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Comparison of Gravity Model, Survey and Location Quotient-based Local Area Tables and Multipliers

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RIDDINGTON G., GIBSON H. and ANDERSON J. (2006) Comparison of gravity model, survey and location quotient-based local area tables and multipliers, *Regional Studies* **40**, 1–13. Regional economic impact assessment requires relevant local area multipliers. The best approach is to establish a local input–output table, which is a time-consuming, data-exhaustive process. Some authors have instead used national tables or national tables modified to reflect regional specializations. The apparent limitations of these approaches led to the development of a gravity model-based method for estimating local trade and input–output tables. A description of this model is the main focus of the first part of this paper. Whilst this approach appeared to produce reasonable results, it was unclear how significantly the outcomes differed from tables produced by survey or utilizing national and location quotient-based tables. A comparison of these for the Moray, Badenoch and Strathspey Enterprise Area in Scotland is the main subject of the second half of the paper. The results confirm earlier findings that the national or location quotient approaches may produce misleading results. The gravity model-based approach, on the other hand, produces similar results to the survey and has the added advantage of being comprehensive and compatible with the other 40 plus tables produced for other areas of Scotland. It is suggested, therefore, that this approach be utilized and extended.

Input–output Multipliers Gravity models

RIDDINGTON G., GIBSON H. et ANDERSON J. (2006) Une comparaison des tableaux et des multiplicateurs locaux construits à partir des modèles de gravité, des enquêtes et des quotients de localisation, *Regional Studies* **40**, 1–13. Une étude de l'impact économique régional nécessite des multiplicateurs locaux pertinents. La meilleure approche serait la construction d'un tableau d'échanges inter-industriels, un processus qui prend du temps et qui s'avère statistiquement très détaillé. Certains chercheurs ont plutôt employé des tableaux nationaux ou des tableaux nationaux modifiés afin de tenir compte des spécialisations régionales. Les limites évidentes de ces approches ont amené au développement d'une approche fondée sur un modèle de gravité qui estime des tableaux relatifs au commerce local et aux échanges inter-industriels. Dans un premier temps, alors, cet article porte principalement sur une description de ce modèle. Alors que cette approche semblait fournir des résultats raisonnables, il n'était pas tout à fait évident dans quelle mesure les résultats variaient de ceux des tableaux construits à partir des enquêtes ou des quotients nationaux et de localisation. Dans un deuxième temps, alors, cet article porte sur une comparaison de ces dernières approches pour la zone d'entreprise de Moray, Badenoch et Strathspey. Les résultats confirment les conclusions antérieures: il se peut que les approches fondées sur les quotients nationaux et de localisation fournissent des résultats trompeurs. D'autre part, l'approche fondée sur un modèle de gravité fournit des résultats similaires à ceux de l'enquête et, en plus, est détaillée et correspond aux quarante autres tableaux fournis pour d'autres zones écossaises. On laisse supposer, alors, que cette approche devrait être employée et approfondie.

Echanges inter-industriels Multiplicateurs Modèles de gravité

RIDDINGTON G., GIBSON H. und ANDERSON J. (2006) Ein Vergleich sich auf Schwerkraftsmodell, Untersuchung und Standortquotient stüzender Ortsgebietstabellen und Multiplikatoren, *Regional Studies* **40**, 1–13. Regionalwirtschaftliche Auswirkungsbeurteilung verlangt diesbezügliche Ortsgebietsmultiplikatoren. Der beste Ansatz ist die Aufstellung einer Ortsaufwands-/Ertragstabelle, ein Zeit erforderndes, Daten verschlingendes Verfahren. Manche Autoren haben stattdessen Landestabellen benutzt, bzw. Ländertabellen so modifiziert, dass sie regionale Spezialisierungen widerspiegeln. Die offensichtlich beschränkten Möglichkeiten dieser Ansätze führten zur Entwicklung einer auf einem Schwerkraftmodells beruhenden Methode zur Berechnung des Handels vor Ort und der Aufwands-/Ertragstabellen angewandt wird. Die Beschreibung dieses Modells steht im Mittelpunkt

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des ersten Teils des Aufsatzes. Obschon dieser Ansatz annehmbare Resultate zu zeitigen schien, blieb es doch unklar, wie signifikant die Ergebnisse von den Tabellen abwichen, die durch Untersuchungen oder auf Landesebene bzw. Standortquotienten basierende Tabellen gewonnen wurden. Vergleiche der Ergebnisse für die Fördergebiete von Morey, Badenoch und Strathspey in Schottland bilden den Hauptgegenstand der zweiten Hälfte des Aufsatzes. Die Ergebnisse bestätigen frühere Befunde, dass überregionale oder ortsgebundene Quotientenansätze zu irreführenden Ergebnissen führen können. Der auf dem Schwerkraftsmodell fußende Ansatz führt jedoch zu ähnlichen Resultaten wie die Untersuchung und hat zusätzlich den Vorteil, umfassend und mit 40 oder mehr Tabellen, die für andere Gebiete Schottlands zusammengestellt wurden, vereinbar zu sein. Es wird daher vorgeschlagen, diesen Ansatz zu verwenden und auszuweiten.

Aufwand/Ertrag Multiplikatoren Schwerkraftmodelle

RIDDINGTON G., GIBSON H. y ANDERSON J. (2006) Comparación de tablas y multiplicadores para zonas locales basados en modelos de gravedad, estudios y cocientes de ubicación, *Regional Studies* **40**, 1–13. Para evaluar el impacto en la economía regional es necesario disponer de los multiplicadores pertinentes para la zona local. El mejor enfoque es establecer una tabla input–output local, un proceso que requiere muchos datos detallados y tiempo. Algunos autores utilizan tablas nacionales o estas tablas modificadas de modo que reflejan las especializaciones regionales. Las obvias limitaciones de estos enfoques han llevado al desarrollo de un método basado en el modelo de gravedad para calcular el comercio local y las tablas de input–output. En la primera parte de este artículo se da una descripción de este modelo. Si bien este enfoque parecía producir resultados razonables, no estaba claro el grado en el que se diferenciaban los resultados de las tablas producidas por un estudio o utilizando tablas nacionales y tablas basadas en el cociente según el lugar. En la segunda parte de este artículo el principal tema es comparar estas tablas para las áreas empresariales de Moray, Badenoch y Strathspey en Escocia. Los resultados confirman los hallazgos anteriores de que los enfoques de cocientes nacionales o locales pueden producir resultados erróneos. Por otra parte, el enfoque basado en el modelo de gravedad arroja resultados similares al estudio y tiene la ventaja añadida de ser global y compatible con las otras más de 40 tablas producidas para otras zonas de Escocia. Por ende, sugiero que se utilice y amplíe este enfoque.

