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On the Relative Importance of Agglomeration Economies in the Location of FDI Across British Regions

Jonathan Jones (SERC, Newcastle University Business School)
Colin Wren (SERC, Newcastle University Business School)

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** SERC, Economics, Newcastle University Business School

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Abstract
The paper examines the relative importance for industrial location of production linkages and knowledge spillovers, distinguishing between intermediate and non-intermediate goods that are backwards or forwards in nature. A novel approach is used to construct proxies for non-intermediate goods at a sub-national industry level based on an Input-Output transaction table. Taking data on location decisions by foreign-owned plants across British regions over 1985-2007, the paper finds support for the new economic geography explanation of location based on linkages over that due to spillovers. However, the importance of intermediate and non-intermediate linkages differs between manufacturing and service industries.

Keywords: Industrial location; agglomeration economies; intermediate goods; FDI
JEL Classifications: H3, O2, L2, R3

1 Introduction

Agglomeration economies reflect proximity and are an important explanation for industrial location. They have antecedents in the work of Marshall (1920), and feature prominently in the recent theories of location, including the intermediate inputs (Venables, 1996) and labour mobility (Krugman, 1991) of the new economic geography and the knowledge spillovers of the new growth theory (Griliches, 1992). However, while there is a good supply of theories, there is much less evidence on the relative importance of these explanations, which Ellison *et al* (2010) characterize as "the cost of moving goods, people, and ideas" (p. 1195). It is partly because research on agglomeration economies tends to be partial, so that production linkages are often ignored in the literature on knowledge spillovers (e.g. Rosenthal and Strange, 2004) and conversely (e.g. Amiti and Javorcik, 2008).[1] Further, there is the difficulty of adequately measuring all production linkages at the sub-national industry level, which include backward and forward effects in both intermediate and non-intermediate goods markets.

This paper examines the relative strength of the different agglomeration economies on industrial location, adopting a novel approach to measure the strength of the non-intermediate goods at the sub-national industry level. This is based on an Input-Output transaction table, which not only incorporates the 'core Input-Output table' that shows the exchange of goods and services between industries, but records the flows of goods and services to or from agents that are outside of the industrial sector, e.g. labour services and final household demand (see Armstrong and Taylor, 2000). The approach is advantageous, as in an accounting sense it permits all possible non-intermediate and intermediate goods to be included, and which are measured on a comparable basis. In this paper two forward non-intermediate goods terms are included, for final domestic demand and exports, and two backward non-intermediate terms for the gross value added of labour services and residual surplus. Terms are also included for the backward and forward intermediate goods and for knowledge spillovers.

The investigation utilises data on about 13,000 investments by foreign-owned plants across the regions of Great Britain over the period 1985-2007. The data relate to flows rather than stocks (i.e. the location decision), while foreign direct investment (FDI) is highly mobile across geographic space. The data are known for both manufacturing and service industries. The linkage terms are constructed from the *UK Supply and Use Table*, which is a transaction

[1] Ellison *et al* (2010) use input-output and other tables to measure the strength of three Marshallian economies between industry pairs. In principle, this approach could be extended to include other sources of agglomeration economy, but it has strong data requirements, while it is regressed for a single cross-section, which as Ellison *et al* acknowledge, raises issues about the role of natural advantages.

table that is available at the national level only. This restricts the analysis to NUTS 1 regions, although offering a good trade-off between the geographical reach of production linkages and knowledge spillovers. Research finds that spillovers can extend over large areas (see Döring and Schnellenbach, 2006; Baldwin *et al*, 2008), while Lamorgese and Ottaviano (2002) argue that if anything pecuniary effects occur over relatively greater distances.[2]

The paper finds significant effects for each kind of agglomeration economy, which is sensitive to the inclusion of all such terms. Overall, when calculated on a comparable basis as elasticities, the production linkages are more important for location than are knowledge spillovers, which supports the new economic geography over the new growth theory. In their relative effect the estimates differ between sectors, which indicates that this is a consideration when discriminating between competing explanations. Thus, backward intermediate goods markets are important for manufacturing and forward intermediate goods are more important for services, while the opposite tends to be the case for non-intermediate goods (e.g. labour is relatively more important for services and exports less important). In the case of knowledge spillovers there are significant differences between industries, which indicate differences in the transferability of knowledge between these sectors. Intra-industry flows have a relatively greater effect on manufacturing location but inter-industry flows more so for services.

In the next section, the literature is reviewed and the measurement of the intermediate and non-intermediate goods terms is considered. Section 3 sets out the empirical model and section 4 describes the data. The results are presented in section 5 and section 6 concludes.

2 Intermediate and Non-Intermediate Linkages

Agglomeration economies are an important factor in FDI location, but in the literature these were initially measured at the aggregate level, as either the employment level or the number of plants in an area (e.g. Coughlin *et al*, 1991; Wheeler and Mody, 1992; Woodward, 1992), and only occasionally at the industry level (Carlton, 1983). Later studies distinguish between domestic and foreign firms, such as Head *et al* (1995), and a consistent finding is that foreign

[2] Rosenthal and Strange (2001) and Henderson (2003) find that spillovers attenuate rapidly with distance, but Beenstock and Felsenstein (2010) argue that there is no intrinsic reason why these should be restricted to a local level. Jaffe *et al* (1993) and Audretsch and Feldman (1996) find evidence for knowledge spillovers at the level of US states, and others at even greater distances. Significant spatial lag effects are found below for linkages and spillovers, indicating that these flow between the NUTS 1 regions. The use of NUTS 1 regions means that there are is a choice for each investment across ten regions only, but the data are available for a long time period, over which the agglomeration terms and other controls vary greatly, offering a good test of the approach.

plants exert a stronger influence on FDI location than do domestic plants, whether or not the FDI originates from the same source country (e.g. Crozet *et al*, 2004; Hilber and Voicu, 2007; Devereux *et al*, 2007; and Basile *et al*, 2008). This is generally attributed to agglomeration economies, although it could pick-up an unobserved location effect, such as demand or even an information asymmetry on the host economy (Procher, 2009; Mariotti *et al*, 2010).

When consideration is given to the nature of an agglomeration economy affecting FDI location, early studies also do not impose any formal linkage structure on the data (e.g. Head and Mayer, 2004). This is achieved by the use of input-output tables to examine backward or forward intermediate effects (Javorcik, 2004), although research has generally focused on just one of these (e.g. Milner *et al*, 2006, on backward linkages for Japanese FDI in Thailand and Bekes, 2006, on forward FDI linkages in Hungary). In the relatively small number of studies that consider both kinds of effect there are omissions that can give rise to identification issues. Thus, Amiti and Javorcik (2008) consider input-output linkages and omit externalities, but the input-output tables may also used to examine the channels through which the spillovers occur (e.g. Driffield *et al*, 2004; Javorcik and Spartareanu, 2009; Mariotti *et al*, 2010). Du *et al* (2008) and Debaere *et al* (2010) include terms for externalities, but do not allow for the inter-industry economies that can arise from industrial diversity. Finally, even when a full set of terms is included, such as in Lee *et al* (2008), the differences between the intermediate and non-intermediate goods are not analysed, so that the relative importance of the different kinds of agglomeration economy remains to be fully explored in the literature.

