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On the Relative Importance of Intermediate and Non-Intermediate Goods for FDI Location: A New Approach

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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 for location, which Ellison *et al* (2010) characterize as “the cost of moving goods, people, and ideas” (p. 1195). This is partly because research on production linkages and knowledge spillovers has tended to proceed in parallel (e.g. Debaere *et al*, 2010; Rosenthal and Strange, 2004), while there are difficulties in measuring the various kinds of linkage at a sub-national industry level, including backward and forward effects in intermediate and non-intermediate markets.

In this paper the relative strength of agglomeration economies on industrial location is examined by adopting a new approach to measure the strength of the non-intermediate goods at a sub-national industry level. This is based on an Input-Output transaction table, which not only incorporates the ‘core Input-Output table’, showing the exchange of goods and services between industries, but it includes the flow of goods and services to or from agents outside of the industrial sector, such as labour services or household demand (see Armstrong and Taylor, 2000). The advantage of this approach is that it permits all possible non-intermediate goods to be included, measuring these on a comparable basis to the intermediate goods. A further contribution of the paper is to show that basing the intermediate goods terms solely on the

¹ The authors gratefully acknowledge the financial support of the ESRC Spatial Economic Research Centre (<http://www.spatial-economics.ac.uk>). Earlier versions of this paper were presented at the British and Irish Section of the Regional Science Association International, Glasgow, August 2010, and at the INFER conference, Orléans, France, March 2011. The authors are grateful for comments from participants at these events. The authors also thank *UK Trade and Investment* for supplying the investment data.

core Input-Output table imposes constraints on the regression and leads to biased estimates. In this paper two forward non-intermediate goods terms are considered, for the final domestic demand and exports, and two backward non-intermediate goods, for labour services and the residual surplus. Terms for backward and forward intermediate goods are included, as well as for knowledge spillovers, so that the relative location effect of these is examined.

The investigation utilises data for over 13,000 investments by foreign-owned plants across the regions of Great Britain over the period 1985-2007. These data are available for manufacturing and service industries, and they relate to flows, i.e. the location decision. This is important as Ellison *et al* (2010) argue that industrial linkages might endogenously reflect agglomeration patterns, but by considering *new* activity rather than *all* activity it is possible to eliminate this as a source of reverse causation.² The linkage terms are constructed from the *UK Supply and Use Table*, which is a transaction table. It is available at the UK national level only, which means that relatively large regions are used to ensure that the trade patterns are represented at the sub-national level. These are the Government Office Regions, which offer a good trade-off between the geographical reach of production linkages and knowledge spillovers. Research finds that spillovers can extend over relatively large areas (see Döring and Schnellbach, 2006; Baldwin *et al*, 2008), while Lamorgese and Ottaviano (2002) argue that production linkages tend to occur over even greater distances.³

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, production linkages are more important for location than knowledge spillovers, supporting the new economic geography over new growth theory.⁴ Each of the intermediate and non-intermediate goods has a significant effect on location, which is like elsewhere, but in their relative effect there are important differences between industrial sectors. Backward intermediate goods are more important for manufacturing and forward intermediate goods for services, while the opposite is the case for the non-intermediate goods, such that labour and the surplus that can be earned in a region are more important for services, but regional demand

² Ellison *et al* (2010) calculate geographic concentration indices for all industry using cross-section data, so they look at the stock of plants for a given year. However, since agglomeration will reflect location decisions taken over very many years, then industrial relationships may be a result of location rather than a cause of it.

³ 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 over even greater distances. Significant spatial lag effects are found below for linkages and spillovers, which indicate that these flow for distances greater than the NUTS 1 geographic level.

⁴ Fingleton (2006) distinguishes between market effects of the new economic geography and producer linkages of urban economics, so that the results potentially allow an even finer distinction between competing theories.

and exports are less so. The transferability of knowledge also varies between sectors in its intra- and inter-industry location effect. Overall, the results point to important differences in the agglomeration economies, while supporting the methodological approach.

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. Section 5 presents the results and section 6 concludes.

2 Intermediate and Non-Intermediate Linkages

Agglomeration economies are an important factor in FDI location. Early studies measured these at the aggregate level as either the employment level or number of plants in an area (e.g. Coughlin *et al.*, 1991; Woodward, 1992), but only occasionally at the industry level (Carlton, 1983). Since then, a distinction is made by ownership (Head *et al.*, 1995), and a consistent finding is that foreign plants exert a stronger influence on FDI location than do domestic plants, whether or not the FDI originates from the same source country (Crozet *et al.*, 2004; Hilber and Voicu, 2007; Basile *et al.*, 2008). This is attributed to agglomeration economies.

When consideration is given to the nature of an agglomeration economy affecting FDI location, early studies 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 and forward intermediate effects (Javorcik, 2004), although research generally focuses on just one of these, such as Milner *et al.* (2006) on backward linkages for Japanese FDI in Thailand and Bekes (2006) on forward FDI linkages in Hungary. There are a relatively small number of studies that consider both backward and forward effects (e.g. Amiti and Javorcik, 2008). These studies generally do not include externalities, which can be problematic as input-output tables are also used to examine the channels through which spillovers occur (Driffield *et al.*, 2004; Javorcik and Spartareanu, 2009; Mariotti *et al.*, 2010). Further, where externalities are included, there may be no consideration of the economies that arise from industrial diversity, e.g. Du *et al.* (2008) and Debaere *et al.* (2010), while when these are considered, as in Lee *et al.* (2008), the relative importance of the different economies is not fully explored.

