**Beyond Intermediates: The Role of Consumption and Commuting in the Construction of Local Input-Output Tables**

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**Abstract**

Estimating intermediate trade using non-survey methods produces biased results. This has led to a methodological recommendation which emphasises the accurate estimation of intermediate trade flows. This paper argues for a qualification of the consensus view: When simulating IO tables, construction approaches need also to consider spill-over effects driven by wage and consumption flows. In particular for metropolitan economies, wage and consumption flows are important to obtain accurate Type II multipliers. This is demonstrated by constructing an interregional Input-Output table, which captures the interdependence between a city and its commuter belt, nested within the wider regional economy.

**JEL Codes:** C67; R12; R15; R23.

**Keywords:** Input Output; Location Quotients; Commuting; Consumption; Glasgow; Scotland.

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# Introduction

Input-Output (IO) tables offer a variety of applications and are frequently used as inputs for other modelling approaches. The best IO tables are produced based on extensive surveying by statistical agencies. However, an IO table is often not available for a desired geographic unit and has to be simulated. Many authors are critical of non-survey methods for this task (e.g. Harris & Liu, 1998). Hybrid methods are favoured as they retain significant accuracy while requiring less primary data collection than full surveying (Lahr, 1993). Although thoughtful streamlining of data requirements reduces the cost of hybrid approaches (Boomsma & Oosterhaven, 1992), conducting surveys and consulting industry experts requires non-trivial resources[[1]](#footnote-1). Therefore practitioners often fall back on non-survey methods such as Location Quotients (LQs). Given this requirement for local IO tables on limited resources it is useful to refine the use of LQs. Hitherto, most such efforts have focussed on trade. However, given the prominent share of consumption in final demand this is incomplete. In particular when applied to smaller spatial scales, where interregional wage and consumption flows play an important role, whether in rural (Roberts, 2003) or metropolitan settings (Hewings et al, 2001).

This paper explores the relative importance of interregional wage and consumption flows as driven by commuting and shopping trips. To examine this issue an interregional IO table is constructed for Scotland's largest city Glasgow, its commuter belt and the rest of the regional economy, based on the official Scottish IO tables. This is carried out using an LQ approach, which is augmented with secondary data. Sensitivity analysis reveals the relative importance of specifying interregional wage and consumption flows at the metropolitan level. The results support the emphasis on accurately specifying intermediate trade, but suggest that accounting for wage and consumption flows is also important when working with Type II multipliers at a sub-regional scale.

The paper is structured as follows. The next section introduces the literature on estimating IO tables. The third section describes the Glasgow metropolitan economy and its interdependence with the rest of Scotland. The fourth section explains the construction of the baseline IO table. In the fifth section a sensitivity analysis is carried out where the table is re-estimated based on a range of assumptions about intermediate trade and wage and consumption flows. The sixth section concludes.

# Non survey and partial-survey methods for construction of Input-Output tables

Where an Input-Output table is not available, one can be simulated using hybrid (partial-survey) approaches or non-survey approaches, such as location quotients. A comprehensive overview is provided in Miller & Blair (2009, Chapters 7-8). When using Location Quotients (LQs), regional input coefficients are calculated as

 $a\_{ij}^{RR}=a\_{ij}^{NR}×LQ\_{ij}^{R}$ (1)

where $a\_{ij}^{NR}$ is the input coefficient determining the intermediate input requirement for sector j in Region R from sector i in the whole of the national economy N and $LQ\_{ij}^{R}$ is a location quotient[[2]](#footnote-2). However, when $LQ\_{ij}^{R}>1$ no adjustment is made so that $a\_{ij}^{RR}=a\_{ij}^{NR}$. The basic idea is captured in the Simple Location Quotient (SLQ), which is defined for sector i in region R is as:

 $SLQ\_{i}^{R}=\left[\frac{^{E\_{i}^{R}}/\_{E^{R}}}{^{E\_{i}^{N}}/\_{E^{N}}}\right]$ (2)

Where $E\_{i}^{R}$ and $E^{R}$ are employment in sector i in region R and total employment in region R respectively and $E\_{i}^{N}$ and $E^{N}$ are employment in sector *i* and total employment in the nation as a whole.

Several alternatives have been proposed (see Miller & Blair (2009, pp. 349-360) and Flegg & Tohmo (2013a)). The Cross Industry Location Quotient (CILQ) extends the SLQ by allowing for the relative size of the sectors engaged in intermediate transactions:

 $CILQ\_{ij}^{R}=^{SLQ\_{i}^{R}}/\_{SLQ\_{j}^{R}}$ (3)

where sector i is assumed to be supplying inputs to sector j. In turn, the FLQ approach (Flegg & Webber, 1997)[[3]](#footnote-3) modifies the CILQ to incorporate a measure of the relative size of the region such that

 $FLQ\_{ij}^{R}=\left(λ^{\*}\right)CILQ\_{ij}^{R}$ (4.a)

 $λ^{\*}=\left\{log\_{2}\left[1+\left(E^{R}/E^{N}\right)\right]\right\}^{δ}$ (4.b)

where $0\leq δ\leq 1$. The aim is to reduce national coefficients more for smaller regions, under the general expectation that smaller regions are more import intensive. The FLQ formula uses $SLQ\_{i}$ along the principal diagonal of the adjustment matrix.