2.1 Measurement of the Linkage Terms

Expressions for the intermediate and non-intermediate linkage terms are now derived. These are based on the Input-Output *transaction table* that includes *all* inputs and outputs, such that total output is equal to total inputs for each industry. Initially, the intermediate goods term is derived based on the Input-Output (I/O) *core table*, i.e. the processing sector for the domestic industry (see Armstrong and Taylor, 2000). The purpose of this is to show that this can give biased estimates, even though linkage terms based on this or similar are used in the literature. The linkage terms that are adopted in this paper are then presented. Each is for the backward effect, while Appendix A gives the expressions for the corresponding forward terms.

Suppose there are K industries and that firms in each industry are homogeneous. Let q_l be the total value of output of industry $l \in \{1, 2, \ldots, K\}$, and suppose that this industry uses intermediate inputs from other industries to the total value of v_l, where $v_l < q_l$, so that $q_l - v_l$ are non-intermediate inputs. Further, let a_{kl} be the value of inputs from industry k to l from the core I/O table and e_{kr} denote the importance of industry k in region r, as measured by its output or employment in this region. Then, the usual backward intermediate goods term for a firm in industry l, that uses the total value of intermediate goods v_l in the denominator, is:

$$BW(CORE)_{lr} = \sum_{k=1}^{K} \left(\frac{a_{kl}}{v_l} \right) e_{kr} \, . \qquad (1)$$

This is much used, but it is based on the core I/O table only, and so takes no account of the relative importance of intermediate goods in the total inputs of industry l.[3] This can lead to a biased estimate, since by ignoring non-intermediate goods it may take a high value compared to other industries, even though intermediate inputs have little importance to industry l. In particular, it is shown below that it constrains the estimates on the backward intermediate and non-intermediate goods terms to be the same. The bias may be substantial, as in the UK non-intermediate inputs and outputs each account for about half of the total value of goods.

To allow for the role of the non-intermediate inputs, the backward intermediate goods term should instead be specified using the total value of l's output in the denominator:

$$BW(INT)_{lr} = \sum_{k=1}^{K} \left(\frac{a_{kl}}{q_l} \right) e_{kr} \, . \qquad (2)$$

This embodies the Leontief technology of fixed factor proportions and is independent of scale. Further, when intermediate inputs have no importance (i.e. $a_{kl} = 0$ for all k) it is zero. Given this, then the proxy for the non-intermediate inputs can also be specified as follows. This has the same desirable properties, as when non-intermediate inputs have no importance it is zero (i.e. $q_l = v_l$), while when many non-intermediate inputs are introduced below it can be shown that it embodies the Leontief property and is independent of scale.

[3] This is the backward linkage term constructed by Lee *et al* (2008) and Debaere *et al* (2010), where the input-output coefficients are normalised by the total value of intermediate inputs. In the case of the forward terms the denominator sometimes includes non-intermediate inputs from the transaction table, but not all such inputs, so that a similar bias may result. Thus, for example, Amiti and Javorcik (2008) use industry and final consumer demand to normalise outputs, but do not include export demand or that from the government sector.

$$BW(NON-INT)_{lr} = \left(\frac{q_l}{v_l} - 1\right)\left[\sum_{k=1}^{K}\left(\frac{a_{kl}}{q_l}\right)e_{kr}\right]. \qquad (3)$$

This expression is not intuitively obvious, but it can be seen that if (2) is a good proxy for the intermediate inputs then (3) is a good proxy for the non-intermediate inputs. In particular, if in some region non-intermediate inputs are α (> 0) of the value of intermediate inputs, i.e. q_l - v_l, = $\alpha\, v_l$, then (3) is α of the value of (2), as this rearranges to (q_l / v_l - 1) = α. Further, if the intermediate and non-intermediate inputs each increase by a scale parameter λ (> 0) then (2) and (3) are unchanged, as in this case a_{kl}, v_l and q_l all increase by λ.

Given this, it can now be seen that using (1) in place of (2) yields biased estimates of the intermediate goods term. This is because (2) plus (3) is identically equal to (1), so that (1) constrains the coefficients on the intermediate and non-intermediate terms to be the same:[4]

$$\sum_{k=1}^{K}\left(\frac{a_{kl}}{q_l}\right)e_{kr} + \left(\frac{q_l}{v_l} - 1\right)\left[\sum_{k=1}^{K}\left(\frac{a_{kl}}{q_l}\right)e_{kr}\right] \equiv \sum_{k=1}^{K}\left(\frac{a_{kl}}{v_l}\right)e_{kr}\,.$$

Finally, if there are many potential non-intermediate inputs, then (3) can be decomposed to construct a term for each of these. Suppose that there are G non-intermediate inputs, v_l^g, such that $v_l^1 + v_l^2 + \ldots + v_l^G = q_l - v_l$, then proxies for these are (g = 1, 2, …, G):

$$BW(g)_{lr} = \left(\frac{v_l^g}{v_l}\right)\left[\sum_{k=1}^{K}\left(\frac{a_{kl}}{q_l}\right)e_{kr}\right]. \qquad (4)$$

These G terms sum to give (3), which as noted above has the requisite Leontief property. An advantage of these proxies is that each non-intermediate input is defined at the sub-national industry level and measured on a comparable basis to the intermediate goods term. However, since they are defined relative to the intermediate goods term in (2) they do not completely solve the identification issue. In particular, as v_l^g is the same for all firms in an industry, then (4) is collinear with the intermediate and other non-intermediate terms for a single industry. Identification of these terms therefore relies on a regression across firms that are in different

[4] (1) and (2) are only the same if there are no non-intermediate inputs, i.e. $v_l = q_l$. Following the same argument, it can be seen that if the denominator of (1) includes intermediate and only some of the non-intermediate inputs, then the coefficients on the intermediate and non-intermediate inputs are also constrained to be the same.

industries, so that there must be a reasonable number of these industries.

3 Empirical Model of Location Choice

The profits $\boldsymbol{\pi}_{irt}$ of a firm i (= 1, 2, …, n) from locating its investment in a region r (= 1, …, R) at time t (= 1, 2, …, T) are specified as a linear function of a vector of deterministic attributes of the region $\boldsymbol{x}_{ir,t-1}$, with coefficients $\boldsymbol{\beta}$, and a stochastic term ε_{irt} as follows:

$$\pi_{irt} = x'_{ir,t-1}\beta + \varepsilon_{irt} . \tag{5}$$

A firm investing at time t can locate in any region, but it chooses r if the profits are greater than in any other region, so that the probability P_{irt} of firm i locating in r is:

$$P_{irt} = \mathrm{Prob}(\pi_{irt} > \pi_{ist} : \forall s \in \{1, 2, ..., R\},\ s \neq r,\ t \in \{1, 2, ..., T\}) . \tag{6}$$

Using (5), then if at time t the R stochastic terms in (6) are i.i.d. with a Type 1 extreme value distribution, the probability that the firm chooses r (McFadden, 1974) is:

$$P_{irt} = \frac{\exp(x'_{ir,t-1}\beta)}{\sum_{s=1}^{R}\exp(x'_{is,t-1}\beta)} . \tag{7}$$

From the log-likelihood of the conditional logit model it follows that (Greene, 2011):

$$\ln L = \sum_{i=1}^{n}\sum_{r=1}^{R} d_{irt} \ln P_{irt} , \tag{8}$$

where for a firm i investing at time t the indicator variable d_{irt} is unity if it chooses region r, but zero otherwise. Like Head *et al* (1999), this is regressed by maximizing the likelihood of the location choices of foreign investors over time, where the coefficients give the log-odds ratio from choosing location r over not choosing r in the set of locations R.