Input–output Multiplicadores Modelos de gravedad

JEL classifications: C67, R15

BACKGROUND

During the summer of 2003, the authors were involved in two studies of the economic impact of water-based tourism. The sponsors of this work required estimates of the impact at the 'local' area level. The first study had seven defined areas covering the whole of Scotland: Dumfries and Galloway, Borders, Central, North East, Highlands, Western Isles, and Northern Isles. The second study was concerned with the area covered by the Moray, Badenoch and Strathspey Local Enterprise Company, which lies in the eastern Highlands of Scotland.

Economic impact analysis seeks to trace the effects of change through the defined economy to explore employment and income generation. These in turn arise from an analysis of the effect on demand for products of local industries. The best method of undertaking this analysis is via an input–output (I-O) table for the region.

The study remits required an estimate of the impact of a specific type of tourist expenditure on specific areas. The figures derived in the Scottish National Tourist Multiplier Study (SRG, 1993) were not thought to be applicable to the local area. First, the expenditure pattern of anglers and canoeists was considered to be substantially different from the average tourist resulting in different impacts. Second, the local/regional economy imports a far larger proportion of its sales and consequently has far more leakage (and hence lower multipliers) than Scotland as a whole.

The construction of local I-O tables was both an identified requirement and had the added advantage of providing insight into the impact on specific local industries.

Three approaches were considered. The first was based on modifying a national regional I-O table to reflect the relative density of activity in each area. These Location Quotient (LQ) models are discussed in the second section.

The second approach initially considered was to utilize existing regional tables and integrate them within the constraints of the national table, carrying out survey work where necessary, which is the hybrid approach advocated by BRAND (1998b). The majority of activity in small regions is, however, exported and any integration must 'balance' imports and exports between regions. This proved impossible and a decision was then taken to build a comprehensive model from the bottom up based on the Nomenclature of Territorial Units for Statistics (NUTS) 4 areas in Scotland. Estimates of trade flows were based on economic activity in each sector in each region and on the distance between the regions. These very small areas were then combined to create the required local area models. The assumptions and construction of this model (hereafter referred to as DREAM) are described in the third section of this paper.

The third approach was to utilize surveys either as a complete solution or to use surveys to modify the national tables. The data intensity of the survey approach meant it was only feasible for the single small Moray, Badenoch and Strathspey Enterprise (MBSE) area. Details of the construction and description of this model (henceforth known as the Survey model) are given in the fourth section.

The fifth section compares the results from the three approaches, identifies advantages and disadvantages, and uses this analysis to suggest how both models might be reconciled and developed. The sixth section concludes.

LOCAL INPUT–OUTPUT TABLES AND LOCATION QUOTIENTS

The original Leontieff structure envisaged a closed economy with industries responsible for single commodities and with a technology stable over time. The reality, of course, is significantly different. At the local level it is quite conceivable that none of the raw material input to a process is locally produced and equally that consumers in the local industry choose to consume goods that are not produced locally. Thus, to understand the impact of an activity at the local level local use tables are required. However, goods purchased from outside the region (imported) and locally produced goods may be perfect substitutes; with slight changes in price causing significant changes in the input coefficients. Thus, for reasons of stability the UK tables combine UK and imported commodities to produce products. These combined use tables are likely to be more stable over time or between regions because they reflect the underlying technology. The coefficients are also transferable between regions of vastly different size under the not wholly unrealistic assumption of similar technologies.

At the Scottish level, however, the level of import penetration is such that only local use tables are deemed to be of use and published. For regions within Scotland it is sometimes assumed that import penetration is similar to Scotland as a whole and that the Scottish coefficients are suitable for measuring impact (e.g. SHIEL *et al.*, 2002).

However, since local economies are normally very open, the effect of a rise in local demand is normally very small. For example, although there is local production of beer in the MBSE, the result of a rise in demand for beer will largely be due to an increase in imports of beer into the region, i.e. the technical coefficient linking hospitality services and brewing will be low. However, if there is substantially more local production than the norm, as in the case of whisky in the MBSE area, then the effect will be more pronounced. Thus, it is argued that the propensity to import is a direct function of the relative importance of local production and coefficients should be adjusted up where a sector is above the norm and adjusted down when beneath.

Attempts to generate regional tables without survey have a long history, including BURFORD and KATZ (1977), ROUND (1978), SAWYER and MILLER (1983), FLEGG *et al.* (1995), TWOMEY and TOMKINS (1996a, b) and FLEGG and WEBBER (1997, 2000). HARRIS and LIU (1998) identify four necessary assumptions for an LQ approach to be accurate:

- There must be identical productivity per employee in each region so that a regions share of national employment accurately represents its share of national production.
- There must be identical consumption per employee of the products of industry *i* in the region and the nation.
- There must be no 'cross-hauling' between regions of the products belonging to the same industrial category, so if a region is an exporter of *i*, its consumption of *i* is entirely from the region's production.
- The nation is neither a net exporter nor an importer of *i*, so that the entire nation's production and consumption balance.

