manufacturers might improve the capabilities of their suppliers in a number of ways. For example, closer communication, perhaps aided by Electronic Data Interchange (EDI) may provide the basis for joint problem solving, exchange of ideas and technical information. Morris et al. (1993) demonstrate how Japanese multinationals within closer buyer-supplier partnerships provide technological assistance, in terms of design, purchasing, marketing information, tooling, and in the promotion and reward of productivity improvements. Moreover, buyer-supplier partnerships and close inspection of foreign firm activities has sometimes prompted indigenous supplier firms to adopt methods of personnel management and work organisation found in the foreign sector (Oliver and Wilkinson 1992).

A growing body of empirical evidence (Barrell and Pain 1997; Gillespie *et al.* 2000), suggests that the UK economy improves technologically in the aggregate as a result of such production externalities. Crone and Roper (1999) demonstrate the

[1] Helper classifies supplier relationships by methods with which the parties involved resolve problems. In an exit relationship, the customer finds a new supplier, while in a voice relationship the customer works with the supplier to resolve problems.

importance of transactions linkages from the foreign sector to indigenous suppliers as a critical driver of such positive production externalities. However, this production externality might not be reflected in the growth of value added in suppliers serving the foreign sector. Ultimately, foreign manufacturers by their size may have sufficient market/purchasing power to squeeze margins in supplying sectors. These market power effects are even more likely to occur in the context of modern buyer-supplier partnerships, where restructuring has often involved increased attention on supplier selection or even take-over (see O'hUllachain and Wasserman 1999), a rationalisation of the supply base i.e. a movement away from multiple to single sourcing, and the development of longer term contractual relations, with contracts being awarded across model lives. Moreover, a manufacturing preference for just-in-time delivery of components can potentially increase the stock holding costs of smaller suppliers which are unable insist on just-in-time delivery from their own supplier set (Oliver and Wilkinson 1992).

Linked to the above review is previous research that has showed how closer buyer-supplier partnerships can involve the supplier providing details of financial costs to the manufacturer. In part the free exchange of cost information can assist in processes of value analysis and value engineering, leading to systematic cost reductions in products (see for example Hiromoto 1988), albeit with Munday (1992) demonstrating that assemblers tended to use cost data as a means of putting pressure on supplier prices. Indeed, some suppliers facing increased pressures within a more monopsonistic situation may actually try to diversify their client bases (Morris *et al.* 1993) and reduce dependence. While indigenous suppliers might be well placed to appropriate productivity externalities from the foreign sector, these gains might not result in consistent improvements in their value added. The stronger bargaining position of larger foreign manufacturing firms, coupled with more stringent price, quality and delivery standards, could effectively reduce margins vertically up the supply chain. Through its market power, particularly purchasing bargaining power, the multinational is better placed to appropriate the gains from closer supplier linkages.

3.2 Forward linkages and spillovers

In cases where indigenous firms buy from the foreign sector they potentially benefit from the greater scale and scope efficiencies, competency, innovative capacity and technology of the multinational. In some cases, foreign multinationals may provide direct assistance to customer groups. For example, Dunning (1993) found that US affiliates in the UK were more likely to provide training for clients, than their domestic customers. Moreover, reviewing what scarce evidence there is, Dunning suggests that foreign firms, through inward investments bringing new management techniques and production processes to host nations, have had the effect of raising standards in downstream sectors, this linking to the fact that by improving the quality of the output of their industrial customers, they create new advantages for themselves. Then domestic customers of foreign manufacturers could be in a stronger bargaining and 'learning' position than domestic suppliers, such that the proprietary knowledge embodied in the product and technology of the multinational will spill over more easily into domestic firms who are essentially the customers in the agreement.

Further, Caves (1996) shows that entry by foreign multinationals can increase competition in domestic markets, whilst Geroski (1995), in a review, demonstrates that high price cost margins may serve to induce entry by foreign firms. In either case foreign entry could break through domestic industry entry barriers, reduce prices, and be a partial solution to market failure (see also Driffield and Munday, 1998). Clearly, market power approaches to the theory of the multinational would suggest that the objective of overseas operations is simply to increase monopoly rents, and as such foreign entry simply leads to greater industry concentration. However, Driffield (2001) in a study of foreign entry into the UK, revealed that entry by foreign manufacturing reduced concentration, and increased the speed at which industry sectors move to equilibrium.

The above review indicates that there are expected to be production spillovers from the foreign sector arising through their direct buyer-supplier linkages. However, the review also suggests that these effects may be pronounced in cases where foreign firms sell to the domestic sector, rather than in the case of domestic firms who sell to the foreign sector. In the latter case the foreign firms may be better able to appropriate the gains from closer linkages. Normal transaction relationships would also suggest that evidence of externalities will be found within industry, for example, where foreign firms transact with industries in their own broad sector, and also where they transact with industries in other sectors. Moreover, given the intra-regional supply and demand constraints that inevitably mitigate the attempts of foreign manufacturing plants to purchase/sell extensively in their immediate localities, then it is expected that evidence for externalities will be found both within and outside the host region.

4. Assessing Production Externalities: Method, Data and Variables.

4.1. Method

The general literature on the growth of productivity is connected to that concerning the measurement of production externalities through production function approaches (see for example, Griliches 1992; Griliches and Lichtenberg 1984). Caballero and Lyons (1990, 1992) examine industry-level spillovers from output growth and use a production function of the following type:

$$\ln Q_{irt} = a + \sum_{m=1}^{s} \beta_m \ln Y_{m,irt} + \sum_{c=1}^{n} \alpha_c X_{irt} + u_{irt} \quad \text{....(1)}$$

In Equation 1, Q is a measure of output, Y represents the vector of s factors of production, and X represents the vector of potential externalities. This model incorporates industry (i), region (r), and time (t) dimensions. There are a series of methodological considerations with this type of model. Firstly, econometric studies of productivity growth indicate the importance of learning by doing and the cumulative effects of continuous production (Irwin and Klenow 1994). This suggests that accumulated experience is expected to be an important determinant of current productivity levels (see for example, Islam 1995). Therefore there is a need for a dynamic specification in which accumulated experience is proxied by a lagged output. This is shown in Equation (2). Equation (2) captures the importance of past levels of inputs in the current production process.