In the empirical work the profit function $\boldsymbol{\pi}_{irt}$ in (5) is specified as:

$$\pi_{irt} = A'_{ir,t-1}\,\beta^{A} + Z'_{r,t-1}\,\beta^{Z} + \beta_{r} + \varepsilon_{irt}, \qquad (9)$$

where $\boldsymbol{A}_{ir,t-1}$ captures the agglomeration economies for firm *i* in region *r* at *t*-1, $\boldsymbol{Z}_{r,t-1}$ controls for other regional attributes and β_r are region-specific fixed effects (the conditional logit does not permit time dummies). The backward and forward linkage terms for the intermediate and non-intermediate goods in $\boldsymbol{A}_{ir,t-1}$ are measured for the industry in which the firm operates. In addition, $\boldsymbol{A}_{ir,t-1}$ includes terms for knowledge spillovers, which are set out below.

The independence of the error terms in (9) means that the conditional logit model is subject to the independence of irrelevant alternatives (IIA) (Liao, 1994), whereby changes in the characteristics of some third region do not affect the relative odds between any two other regions. A popular response to this is to use a nested logit model, but this suggests that there is an ordering to the location choice of FDI across British regions. Nesting is not used here as there is no *a priori* reason to do so, while the inclusion of regional fixed effects and a large number of covariates will in any case give similar results (Dahlberg and Eklöf, 2003).[5]

4 Data and Variables

The data give annual information on over 13,000 investments by foreign-owned plants across the regions of Great Britain over 1985-2007. These data are used by UK central government to report foreign direct investment (FDI) for Great Britain as a whole, and are available on a project basis. Project data have been much used to examine FDI location (e.g. Dimitropoulou *et al*, 2006; Alegria, 2009; Wren and Jones, 2011).[6] Since different types of FDI may serve as substitutes for one another, a broad definition of FDI is adopted, which comprises start-ups

[5] Nesting is unreasonable for a small number of regions (Mucchielli and Puech, 2004), while it is not without its own difficulties, as there is no testing procedure for the correct model specification (Greene, 2011), while the IIA property is still present within each nest (Arauzo-Carod *et al*, 2010).

[6] The data were supplied by the UK's national inward investment agency *UK Trade and Industry* (UKTI). They are collected in the regions by government departments and agencies and by UKTI from its direct involvement with projects. The data refer to firm commitments, possibly unannounced, but a detailed analysis for a single region finds that virtually all of the projects go ahead (Jones and Wren, 2004). A comparison of the regional distribution of FDI projects over 1996-05 with that from the *Annual Business Inquiry* (ABI) production census shows no statistically significant difference between these, where the later is measured as the employment in foreign-owned plants at the end of the period (Wren and Jones, 2011). Unlike the ABI, the data identify service activities prior to 1997 and all location decisions by foreign-owned plants, including acquisitions.

('greenfield' investments), acquisitions and re-investments, where each of these is potentially mobile across regions.[7] Re-investments involve a substantial upgrading to an existing plant, e.g. a new production line, for which further details are given in Wren and Jones (2009).

The areas are the Government Office Regions for Great Britain, where London is included in the South East region, giving ten regions (R = 10).[8] Brand *et al* (2000) find that the regions build-up FDI in distinct activities, which offers *prima facie* evidence for the existence of agglomeration economies at this level. Input-output tables are not produced at the sub-national level, but as noted above the regions are sufficiently large in scale to offer a good trade-off between the likely spatial reach of linkages and spillovers. The FDI data are available at the 3-digit industry level, but the UK input-output tables report the coefficients for 123 industry groups that range from aggregates of 2-digit industries to single 4-digit industries. These map to the 97 divisions of the NACE industrial classification (ONS, 2006), but as some industries receive little or no FDI then 46 broadly homogeneous industries are formed through aggregation (K = 46). These are given in Appendix B, which shows that 23 industries are in manufacturing and 19 in services.[9] They are based on 2-digit industries, although disaggregated to identify several activities where FDI is particularly strong.

The measurement of the variables is now considered, which begins with those for the agglomeration terms in $\boldsymbol{A}_{irt}$ in (9). The variables and their labels are given in table 1.

4.1 Intermediate goods

The intermediate goods terms are constructed from the input-output coefficients of the *UK Supply and Use Table*. For years prior to 1995 this table is produced at 5-year intervals using a different industrial classification, so that a single table is used for 1995 (ONS, 2007), which is similar to the practice adopted elsewhere.[10] The input-output coefficients a_{kl} are essentially

[7] The data include a small numbers of joint ventures and mergers. Start-ups and re-investments each account for about 40% of the total number of projects.

[8] These are the *Eurostat* NUTS 1 regions. The London Government Office Region is drawn tightly around the urban area, so that it is included with the surrounding South East Government Office Region, with which it has strong economic links. This makes it comparable with other regions, which have an economic core where FDI tends to locate and a surrounding more rural area, so that each region is reasonably self-contained. In any case, the FDI data are not identified for London prior to 1996. Changes to the boundaries in 1996 affected a few regions, so that some rescaling of the data is necessary (see Jones and Wren, 2011).

[9] This approach means that each industry is of a reasonable size in terms of the number of investments, which is important given that the agglomeration terms are measured at the industry level.

[10] For example, Debaere *et al* (2010) use an I/O table for the year 2000 when looking at Korean FDI in China over 1988-2004. Elsewhere the period of study can be shorter, such as Amiti and Javorcik (2008). Ellison *et al* (2010) use input-output and other tables for 1987 to examine co-agglomeration patterns in the same year, but

technical relationships, which are expected to change little from year to year, while of greater importance is likely to be the regional profile of economic activity e_{kr} in (1) to (4), which are measured on an annual basis.[11] There is the possibility that FDI will affect the intermediate (and non-intermediate) goods terms, although in the case of the input-output coefficients a_{kl}, more than three-quarters of FDI projects in the sample are after 1995, reflecting the strong growth in UK inward FDI after this time (see Jones and Wren, 2006). In the case of the e_{kr} increasing levels of FDI may alter the regional profiles of economic activity, so that these are lagged one period. The e_{kr} are measured for each region r as follows, where E_{kr} is the region industry employment level and E_r is the total regional employment level:

$$e_{kr} = \left(\frac{E_{kr}}{E_r} \right). \tag{10}$$

Measuring these in this way is advantageous as it reduces the correlation between the linkage terms, which can undermine work in this area (see Amiti and Javorcik, 2008). An alternative is to specify e_{kr} as the industry-region employment level E_{kr}, but as large regions tend to have more employees in each industry then this induces correlation.[12] The correlation coefficients between the agglomeration terms are reported in table 2, based on (10). For the backward and forward intermediate terms the correlation coefficient is 0.38, although 0.76 when $e_{kr} = E_{kr}$, while otherwise the correlation coefficients are not on the high side.[13]

4.2 Non-intermediate goods

The *UK Supply and Use Table* identifies the gross value added of an industry, disaggregated according to employee compensation (*LABOUR*) and the gross operating surplus (*SURPLUS*). These are used to construct two backward non-intermediate terms (G = 2):[14]

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this is also employed for an analysis at 1997. Constructing coefficients for each year is onerous, while in any case there is the issue of years prior to 1995. The results by sub-period are considered below.