Whilst selected elements will change, the overall level of import penetration remains constant. This appears difficult to justify. Industries where product differentiation and brand preference are important exhibit considerable cross-hauling. For example, one would not expect all tinned soup in the MBSE to be supplied by Baxter's, the only and very large supplier. On average smaller areas will be less self-sufficient than large and almost certainly less self-sufficient than Scotland as a whole, i.e. one would expect multipliers at the Scottish level to exceed local multipliers simply because of the much larger range of goods that will be supplied at that level. However, importantly, some island communities may have levels of self-sufficiency that far exceed similarly sized areas close to urban centres. Equally, a multiplier for a development in an area in which there already exists a cluster of suppliers might well be larger than the Scottish norm. As an example, the tourist multiplier for a local area featuring a National Park could well be larger than for Scotland as a whole if the import penetration in the key sectors is lower. What is unclear is the significance, in terms of the size of multipliers, of trying to estimate import penetration on a case-by-case basis and the difficulties and problems of a case-by-case approach.

Based on both theory and results, approaches using location quotients have been heavily criticized by JENSEN and HEWINGS (1985), BRAND (1997, 1998a) and TOHMO (2004). Brand, for example, writes:

> leading commentators have repeatedly warned against the use of non-survey methods on the grounds that their naivety debases regional input–output analysis.
>
> (BRAND, 1998a, p. 769)

Similarly, TOHMO (2004) compares the results of the LQ, Cross Industry Local Quotient (CILQ) and Flegg's Location Quotient (FLQ) modifications of the Finnish input–output table with a table produced by survey for the Keski-Pohjanna region. He found that the Simple Location Quotient (SLQ) and CILQ both produce misleading coefficients and results. As might be expected, the FLQ formulation failed to make proper allowance for interregional trade but, with $\beta = 1$, gave reasonable estimates of regional multipliers in nearly all sectors.

Nevertheless, others clearly continue to believe that with only limited resources these methods do provide useful information for decision-makers. Flegg and Webber, for example, write 'we believe that the FLQ approach offers a flexible and cost effective way of generating an initial set of regional input–output coefficients' (FLEGG and WEBBER, 1997, p. 803). Similarly, Twomey and Tomkins write that:

> the reality of the policy environment, however, is that decisions are made . . . on the basis of limited knowledge. . . . Those seeking guidance cannot generally wait for three or four years while survey tables are constructed.
> (TWOMEY and TOMKINS, 1998, p. 778)

In essence, the debate centres on whether the mechanical procedures are more likely to be misleading than informative. The present paper reports the outcomes from applying the two simplest adjustment methods.

SLQ measures specialization by the labour involved and utilizes the relative proportion of employment in an industry. It is given by:

> LQ_{ik} = ratio of local employment in industry i in region k to employment in k/ratio of national employment in industry i to total employment $= (n_{ik}/n_k)/(n_i/n)$

The adjustment is then applied equally to all using industries. Thus, the coefficient linking in a local I-O table for region k linking supplying industry i to producing industry:

$$ja_{ijk} = a_{ij} * \mathrm{LQ}_{ik}$$

The SLQ, however, takes no account of the size of the consuming industry. If the consuming industry is large, then one would expect a smaller proportion to be exported from the region than the norm, i.e. the technical coefficient would be larger and the consequent local absorption larger. The CILQ thus adjusts the SLQ by the relative size of the consuming industry:

$$\mathrm{CILQ}_{ijk} = \mathrm{LQ}_{ik} * [(n_{jk}/n_k)/n_j/n)]$$

The resulting coefficient is thus:

$$a_{ijk} = a_{ij} * \mathrm{CILQ}_{ik}$$

with trade as simply the balance between production and local consumption.

FLEGG *et al.* (1995) suggest a modification of the CILQ to incorporate the ratio of the size of the local economy (TRE) to the size of the national economy to reflect increasing propensity to purchase outside an area if the area is small. This is stated as:

$$\mathrm{FLQ}_{ij} = \mathrm{CILQ}_{ij} * \gamma_r^{\beta}$$

where

$$\gamma = (\mathrm{TRE/TNE})/\log_2(1 + \mathrm{TRE/TNE})$$

where TNE is the size of the national economy. The value of β is, however, unknown. FLEGG and WEBBER (1997) modify the formula to increase the sensitivity of γ by utilizing:

$$\gamma* = \log_2(1 + \mathrm{TRE/TNE})^{\delta}$$

but again there is no guide to the appropriate value for δ. TOHMO (2004) considers these modifications and found that, unlike the LQ and CILQ formulations for $\beta = 1$, the FLQ formula produced reasonable estimates of the multiplier. The impact on the estimates of using this scalar with the CILQ results is discussed in the fifth section.

DETAILED REGIONAL ECONOMIC ACCOUNTING MODEL (DREAM)

Introduction

Scotland is a nation with a developing set of accounts and economic statistics. It has had I-O tables for a number of years and has been developing databases on production and exports in manufactured products, agriculture and fisheries. It is not, however, comprehensive and there remain gaps in areas such as trade in financial or educational services. The only capital account available was estimated by GIBSON *et al.* (1997).

Institutionally there are a number of defined geographies. At the political level there are 32 unitary authorities. For development purposes there are two networks of Local Enterprise Companies (LECs). Highlands and Island Enterprise (HIE) is responsible for ten LECs: Argyll and the Islands; Caithness and Sutherland; Inverness and Nairn; Lochaber; Moray Badenoch and Strathspey; Orkney; Ross and Cromarty; Shetlandl Skye and Lochalsh; and Western Isles. The rest of Scotland is covered by the Scottish Enterprise Network (SE), and has responsibility for 12 LECs. It is important to recognize that LEC boundaries do not follow political boundaries. In the case of Argyll and Islands LEC it excludes the Lomond area of the council (which is in Scottish Enterprise Dumbartonshire) and includes the Isle of Arran. These subdivisions relate to yet another (and the smallest) internal geography known as NUTS4.

The core of the DREAM is a comprehensive and compatible framework based on 40 NUTS4 units that can be aggregated to correspond with every official geography, local authority, local economic, NUTS3 or transport areas. In this case, the MBSE is the result of combining three NUTS4 tables: the Badenoch and Strathspey area of Highland; North East Moray; and the Rest of Moray. Fig. 1 shows the 40 areas; Appendix 1 lists them.