2.1 Measurement of the Linkage Terms

The measurement of the intermediate and non-intermediate linkage terms is now considered. This is based on the Input-Output *transaction table* that includes *all* inputs and outputs, such

that for each industry the total value of output is equal to the total value of inputs. Initially, the intermediate goods term is derived based on the *core Input-Output (I/O) table*, which gives the processing sector for the domestic industry (ten Raa, 2006; Armstrong and Taylor, 2000). Subsequently, the linkage terms used in this paper are presented. These are for the backward effects, while the corresponding forward terms are given in Appendix A. It is shown that the linkage terms based solely on the core I/O table give biased estimates.

Suppose there are K industries and that the firms in each industry are homogeneous. Let q_l be the value of output of industry $l \in \{1, 2, \dots, K\}$, and suppose that this industry uses intermediate inputs from other industries (including the own-industry) 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} denote the value of inputs from industry k to l from the core I/O table, where $\sum_k a_{kl} = v_l$, and let e_{krt} denote the importance of industry k in region r at time t , which is measured by employment (see below). Then the usual backward intermediate goods term for a firm in industry l is:⁵

$$BW : CORE_{lrt} = \sum_{k=1}^K \left(\frac{a_{kl}}{v_l} \right) e_{krt}. \quad (1)$$

This is based on the core I/O table, so that it uses the total value of intermediate goods v_l in the denominator. However, this means that it takes no account of the relative importance of intermediate goods to industry l . This is problematic as (1) may take a high value for some industry, even though the intermediate goods have little importance to this industry compared to non-intermediate inputs.⁶ In fact, it is shown below that (1) constrains the estimates on the backward intermediate and non-intermediate goods terms to be the same. The bias that this imposes could 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 non-intermediate goods, the backward intermediate goods term in (1) should instead be specified using the total value of l 's output in the denominator:

⁵ This is the backward linkage term used by Driffield *et al* (2004), Lee *et al* (2008) and Debaere *et al* (2010), where the input-output coefficients are normalised by the total value of intermediate inputs. The forward term may be constructed in a similar way, as in Driffield *et al* (2004), although the denominator sometimes includes non-intermediate inputs from the transaction table as in Amiti and Javorcik (2008).

⁶ For example, in oil and gas extraction, construction accounts for 16.4% of the value of intermediate inputs, but only 5.5% of all inputs, whereas for ceramic goods, mining and quarrying accounts for a greater proportion of all inputs, at 5.9%, but a smaller share of intermediate inputs at 12.5% (ONS, 2007). Once allowance is made for all inputs and the size of the industries in different regions then these differences may be magnified.

$$BW : INT_{lrt} = \sum_{k=1}^K \left(\frac{a_{kl}}{q_l} \right) e_{krt}. \quad (2)$$

To use this at the regional level, it is supposed that there is the Leontief technology of fixed factor proportions and constant returns to scale, so that it is independent of scale.⁷ Also like (1) it is zero when the intermediate inputs have no importance, i.e. $a_{kl} = 0$ for all k .

The expression in (2) is a proxy for backward intermediate goods, but in an analogous way a proxy for the backward non-intermediate inputs can be specified as:

$$BW : NON - INT_{lrt} = \left(\frac{q_l}{v_l} - 1 \right) \left[\sum_{k=1}^K \left(\frac{a_{kl}}{q_l} \right) e_{krt} \right]. \quad (3)$$

This captures the importance of the backward non-intermediate goods, as if these inputs are α (> 0) of the value of intermediate inputs, i.e. $q_l - v_l = \alpha v_l$, then rearranging this gives $(q_l / v_l - 1) = \alpha$, from which it follows that (3) is α of (2). It has the same desirable properties as (2), as it is zero when non-intermediate inputs have no importance (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. Thus, if intermediate and non-intermediate inputs each increase by a scale parameter λ (> 0) then both (2) and (3) are unchanged, as in this case a_{kl} , v_l and q_l all increase by λ by the property of linear homogeneity.

There are two important implications of the proxy variable in (3). First, it suggests 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) implicitly constrains the coefficients on the intermediate and non-intermediate goods terms in (2) and (3) to be the same.⁸

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

Second, if there are many backward non-intermediate goods, 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 $v_l^1 + v_l^2 + \dots + v_l^G = q_l - v_l$, then proxies for each of these are ($g = 1, 2, \dots, G$):

⁷ The input-output approach embodies other assumptions, such as no regional interaction, no distance decay, as well as a lack of supply constraints and instantaneous responses (see Miller and Blair, 2009).