[11] The invariance of the input-output coefficients is reflected in the fact that UK I/O tables are sometimes used in the context of other countries (e.g. Ellison *et al*, 2010; Mariotti *et al*, 2010). Of course, the I/O relationships are not purely technical relationships, and reflect factor and goods prices, but these are also reflected in the e_{kr}.

[12] At 2005, most regions had a UK GDP share in the range 7-10%, except that the South East region share was 32.0%, while the smallest region was North East England, with a 3.5% share of national output.

[13] They reach up to 0.65 for some of the backward terms, but still lower than 0.85 when $e_{kr} = E_{kr}$.

[14] Gross value added is the difference between total output at basic prices and total intermediate consumption at purchasers' prices. The *UK Supply and Use Table* also disaggregates gross value added according to 'taxes less subsidies on production', but these are relatively trivial and so omitted. Taxes are national in nature, and terms

$$BW(LABOUR)_{lr} = \frac{LABOUR_l}{v_l}\left[\sum_{k=1}^{K}\left(\frac{a_{kl}}{q_l}\right)e_{kr}\right], \qquad \text{and} \tag{11}$$

$$BW(SURPLUS)_{lr} = \frac{SURPLUS_l}{v_l}\left[\sum_{k=1}^{K}\left(\frac{a_{kl}}{q_l}\right)e_{kr}\right]. \tag{12}$$

The first of these terms proxies the importance of labour to each industry in each region. It is associated with the Marshallian agglomeration economy of 'thick' labour markets, which arises as pools of labour offer a market for industry-specific skills (Duranton and Puga, 2004). Underlying this, there could be many potential processes, but which are not explored here.[15] The second term captures the residual surplus accruing to shareholders after the payment of intermediate goods (including raw materials and capital goods), employees and net taxes. It measures the attractiveness of a region to an industry not captured by the other agglomeration terms (e.g. intermediate goods, labour, knowledge spillovers, final demand and so on) or by the control variables. It includes the natural advantages of Ellison and Glaeser (1997) that make some regions a better location for particular industries (e.g. access to coastal areas for shipbuilding). Following the above, the sum of (11), (12) and (2) gives (1).

As regards the forward non-intermediate terms, the *Supply and Use Table* defines the final demand for products corresponding to each industry. This is used to form two forward non-intermediate terms (H = 2) for the final home demand (*HOME*) and exports (*EXPORT*). They are given by (A5) and (A6) in Appendix A, where these plus (A2) sum to give (A1). In the case of exports, for a firm in industry k the forward non-intermediate variable proxies the importance of region r as a location for exports, which, like the other terms, is based on the behaviour of existing firms in the industry. Both forward terms capture market access effects, although *HOME* is slightly different in this respect, since if firms serve major UK regional markets from other regions then a negative sign is expected on this term.

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for the regional subsidies are included below as one of the control variables. The transaction table does not separately identify imports, so that inputs are recorded the same whether from UK or from foreign suppliers.

[15] The processes include the matching of jobs and workers, greater productivity from specialization, dual-careers for couples and the better adaption of individual establishments to idiosyncratic shocks, although Overman and Puga (2010) attribute only the latter to the Marshallian agglomeration economy of labour pooling.

4.3 Knowledge spillovers

To measure the intra-industry knowledge spillovers, or MAR externalities, then like Basile *et al* (2008) and other work dating back to Woodward (1992), this is measured by the number of FDI projects in industry l that locate in region r in the preceding period t-1, i.e. MAR_{lrt-1}. It is an indirect method that assumes that knowledge flows in proportion to the number of recently locating FDI projects. Other approaches exist, such as patent citations (Jaffe *et al*, 1993) or technology flows (Ellison *et al*, 2010), but ultimately these are also indirect in nature. In net terms, knowledge flows to rather than away from domestic plants (Mariotti *et al*, 2010), so that FDI location is assumed to be independent of domestic investment in this respect. Since it is measured at the industry level it does not capture backward production linkages.

The Jacobs knowledge-based agglomeration economies arise from industrial diversity, and can occur over large areas (Henderson *et al*, 1995). It can be captured in different ways, potentially producing different results (Beaudry and Schiffauerova, 2009), but broadly these are classified into measures that use the inverse of either the coefficient of absolute or relative regional specialisation (see Wren and Taylor, 1999). Given that the UK national economy is reasonably diversified across the 46 industries, then measures that are defined relative to this may just capture 'differentness' rather than 'diversity', so that the following absolute measure is used.[16] This is the inverse of the mean deviation of the industry employment shares across the K = 46 industries, where the negative sign means that a positive coefficient is expected.

$$JACOBS_{rt} = \frac{-K}{\sum_{k=1}^{k=K}\left|\frac{E_{krt}}{E_{rt}} - \frac{1}{K}\right|}. \qquad (13)$$

4.4 Controls and other terms

As regards the Z_{rt} terms in (9), these are the classical location factors that are suggested by the literature. Head *et al* (1995) note that it is not possible to include terms for all possible

[16] If regional employment is uniformly distributed across the 46 industries then a relative measure will indicate a diversified regional economy when the opposite is in fact the case, so the absolute measure in (13) is preferred. Using employment makes it comparable to the linkage terms, and it is preferred to that based on the number of enterprises used by Lee *et al* (2008). It is reasonable to include both manufacturing and service industries. As a sensitivity check, the relative measure of Duranton and Puga (2000) was instead used and if anything this gave stronger effects for Jacobs term, i.e. larger elasticities, but (13) is preferred for the reason given.

location factors, so that four variables are included for each of four factors that determine the investment decision. These are for revenue, costs, the forward-looking nature of investment and policy, the latter since FDI has been targeted by UK regional policy.[17] Control terms are measured for each region and year, for which theory offers guidance. The variables are the same as those used by Wren and Jones (2011), where details can be found. Since they are not the main interest, the estimates for these are not formally presented below.

Finally, to allow for the possibility that agglomeration economies go across regional boundaries, spatial lags (*SPATIAL*) are included for the linkage, MAR and Jacobs terms. To minimise the number of such terms, they are summed for each of the backward and forward markets. As the regions are relatively large in scale, 'spillovers' are more likely for regions that share a common land boundary, so that the spatial weight is based on the contiguity of regions. A positive sign indicates a positive spillover from neighbouring regions.