The resulting tables cover all of the 123 products identified in UK I-O tables plus the five specific Scottish subdivisions: fishing and fish farming; forestry planting and harvesting; brewing and distilling; financial services and auxiliary financial services; and insurance services and auxiliary insurance services (the latter two splits to identify call-centre work). For specific tasks, these can be split further, e.g. between oil and gas processing; and between education and higher education.

For each product the tables show how much of local demand is sourced from within the area; from within the same region of Scotland; from the rest of Scotland; from the rest of the UK; and as imports from abroad.

Principles of construction

An important principle of the system is that at any time it should be based on the best and most detailed consistent information available. Because many government statistics are continually updated, it is often the case that official statistics are not completely consistent. Two main reference markers were initially adopted:

- The basic benchmark for Scottish data was an adjusted version of the latest Scottish I-O tables, which cover 1999. The adjustments made were solely to take account of a small number of known errors in the published tables.
- For the other UK regions the references are the UK I-O balances and the revised 1999 Regional Accounts published in September 2003. These superseded the 1998 figures published in February 2001.

Each year DREAM estimates are revised to ensure compatibility with the latest Scottish I-O tables and the equivalent UK I-O tables. In 2005 these relate to 2001.

Estimating production

There are three data sets of direct relevance. The Scottish Production Database (SE, 2005) contains data on output by area, but at an aggregated level. In places these data have now been 'obscured' for publication to prevent identification of the output of individual companies. The Scottish I-O tables (SE, 2004) produce output by industry for the whole of Scotland and the Annual Business Inquiry (ABI, 2005) the employment by industry by local area. A license from the Chancellor is required for access to four-digit Standard Industrial Classification (SIC) classification in the ABI. The main method of estimating production for each local unit was to utilize the employment data (mainly collected in the first section of the Office of National Statistics (ONS) Annual Business Inquiry ABI1) to disaggregate output information. However, the assumption of equal labour productivity is untenable as evidenced by the fact that at area level the 15 output subtotals do not tally with the totals given in the Scottish Production Database (SPD). The labour productivity for all the categories that make up each group is adjusted to make these 40 subtotals compatible. However, combining the new $40 * 123$ productivity figures with the employment and aggregating over the regions does not then give the appropriate national total. Hence, the individual productivity figures have to be modified again. These are then used to subdivide the 123 national totals; giving $40 * 123$ outputs which are then aggregated to give $40 * 15$, compared and modified. This iteration process continues until there is convergence. Further details are given in Appendix 2.

There are, of course, other potential indicators of the local share of output, e.g. housing completions for construction. However, these are limited both in terms of number and, more importantly, in area detail. Only the employment data are readily available for all sectors at a small area level. In addition, limiting data sources ensures a measure of consistency and allows relatively easy updating procedures as new data become available.

Estimating product supply

The local estimates of industry output derived above are transformed into the local production of products (product supply) by applying a Scottish make matrix. Because the make matrix is typically very sparse for reasons of commercial confidentiality, it has not been published in Scotland since 1989 and the last UK make matrix was a very condensed table relating to 1995.

The 1989 matrix was used as a base, but there were immediate problems in that this table was based on the SIC80 classification and needed to be adjusted to SIC92. A converter had been developed for the Caledonian Blue Book (GIBSON *et al.*, 1997) and was utilized. Published tables provide row and column totals and the diagonals (percentage of product produced by the principal industry). The off-diagonals were then estimated utilizing the 1989 matrix and the UK 1995 matrix as guides. Clearly, errors are possible in assuming a common matrix, but because of the sparseness these are thought to be very small.

Estimating consumption

Under the assumption that the I-O ratios revealed in the UK combined use tables are similar throughout the UK, one can estimate the intermediate demand for local