⁸ Expressions (1) and (2) are the same only if there are no non-intermediate inputs, i.e. $v_l = q_l$. Following this argument, if the denominator of (1) includes the intermediate but only some of the non-intermediate inputs, then the coefficients on the intermediate and non-intermediate inputs are still constrained to be the same.

$$BW :NON - INT_{irt}^g = \left(\frac{v_l^g}{v_l} \right) \left[\sum_{k=1}^K \left(\frac{a_{kl}}{q_l} \right) e_{krt} \right]. \quad (4)$$

These G terms sum to give (3), and as indicated above they have the required properties. The advantages of these proxies are that each non-intermediate input is defined at the sub-national industry level and measured on the same basis as the intermediate goods term. The drawback is that since (3) is $\alpha = (q_l / v_l - 1)$ of (2), and α is the same for all firms in an industry, then (3) is collinear with (2) at the industry level. Identification therefore relies on regressing these for firms across industries. However, if (2) is a good proxy for the intermediate inputs, then by the same argument (3) and hence (4) are good proxies for the non-intermediate inputs.

3 Empirical Model of Location Choice

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

$$\pi_{irt} = x'_{ir,t-1} \beta + \varepsilon_{irt}, \quad (5)$$

where $x_{ir,t-1} \equiv (A_{ir,t-1}, Z_{r,t-1}, \beta_r)$ comprises variables for the agglomeration economies $A_{ir,t-1}$, controls for regional attributes $Z_{r,t-1}$, and region-specific fixed effects β_r .⁹ If investment is mobile across regions at time t , then firm i chooses region r if profits are greater than in each other region, so that the probability P_{irt} of locating in r is:

$$P_{irt} = \text{Prob}(\pi_{irt} > \pi_{ist} : \forall s \in \{1, 2, \dots, R\}, s \neq r). \quad (6)$$

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

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

⁹ The conditional logit does not permit the inclusion of time dummies.

and the log-likelihood of the conditional logit model (Greene, 2011) is:

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

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 .

As is well known, the independence of the error terms in (5) means the conditional logit model is subject to the independence of irrelevant alternatives (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, although this is not used here as there is no *a priori* reason to suppose that there is an ordering the location choice of FDI across British regions.¹⁰ In any case, the inclusion of regional fixed effects and a large number of covariates gives similar results (Dahlberg and Eklöf, 2003).

4 The 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. Similar data are used to examine FDI location (e.g. Dimitropoulou *et al*, 2006; Wren and Jones, 2006; Alegria, 2009). Since different FDI types can serve as substitutes for one another a broad definition of FDI is taken comprising start-ups ('greenfield' investments), acquisitions and re-investments, plus a small number of joint ventures and mergers.¹¹ Each FDI type is potentially mobile across regions, where a re-investment involves a substantial upgrading to an existing plant, such as a new production line, for which further details can be

¹⁰ Nesting is unreasonable for a small number of regions (Mucchielli and Puech, 2004), while it is not without its difficulties, as there is no testing procedure for the model specification (Greene, 2011) and the independence of irrelevant alternatives property is still present within each nest (Arauzo-Carod *et al*, 2010).

¹¹ The data were supplied by the national inward investment agency *UK Trade and Industry* (UKTI). The data refer to firm commitments, possibly unannounced, but a detailed analysis for a single region finds that virtually all projects go ahead (Jones and Wren, 2004). A comparison of the regional distribution of FDI over 1996-05 with 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. Unlike the ABI, the data identify service activities prior to 1997 and all location decisions by foreign-owned plants, including acquisitions.

found in Wren and Jones (2009). Start-ups and re-investments each account for about 40% of projects. Three-quarters of projects over 1985-07 occur after 1995 due to growth in service FDI, from around 150 projects in 1995 to over 750 in 2007. Manufacturing FDI is constant and in the range 200-300 investments per annum (Jones and Wren, 2012).

The regions are the Government Office Regions for Great Britain, where London is included with the South East, giving ten regions (i.e. $R = 10$).¹² These regions are sufficiently large to adequately reflect the relationships in the national input-output table, while as noted above they offer a good trade-off between the likely spatial reach of linkages and spillovers, which is supported by the results for the spatial lag terms below. The relatively small number of regions is compensated for by the long time period, giving many observations by region and year. Brand *et al* (2000) find that these regions build-up FDI in distinct activities, which offers *prima facie* evidence for the existence of agglomeration economies.

The FDI data are available at the 3-digit industry level, but the UK input-output tables report the coefficients for 123 industry / product groups that range from aggregates of 2-digit industries to single 4-digit industries. These map to the 59 divisions of the NACE industrial classification (ONS, 2006), but since some divisions have either a very small or large number of investments, they are aggregated to form broadly homogeneous groups or disaggregated in the case of chemicals, electronics and computing. This is because the agglomeration terms are measured at the industry level, which might otherwise lead to perverse results by giving these too much or too little weight in the regression. It gives 46 industries ($K = 46$), which are described in Appendix B, where 23 industries are in manufacturing and 19 in services.

The variables are now considered, beginning with those for the agglomeration terms A_{irt} in (5). These include linkages and spillovers, for which details 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*. This is produced annually, except at 5-year intervals using a different industrial classification for years prior to 1995, and at a higher level of industrial aggregation

¹² 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. The FDI data are not identified for London prior to 1996 and nor by sub-region. Changes to the regional boundaries in 1996 mean that some limited rescaling of the data is necessary (see Jones and Wren, 2012).

more recently (see Mahajan, 2007). Like practice elsewhere a single transaction table is used, which is the latest revision of the 1995 *Supply and Use Table*.¹³ Input-output coefficients can be viewed as technical relationships that change relatively little in their magnitude from year to year, so that it is not believed to be of great significance, while of much more importance is likely to be the regional distribution of activity e_{krt} in (2).¹⁴ The e_{krt} terms are measured annually and lagged one year, so not only do they capture changes in relative prices, but they reflect changes in the industrial structure arising from previous FDI.