5 Regression Results

The results from the conditional logit estimation of (8) are reported in column I of table 3. This uses the profits expression in (9), where the variables are defined in table 1. Half of the control variables are significant, all at the 1% level, of which each is correctly signed.[18] The backward and forward intermediate terms (*INT*) are significant, which is also the case for the forward non-intermediate market access terms. The negative sign on *FW*(*HOME*) indicates that firms locate away regions with high domestic final demand for their output, and suggests that FDI does not serve regional markets, while *FW*(*EXPORT*) shows that locations with high industry exports are more attractive to FDI, suggesting that they serve international markets. However, both backward non-intermediate terms, *BW*(*LABOUR*) and *BW*(*SURPLUS*), are insignificant. The knowledge terms are significant and correctly signed, and the spatial lags

[17] For the revenue that can be earned in a region, terms are included for the population size, per capita income, distance to major markets and education qualifications, the latter to capture knowledge in general. The variables for costs are the wage rate, availability of unskilled labour and terms for access and congestion based on road data. For regional prospects they are the growth rate, the proportion of strikes, and indicators of development (one based on unemployment and the other on the European regional policy spending, including infrastructure). Finally, policy terms are expenditure on UK regional investment grants (of which half goes to FDI), the grant rate applied in each region, a spatial lag term to pick-up regional competition for projects and the involvement of UKTI in each region to capture the non-financial support for FDI. The spatial lag is based on the amount of grant going to contiguous regions, arising from the regional administration of the national grant scheme.

[18] They cover each of the four factors, comprising population size, distance to major markets, knowledge, access, congestion, growth rate, grant amount and FDI promotion. Full results are available from the authors.

indicate that regional spillovers are present for each kind of agglomeration economy.

Column II of table 3 reports the estimates for when the linkage terms are constructed using the core input-output table only, i.e. (1) and (A1). These constrain the estimates on the respective intermediate and non-intermediate terms to be the same, and give different results. Hence, compared to the estimates for the intermediate goods terms in column I, a smaller but significant estimate is obtained for the backward linkage term and an insignificant estimate is found for the forward term. This confirms that in constructing the terms for the intermediate goods markets care should be taken over the choice of the appropriate denominator. In fact, the constraints imposed by (1) and (A1) are heavily rejected by the data.[19]

Examination indicates that a single lag on the right-hand side terms of (9) is optimal, while the other columns in table 3 carry out sensitivity tests of the regression result in column I.[20] In columns III and IV the spatial lags and control variables are dropped, but the estimates on the linkage and spillover terms are robust. In column V the non-intermediate goods terms are omitted (spatial lags are measured for the intermediate terms only), but again the results are robust, except that a lower estimate is found for the forward intermediate term. Finally, column VI drops the *MAR* and *JACOBS* terms (and associated spatial lags) and the backward non-intermediate terms *BW*(*LABOUR*) and *BW*(*SURPLUS*) are now significant, although the latter has a negatively-signed coefficient. This seems to be related to the *MAR* spillover term, for which there are several possible explanations.

The first is that the two linkage terms depend on *MAR*, so that they are endogenous.[21] As *MAR* is measured by the number of FDI projects, then variations in this may be expected to affect the total number of employees and total surplus earned in a region. However, as an explanation this is doubtful, as *LABOUR* and *SURPLUS* are drawn from the 1995 *Supply and Use Table*, whereas the vast majority of projects are after this time. Further, while *MAR* may affect these backward non-intermediate terms through the regional employment structure e_{kr}, the terms in square brackets in (11) and (12) that include e_{kr} are just *BW*(*INT*) in (2), but the estimate on this term is robust to the different specifications in table 3.

The more plausible explanation is that there is multicollinearity between *MAR* and the backward non-intermediate goods terms *BW*(*LABOUR*) and *BW*(*SURPLUS*), despite *MAR*

[19] The LR test statistic is 157.8 against a χ^2 critical value of 13.3 at the 1% level.
[20] Introducing a further lag on the right-hand side terms in (9) gives more or less identical estimates for the agglomeration terms, except that those for *MAR* and *JACOBS* are smaller. It gives a smaller log-likelihood at -25,868.1, compared to -25,847.8 in column I of table 3, so that a single lag is preferred.
[21] We rule the other possibility, that *MAR* depends on *BW*(*LABOUR*) and *BW*(*SURPLUS*), as the estimates on the other linkage terms in table 3 are robust to the exclusion of *MAR* in column VI of table 3. Attempts to assess the exogeneity of the variables using a Hausman test were unsuccessful due to collinearity.

not exhibiting a high correlation with either of these in table 2.[22] This is because industries that have both a high labour content and greater surplus will tend to be in services, but which have received greater levels of FDI, particularly since the late 1990s (Jones and Wren, 2006). It suggests that manufacturing and service industries should be considered separately, and indeed when this is done below it is found that not only is the estimate of *MAR* significantly different between these, but the backward non-intermediate goods terms appear to be much better determined. It suggests that the multicollinearity is much reduced, although it may not be eliminated altogether, as a structural break exists for each sector related to the backward non-intermediate goods terms, but not as great as for all industry.[23]

5.1 By industrial sector

The estimated coefficients on the agglomeration terms from regressing column I of table 3 with dummies on these terms for industries in each of the manufacturing and service sectors are reported in part (a) of table 4. The row for All Industry in this table reproduces the results from column I of table 3. When taken as a group the null hypothesis that the estimates on the agglomeration terms are the same across sectors is heavily rejected by the data.[24] Further, when examined individually, four agglomeration terms differ significantly between sectors (the first of these at the 5% level and others at the 1% level): the backward intermediate term, *BW*(*INT*); the forward non-intermediate term for domestic demand, *FW*(*HOME*); and the two spillover terms, *MAR* and *JACOBS*. The backward non-intermediate goods terms are each positive and generally significant, but do not differ statistically between the sectors.

To assess the relative importance of the agglomeration terms it is possible to evaluate elasticities. These are for the change in the probability of FDI location at the regional level with respect to the change in the respective agglomeration term. Letting $\overline{P}$ denote the mean probability that a firm chooses a location (evaluated across firms, regions and time) and $\overline{A}$

[22] In support of this, if *MAR* is lagged a further period in column I of table 3 then *BW*(*LABOUR*) is significant at the 5% level (a coefficient of 0.310), while *BW*(*SURPLUS*) continues to be insignificant (a p-value of 0.44).

[23] Column I of table 3 was regressed with dummies on the intermediate and non-intermediate linkage terms for the sub-period 1996-07. The LR statistic for the null hypothesis that these slope dummies are jointly zero is 47.4, against a $\chi^2(6)$ critical value of 16.8 at the 1% level. Examination shows that it is related to the backward non-intermediate goods terms. When the same test was carried out for projects in the manufacturing and service industries only, the statistics are 23.8 and 27.7 respectively, where the same critical value applies. The input-output coefficients are measured at 1995, but given that the structural break relates to the backward non-intermediate goods terms only then this seems to relate to the different nature of FDI from the mid-1990s when service-based FDI was much more prominent and grew strongly.