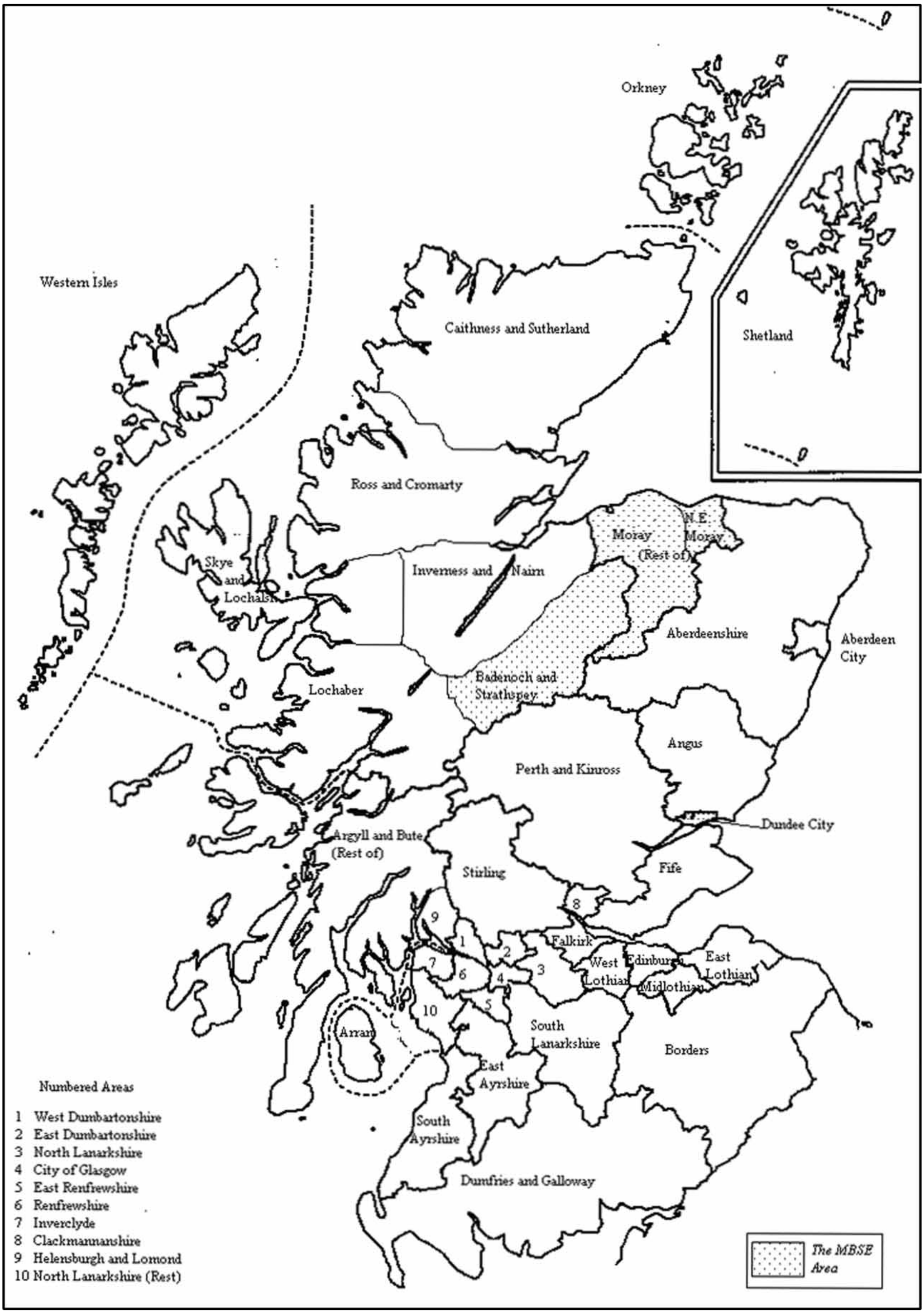

Fig. 1. *Forty local areas in the detailed regional economic accounting model (DREAM)*

products given industry output. Gross fixed capital formation is also assumed to be directly related to local output, i.e. for each sector gross fixed capital in Scotland is split by the proportion of local output to Scottish output. Whilst this is probably reasonable on average, it is recognized that investment is extremely lumpy in a small area and the assumption may lead to bias in a specific year. Elsewhere, the Scottish Household

Survey is used to disaggregate total Scottish Household demand, higher education employees to estimate higher education demand (NPISH) and population to split government spend. The procedures are summarized in Appendix 3.

Trade

The most novel part of the DREAM approach is the use of gravity models to estimate trade between each local area. These estimates are needed to identify the extent to which economic activity will be absorbed or leak from the local economy.

Gravity models have been central to modelling trade flows for over 40 years stemming from the work of TINBERGEN (1962), POYHONEN (1963) and LINNEMAN (1966). Performance of these models has often been poor and consequently the nature and number of other factors considered has grown and changed (e.g. BERGSTRAND, 1985; OGULEDO and MCPHEE, 1994; DEARDORFF, 1995; DJANKOFF and FRIEND, 2000). VIDO and PRENTICE (2003), for example, model the flow of pork between Canadian provinces and US states, and the flow of lentils between western Canada and some 97 countries throughout the world. The 'attraction' is taken to be gross income in the region/country and the impedance either freight costs or distances. Dummies were introduced to account for production in the importing region and the established pattern of trade. The results confirm that gravity models explain a high proportion of the variance in trade (typically around 75%) and that distance is a reasonable but imperfect proxy for freight costs.

Data at a local level to develop equivalent econometric models are almost completely absent. At this level the gravity model is normally used as a means of forecasting rather than explaining flows. CONVERSE (1949) and HUFF (1963) first applied the gravity model to estimate the flow of shopper to retail outlets and the basic model has been applied in numerous situations since then. As an example, RIDDINGTON (2002) forecasts the patronage of a proposed supermarket by utilizing a multidimensional gravity model involving the size of competing stores, the size of local communities and distances between them. GHOSH and MCLAFFERTY (1987) suggest that repeated use of gravity models in retailing indicates success and that they are now an indispensable tool in retail planning.

The basis of all these models is that the flow between two locations is a function of the supply/production at the origin, the demand/consumption at the destination, and the impedances between, normally distance and borders. In the present case data limitations limit the gravity model to three key factors: the productive capacity in the source area; the demand in the destination area; and the transport cost between them as proxied by the distance. This relationship is identified by a regression model of the form:

$$\ln(\text{trade flow}_{ij}) = \alpha + \beta^* \ln(\text{local production at source}_i) + \gamma^* \ln(\text{local absorption at destination}_j) + \delta^* \ln(\text{distance from source}_i \text{ to destination}_j) + \varepsilon_{ij}$$

To ensure compatibility with the I-O tables, it was decided at the outset to work at the 123 product level. The result is that an estimate of trade flows between 53 local regions for 123 products is required.

The estimation procedure utilizes three levels:

- National with three sectors: Scotland; Rest of the UK (RUK); Rest of the World (ROW).
- Regional with 18 sectors: five Scottish (Highland; Argyll and the Islands; Moray; the Islands; Rest of Scotland), 11 in RUK, '*extra regio*' (mainly the UK Continental Shelf) and ROW. The five Scottish areas used reflect the availability of some published and unpublished data on trade that could be used as a check/reference.
- Local with 53 sectors: the 40 Scottish areas defined in Appendix 1, 11 RUK, one *extra*, and ROW.[1]

At each level the estimation procedure for each product utilizes three basic elements:

- Flow estimation: forecasting trade flows F_{ij}^r on the basis of the parameters estimated at the national level by regression, the supply at the local origin and consumption at local destination and the distance between them.
- RAS iteration: the row and column totals of the individual estimated flows in the matrix are reconciled to known row and column totals by successively adjusting all the elements in the row and then all the elements in the column pro rata until convergence.
- Distance iteration: the mean distance travelled between any identified source/destination will vary by product. For any product it is assumed that the price is roughly constant and that consequently the value of the flow is a good proxy for the volume. Consequently, the value of flow $*$ distance would appear to be a reasonable proxy for transport costs. Once the flow has been adjusted by the RAS iteration, a new estimate of distance can be obtained by taking the old estimate of transport cost and dividing it by the new estimate of flow. This iteration continues until there is convergence.

The initial basic data were extracted from the UK and Scottish I-O tables (ONS, 2003; SE, 2004). By simple subtraction, flows between Scotland, the RUK and the ROW are obtained. Although the data on flows to/from the ROW are available, in practice attempts to utilize them failed for two reasons:

- It was not possible to make a meaningful initial assumption about distance.