$$\ln Q_{irt} = a + \beta_0 \ln Q_{irt-1} + \sum_{m=1}^{s} \beta_m \ln Y_{m,irt} + \sum_{c=1}^{n} \alpha_c X_{irt} + u_{irt} \quad \text{....(2)}$$

In addition however, as is well understood, there is the possibility for spatial dependence with these type of data. In models such as this, it is likely that the fixed effects model will not sufficiently control for the spatial component in productivity growth, particularly where spillovers between regions occur. For example, Case (1991) examined the possibility of spatial dependence where a region's output growth is in part dependent on output growth in a neighbouring region. This is well understood in the regional science literature (see for example, Anselin and Kelejian

1997). The crucial distinction here is between a spatial error model, and a spatial lag model. The spatial lag model generally takes the form:

$$\ln Q_{irt} = a + \beta_0 \ln Q_{irt-1} + \lambda W_r Q_{irt} + \sum_{m=1}^{s} \beta_m \ln Y_{m,irt} + \sum_{c=1}^{n} \alpha_c X_{irt} + u_{irt} \; \ldots.(3)$$

Where W_r is the spatial contiguity matrix for region r.

In the above case, output of the industry in other regions may impact on the output in the region r. The econometric issues associated with such a specification are discussed within a standard cross-sectional framework in Anselin and Florax (1995), and LeSage (1999). The econometric treatment of spatial dependence is an important issue when seeking to identify sources of productivity spillovers, particularly when seeking to distinguish between genuine productivity effects. In the industrial economics literature, there is considerable debate on the degree to which productivity or technology spillovers can be correctly identified. For example, there is the possibility that observed increases in productivity represent simply a demand or scale effect, where output increases simply due to aggregate demand shocks, rather than spillovers that impact on productivity (Oulton 1996; Basu and Fernald 1995). Spatial dependence is an important issue here. If productivity spillovers can still be detected in the presence of spatial dependence, then one can be more confident in the interpretation. However, while this clearly represents an improvement on Equation (2), this nevertheless implies a restriction that the size of the inter-regional dependency does not vary across regions other than by variations in the contiguity matrix across columns. Within a cross-sectional framework this restriction is difficult to avoid, due to degrees of freedom constraints. Using panel data, where there is an industry as well as regional component to the data, then the following relaxation of this restriction can be employed:

$$\ln Q_{irt} = a + \beta_0 \ln Q_{irt-1} + \lambda_r W_r Q_{irt} + \sum_{m=1}^{s} \beta_m \ln Y_{m,irt} + \sum_{c=1}^{n} \alpha_c X_{irt} + u_{irt} \quad \ldots.(4)$$

Where $u_{irt} = \alpha_i + \varpi_t + \tau_r + \upsilon_{irt}$..

This therefore allows the spatial dependence term to vary across regions. It is also possible to allow λ to vary across industries and time, though not of course jointly due to degrees of freedom constraints. There is, however, no evidence of variation across industries or time, while the region-specific measures are presented in Table 3.

A standard way of estimating a spatial dependence model is to employ a maximum likelihood approach (LeSage 1999, see also Fingleton 2001). However, this approach becomes rather cumbersome, particularly with large data sets (see Kelejian and Prucha (1999) for further discussion of this). Further alternatives are discussed in Elhorst (2003), who highlights the problems of dealing with large panel data models where N is large relative to t, and also the problem of dealing with endogeneity of regressors within any of the standard maximum likelihood approaches to this type of problem. A similar comparison is made by Bell and Blockstael (2000). This problem becomes particularly pertinent in models that include a lagged dependent variable which by construction is correlated with the fixed effects specified in Equation (4). Converting the data to first differences removes this problem, but the lagged dependent variable becomes endogenous and must therefore be instrumented. This is done by employing further lags. Equally, the Y terms may also be endogenous, and so again can be instrumented with further lags within this framework.

$$\Delta \ln Q_{irt} = \beta_0 \Delta \ln Q_{irt-1} + \lambda_r W_r \Delta Q_{irt} + \sum_{m=1}^{s} \beta_m \ln \Delta Y_{m,irt} + \sum_{c=4}^{6} \alpha_c \Delta X_{irt-1} + e_{irt} \ldots.(5)$$

The General Method of Moments Instrumental Variables (GMM) estimator suggested by Arellano and Bond (1988, 1991) can be applied to estimate (5), and this generates heteroscedastic-consistent estimates.

Irrespective of the chosen specification between (3) and (4), there are further considerations with this estimation, as it is potentially inefficient in the presence of spatial autocorrelation. The appropriate estimation of space-time models with endogenous variables in the presence of spatial autocorrelation and spatial dependency is however the subject of on going work. There remains a distinction however between models that present the problem of spatial error, requiring spatial autocorrelation to be allowed for in the estimation process, and spatial lag models where the cause of the autocorrelation can be identified. The results presented here are in the spirit of the latter.

The most efficient test for spatial autocorrelation, following Anselin and Rey (1991) is based on Moran's *I* statistic (Moran 1950). Once the spatial lag model was employed in this case, there was no evidence of any spatial autocorrelation in the errors. Equally, there is no evidence of inter-industry autocorrelation, or serial correlation in the errors.

4.2. Variables and data

Industry data for output, capital and labour in 20 manufacturing sectors were based on two digit industry (SIC 80) classifications and derived from the UK Census of Production from the UK Office for National Statistics (ONS). Data were available for 1984-1992 for 10 UK regions (for descriptive statistics see Appendix 1). The dependent variable (Q_{irt}) is gross value added in the domestic industry in the region. The independent variable is the capital stock (K_{irt}) of the domestic industry. The change in this is given by net capital investment in the UK owned sector. Data on the capital stock are not available at this level of aggregation, so the sum of net investment over the previous five years is used as a proxy. A standard depreciation rate of 10% was used.