Work in this area can be undermined by high correlations between the linkage terms, so that the e_{krt} are measured for each region as the industry employment share:

$$e_{krt} = \left(\frac{E_{krt}}{E_{rt}} \right), \quad (9)$$

where E_{krt} is the employment level of industry k in region r at time t and E_{rt} is total regional employment, i.e. $\sum_k E_{krt} = E_{rt}$. It means that the linkage terms are weighted by the regional employment sizes. This makes sense, as large regions tend to have more employees in each industry, which would otherwise induce correlation.¹⁵ The correlation coefficients for the agglomeration terms are given in table 2, based on (9). It shows that the correlation between the backward and forward intermediate terms is 0.38 (but 0.76 if e_{krt} is instead specified as E_{krt}). Measuring e_{krt} by (9) the correlations in table 2 are acceptable, and while they reach up to 0.65 between some of the backward linkage terms, this is 0.85 if $e_{krt} = E_{krt}$.

4.2 Non-intermediate goods

The *UK Supply and Use Table* identifies the gross value added of an industry according to the employee compensation (*LABOUR*) and gross operating surplus (*SURPLUS*). These are

¹³ Driffield *et al* (2004) use an I/O table for 1990 when examining the productivity effect of British inward FDI over 1984-92, Debaere *et al* (2010) use an I/O table for 2000 when looking at Korean FDI in China over 1988-2004, and Ellison *et al* (2010) use I/O and other tables for 1987 to examine co-agglomeration patterns at 1997.

¹⁴ The invariance of the input-output coefficients is reflected in the fact that the UK I/O tables are sometimes used for other countries, e.g. Mariotti *et al* (2010) for Italy and Ellison *et al* (2010) for the US. It was examined for a single industry, Research and Development, which is both one of the 123 industries in the *Supply and Use Table* and one of the largest recipients of FDI (see Appendix B). Comparison of the input coefficients from the 123 industries for this industry in 1995 with that for a *Supply and Use Table* at the end of the study period gives a correlation coefficient of 0.977. Research and Development does not draw inputs from 41 industries in either period, but excluding these then after rounding an identical value for the correlation coefficient is found. For Research and Development outputs the correlation coefficient is 0.957, while there are few zero industries.

¹⁵ At 2007, most regions had a UK GDP share in the range 7-10%. The exception is the South East region with a 32.0% share, while the smallest region is North East England that has a 3.5% share of national output.

used to construct two backward non-intermediate terms (i.e. $G = 2$):¹⁶

$$BW: LABOUR_{irt} = \frac{LABOUR_l}{v_l} \left[\sum_{k=1}^K \left(\frac{a_{kl}}{q_l} \right) e_{krt} \right], \quad \text{and} \quad (10)$$

$$BW: SURPLUS_{irt} = \frac{SURPLUS_l}{v_l} \left[\sum_{k=1}^K \left(\frac{a_{kl}}{q_l} \right) e_{krt} \right]. \quad (11)$$

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, although these are not explored.¹⁷ The second term captures the residual surplus accruing to shareholders after the payment of employees, net taxes and intermediate goods, including raw materials and capital goods. 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) or by the controls (see below). It includes such things as the ‘natural advantages’ of Ellison and Glaeser (1997) that might make some regions a better location, e.g. access to coastal areas for shipbuilding. Like the intermediate and other non-intermediate terms it is based on the experience of the existing firms in an industry. By the above, the sum of (10), (11) 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 again is based on the behaviour of the existing firms in the industry. Both forward terms capture market access, although *HOME* is different in this respect since if a firm serves major UK markets from other regions within the

¹⁶ 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 omitted. Taxes are national in nature, and terms for regional subsidies are included below as one of the control variables. The transaction table does not identify imports, so that the inputs are recorded the same whether they are from the UK or elsewhere.

¹⁷ 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.

UK then a negative sign is expected, i.e. FDI locates away from major UK markets.

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 for the own-industry it does not capture the 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 various ways that may produce different results (Beaudry and Schiffauerova, 2009). Broadly, these can be 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 then measures that are defined relative to the national pattern may just capture ‘differentness’ rather than ‘diversity’, so that an absolute measure is preferred.¹⁸ It is the inverse of the mean deviation of the industry employment shares across the 46 industries, where the negative sign means that a positive coefficient is expected:

$$JACOBS_{rt} = \frac{-K}{\sum_{k=1}^{k=K} \left| \frac{E_{krt}}{E_{rt}} - \frac{1}{K} \right|}. \quad (12)$$

4.4 Controls and spatial lags

Finally, as regards the Z_{rt} terms in (5) these are the classical location factors suggested by the literature. It is not feasible to include terms for all possible location factors (Head *et al*, 1995),