- The Borders effect (Helliwell, 1998) is likely to magnify the real distance effect by a significant but unknown factor. In the case of the USA/Canada this was estimated to be a factor of 12.

Reducing the data set to Scotland–RUK would appear fatal. However research (e.g. Feenstra, 2002) suggests that the parameters β and γ are close to unity, i.e. an area with twice the population will tend to import twice as much, all things being equal. Thus, by making assumptions about distances it is possible to estimate the two remaining parameters from the four data points. The initial values were Scotland–Scotland, 50 miles; Scotland–RUK, 400 miles; RUK–RUK, 80 miles; and RUK–Scotland, 350 miles, but these distances are successively revised and end up unique to each product.

The estimation procedure has two stages. Stage 1 estimates national distances and regional flows and involves iterating distances. RAS iteration to balance regional and national flows occurs within that loop typically around eight times. For most products only two or three distance iterations are required for convergence.

Stage 2 repeats this basic procedure utilizing the regional flow estimates obtained at stage 1 as controls which are modified in the light of changes in estimated regional distances. In this case the distance estimation rarely exceeds two iterations for convergence.

At each stage any external information available is used to ensure validity. The distance coefficients obtained, for example, are subjected to review on a number of bases. They were compared with similar coefficients estimated in Canada (where the available I-O tables distinguish several provinces, so there are more degrees of freedom); they were compared with international and intercontinental gravity coefficients estimated in models of world trade; they were compared with 'physical' distance regressions based on transport statistics; and they were ranked across commodities, and reviewed in the light of such factors as diversity of source and destination, physical characteristics of the product and its 'transportability'.

Similarly data at a regional level are available for some commodities (albeit not at the 128 level) and the relevant regional estimates have been aggregated and compared. These totals can either generate a new round of iteration or are disaggregated pro rata and enter the local model as survey data.

The results of much iteration and reconsideration are 123 trade matrices for products as diverse as food processing and financial services. The diagonals of each matrix give an estimate of the local production of the commodity in each region which can be compared with the total input to the region (the column total) and the total output from the region. It is assumed that the import penetration by a commodity in each industry and the household sector within a region is equal. For example, if 80% of an agricultural product is imported, that ratio applies to food manufacture and retail equally. With this assumption the internal flows can be allocated based on local input and output in each industry. The final result is a local use a $123 * 123$ I-O table for the 40 regions, which in turn allows the calculation of a multiplier for any given expenditure in a region (or aggregation thereof).

SURVEY METHOD

The most obvious method of trying to establish the impact of expenditure at a local level is to try to trace the effects through the local economy by surveying those who are directly or indirectly involved.

The exhaustive data requirement of such a model normally results, in practice, in a hybrid model such as that advocated by Brand (1998b) and Harris and Liu (1998). This approach is based on the use of survey figures on sales/turnover; percentage of sales exported; percentage of materials and fuels imported; and total labour costs to obtain row and column totals. I-O tables are then modified using the RAS procedure. As a test Harris and Liu (1998) compare the survey-based Scottish table with UK tables modified for Scotland using the LQ and hybrid approaches.

A key assumption of the hybrid approach is that economies tend to have a similar 'shape' that can be sensibly modified. Such an approach would undoubtedly have been valid for the larger regions of the fishing study. Within each area there are major centres for retail, transport services, financial services, etc. The MBSE, however, is an area that has a very limited number of large employers, an industry (whisky) that exports 99% of its output and very limited services. Because it has a significantly different 'shape', modifying the Scottish table makes less sense; a survey of all the major companies was still required.

Because of the size of the MBSE a census of the key industries was just feasible. Thus, the alternative approach adopted was a survey that focuses on the sectors of most interest and industry links regarded as unimportant gathered in groups or in an 'other' category. This was the approach adopted by the Scottish Multiplier Study (SRG, 1993). The resulting I-O table is typically very limited in the number of sectors and these sectors may not correspond with the SIC classifications.

The MBSE survey described here was initially confined to nine sectoral groupings, but as the survey progressed more were added (e.g. mining and quarrying) to give a total of 14. The method employed was direct contact with key local companies identified via lists supplied by the LEC and supplemented from trade directories and Yellow Pages. In a small area such as the MBSE a census is essential; omitting one key firm will seriously distort the resulting table. It would be desirable to be able to report that cooperation from 100% of identified key companies was obtained, but inevitably this was not the case. In these cases competitors assisted with information, but the reliability of this might be queried.

One result of the focused data strategy is a number of missing values (assumed to be zero) in the table. It would have been both extremely time consuming and inefficient in terms of estimating the impact to try to cover in detail those industries that are at the far end of the chain of effects. One imagines/expects research for any other commodity (e.g. whisky) to have followed a similar logic and, consequently, to produce a very partial picture of the local economy. As a result transfer of survey-based tables from one study to another, particularly in a different industry, is extremely problematic.

For the Type 2 multiplier the local spend by local labour on products from each sector is required. Where this expenditure occurred in local retail, data estimates had already been obtained. However, a substantial proportion of spending by locals in an area the size of the MBSE occurs outside the area in both retail and services. Some limited information was obtained by survey, but it could not be claimed to be large enough for a confident claim on accuracy or representation. Here again the limitations of the survey approach are obvious.

COMPARISON OF RESULTS

Comparing results of estimation procedures when the true values are unknown is problematic since formal methods such as the root-mean-square error (RMSE) or a χ^2-test analysis assume some 'correct' estimate. The discussion in this exercise, therefore, is based on three criteria. First, it is examined if the outcomes make economic sense. This normally requires local multipliers to be smaller than national multipliers and greater than one. In some circumstances, after subtracting value added tax and the value of the 'imported' goods to retail, the direct effect of tourist expenditure might be so reduced that the resulting multiplier is actually less than unity. Similarly, it is just possible, if very unlikely, for the import penetration for a specific locality (e.g. a remote island) to be smaller than for Scotland as a whole. However, these special circumstances are not likely to apply in this case.