Following Haskel and Heden (1999) it is expected that types of labour affect industry output differently i.e. labour is heterogenous. The Census of Production provides information on manual (ML_{irt}: employment of operatives in domestic owned industry at time t in the region) and non-manual labour (NML_{irt} employment of non-operatives in domestic owned industry at time t in the region) and the model estimated then distinguishes between labour type. Finally, time dummies were included to proxy exogenous technological progress.

More complex is the process of designing a variable that combines estimates of the linkage intensity of domestic firms with foreign firms (i.e. allowing exploration of inter/intra industry/region effects, both backwardly from the multinational to its domestic suppliers, and forwards from the multinational to its customers), with an estimate of new foreign manufacturing investment in those industries connected to domestic industries.

The approach taken is to specify how the ideal variables might be estimated and then to show how the measure was constructed with limited information. Construction of the linkage component of the variables would require inter-regional input-output tables (for an example of this see Miller and Blair 1985) or sets of bi-regional tables (see for example, Oosterhaven et al. 2001). Within these tables it would be necessary to separate out the foreign and domestically-owned elements of individual industries.

More formally, Z can be defined as a matrix of intermediate inter-regional transactions. For ease of description in the forthcoming discussion in relation to construction of ideal variables, the regions are denoted in superscripts. Hence an element in Z is defined Z^{hk}, where $1 \leq h,\ k \leq R$ (R is the number of regions considered), and each Z^{hk} describes transactions between a number S_h of selling industries in the h^{th} region and a number P_k of purchasing industries in the k^{th} region. In addition, in this discussion individual selling industries are denoted by i, and purchasing industries by j, $1 \leq i \leq S_h$, and $1 \leq j \leq P_k$. Within this framework (but not shown here) would be associated matrices of final demands and of outputs.

$$Z = \begin{pmatrix} Z^{11} & Z^{12} & \cdots & Z^{1R} \\ Z^{21} & Z^{22} & \cdots & Z^{2R} \\ \vdots & \vdots & \ddots & \vdots \\ Z^{R1} & Z^{R2} & \cdots & Z^{RR} \end{pmatrix}.$$

Matrix Z could then be expanded by separating the industries into foreign-owned (F) and domestically-owned (D) components. Then for each Z^{hk} element in the matrix Z, a sub-matrix of the form $Z^{hk} = \begin{pmatrix} z^{hk}_{DD} & z^{hk}_{DF} \\ z^{hk}_{FD} & z^{hk}_{FF} \end{pmatrix}$ can be specified. The first (top left) element, z^{hk}_{DD}, represents transactions between domestic selling industries in region h and domestic purchasing industries in region k. The top right transaction, z^{hk}_{DF}, has the same interpretation, except that selling industries are domestically owned and purchasing industries are foreign owned. By identifying the industry transactions, each single element Z^{hk} can be further expanded into the form

$$Z^{hk} = \begin{pmatrix} z^{hk}_{DD} & z^{hk}_{DF} \\ z^{hk}_{FD} & z^{hk}_{FF} \end{pmatrix} = \begin{pmatrix} z^{hk}_{11DD} & z^{hk}_{11DF} & \cdots & z^{hk}_{1P_kDD} & z^{hk}_{1P_kDF} \\ z^{hk}_{11FD} & z^{hk}_{11FF} & \cdots & z^{hk}_{1P_kFD} & z^{hk}_{1P_kFF} \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ z^{hk}_{S_h1DD} & z^{hk}_{S_h1DF} & \cdots & z^{hk}_{S_hP_kDD} & z^{hk}_{S_hP_kDF} \\ z^{hk}_{S_h1FD} & z^{hk}_{S_h1FF} & \cdots & z^{hk}_{S_hP_kFD} & z^{hk}_{S_hP_kFF} \end{pmatrix}.$$

To construct the ideal linkage variable described earlier, certain coefficients would be derived (describing the intensities of both purchases and sales between industries). The purchasing coefficients would be constructed for each industry by dividing each transaction (z_{ijDD}^{hk} etc.) by the sum of intermediate purchases (i.e. the column totals from matrix *Z*), rather than the more usual gross output denominators. The objective in constructing this variable is to measure the strength of inter/intra industry linkages. A gross output denominator includes wages, imports, and other value added which could serve to obscure the scale of inter-sectoral transactions, and it is the latter which are hypothesised to influence spillover effects.

The column totals for domestic purchasing industries in matrix *Z* above in a particular region *k* are given by, $\sum_{h=1}^{R}\sum_{i=1}^{S_h}\left(z_{ijDD}^{hk} + z_{ijFD}^{hk}\right)$, whilst for foreign purchasing industries, the column totals would be : $\sum_{h=1}^{R}\sum_{i=1}^{S_h}\left(z_{ijDF}^{hk} + z_{ijFF}^{hk}\right)$.

Hence, without loss of generality, in relation to the case of a particular transaction (z_{ijDD}^{hk}) between domestic industry *i* located in region *h*, and domestic industry *j* located in region *k*, a purchasing coefficient, here denoted by l_{ijDD}^{hk}, is derived by dividing this transaction by the column total for the domestic purchasing industry in region *k*,

$$l_{ij\,DD}^{hk} = \frac{z_{ij\,DD}^{hk}}{\sum_{h=1}^{R}\sum_{q=1}^{S_h}\left(z_{qjDD}^{hk} + z_{qjFD}^{hk}\right)} \quad .$$

(To avoid confusion, the index *q* is used for selling industries in place of *i*, which represents a specific industry in this expression.)