¹⁸ If regional employment is uniformly distributed across the 46 industries then a relative measure will indicate a diversified regional economy when the opposite is the case, so the absolute measure in (12) is preferred. Using employment makes it comparable to the linkage terms, while it is reasonable to include both manufacturing and service industries. As a sensitivity check, the relative measure of Duranton and Puga (2000) was used instead, which tended to give larger elasticities, but the absolute measure is preferred for the above reason.

so that terms are included for each of four factors that affect the investment location decision. These are for revenue, costs, forward-looking nature of investment and policy, where these are measured at the regional level for each year.¹⁹ Policy terms are relevant, as FDI has been targeted by UK regional grants. The controls are the same as those used by Wren and Jones (2012), where details can be found. Since these are not the main interest, to save space, the estimates for these are not presented below. The agglomeration economies may go across regional boundaries, so that spatial lags (*SL*) are included for linkage, MAR and Jacobs terms. To reduce the number of these lags they are summed for each of the backward and forward markets. As the regions are large, spillovers are most likely for regions that share a common land boundary, so that the spatial weight is the (first-order) contiguity of 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 (5), where the variables are defined in table 1. Half of the control variables are significant, all at the 1% level, each of which is correctly signed.²⁰ 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, suggesting that FDI serves national rather than regional markets. The estimate on *FW: EXPORT* shows that locations with high industry exports are more attractive to FDI, so that FDI also serves international markets. However, both backward non-intermediate terms, *BW: LABOUR* and *BW: SURPLUS*, are insignificant, on which more is said below. Both knowledge terms are significant and correctly signed, while the spatial lags indicate that regional spillovers exist for each kind of economy, suggesting that the regions are not so large that they contain all these effects whether they are market-based or externalities.

¹⁹ 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.

²⁰ They cover the above 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.

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. In fact, the constraints implied by (1) and (A1) are heavily rejected by the data (the LR test statistic is 157.8 against a $\chi^2(6)$ critical value of 13.3 at the 1% level), which demonstrates the need to exercise care over the choice of the appropriate denominator.

As regards the results in column I of table 3, the introduction of a further lag on the right-hand side terms in (5) gives more or less identical estimates for the agglomeration terms, while those for *MAR* and *JACOBS* terms are smaller. Since the log-likelihood is smaller (at -25,868.1) it suggests that a one-period lag is optimal. The regressions in the other columns of table 3 carry out some sensitivity tests of the result in column I. Columns III and IV drop the spatial lags and controls, but the estimates on the linkage and spillover terms are robust to each of these. Column V omits the non-intermediate goods (spatial lags are measured for the intermediate terms only), but again the results are robust, except that a lower estimate is now found for the forward intermediate term. Finally, column VI drops the *MAR* and *JACOBS* terms (and the associated spatial lags) and the backward non-intermediate terms for *LABOUR* and *SURPLUS* are now significant, the latter has a negative sign. Inspection shows that this is related to the *MAR* term, which is measured by the number of projects.

The results in column VI of table 3 indicate that there is multicollinearity between *MAR* and the backward non-intermediate goods terms, *BW: LABOUR* and *BW: SURPLUS*, which is despite the pairwise correlations between these terms being not particularly strong in table 2. It seems to be related to the growth in the number of FDI projects over time, which reflects the strong growth in service-based FDI.²¹ This is because not only do the service industries have a higher labour content and residual surplus compared to manufacturing (the means are 34% and 12% against 19% and 9% respectively for the 123 industries in the 1995 transaction table), but the strong growth in service FDI means that *MAR* also has a higher value for services.²² It reflects the growth pattern for FDI, but which is evident for other advanced economies, rather than the way in which these terms are measured. It is addressed by estimating the regression equation separately for each industrial sector.

²¹ If *MAR* is lagged a further period in column I of table 3 then *BW: LABOUR* is significant at the 5% level (coefficient of 0.310), although *BW: SURPLUS* continues to be insignificant (p-value of 0.44).

²² The other possibility is a causal relationship, as variations in the number of FDI projects may affect the regional employee compensation share and residual surplus (the *MAR* estimate is robust to the exclusion of *LABOUR* and *SURPLUS*, so that the opposite is certainly not the case). However, these terms are measured contemporaneously, while a Hausman test for exogeneity does not support this explanation.

5.1 Explorations by industrial sector

The results for the agglomeration terms from regressing column I of table 3 with dummies on these terms for each of the manufacturing and service sectors are given in part (a) of table 4. When taken as a group the null hypothesis that the estimates on the agglomeration terms are the same across these sectors (i.e. manufacturing, services and other industries in Appendix B) is heavily rejected by the data. The LR test statistic is 256.6 against a $\chi^2_{0.01}(16)$ critical value of 32.0. Considered individually, four terms differ significantly between manufacturing and services: *BW: INT* at 5% level and *FW: HOME, MAR* and *JACOBS* at the 1% level. Given this, the estimates on *BW: LABOUR* and *BW: SURPLUS* are now positive and significant.