[24] The LR test statistic is 256.6 against a $\chi^2(16)$ critical value of 32.0 at the 1% level.

the mean of an agglomeration term then the marginal effect from (7) is $\partial\overline{P}/\partial\overline{A} = \overline{P}\left(1-\overline{P}\right)\hat{\beta}$, so that the elasticity can be calculated as:

$$\frac{\partial\overline{P}}{\partial\overline{A}}\frac{\overline{A}}{\overline{P}} = \overline{A}\left(1-\overline{P}\right)\hat{\beta}. \tag{14}$$

The elasticities are presented in part (b) of table 4 (each is multiplied by 100). They show that the backward intermediate goods are more important for manufacturing and that forward intermediate goods are more important for services (although only the former is significantly different by the above). For non-intermediate goods a different pattern emerges, as backward effects are now more important for services, while for manufacturing UK regional markets are even less important and export markets are more important. Finally, there are significant differences in the MAR and Jacobs knowledge terms between industrial sectors that indicate differences in the nature of knowledge transfer. While larger effects are generally found in the literature for MAR compared to Jacobs externalities (Beaudry and Schiffauerova, 2009), much of this evidence is for manufacturing, but these results suggest that the opposite is the case for services, where knowledge is more transferable across industries.

The elasticities were also evaluated for manufacturing and services for each region by allowing $\overline{P}$ and $\overline{A}$ to vary according to these. Space constraints prevent the presentation of these estimates, which are available from the authors on request. Overall, they indicate very similar effects, except where they vary strongly they add plausibility to the results concerning the effect of particular agglomeration terms. For example, in the case of the externality terms the elasticities for the Jacobs term are greater in the more diversified regional economies of the East and East Midlands regions (at 25% and 21%), while that for the MAR term is greater in the large South East region (at 28%). In relation to the South East region a slope dummy was placed on *FW*(*HOME*) for this region to allow for its relatively large market size. This was positive and significant, while the estimate on this term for all the regions continued to be negative, albeit smaller and significant at the 10% level only. It suggests that the negative coefficient on *FW*(*HOME*) in table 4 to some extent reflects access to this market.

5.2 By industry

Finally, the agglomeration effects were explored at the individual industry level. This poses a difficulty as it was noted that the intermediate and non-intermediate terms are collinear with each other at this level in the case of both the backward and forward effects. It makes it necessary to sum the intermediate and non-intermediate terms for each of the backward and forward effects, so that this analysis is based on (1) and (A1). This constrains the estimates on the respective intermediate and non-intermediate terms to be the same, which are known to vary, so that the results presented here give an aggregate net effect for each of these.[25]

The estimates for the four agglomeration terms, obtained from re-estimating column II of table 3 with these terms in spline form for each industry, are presented in Appendix B. Briefly, they show that the MAR term is significant for many of the manufacturing industries, especially labour-intensive (NACE codes 17 to 22) and more high-technology industries (31 to 35), while there is a less certain pattern for the Jacobs externalities. The linkage terms are best explored by plotting the backward and forward estimates against one another, in figure 1. This shows that there is a negative relationship between these, such that the more important are backward linkages the less important are forward linkages at the industry level. Fitting lines to these as follows (t-ratios in parentheses) shows that a negative relationship exists for each sector, but that it is more pronounced for manufacturing industries. In general, it shows that either backward or forward effects will tend to dominate at the industry level, although Appendix B shows that there are industries for which both factors are important.

<u>Manufacturing</u>: $$\underset{(5.61)}{FW(CORE) = 1.174} - \underset{(3.76)}{0.696\, BW(CORE)} \qquad n = 23 \quad R^2 = 0.40$$

<u>Services</u>: $$\underset{(1.22)}{FW(CORE) = 0.540} - \underset{(2.27)}{0.400\, BW(CORE)} \qquad n=19 \quad R^2 = 0.23.$$

6 Conclusions

The paper examines the relative strength of agglomeration economies on the location of foreign direct investment (FDI) across British regions over the period 1985-2007. It uses a novel approach to measure the backward and forward non-intermediate goods, which is based

[25] It is consistent with the earlier analysis, where it was argued that (1) and (A1) alone will give biased estimates of the backward and forward intermediate goods terms. We now use (1) and (A1), but recognising that these constrain the estimates of the respective intermediate and non-intermediate goods terms to be the same.

on an Input-Output transaction table that is on a comparable basis to the more usual proxies for intermediate goods. The paper finds that production linkages and knowledge spillovers explain location, but that when measured as elasticities the former are more important, which offers support for the New Economic Geography explanation for industrial location over the New Growth Theory based on knowledge spillovers. The effects vary between manufacturing and service industries, such that backward intermediate goods markets are more important for manufacturing and forward intermediate goods markets for services, while the converse tends to be the case for non-intermediate goods markets. The transferability of knowledge, whether intra- or inter-industry, also varies in relative importance between these sectors.

Overall, the paper produces interesting and plausible findings on the relative effects of agglomeration economies, and points to interesting differences between these at the level of the industrial sector. It makes a contribution to methodology, since as a guide to future work it suggests that the full range of terms for agglomeration economies should be included and that the intermediate goods should be measured in an appropriate way, while it also proposes an approach for proxying the non-intermediate inputs and outputs at the sub-national industry level. Taking all of these factors into the account, the conclusion of the paper is that the New Economic Geography provides a more powerful explanation for location than does the New Growth Theory based on knowledge spillovers. This is based on the location of FDI at the UK regional level, so that it interesting to be seen if these findings apply elsewhere.

Table 1: Variables

Variable label	Description	Mean	s.d.
Backward linkages for industry *l* in region *r* at time *t* (x 100) - BW_{lrt}:			
(*INT*)	Intermediate goods, defined by equation (2).	1.089	0.407
(*LABOUR*)	Compensation of employees, by (11).	0.818	0.639
(*SURPLUS*)	Gross operating surplus, by (12).	0.438	0.345
(*CORE*)	Core input-output linkages, by (1).	2.301	1.192
Forward linkages for industry *l* in region *r* at time *t* (x 100) - FW_{lrt}:			
(*INT*)	Intermediate goods, measured by equation (A2).	1.704	1.084
(*HOME*)	Domestic non-firm demand, by (A5).	1.242	1.206
(*EXPORT*)	Export demand, by (A6).	0.566	0.574
(*CORE*)	Core input-output linkages, by (A1).	3.254	1.634
Externalities:			
MAR_{lrt}	Number of industry *l* projects in region *r* at time *t*.	0.332	0.834
$JACOBS_{rt}$	Diversity of activity in *r* at time *t*, by (13).	4.773	6.484
Spatial lags using contiguity as weight for industry *l* in region *r* at time *t* - $SPATIAL_{lrt}$:			
(*BW*)	Measured according to (1) (x 100).	2.659	0.763
(*FW*)	Measured according to (A1) (x 100).	3.532	1.076
(*MAR*)	Measured by number of own-industry projects.	1.664	1.440
(*JACOBS*)	Measured according to (13) x 100.	3.302	0.242

Note: Means and standard deviation (s.d.) calculated across 13,064 observations.
Sources: Backward and forward terms from *Supply and Use Tables* (ONS, 2007) and *National Online Manpower Information Service* (NOMIS), Office for National Statistics, Newport. *JACOBS* constructed using NOMIS data, and *MAR* based on FDI project data supplied by *UK Trade and Industry*, HM Government, London.