Following the same descriptive process set out in relation to the elements in matrix *T*, these purchasing coefficients can analogously be represented in a matrix, here defined *L*, and given by

$$L = \begin{pmatrix} L^{11} & L^{12} & \cdots & L^{1R} \\ L^{21} & L^{22} & \cdots & L^{2R} \\ \vdots & \vdots & \ddots & \vdots \\ L^{R1} & L^{R2} & \cdots & L^{RR} \end{pmatrix},$$

which contains elements L^{hk}, which again as described in relation to *Z*, can be expanded to specify industry trade relationships.

$$L^{hk} = \begin{pmatrix} l^{hk}_{DD} & l^{hk}_{DF} \\ l^{hk}_{FD} & l^{hk}_{FF} \end{pmatrix} = \begin{pmatrix} l^{hk}_{11DD} & l^{hk}_{11DF} & \cdots & l^{hk}_{1P_kDD} & l^{hk}_{1P_kDF} \\ l^{hk}_{11FD} & l^{hk}_{11FF} & \cdots & l^{hk}_{1P_kFD} & l^{hk}_{1P_kFF} \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ l^{hk}_{S_h1DD} & l^{hk}_{S_h1DF} & \cdots & l^{hk}_{S_hP_kDD} & l^{hk}_{S_hP_kDF} \\ l^{hk}_{S_h1FD} & l^{hk}_{S_h1FF} & \cdots & l^{hk}_{S_hP_kFD} & l^{hk}_{S_hP_kFF} \end{pmatrix}.$$

Ideally the components of sub-matrix L^{hk} (i.e. l^{hk}_{ijDD}, l^{hk}_{ijFD} etc) become the basis for estimating the linkage variables representing the purchasing patterns/intensities of domestic industries.

In a similar way, and using elements within matrix *Z*, sales coefficients, representing the sales of domestic *i* industries to other industries could be derived. In this case, each specific transaction within *Z* is divided by the corresponding row total (i.e. the sum of intermediate sales).

In relation to matrix *L*, and the construction of the ideal variables described earlier, there would be a requirement for a different matrix representing linkages in each of the nine years included within the analysis. Hence in the forthcoming matrix a further sub-script t (time) could be added to each element. However this has not been included for presentational purposes. In addition, to create the variables only particular elements of L (and its associated sub-matrices) would be required. For example, to examine potential spillovers to domestic industries as a result of their purchases from foreign industries, only the FD coefficients would be used. Hence a sub-matrix of L could be defined (L_{FD}) which would only include FD coefficients of the general form l^{hk}_{ijFD}. This L_{FD} sub-matrix, expanded to define specific industrial and regional trade, is therefore given by,

$$L_{FD}=\begin{pmatrix} l^{11}_{11FD} & l^{11}_{12FD} & \cdots & l^{11}_{1P_1FD} & \cdots & \cdots & l^{1R}_{11FD} & l^{1R}_{12FD} & \cdots & l^{1R}_{1P_RFD} \\ l^{11}_{21FD} & l^{11}_{22FD} & \cdots & l^{11}_{2P_1FD} & \cdots & \cdots & l^{1R}_{21FD} & l^{1R}_{22FD} & \cdots & l^{1R}_{2P_RFD} \\ \vdots & \vdots & \ddots & \vdots & & & \vdots & \vdots & \ddots & \vdots \\ l^{11}_{S_11FD} & l^{11}_{S_12FD} & \cdots & l^{11}_{S_1P_1FD} & \cdots & \cdots & l^{1R}_{S_11FD} & l^{1R}_{S_12FD} & \cdots & l^{1R}_{S_1P_RFD} \\ \vdots & \vdots & & \vdots & \ddots & & \vdots & \vdots & & \vdots \\ \vdots & \vdots & & \vdots & & \ddots & \vdots & \vdots & & \vdots \\ l^{R1}_{11FD} & l^{R1}_{12FD} & \cdots & l^{R1}_{1P_1FD} & \cdots & \cdots & l^{RR}_{11FD} & l^{RR}_{12FD} & \cdots & l^{RR}_{1P_RFD} \\ l^{R1}_{21FD} & l^{R1}_{22FD} & \cdots & l^{R1}_{2P_1FD} & \cdots & \cdots & l^{RR}_{21FD} & l^{RR}_{22FD} & \cdots & l^{RR}_{2P_RFD} \\ \vdots & \vdots & \ddots & \vdots & & & \vdots & \vdots & \ddots & \vdots \\ l^{R1}_{S_R1FD} & l^{R1}_{S_R2FD} & \cdots & l^{R1}_{S_RP_1FD} & \cdots & \cdots & l^{RR}_{S_R1FD} & l^{RR}_{S_R2FD} & \cdots & l^{RR}_{S_RP_RFD} \end{pmatrix}.$$

The L_{FD} sub-matrix above shows the intensities of the purchasing relationships between domestic and foreign industries. Using the notation given previously for elements within L_{FD} (i.e. l^{hk}_{ijFD}) four sets of linkage relationships could be defined for each domestic industry j located in region k. To assess linkages between domestic and foreign firms in the same industry and in the same region, the coefficients in L_{FD} where $i = j$ and $h = k$ would be taken from L_{FD}. To show domestic firm linkages to foreign firms in the same industry but in a different region, the coefficients where $i = j$, $h \neq k$ would be used. For linkages with different foreign industries within the same region all $i \neq j$, $h = k$ coefficients would be required, and finally all coefficients where $i \neq j$, $h \neq k$ would represent connections to different foreign industries in different regions.

In the same way, but not illustrated here, a sub-matrix of sales coefficients could be derived to show domestic industries selling to foreign industries. In this case, the sub-matrix would contain only *DF* coefficients, and a further four sets of linkage relationships could be defined.

Finally, each of the linkage coefficients (or sums of groups of coefficients) in each time period would be combined with a measure of new foreign direct investment in those industries linked to given domestic industries. Corresponding with the sets of linkage relationships described earlier (i.e. l_{ijFD}^{hk}), the FDI measures (i.e. FDI_i^h) in each time period are: the stock of foreign capital in the same industry and region; the stock of foreign capital in the same industry across all other regions; the stock of foreign capital in other industries in the region, and the stock of foreign capital in other industries across all other regions.

This process would result in eight measures of FDI intensity in inter-linked industry sectors. For any given domestic industry *j* in region *k* there would be four FORWARD linkage variables:

FWD INTRA-INDREG would measure the concentration of new foreign manufacturing in industry *i* and in region *h* which domestic firms in industry *j* and region *k* buys from, where $i = j$ and $h = k$, (i.e. same industry and same region). It follows that FWD INTRA-INDREG would be given by $\left(FDI_i^h \times l_{iiFD}^{hh}\right)$.

FWD INTER-INDREG would measure the concentration of new foreign manufacturing in all selling industries which domestic industry *j* buys from, where $i \neq$

j, but $h = k$ (i.e. different industries within the same region). Therefore FWD INTER-INDREG could be defined as $\sum_{h=1}^{R}\sum_{\substack{i=1 \\ i\neq j}}^{S_h}\left(FDI_i^h \times l_{ijFD}^{hh}\right)$.