To examine their relative importance, elasticities are calculated for the probability P of location with respect to each agglomeration economy A , where these are evaluated across firms, regions and time. The marginal effect is $\partial \bar{P} / \partial \bar{A} = \bar{P} (1 - \bar{P}) \hat{\beta}$, from which:

$$\frac{\partial \bar{P}}{\partial \bar{A}} \frac{\bar{A}}{\bar{P}} = \bar{A} (1 - \bar{P}) \hat{\beta}. \quad (13)$$

The elasticities are given in part (b) of table 4 (multiplied by 100 in each case). They show that the backward [forward] intermediate goods are more [less] important for manufacturing than for services, but that the opposite is the case for the non-intermediate goods (only some are significantly different by the above). The backward non-intermediate goods of labour and residual surplus are more important for services, and exports for manufacturing, while FDI tends to locate away from the major national markets, but more so for manufacturing. Knowledge spillovers are significantly different between the sectors, but whereas the own-industry MAR spillovers are more important for manufacturing, the inter-industry Jacobs spillovers are more important for services, suggesting greater knowledge transferability.

The elasticities were evaluated by allowing \bar{P} and \bar{A} to vary by region, but a similar pattern of results was obtained, except that where they varied strongly they added plausibility to the results about particular agglomeration terms.²³ For example, elasticities for the Jacobs term were greater in the more diversified economies of the East and East Midlands, at 25% and 21%, while the MAR elasticity was greater in the South East, at 28%, where knowledge spillovers are likely to increase more than proportionately with scale. Given its larger scale, a

²³ Space constraints prevent the presentation of these, which are available from the authors on request.

dummy was placed on *FW: HOME* for the South East to allow for its market size. This was positive and significant, but the estimate on *FW: HOME* for all regions continued to be negative, albeit smaller and significant at the 10% level only. Thus, in general, the FDI tends to locate away from major regional markets (even with the controls), perhaps because export markets are more important. This is present for both manufacturing and services, and so does not reflect the operation of UK regional policy, which is targeted on the former.

To examine for a structural break time dummies were placed on the intermediate and non-intermediate goods terms for the sub-period 1996-07 for the equation shown in table 4. The null hypothesis that the slope dummies are jointly zero was rejected at the 1% level for both manufacturing and services.²⁴ A possibility is that it reflects the measurement of these terms, but the input-output coefficients vary little over time, while the weights in (9) capture changes in the regional industrial structure from FDI. Rather, inspection again suggests that it is related to the two backward non-intermediate terms, *BW: LABOUR* and *BW: SURPLUS*, arising from the strong growth in service FDI. As such, no further adjustments were made to the regression and the results in table 4 report an average effect over time.

As a final exercise, the *net* effect of the agglomeration economies was explored at the individual industry level for the backward or forward effects.²⁵ It is based on (1) and (A1), so that there are now four agglomeration terms, *BW: CORE*, *FW: CORE*, *MAR* and *JACOBS*. The coefficient estimates with these in spline form for each industry are given in Appendix B. The net backward and forward estimates are plotted in figure 1, which shows a pronounced negative relationship between these, which is strong for both manufacturing and services.²⁶ While there are industries for which both backward and forward net effects are important (i.e. positive coefficients), the overall impression from figure 1 is that there is a trade-off between these location factors and that is evident for manufacturing and service industries.

5.2 Discussion of the results

Where empirical evidence exists on the relative importance of the agglomeration economies it tends to be for manufacturing, but it supports the results of this paper. For example, in the

²⁴ The LR test statistics were 23.8 and 27.7 respectively against $\chi^2_{0.01}(6) = 16.8$. These are lower than the test statistic of 47.4 obtained for all industry in column I of table 3, for which the same critical value applies.

²⁵ Gross effects cannot be examined as the intermediate and non-intermediate terms are collinear at this level for each of the backward and forward effects. It constrains the estimates on the intermediate and non-intermediate goods terms to be the same for each of the backward and forward effects, so that a net effect is measured.

²⁶ Correlation coefficients between the backward and forward effects are -0.63 and -0.48 respectively. Fitting lines shows the negative relationships are significant at 1% level in each case (see Jones and Wren, 2011).

case of linkages, Lee *et al* (2008) emphasise the importance of backward intermediate goods for FDI location in South Korea, while using local wage data Fingleton (2006) finds support for the backward effects over market potential. Ellison *et al* (2010) look at co-agglomeration patterns for the US and find that intermediate goods are more important relative to labour and knowledge. Likewise, in the case of knowledge larger effects tend to be found for MAR over Jacobs externalities for manufacturing (Beaudry and Schiffauerova, 2009), which is also like here. Of course, an important finding of this paper is that these relationships tend not to hold for service industries, and if anything they are reversed. It seems likely to reflect the intrinsic nature of service activities, which are more reliant on human capital for its inputs, while also more reliant on other producers and domestic markets as an outlet for its output.

6 Conclusions

The paper investigates the relative strength of agglomeration economies on the location of foreign direct investment across the regions of Great Britain over the period 1985-2007. It uses a new approach to form proxies for the backward and forward non-intermediate goods that measures these in a comparable way to the intermediate goods terms, based on the Input-Output transaction table. The paper finds that backward intermediate goods are important for manufacturing and forward intermediate goods for services, but that the opposite tends to be the case for the non-intermediate goods. Knowledge spillovers are of less importance, but they also differ between sectors. The results are plausible and consistent with the literature, while they indicate that care should be taken in the construction of the input-output terms. The results also indicate that when discriminating between competing theories of location an important distinction exists between manufacturing and service industries.