Closely related to the economic sense is an assessment of how closely forecasts of the impacts correspond to subjective priors (and the size of the affected sectors).

Finally, it is examined how closely the forecasts from one method match those from another using the triangulation principle for estimates. The use of triangulation has been criticized as pseudo-scientific (FIELDING and FIELDING, 1986), but as Oppermann states:

> A multi-method approach allows researchers to be more confident in their results. It also may help in uncovering a deviant or off-quadrant dimension of a phenomenon.
>
> (OPPERMANN, 2000, p. 145)

Although the I–O-based model and DREAM are full 128 industry models, for comparison purposes these have been condensed to be compatible with the Survey model.

Type 2 multipliers have been calculated rather than Type 1. At the local level it seems reasonable to endogenize the limited spending by the local labour force employed that remains in the local economy. For tourism the induced effect, small as it is, is as important as the indirect effect.

Because the Survey model was focused on the impact of angling, the expenditure vector utilized was based on total angling expenditure in the MBSE. Table 1 shows the impact of this expenditure as estimated by the various models.[2]

The results show major differences between the models. As expected, estimates generated from the Scottish table are substantially larger than for the 'local' models. As a result the multiplier of two is almost undoubtedly too high. The figures for the SLQ and CILQ are surprising, since on average they should equal the Scottish multiplier. In fact within the MBSE the dominant industry is not tourism but food and drink processing (Baxter's soup, Walker's shortbread and whisky), of which the vast majority, far more than the norm, is exported. In the LQ models this leads to a below average absorption in other tourist related sectors and, hence, a lower than Scottish average multiplier for tourism.

The effect of the adjustment for location of the producing industry only (the SLQ) produces a multiplier indicating the least impact. The unlikely larger impact on agriculture does not compensate for reductions in locally based construction and business and scientific services. In particular, scientific services supporting angling are known to exceed over £100 000 in value, as opposed to the SLQ estimate of £1900.

The most noticeable feature of the CILQ is in the food manufacturing sector. This reflects the substantial employment in this sector in two plants. In reality the vast majority (if not 100%) is exported from the area and the vast majority of processed foods imported from plants throughout Scotland. The Scottish table reflects a breadth of production and relatively low import penetration whilst in a local area the plants in the sector are specialized and hence import penetration is very high.

The FLQ adjustment is based on the ratio of regional to national employment. The MBSE has some 2.3% of the employment in Scotland, which produces a value of

Table 1. Estimates of the impact of angling expenditure obtained from the five models

Sectors	Tourist expenditure	Effective local demand	Scottish Input–Output	SLQ	Cross Industry Local Quotient (CILQ)	DREAM	MBSE survey
Agriculture, forestry and fishing	£46 371	£20 902	£311 122	£619 140	£481 279	£173 559	£102 502
Mining			£75 470	£62 069	£11 058	£4 648	£10 933
Manufacturing			£895 116	£686 930	£311 553	£15 197	£46 418
Food processing			£584 412	£393 664	£1 551 422	£131 364	£267 587
Energy and water			£939 169	£210 859	£405 346	£291 967	£280 002
Construction	£306 645	£213 177	£946 245	£492 094	£946 781	£687 211	£524 364
Distribution, catering and hospitality	£2 419 496	£1 968 175	£2 028 516	£1 993 139	£2 036 520	£2 016 880	£2 195 169
Transport and communication	£943 213	£272 885	£876 228	£411 087	£724 826	£639 621	£728 953
Finance and business			£2 006 448	£639 182	£890 947	£2 118 393	£1 507 975
Public administration, etc.			£393 341	£231 897	£404 785	£936 785	£378 048
Scientific services			£18 361	£1849	£2966	£116 994	£194 664
Recreational services	£5 334 566	£4 544 748	£4 797 637	£4 674 895	£4 823 785	£4 709 378	£4 684 859
Retail trade	£1 441 985	£590 337	£1 574 866	£1 428 509	£1 637 699	£1 678 334	£2 084 954
Other services	£875 009	£213 177	£298 462	£273 810	£303 257	£299 350	£293 888
Total	£11 367 284	£7 823 400	£15 745 392	£12 119 125	£14 532 224	£13 819 682	£13 300 314
Type 2 output multiplier			2.013	1.549	1.858	1.766	1.700
Type 2 expenditure multiplier			1.385	1.066	1.278	1.216	1.170

Note: DREAM, detailed regional economic accounting model; SLQ, Simple Location Quotient; MBSE, Moray, Badenoch and Strathspey Enterprise.

γ used in the FLQ approach of 0.7. Assuming $\beta = 1$ implies an output multiplier of 1.285, which is substantially lower than all other estimates. However, this assumption would appear to be invalid because the expenditure multiplier is then reduced to an improbable 0.89. In order for the FLQ adjustment to have the same multipliers as the survey would imply $\beta = 0.25$. It is unclear how any researcher could reach such a value and, consequently, the authors seriously question the utility of this approach.

It is difficult to understand how tourist spending has a major impact on the very limited manufacturing in the local area. In this context the returns from the DREAM and Survey models appear more plausible than the Scottish table-based models.

Differences between DREAM and the Survey model are relatively small. The biggest difference is in public administration that the DREAM estimates to be close to £1 million on tourist expenditure of under £12 million compared with between £230 000 (Scottish) and £405 000 (CILQ) for the other models. Within the MBSE area, in addition to Moray Council and the MBSE company itself, there are offices for Scottish National Heritage (SNH), the Forestry Commission, tourist offices and the National Park which all support tourism in some form or other. Whilst £937 000 might appear over large, a figure in excess of £500 000 would not seem unreasonable.

CONCLUSIONS

Local I-O tables were produced by three different methods. The location quotient approach was simple and cheap, but it is difficult not to agree with the detractors who consider it to be potentially dangerous and misleading. In the case of the MBSE, this appears to be the case with the estimates appearing to have even more bias with the adjustment suggested to produce the FLQ estimate.