FWD INTRA-INDOREG would measure the concentration of new foreign manufacturing in industry i which domestic firms in industry j buys from, where $i = j$ and $h \neq k$, (i.e. same industry in different regions). FWD INTRA-INDOREG would then be defined as $\sum_{\substack{h=1 \\ h\neq k}}^{R}\sum_{i=1}^{S_h}\left(FDI_i^h \times l_{iiFD}^{hk}\right)$.

FWD INTERIND-OREG is a measure of the concentration of new foreign manufacturing in all selling industries which domestic industry j buys from, but where $i \neq j$ and $h \neq k$ (i.e. different industries in different regions). This variable would be specified by $\sum_{\substack{h=1 \\ h\neq k}}^{R}\sum_{\substack{i=1 \\ i\neq j}}^{S_h}\left(FDI_i^h \times l_{ijFD}^{hk}\right)$.

BACKWARD linkage variables would be derived in a similar fashion but would be in terms of the concentration of new FDI in those industries to which domestic industries sell (hence the linkage coefficient would have a *DF* subscript and the FDI measure would be FDI_j^k.

The inter-regional ownership disaggregated trade data to enable construction of the above defined variables is, however, not currently available in the UK, although attempts have been made to examine ownership disaggregated transactions at the single region level (see Munday and Roberts 2001; see also Gillespie et al. 2000).

The linkage measures were therefore constructed using the UK input-output data for 1990 from the Office of National Statistics. Using the 'Make' and 'Use' matrices it was possible to construct a symmetrical industry by industry transactions matrix for the UK, with the manufacturing industries aggregated to the defined 2 digit industry groups.

With this limited input-output information, the analysis of the impacts of inward FDI on domestic productivity growth is based on two input-output matrices, Φ (representing the intensity of sales from each industry to other industries) and Γ (representing the strength of purchasing relationships between industries) for the UK.

In this framework, for example, the matrix Γ can then be written as:

$$\Gamma = \begin{pmatrix} \gamma_{11} & \gamma_{12} & \cdots & \gamma_{1n} \\ \gamma_{21} & \gamma_{22} & \cdots & \gamma_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \gamma_{n1} & \gamma_{n2} & \cdots & \gamma_{nn} \end{pmatrix},$$

where n is the number of industries. The leading diagonal refers to intra-industry linkages, and the other terms to inter-industry linkages. The linkage coefficients were derived in the same manner as described earlier in relation to the ideal data i.e. to derive purchasing coefficients for each specific industry, each transaction was divided by the sum of intermediate purchases, whereas the sales coefficients have intermediate sales as a denominator. Hence in relation to the FORWARD linkage variables defined earlier, the respective l_{ijFD}^{hk} elements are approximated by (and replaced with) a national linkage coefficient, defined here as v_{ij}^{hk}. Similarly, the BACKWARD linkage variables also contain coefficients derived from the national input-output matrix. The h and k superscripts have been maintained for the construction of the variables, however, there is no variation in these industry linkage coefficients by region.

By combining data from the two input-output matrices of national linkage coefficients with measures of foreign direct investment (by industry, region and time) an index is provided for each of the manufacturing groups of the significance of new foreign manufacturing investment in industries that domestically based industries buy from/sell to both in the same region, and in other regions. Hence whilst there is no variation in industry linkage coefficients by region or by time, variation in these independent variables is attained through the FDI measures which are stratified by industry, region and time.

There are a number of issues related to variable construction. First, the linkage coefficients were derived for 1990. It was not possible to derive inter- or intra-industry linkage coefficients for each of the years corresponding to the sample of industry data (i.e. 1984-1992) as the required input-output tables are only produced at discrete intervals. For this exercise linkage coefficients for 1990 are assumed to be a reasonable proxy for those occurring in the period.

Second, the foreign-owned capital stock is used as the measure of foreign direct investment in linked sectors. As the foreign-owned capital stock is calculated using a perpetual inventory method, and depreciated at 10% p.a., more weight is naturally given to new investment. As the estimation of the model is carried out on first-differenced data, we are effectively relating the change in FDI stocks to changes in total factor productivity.

Third, the measure introduces restrictions on the model in that the linkage coefficients derived only proxy for the transactions relationships between domestic and foreign industries, such as those defined earlier in matrix L_{FD}. With limited information, the coefficients reflect the activities of all industries (foreign-owned and domestic), with some expectation that these relationships will differ between domestic and foreign industries (Brand et al., 2000). However, the purpose of this analysis was to generate a general measure of linkages between industry groups. Moreover, this process, which relies on national rather than inter-regional trade information, assumes that firms in industries in one region, have similar purchasing propensities to the same industries in another region. As highlighted earlier, in order to derive more accurate linkage coefficients, an ownership disaggregated inter-regional input-output table, with each industry separated into foreign and domestic components would be required. Nevertheless, the methodology presented here marks a significant improvement on previous work seeking to investigate econometrically the impacts of FDI on total factor productivity growth. This analysis presents a first attempt to relate FDI across the full population of industries and regions, to impacts in both upstream and downstream industries.

Constructing eight variables in this fashion enables an examination of the extent to which there are different effects on domestic industries related to whether there is new FDI in the same industry or different industries to which they are linked. For example, it might be the case that where a domestic industry sells/buys to a foreign firm in the same industry the degree of externality may be mediated because firms have better knowledge of one another and the potential for opportunistic behaviour is limited in both parties to the transaction. As outlined in the previous section the expectation is that where industries with concentrations of new foreign manufacturing sell to domestic industries (i.e. the FORWARD variables) then there are positive output externalities. However, where industries with concentrations of new foreign manufacturing buy from domestic industries (i.e. the BACKWARD variables) then effects are expected to be negative.

5. Results.

There are potential collinearity problems in estimating Equation 5 with eight externality variables. The process undertaken here was to estimate the model with the forward and backward linkage variables separately to evaluate the different sets of effects. The full model is reported in Appendix 2. Additional diagnostics, with regard to model specification and other tests are detailed in the footnote to Table 1.