Table 1: The Variables

Variable label	Description	Mean	s.d.
<u>Backward linkages for industry l in region r at time t (x 100):</u>			
<i>BW: INT_{lrt}</i>	Intermediate goods, defined by equation (2).	1.089	0.407
<i>BW: LABOUR_{lrt}</i>	Compensation of employees, by (10).	0.818	0.639
<i>BW: SURPLUS_{lrt}</i>	Gross operating surplus, by (11).	0.438	0.345
<i>BW: CORE_{lrt}</i>	Core input-output linkages, by (1).	2.301	1.192
<u>Forward linkages (x 100):</u>			
<i>FW: INT_{lrt}</i>	Intermediate goods, measured by equation (A2).	1.704	1.084
<i>FW: HOME_{lrt}</i>	Domestic non-firm demand, by (A5).	1.242	1.206
<i>FW: EXPORT_{lrt}</i>	Export demand, by (A6).	0.566	0.574
<i>FW: CORE_{lrt}</i>	Core input-output linkages, by (A1).	3.254	1.634
<u>Knowledge spillovers:</u>			
<i>MAR_{lrt}</i>	Number of industry l projects in region r at time t .	0.332	0.834
<i>JACOBS_{lrt}</i>	Diversity of activity in r at time t , by (12).	4.773	6.484
<u>Spatial lags using contiguity as weight:</u>			
<i>SL: BW_{lrt}</i>	Measured according to (1) (x 100).	2.659	0.763
<i>SL: FW_{lrt}</i>	Measured according to (A1) (x 100).	3.532	1.076
<i>SL: MAR_{lrt}</i>	Measured by number of own-industry projects.	1.664	1.440
<i>SL: JACOBS_{lrt}</i>	Measured according to (12) 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: <i>BW</i> :			Forward: <i>FW</i> :			<i>MAR</i>	<i>JACOBS</i>
	<i>INT</i>	<i>LABOUR</i>	<i>SURPLUS</i>	<i>INT</i>	<i>HOME</i>	<i>EXPORT</i>		
<i>BW: INT</i>	1.00							
<i>BW: LABOUR</i>	0.64	1.00						
<i>BW: SURPLUS</i>	0.56	0.65	1.00					
<i>FW: INT</i>	0.38	0.58	0.45	1.00				
<i>FW: HOME</i>	0.30	0.12	0.06	-0.29	1.00			
<i>FW: EXPORT</i>	-0.09	-0.07	-0.16	0.23	-0.17	1.00		
<i>MAR</i>	0.34	0.38	0.24	0.13	-0.01	0.01	1.00	
<i>JACOBS</i>	-0.07	-0.08	-0.07	-0.04	-0.03	0.01	-0.11	1.00

Note: Correlation coefficients between variables described in table 1.

Table 3: Regression Results

Column	I	II	III	IV	V	VI
Dependent variable = 1 if inward investor locates in region r at time t ; otherwise = 0.						
<u>Backward linkages (x100):</u>						
<i>BW: INT_{t-1}</i>	1.376***	-	1.351***	1.411***	1.333***	1.274***
<i>BW: LABOUR_{t-1}</i>	-0.010	-	-0.035	0.003	-	0.884***
<i>BW: SURPLUS_{t-1}</i>	-0.089	-	-0.091	0.130	-	-0.503**
<i>BW: CORE_{t-1}</i>	-	0.765***	-	-	-	-
<u>Forward linkages (x100):</u>						
<i>FW: INT_{t-1}</i>	0.343***	-	0.332***	0.296***	0.123***	0.353***
<i>FW: HOME_{t-1}</i>	-0.382***	-	-0.370***	-0.450***	-	-0.443***
<i>FW: EXPORT_{t-1}</i>	0.320***	-	0.290***	0.275***	-	0.334***
<i>FW: CORE_{t-1}</i>	-	-0.010	-	-	-	-
<u>Externalities:</u>						
<i>MAR_{t-1}</i>	0.015***	0.012***	0.015***	0.017***	0.015***	-
<i>JACOBS_{t-1}</i>	2.200***	2.242***	2.197***	3.301***	2.237***	-
<u>Spatial lags:</u>						
<i>SL: BW_t (x 100)</i>	0.246***	0.444***	-	0.304***	0.819***	0.287***
<i>SL: FW_t (x 100)</i>	0.347***	0.333***	-	0.399***	0.155	0.419***
<i>SL: MAR_t</i>	0.013**	0.012**	-	0.005	0.015***	-
<i>SL: JACOBS_t</i>	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***