Table 2: Correlation Matrix

	Backward - *BW*:			Forward - *FW*:			*MAR*	*JACOBS*
	(*INT*)	(*LABOUR*)	(*SURPLUS*)	(*INT*)	(*HOME*)	(*EXPORT*)		
BW (*INT*)	1.00							
BW (*LABOUR*)	0.64	1.00						
BW (*SURPLUS*)	0.56	0.65	1.00					
FW (INT)	0.38	0.58	0.45	1.00				
FW (*HOME*)	0.30	0.12	0.06	-0.29	1.00			
FW (*EXPORT*)	-0.09	-0.07	-0.16	0.23	-0.17	1.00		
MAR	0.34	0.38	0.24	0.13	-0.01	0.01	1.00	
JACOBS	-0.07	-0.08	-0.07	-0.04	-0.03	0.01	-0.11	1.00

Note: Correlation coefficients between the variables described in table 1.

Table 3: Regression Results

Dependent variable = 1 if inward investor locates in region *r* at time *t*; and = 0 otherwise.						
Column	**I**	**II**	**III**	**IV**	**V**	**VI**
Backward linkages (x100) - BW_{t-1}:						
(*INT*)	1.376***	-	1.351***	1.411***	1.333***	1.274***
(*LABOUR*)	-0.010	-	-0.035	0.003	-	0.884***
(*SURPLUS*)	-0.089	-	-0.091	0.130	-	-0.503**
(*CORE*)	-	0.765***	-	-	-	-
Forward linkages (x100) - FW_{t-1}:						
(*INT*)	0.343***	-	0.332***	0.296***	0.123***	0.353***
(*HOME*)	-0.382***	-	-0.370***	-0.450***	-	-0.443***
(*EXPORT*)	0.320***	-	0.290***	0.275***	-	0.334***
(*CORE*)	-	-0.010	-	-	-	-
Externalities:						
MAR_{t-1}	0.015***	0.012***	0.015***	0.017***	0.015***	-
$JACOBS_{t-1}$	2.200***	2.242***	2.197***	3.301***	2.237***	-
Spatial lags - $SPATIAL_t$:						
(*BW*) (x 100)	0.246***	0.444***	-	0.304***	0.819***	0.287***
(*FW*) (x 100)	0.347***	0.333***	-	0.399***	0.155	0.419***
(*MAR*)	0.013**	0.012**	-	0.005	0.015***	-
(*JACOBS*)	0.195***	0.022***	-	0.342***	0.201***	-
Control variables?	Yes	Yes	Yes	No	Yes	Yes
No. of observations	130,640	130,640	130,640	130,640	130,640	130,640
Number of cases	13,064	13,064	13,064	13,064	13,064	13,064
Log-likelihood	-25,847.8	-25,926.7	-25,890.7	-26,017.5	-25,877.1	-25,942.5
Wald statistic	2,866.4***	2,680.7***	2,817.5***	2,679.4***	2,818.3***	2,776.6***

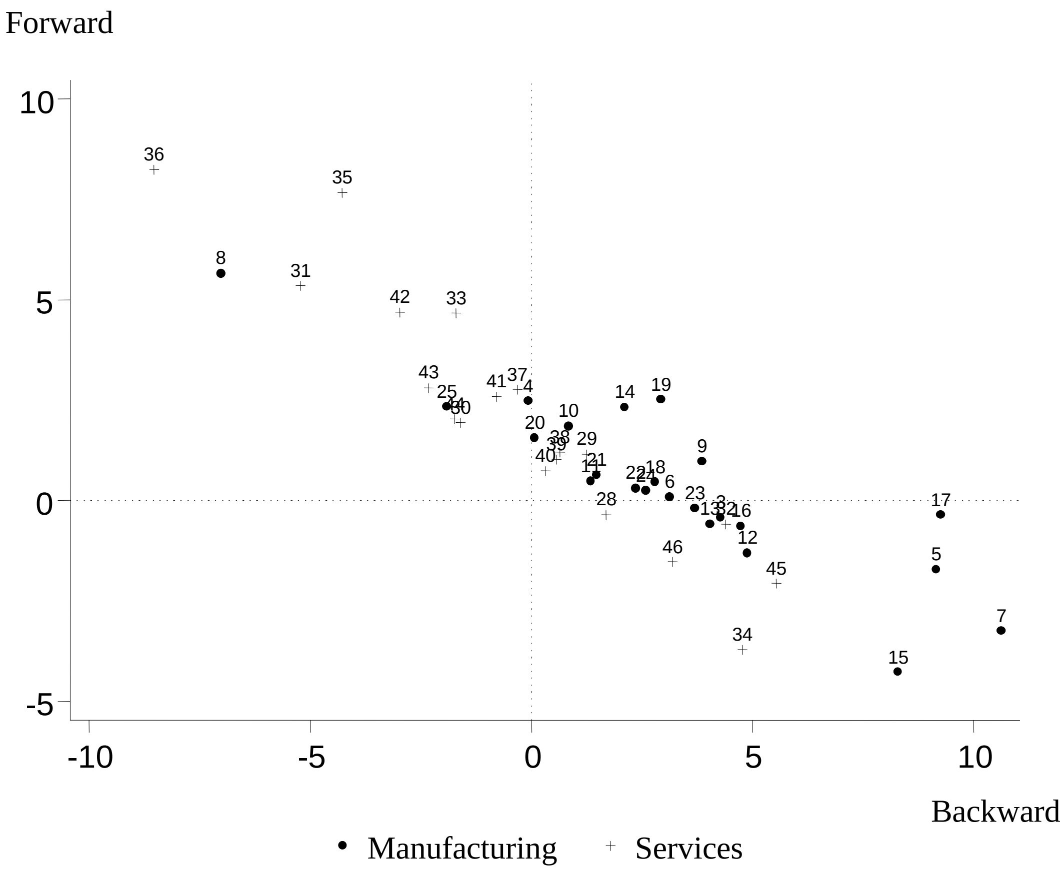
Notes: Conditional logit estimation of equation (8) with (9) and (10). Each regression includes regional fixed effects. Variables described in table 1, where backward and forward spatial lag terms measured as in table 1, except for column V where they are for *INT* only. Significant at *** = 1%, ** = 5% and * = 10%.

Table 4: Agglomeration Estimates and Elasticities by Sector

	BACKWARD: *BW*			FORWARD: *FW*			*MAR*	*JACOBS*
	INT	*LABOUR*	*SURPLUS*	*INT*	*HOME*	*EXPORT*		
(a) Regression Estimates:								
Manufacturing	0.679***	1.351**	0.617	0.452***	-0.693***	0.387***	0.081***	1.129***
Services	0.008	0.771***	0.965***	0.430***	-0.240***	0.438***	0.012***	3.715***
All industry	1.376***	-0.010	-0.089	0.343***	-0.382***	0.320***	0.015***	2.200***
(b) Elasticities:								
Manufacturing	51.9	41.0	10.3	51.0	-61.7	25.2	15.5	5.4
Services	0.9	95.8	61.3	85.8	-32.5	17.2	5.2	13.9
All industry	134.9	-0.7	-3.5	52.6	-42.7	16.3	4.5	9.5

Notes: Part (a) re-estimates column I of table 3 with a dummy on each agglomeration term for each of manufacturing and services (log-likelihood = -25,719.50). Results for all industry are from table 3. Elasticities in part (b) calculated according to (14), as % change in probability of location (x 100) from a 1% change in agglomeration term. Variables defined in table 1. Significant at *** = 1%, ** = 5% and * = 10%.