Equation 3 was estimated, initially to confirm the existence of spatial dependence within these data, and secondly to determine its nature, that is, whether $\lambda_r = \lambda_b$ for $b \neq r$ across regions. The existence of inter-industry dependence was also investigated, but its existence was rejected. Time series lags, as well as spatial lags in spatial dependence were also investigated. Both a rook contiguity, and a standard first order contiguity matrix were employed here, although given the number of the regions, there is little difference between the two, and the results are not sensitive to matrix specification. The results presented here in Tables 1 and 2 are based on the standard first order matrix. The three columns in Tables 1 and 2 relate to the various assumptions concerning the existence (and nature) of spatial dependence discussed above. The first column in each table presents the results based on the estimation of Equation (2), that is, including a lagged dependent variable, but excluding any terms allowing for spatial dependence in total factor productivity growth. The second column in the tables illustrate the results from the estimation of (3), that is with the degree of spatial dependence constant across regions, with contiguity inferred from a standard first order contiguity matrix. The third column in each case refers to the estimation of (4), that is allowing the magnitude of spatial dependence to vary across region, with the mean values of λ presented in Tables 1 and 2, with the regional specific values of λ_r (spatial dependence) presented in Table 3. However, while there is some variation in the regional dependence effects across regions, and the coefficients are significantly different from zero, they are not significantly different from one another.

All inputs into the production function, and the lagged dependent variable are treated as theoretically endogenous, and are therefore instrumented with all available lags. The Sargan test for the validity of the instruments confirms the suitability of this approach. The results shown in Tables 1 and 2 reveal significant evidence of spatial dependence, that is that productivity spillovers (not from FDI, just generally) do occur across the mainland UK regions (or simply that macro, or industry level shocks impact on industries across regions). There is no sign of an equivalent "inter-industry" dependence. The conclusions regarding the beneficial effect of FDI in sectors which domestic industries buy from are sensitive to the specification of spatial dependence. However, in the case of the negative effects occurring where domestic firms sell to industries with the foreign presence then the results are not sensitive to the specification for spatial dependence. The results then indicate that the modelling framework picks up the impacts of foreign influence in the value chain on domestic producers, that is, the framework is not simply describing demand effects. Importantly, the beneficial effects on the domestic sector (Table 1) are found to diminish as restrictions concerning spatial dependence are relaxed, suggesting that inter-regional productivity gains from FDI may simply be demand effects. This is an interesting result, with reference to the more general work on spillovers and model specification, which suggests that many reported spillover effects, are simply demand effects, rather than genuine productivity gains (see for example, Oulton 1996).

Tables 1 & 2 about here

The results in Table 1 indicate that domestic industries could be benefiting from purchasing linkages with industries with strong foreign involvement. Significant results were found where domestic industries purchase from the same industry group with high levels of foreign involvement, but in a different region, and where domestic industries purchase from different industry groups with high levels of foreign involvement in the same region. The remaining externality variables were not significant but have the anticipated sign. Then there is some evidence that domestic firms may be benefiting from the availability of better quality components, better technology and lower prices in linked industries with a strong foreign component. However, as highlighted the results are sensitive to the specification of the model. As revealed in the review in section 3, this finding offers some support for the contention that foreign manufacturers do bring innovative managerial techniques and production processes to host areas which have the effect of improving standards in downstream sectors. It is well understood that the scale and scope of spillovers is partly dependent on the actions of the domestic firm, and their ability to assimilate the externality (Blomstrom et al. 2001). Thus, one would expect that the greater the technological similarities between the foreign and domestic firms, the greater the potential for productivity growth in the domestic sector.

Positive spillovers occurring forward through transaction linkages might ultimately be connectable to longer term improvements in the competitiveness of segments of domestic industry. The presence of these inter/intra-industry <u>and</u> inter/intra regional effects certainly relates closely to the wider national and regional objectives underlying the attraction of foreign capital to the UK, and means that general UK evidence on the more dynamic positive impacts of foreign manufacturing across UK industry cannot be dismissed (see for example, Driffield and Munday 2000).

Table 2 demonstrates that in cases where domestic firms sell to industries with high levels of foreign manufacturing investment the nature of linkage externalities is less clear. Consequently, where domestic industries sell to the same or different industry with higher levels of foreign investment, but in other regions, then there is evidence of a negative impact on gross value added. This provides some evidence that foreign manufacturers in the same industry could have sufficient market power to appropriate the gains from buyer-supplier partnerships. Moreover, where foreign firms purchase from domestic firms in the same industry sector, then they could have more expert knowledge of supplier conditions which reduces scope for supply side opportunistic behaviour. This result does not equate with no efficiency improvements within the indigenous supplier, but that foreign firms are in a stronger position to appropriate the gains.

This situation occurs where the inward investor sources products from outside its immediate locality, for one of several reasons. Firms elsewhere are superior to local firms, either due to economies of scale, or other technological advantages, or it may simply be the case that there are no potential suppliers to be found locally. In either case, it is unlikely that the foreign firm will exhibit the same bargaining advantage over such firms, as they do over local suppliers, and so the foreign firm is unable to assimilate the gain.

6. Conclusions

The paper describes a methodology for assessing the significance of production externalities occurring from foreign enterprise to domestic enterprise through transactions relationships. The paper provides evidence that productivity growth in the domestic sector is affected by the nature of transactions linkages with foreign-owned manufacturing firms. Gains to the domestic sector appear to be greater where domestic firms purchase from foreign firms, although effects weaken with alternative specifications.

One contention of the review section of this paper is that regional policy analysis (in the UK at least) has tended to focus upon the economic significance of backward linkages from the multinational firm into the host region economy. Whilst this focus might be justified in terms of assessing the indirect employment, output and jobs supported by foreign investment, this paper reveals that the nature of production spillovers backwards to the domestic supply sector is far from clear. Whilst the encouragement of forward linkages has assumed a lesser importance in terms of regional policy strategy, this paper has demonstrated that this is likely to be the strongest channel for positive production spillovers to the domestic sector, when considered in terms of generating real productivity growth. The results then suggest that there is merit in policy terms of investigating the issue of who domestic firms buy from. This is problematic largely because the results here tend to suggest that the displacement of purchases from domestic firms, by purchases from foreign-owned ones may actually link through to productivity advantages, and then potentially through to comparative advantage as revealed in manufacturing export performance.