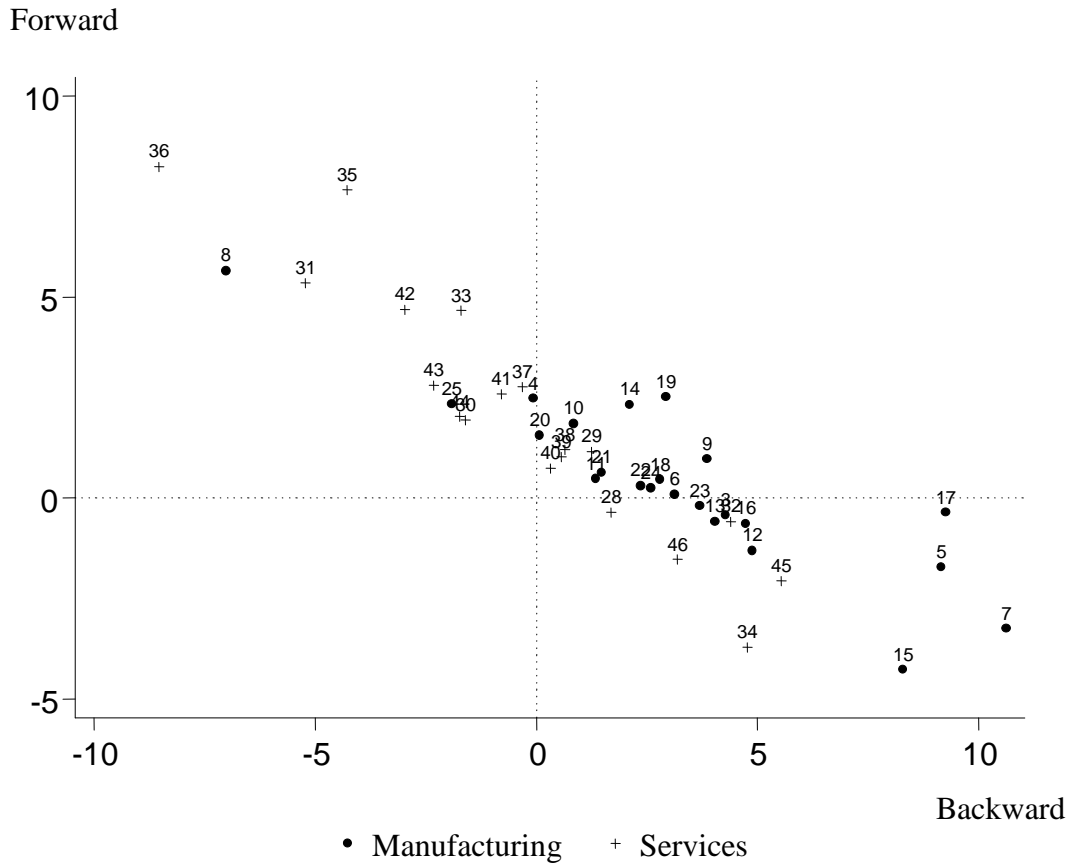
Notes: Conditional logit estimation of equation (8) with (5) and (9). Each regression includes regional fixed effects. Variables described in table 1, where backward and forward spatial lag terms measured as in table 1, except for column V where they are for *BW: INT* and *FW: INT* only. Significant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

Table 4: Agglomeration Estimates and Elasticities by Sector

	BACKWARD: <i>BW</i> :			FORWARD: <i>FW</i> :			<i>MAR</i>	<i>JACOBS</i>
	<i>INT</i>	<i>LABOUR</i>	<i>SURPLUS</i>	<i>INT</i>	<i>HOME</i>	<i>EXPORT</i>		
(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 (13), multiplied by 100. Variables defined in table 1. Significant at *** = 1%, ** = 5% and * = 10%.

Figure 1: Net Backward and Forward Effects by Industry



Notes: Plot of coefficients for net backward and forward effects, *BW: CORE* and *FW: CORE*, for each industry from re-estimation of column II of table 3 with agglomeration terms in spline form for 46 industries. Industry numbers and estimates are given in Appendix B. Estimates outside two standard deviations of the mean estimate are not 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:

$$FW: CORE_{krt} = \sum_{l=1}^K \left(\frac{a_{kl}}{w_k} \right) e_{lrt}, \quad (A1)$$

$$FW : INT_{krt} = \sum_{l=1}^K \left(\frac{a_{kl}}{q_k} \right) e_{lrt} \text{ and} \quad (A2)$$

$$FW: NON - INT_{krt} = \left(\frac{q_k}{w_k} - 1 \right) \left[\sum_{l=1}^K \left(\frac{a_{kl}}{q_k} \right) e_{lrt} \right], \quad (A3)$$

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

$$FW: NON - INT_{krt}^h = \left(\frac{w_k^h}{w_k} \right) \left[\sum_{l=1}^K \left(\frac{a_{kl}}{q_k} \right) e_{lrt} \right]. \quad (A4)$$

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

$$FW: HOME_{krt} = \frac{HOME_k}{w_k} \left[\sum_{l=1}^K \left(\frac{a_{kl}}{q_k} \right) e_{lrt} \right], \text{ and} \quad (A5)$$

$$FW: EXPORT_{krt} = \frac{EXPORT_k}{w_k} \left[\sum_{l=1}^K \left(\frac{a_{kl}}{q_k} \right) e_{lrt} \right], \quad (A6)$$

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

Appendix B: Industry Definitions and Coefficient Estimates

No.	Industry (NACE)	Number of projects	Coefficient estimates:			
			<i>BW: CORE</i>	<i>FW: CORE</i>	<i>MAR</i>	<i>JACOBS</i>
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 with four agglomeration terms in spline form for manufacturing and service industries; log-likelihood = -25,235.2. Significant at *** = 1%, ** = 5% and * = 10%.

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