Figure 1: Backward and Forward Linkage by Industry



Notes: Estimated coefficients from regression of column II of table 3 with backward and forward *CORE* input-output terms in spline form for 46 industries. Industries and coefficient estimates in Appendix B. Only estimates within two standard deviations of mean estimate are shown.

Appendix A: Forward Linkage Terms

In the case of forward linkages, analogous expressions to (1) to (4) are derived, where w_k (< q_k) is the total value of intermediate outputs from industry k, and q_k - w_k are non-intermediate outputs. Again, a_{kl} is the value of inputs from industry k to l from the core I/O table:

$$FW(CORE)_{kr} = \sum_{l=1}^{K} \left(\frac{a_{kl}}{w_k} \right) e_{lr}, \tag{A1}$$

$$FW(INT)_{kr} = \sum_{l=1}^{K} \left(\frac{a_{kl}}{q_k} \right) e_{lr} \quad \text{and} \tag{A2}$$

$$FW(NON-INT)_{kr} = \left(\frac{q_k}{w_k} - 1 \right) \left[\sum_{l=1}^{K} \left(\frac{a_{kl}}{q_k} \right) e_{lr} \right], \tag{A3}$$

where (A2) and (A3) sum to give (A1). If there are H non-intermediate outputs w_k^h, such that $w_k^1 + w_k^2 + \ldots + w_k^H = q_k - w_k$, then proxies for these are (h = 1, 2, …, H):

$$FW(h)_{kr} = \left(\frac{w_k^h}{w_k} \right) \left[\sum_{l=1}^{K} \left(\frac{a_{kl}}{q_k} \right) e_{lr} \right]. \tag{A4}$$

In the empirical work, two forward non-intermediate terms are defined (i.e. H = 2):

$$FW(HOME)_{kr} = \frac{HOME_k}{w_k} \left[\sum_{l=1}^{K} \left(\frac{a_{kl}}{q_k} \right) e_{lr} \right], \quad \text{and} \tag{A5}$$

$$FW(EXPORT)_{kr} = \frac{EXPORT_k}{w_k} \left[\sum_{l=1}^{K} \left(\frac{a_{kl}}{q_k} \right) e_{lr} \right], \tag{A6}$$

where (A5) and (A6) sum to give (A3).

Appendix B: Industries and Coefficient Estimates

No.	Industry (NACE)	No. of cases	Coefficient estimates: *BW* (*CORE*)	*FW* (*CORE*)	*MAR*	*JACOBS*
1	Agriculture, Forestry and Fishing (1, 2 and 5)	27	5.50*	-1.12	-0.429	33.09**
2	Mining and Quarrying (10 to 14)	82	2.00**	0.23	0.360***	12.19*
3	Food, Beverages and Tobacco (15 and 16)	370	0.84***	-0.06	0.031	4.01**
4	Textiles and Textile Products (17 and 18)	170	1.05	-0.67	0.261***	0.68
5	Leather and Leather Products (19)	26	0.87	2.01	0.862***	0.216
6	Wood and Wood Products (20)	90	1.32	0.58	0.276**	0.874
7	Pulp, Paper and Paper Products (21)	200	1.92**	-0.33	0.169***	8.72***
8	Publishing and Printing (22)	149	-1.12	2.50**	0.140**	0.17
9	Coke, Refined Petroleum Products (23)	32	0.61	2.31	0.253	14.65
10	Chemicals (24, excluding 24.4)	485	-0.13	1.36***	0.094***	3.72**
11	Pharmaceuticals (24.4)	277	2.70***	0.28***	0.028	4.23*
12	Rubber and Plastic Products (25)	420	0.62**	0.89***	0.055*	-3.03*
13	Mineral Products (26)	144	1.47***	0.16	0.119	-5.11*
14	Basic Metals (27)	182	0.09	0.84***	0.065	-2.08
15	Metal Products (28)	364	0.83***	0.45*	0.059*	1.41
16	Machinery (29)	722	0.72***	0.26	0.025*	0.04
17	Office Machinery (30)	130	1.50**	-0.29	0.078	12.54***
18	Electrical Machinery (31)	406	0.43	0.85*	0.095***	3.42*
19	Electronic Components (32.1)	479	-0.04	0.41**	0.127***	1.99
20	TV and Radio (32.2 and 32.3)	257	0.84	0.37	0.126***	0.10
21	Medical and Optical Instruments (33)	324	0.82	-0.03	0.098***	0.62
22	Motor Vehicles (34)	810	1.44***	-0.60***	0.039***	0.66
23	Other Transport (35)	240	1.45***	0.11	0.108***	4.02
24	Furniture and Leisure Goods (36)	243	0.87*	0.82***	0.179***	3.50
25	Recycling (37)	45	-0.06	1.53***	0.003	-3.46
26	Electricity, Water and Gas (40 and 41)	157	1.24*	-0.19	0.114***	-2.17
27	Construction (45)	206	0.56	-0.52	0.050*	4.51
28	Wholesale (50 and 51)	438	0.97***	-1.09**	0.067***	0.62
29	Retail (52)	268	2.27***	0.92	0.003	1.17
30	Hotels and Restaurants (55)	111	-1.56***	-0.75	0.069**	1.23
31	Transport and Travel (60 to 63)	373	-0.30	1.12**	0.030	6.11**
32	Telecommunications (64)	314	2.44**	0.75	0.029*	2.40
33	Financial Intermediation (65)	338	1.06***	0.56	0.008	6.18*
34	Insurance and Pension Funding (66)	62	2.23***	-5.14*	-0.185	3.54
35	Auxiliary Financial Intermediation (67)	95	-0.99	2.66***	0.064	4.99
36	Real Estate (70)	44	1.72*	2.64**	0.495***	19.79*
37	Renting (71)	53	0.17	-1.43	0.389**	7.82
38	Computer Consultancy (72.1 and 72.2)	1,176	1.52***	-1.77***	-0.005**	1.35
39	Computer Activities and Software (72.3 to 72.6)	563	0.76***	1.41***	0.005*	-0.90
40	Research and Development (73)	760	0.78***	0.98***	-0.008	2.97***
41	Professional Business Services (74.1 and 74.2)	542	1.13**	-0.34	0.003	10.21***
42	Other Business Activities (74.3 to 74.8)	472	-1.46***	4.14***	0.068***	5.10**
43	Public Administration (75)	23	-6.38	1.85	0.830	20.44
44	Education (80)	45	2.37	1.67***	0.358**	10.99
45	Health and Social Work (85)	116	6.43***	-1.88***	0.033	23.27***
46	Social and Personal Services (90, 92, 93, 95, 99)	234	1.29***	-0.42	0.048**	4.24

Notes: Industry numbers 3 - 25 = manufacturing and 28 - 46 = services. NACE rev. 1.1 industry classification in parentheses. Coefficient estimates from regression of column II in table 3 but with four agglomeration terms, *BW*(*CORE*), *FW*(*CORE*), *MAR* and *JACOBS*, in spline form; log-likelihood = -25,235.2. Significant at *** = 1%, ** = 5% and * = 10%.

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Spatial Economics Research Centre (SERC)
London School of Economics
Houghton Street
London WC2A 2AE

Tel: 020 7852 3565
Fax: 020 7955 6848
Web: www.spatialeconomics.ac.uk

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