The conclusions from the paper are tentative largely because of the difficulties involved in assessing the levels of foreign manufacturing involvement in different domestic industry transaction chains. However, the paper makes steps towards a method of assessing such externalities incorporating information from input-output tables. In further research there may be merit in investigation on an industry by industry basis, such that case material can be used to assist in the interpretation of empirical findings. Case material might also be examined to support the analysis of spillovers amongst complexes of related industry activity at smaller area levels. Furthermore, the results in the current paper are based on purchasing and selling propensities based on the national input-output framework. This necessarily creates a number of restrictions. In assessing inter- and intra- regional effects more progress would be possible with regional level input-output tables, particularly where foreign and indigenously-owned manufacturing are separable within the tables. Currently, in the UK, input-output tables are available for just three government office regions on a fairly consistent basis. However, for these individual regions (Wales, Scotland, and South West) further research might assess the intra-regional-industry effects highlighted in this paper.

Finally, the paper has focused on effects resulting from first round transactions linkages occurring between the foreign and domestic sector. Then further research might focus on spillovers occurring further up and down the value chain, as, for example, clients of the foreign manufacturing sector sell on their outputs to other domestic sectors and so on. Moreover, as explored in the review, the paper here examines spillovers from foreign to domestic sectors. There is clear value in examining the generation of spillovers from the domestic to the foreign sectors with the presence of technology sourcing FDI.

Table 1 Model Estimation Results: Forwards Linkages to the Domestic Industry

	No spatial dependence	Homogeneity in spatial dependence	Heterogeneity in spatial dependence
Variable		Coefficient (t values)	Coefficient (t values)
$W_r Q_{irt}$		0.09*** (2.89)	0.112[i]
K_{irt}	0.301*** (4.32)	0.149*** (3.03)	0.146*** (3.29)
NL_{irt}	0.247*** (5.18)	0.110*** (3.74)	0.136*** (4.01)
ML_{irt}	0.608*** (4.99)	0.557*** (4.28)	0.508*** (3.51)
Q_{irt-1}	0.258*** (3.27)	0.101** (2.54)	0.093 (1.45)
FWD INTRA-INDREG, (intra-industry in same region)	0.009 (1.64)	0.004 (0.54)	0.003 (0.21)
FWD INTER-INDREG, (inter-industry in same region)	0.007** (2.58)	0.009** (2.08)	0.004 (1.54)
FWD INTRA-INDOREG, (intra-industry other regions)	0.019*** (4.65)	0.018*** (3.66)	0.008* (1.97)
FWD INTER-INDOREG (inter-industry other regions)	0.003 (0.97)	0.002 (0.64)	0.000 (0.68)
Spatial autocorrelation (Morans *I*)	2.07** (0.038)	1.287 (0.198)	0.949 (0.322)
Time dummies	Yes	Yes	Yes
Specification $\sim\chi^2(6)$[ii] (p value)	7.731 (0.258)	6.989 (0.322)	6.001 (0.423)
Sargan - p value	0.652	0.507	0.409
Inclusion of further lags of FDI variables LR test $\sim\chi^2(4)$	5.901 (0.207)	5.674 (0.225)	5.034 (0.284)
Inclusion of TIME lags spatial dependence $\sim\chi^2(1)$		1.025 (0.311)	0.554 (0.456)
Industry autocorrelation (Morans *I*)	0.652 (0.514)	0.428 (0.669)	0.377 (0.701)
Serial correlation AR(2)[iii] $\sim \chi^2(1)$	1.568 (0.211)	1.236 (.266)	1.874 (0.171)

Table notes

*, **, *** Significant at the 10%, 5% and 1% level respectively.

i. There are 10 such coefficients in this model (Northern Ireland having no contiguous regions in the UK). The average value is given. See Table 3 for individual coefficients.
ii. This is based on testing the Cobb-Douglas specification against a translog specification.
iii. This LM test is outlined on Baltagi (1995), p.93.

One step heteroscedastic - consistent standard errors, n=1200, 6 years.

Table 2 Model Estimation Results: Backward Linkages to the Domestic Industry

	No spatial dependence	Homogeneity in spatial dependence	Heterogeneity in spatial dependence
Variable		Coefficient (t values)	Coefficient (t values)
W_rQ_{ibt}		0.11*** (2.95)	0.114[i]
K_{irt}	0.302*** (4.09)	0.147*** (2.99)	0.147*** (3.87)
NL_{irt}	0.264*** (5.58)	0.110*** (3.65)	0.150*** (4.21)
ML_{irt}	0.582*** (4.58)	0.551*** (5.69)	0.498*** (3.64)
$Q_{irt\text{-}1}$	0.258*** (3.01)	0.100** (2.07)	0.092* (1.64)
BWD INTRA-INDREG, (intra-industry in same region)	-0.006 (1.56)	-0.003* (1.87)	-0.003 (1.58)
BWD INTER-INDREG, (inter-industry in same region)	-0.005 (0.99)	-0.009 (1.05)	-0.007 (0.85)
BWD INTRA-INDOREG, (intra-industry other regions)	-0.025*** (6.54)	-0.041*** (6.87)	-0.041*** (6.32)
BWD INTER-INDOREG (inter-industry other regions)	-0.035*** (2.83)	-0.029** (2.56)	-0.035*** (3.01)
Spatial autocorrelation (Morans *I*)	2.257** (0.024)	1.128 (0.259)	0.744 (0.457)
Time dummies	Yes	Yes	Yes
Specification $\sim\chi^2(6)$[ii] (p value)	7.46 (0.281)	7.166 (0.306)	6.120 (0.409)
Sargan (validity of instruments)- p value	0.643	0.516	0.408
inclusion of further lags of FDI variables LR test $\sim\chi^2(4)$	5.909 (0.207)	5.401 (0.249)	5.389 (0.249)
inclusion of TIME lags spatial dependence $\sim\chi^2(1)$		1.013 (0.293)	0.556 (0.455)
Industry autocorrelation (Morans *I*)	0.565 (0.572)	0.689 (0.491)	0.439 (0.661)
serial correlation AR(2)[iii] $\sim\chi^2(1)$	1.542 (0.214)	1.114 (0.291)	1.748 (0.186)

For notes please see notes to Table 1.