The hybrid approach is not really suitable for very small areas such as the MBSE. Instead, a limited 'pure' survey was utilized. This would appear to be reasonably satisfactory in this case, but the resulting table is limited to the time and subject under study.

The 'gravity model' approach appears to generate sectoral estimates that are plausible and Type 2 multipliers of the right order of magnitude. Although the fixed cost of producing these tables was very substantial, the outcome is far more than eight regional Scottish tables and one for the MBSE. The comprehensive structure allows tables for any defined geography, whilst the principle of conformity to published national data allows new estimates to be produced every year. Because the individual local models have to be consistent with each other and, when aggregated, comply with national totals, errors cannot be massive. At every stage the data itself generate the checks and balances.

The trade estimates (generated from a combination of a national gravity model and RAS iteration to ensure balance) offer enormous research possibilities. For example, a complete set of gravity equations between the local areas could be estimated and used to examine the importance of industrial and other links, or conversely trade barriers.

It is not yet possible to state that DREAM has no major weaknesses and/or deficiencies. Some of the assumptions are contentious, but in comparison with the alternatives this paper suggests that the approach has much to commend it. As identified, a new larger UK-wide version has recently been developed and further work has been undertaken to deal with internal barriers to trade, specifically ferries. In addition, small area tables ideally require estimation of 'feedback' effects across borders. For example, financial services provided for the MBSE in Inverness (which leaks from the local economy) may be supplied by residents of the MBSE area (with a positive impact on the local economy). Prototype models for estimating such flows and the consequent Type 4 multipliers are now available within the DREAM suite.

From the present research it would appear that the combination of a 'whole economy' approach plus trade estimates based on gravity models produces sensible outputs in the specific case and has massive research potential.

NOTES

1. Current versions of DREAM combine levels 2 and 3 and are based on the 40 NUTS4 Scottish regions plus 137 NUTS3 UK Regions.
2. Copies of the five estimated local I-O tables are available to academic researchers from the authors on request.

APPENDIX 1: SCOTTISH AREAS MODELLED

Name	Part of	Name	Part of
Shetland	UA	City of Edinburgh	UA
Orkney	UA	Midlothian	UA
Western Isles	UA	East Lothian	UA
Aberdeenshire	UA	South Ayrshire	UA
Aberdeen City	UA	East Ayrshire	UA
Angus	UA	South Lanarkshire	UA
Dundee City	UA	Scottish Borders	UA
Perth and Kinross	UA	Dumfries and Galloway	UA
Fife	UA	Caithness and Sutherland	Highland
Stirling	UA	Ross and Cromarty	Highland
West Dumbartonshire	UA	Inverness and Nairn	Highland
East Dumbartonshire	UA	Badenoch and Strathspey	Highland
North Lanarkshire	UA	Lochaber	Highland
Glasgow City	UA	Skye	Highland
East Renfrewshire	UA	Moray X	Moray
Renfrewshire	UA	North East Moray	Moray
Inverclyde	UA	North Ayrshire X	North Ayr
Clackmannanshire	UA	Arran	North Ayr
Falkirk	UA	Argyll and Bute X	A&B
West Lothian	UA	Lomond	A&B

UA, Unitary Authority.

APPENDIX 2: ESTIMATION PROCEDURE FOR LOCAL OUTPUT

Source data	Operation	Resulting level	Resulting data
UK Turnover/GVA (ABI) UK Employees UK (ABI)	Division	SIC4	UK Labour Productivity
UK Labour Productivity Employees Scotland (ABI)	Product	SIC4	Scottish Output and GVA 1
Scottish Output and GVA 1	Aggregation	128 Industry	Scottish Output and GVA 2
Scottish Output and GVA 2	Division	SIC4	Productivity Scale Factor 1
Scottish I-O tables	Disaggregation		

(*Appendix 2 continued*)

APPENDIX 2. *Continued*

Source data	Operation	Resulting level	Resulting data
Labour Productivity UK Employees Scotland (ABI) Productivity Scale Factor 1	Product	SIC4	Scottish Output and GVA 2 Scottish Productivity
Scottish Productivity Employees Local (ABI)	Product	SIC4	Local Output and GVA 1
Local Output and GVA 1	Aggregation	SPD *et al.*	Local Output and GVA AGG
Local Output and GVA AGG Local Production (SPD)	Division Disaggregation	SIC4	Productivity Scale Factor 2
Productivity Scale Factor 2 Local Output and GVA 1	Product	SIC4	Local Output and GVA 2
Local Output and GVA 2	Aggregation	128 Industry	Local Output and GVA 3
Local Output and GVA 3 Scottish I-O tables	Rescaling from totals	128 Industry	Local Output and GVA 4
Local Output and GVA 4 Local Production (SPD)	Rescaling from aggregates	128 Industry	Local Output and GVA 5
Local Output and GVA 5 Scottish Make Matrix	Product	128 Industry	Scottish Supply of commodities to Local Industry

Note: ABI, Annual Business Inquiry; I-O, input–output; SIC, Standard Industrial Classification; SPD, Scottish Production Database; GVA, Gross Value Added; AGG, GVA Aggregated.

APPENDIX 3: PROCESSES TO ESTIMATE LOCAL CONSUMPTION

Source data	Operation	Level	Resulting data
Scottish Make Matrix Local Output and GVA 5	Product		Local Industry Absorption
Scottish Input–Output (Domestic Use) Scottish Imports	Aggregate		Scottish Household Demand
Scottish Household Demand Scottish Household Survey	Disaggregate		Local Household Demand
Scottish NPISH Expenditure Census (Pop, Pop 18–24) Local Higher Education Employees (ABI)	Disaggregate		Local NSIH Demand
Government Spend in Scotland Census (Population)	Disaggregate		Local Spend by Government
Scottish Fixed Capital Formation Local Turnover/GVA 5	Disaggregate		Local Fixed Capital Formation
Scottish Stockbuilding Local Turnover/GVA 5 Local Industry Absorption	Disaggregate		Local Stockbuilding

Note: ABI, Annual Business Inquiry; NPISH, Non-Profit Institutions Serving Households (Largely Universities, Colleges, and Charities).

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