Table 3 Regional specific dependence coefficients, based on standard first order contiguity.

	"backwards" model		"forwards" model	
UK regions	Coefficient	t value	coefficient	T value
South East	0.107	1.32	0.115	1.34
South West	0.109**	2.09	0.115**	1.99
East Anglia	0.108**	2.59	0.109**	2.45
East Mids	0.114*	1.72	0.120*	1.72
West Mids	0.109**	2.46	0.120**	2.46
Yorks & Hum	0.105	1.58	0.114*	1.64
North West	0.108	0.99	0.108	0.95
North	0.112	1.39	0.112	1.37
Wales	0.113**	2.07	0.105**	1.98
Scotland	0.115	0.73	0.110	0.73
mean	0.112		0.114	

*, **, *** Significant at the 10%, 5% and 1% level respectively.

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Appendix 1 Descriptive Statistics from UK Census of Production. Mean and SD: All Firms and Foreign Firms*

	All firms (foreign and domestic)					Foreign firms				
	Total Employment	Manual workers	Value added £000s	Sales £000s	Investment £000s	Total Employment	Manual workers	Value added £000s	Sales £000s	Investment £000s
1984	23422.8	15825.5	327327.6	962701	35627.8	3189.3	2009.6	77380.5	626953.4	335940.6
	(31415.8)	(19577.2)	(476754.4)	(1443131)	(53905.1)	(6797.2)	(4145.5)	(472037.6)	(407612.0)	(205102.0)
1985	24127.4	16275.5	359674.9	1061772	42156.9	3056.6	1918.1	62235.7	7818.0	193333.2
	(32045.4)	(20253.0)	(522231.0)	(1563832)	(63720.0)	(6422.0)	(3886.1)	(142150.2)	(20134.3)	(459197.4)
1986	23582.6	15946.4	386320.5	1131654	43447.8	2737.7	1712.3	60231.6	7400.9	192371.1
	(30871.3)	(19539.7)	(553667.5)	(1640784)	(67177.1)	(5589.5)	(3326.4)	(133842.3)	(19456.2)	(456944.6)
1987	22800.3	15221.9	416662.2	1171572	46487.6	2742.2	1676.9	70386.8	8573.9	220805.7
	(29567.8)	(18218.1)	(581076.7)	(1682283)	(67528.9)	(5342.5)	(3103.1)	(152419.3)	(19434.2)	(517636.9)
1988	22848.2	15349.0	461876.3	1297634	59325.6	2853.6	1753.4	79632.5	10527.6	252179.8
	(29138.6)	(18168.5)	(641007.6)	(1831872)	(83632.4)	(5255.7)	(3071.3)	(164035.1)	(23114.4)	(565555.5)
1989	23036.5	15682.5	494915.6	1408965	68814.4	3244.3	1998.3	98462.5	16426.3	323220.0
	(28849.8)	(18232.5)	(677305.7)	(1957847)	(99229.6)	(5764.2)	(3326.4)	(207683.7)	(39787.1)	(697588.4)
1990	22607.4	15268.6	512756.2	1482927	67849.3	3410.7	2107.4	104722.0	15174.4	352992.3
	(28256.7)	(17655.0)	(710442.6)	(2062426)	(101509.9)	(5967.0)	(3493.4)	(205460.4)	(35645.0)	(736913.6)
1991	20928.1	13918.3	479646.9	1293243	55983.9	3428.3	2111.2	98194.8	16330.9	343361.2
	(26786.2)	(16581.3)	(694469.7)	(1840838)	(93846.8)	(5842.1)	(3448.8)	(185916.5)	(43186.0)	(706977.0)
1992	20991.1	14019.7	512154.9	1522872	59988.9	3474.5	2102.6	110536.2	13844.1	383749.1
	(25793.2)	(16245.0)	(722323.4)	(2194074)	(86515.2)	(5755.7)	(3327.8)	(208975.4)	(28100.4)	(780296.0)

*These figures are derived from the data that is stratified by industry and by region. The mean values therefore are the aggregate figures divided by 200, the number of observations per year..

Appendix 2. Full Model Estimation Results: Backward and Forward Linkages to/from the Domestic Industry

	Heterogeneity in spatial dependence
Variable	Coefficient (t values)
W_rQ_{ibt}	0.104[i]
K_{irt}	0.146*** (3.29)
NL_{irt}	0.136*** (4.01)
ML_{irt}	0.508*** (3.51)
Q_{irt-1}	0.093 (1.45)
FWD INTRA-INDREG, (intra-industry in same region)	0.008 (0.18)
FWD INTER-INDREG, (inter-industry in same region)	0.007* (1.69)
FWD INTRA-INDOREG, (intra-industry other regions)	0.014** (2.31)
FWD INTER-INDOREG (inter-industry other regions)	0.009 (1.21)
BWD INTRA-INDREG, (intra-industry in same region)	-0.009** (2.54)
BWD INTER-INDREG, (inter-industry in same region)	-0.011* (1.97)
BWD INTRA-INDOREG, (intra-industry other regions)	-0.058*** (5.67)
BWD INTER-INDOREG (inter-industry other regions)	-0.067*** (2.69)
Spatial autocorrelation (Moran's I)	0.868 (0.385)
Time dummies	Yes
Specification $\sim\chi^2(6)$ (p value)[ii]	5.482 (0.484)
Sargan - p value	0.409
inclusion of further lags of FDI variables LR test $\sim\chi^2(8)$	12.56 (0.127)
inclusion of TIME lags spatial dependence $\sim\chi^2(1)$	0.621 (0.431)
Industry autocorrelation (Moran's I)	0.562 (0.574)
serial correlation AR(2) $\sim \chi^2(1)$[iii]	1.586 (0.208)

For notes to table please see Table 1 notes.