Norcliffe (1983, pp. 162-163) points out that the use of LQs rests on restrictive assumptions[[4]](#footnote-4) about the regions being examined, i.e. identical productivity, identical consumption and no cross-hauling of products from the same sector. In practice this is unlikely to hold. Therefore, a number of authors have analysed the extent to which LQ-based estimates of IO-account are biased (Schaffer & Chu, 1969; Smith & Morrison, 1974; Round, 1978; Harrigan et al, 1981; Willis, 1987; Harris & Liu, 1998; Tohmo, 2004; Stoeckl 2012). Typically the primary emphasis is on the influence of cross hauling. This is not captured in LQ methods, which results in an underestimation of imports and exports; and overestimation of local intermediate transactions (see Harris & Liu, 1998, for a detailed discussion). An exception is Stoeckl (2012), which explores the role of differences in productivity. Tohmo (2004) summarises the findings of this literature. The SLQ, CILQ and related formulas produce multipliers that are biased upwards by 12-25% on average. Conversely, the FLQ formula is able to recreate on average the multipliers obtained from a surveyed Input-Output table (Tohmo, 2004).

The difficulty with FLQ is that it requires selecting an appropriate value for the parameter δ, which is not known *ex ante* but has to be deduced from comparison with surveyed tables *ex post.* Based on analysis of IO tables for Scotland and Peterborough in England, Flegg & Webber (1997) propose that an approximate value for δ=0.3 ”would seem reasonable” (p. 798). Flegg & Tohmo (2013a) discuss this issue in detail and test parameter values by simulating IO tables for 20 Finnish regions of various sizes. Based on this they recommend a value between δ=0.25 and δ=0.3. A similar result is obtained by Bonfiglio & Chelli (2008), using a Monte Carlo approach. The weight of evidence therefore supports the original Flegg & Webber (1997) recommendation of δ=0.3. However, there are some single-region studies that suggest both lower and higher values. For instance, Flegg & Webber (2000) find a lower value δ=0.15 based on analysis of Scotland. However, as pointed out by Flegg & Tohmo (2013a) this is likely to reflect the fact that the Scottish input coefficients often surpassed corresponding UK coefficients. Similarly, Kowalewksi (2013) studying the German federal state of Baden-Wuerttemberg finds the best results using 0.11 ≤ δ ≤ 0.17. Conversely, Bonfiglio (2oo9), based on a study of the Marche region in Italy, finds a higher value of δ=0.7.

Other non-survey approaches have been suggested. Riddington et al (2006) argue for the use of a gravity model to determine trade flows, which is demonstrated by estimating a local input-output table for the eastern Highlands of Scotland. The study has been criticised on technical grounds (Flegg & Tohmo, 2013a, pp. 707-708). Based on the single application of this approach so far it is not clear that the gravity model approach yields results superior to FLQ. Furthermore it requires more data than non-survey approaches. A recently proposed non-survey technique is the Cross-Hauling Adjusted Regionalization Method (CHARM) presented in Kronenberg (2009). The method explicitly acknowledges the role of cross hauling, which under certain assumptions can be calculated for each sector based on the parent table. Empirical testing of this approach looks promising (see Flegg & Tohmo, 2013b) however the method is not appropriate for this case study as it estimates technical coefficients as opposed to intraregional input coefficients.

## Hybrid approaches

Hybrid approaches improve the accuracy of estimates over purely mechanical approaches by drawing on actual observations to constrain the results. Lahr (1993, p. 278) summarises a typical process. For example, one could start with a location quotient based matrix of intermediate transactions and survey companies in the most important sectors to determine the total of intermediate sales (row sum) and purchases (column sum). The original matrix is then adjusted to conform to control totals using an adjustment algorithm. As Lahr & de Mesnard (2004) point out, these fall into broadly two categories: Scaling algorithms (e.g. the well-known RAS ((see Section 7.4 in Miller & Blair (2009)), and maximizing algorithms, e.g. entropy maximisation approaches (Wilson 1970).

Several templates have been proposed for deriving hybrid Input-Output tables (Miller & Blair, 2009, p. 373). A widely applied examples is the GRIT approach (West, 1990), which combines mechanical approaches with available data. Another well-known approach is the Double-Entry Bi-Regional Input-Output Tables (DEBRIOT) approach (Boomsma & Oosterhaven, 1992). This builds on the observation that firms are generally better informed about the spatial destination of their output than the spatial origin of their inputs. Focussing only on destination of outputs and constraining sub-regional analysis within a bi-regional IO table reduces survey requirements and provides a “good and relatively cheap" alternative to non-survey tables (Boomsma & Oosterhaven, 1992, p. 282). The feasibility of hybrid techniques ultimately hinges on the cost of collecting data and available resources. If a range of regional and sub-regional tables are available it can be possible to use these to inform the structure of a new table by applying an adjustment algorithm in a process known as spatial projection (see e.g. Oosterhaven & Escobedo‐Cardeñoso, 2011).

## Accounting for households

Induced effects occur as increased economic activity boosts income, which in turn increases household consumption expenditures. Type II IO-multipliers can be considered an approximation of this relationship. Using the standard approach, as outlined in Miller and Blair (2009, pp. 34-41) these are calculated by imposing a 1-for-1 relationship between wage income and consumption so that a 10% increase in wage income generates a 10% increase in household consumption. However, wages are only a part of household income and IO tables do not account for non-wage income such as transfers. This biases Type II multipliers upwards. Similarly, it assumes all marginal income is spent and does not differentiate between average and marginal consumption. Conversely, household income from other value-added is ignored, which introduces a downward bias. Earlier work made significant efforts to revise the Type II approach (e.g. Batey 1985, van Dijk & Oosterhaven 1986) However, these methods have not become prevalent and hence the standard approach is adopted here as a familiar, albeit flawed, benchmark. The issue is revisited by Emonts-Holley et al (2015) who compare different approaches and find standard Type II multipliers to overstate impacts by approximately 12% vis-á-vis SAM multipliers. This line of work focusses on the overall accuracy of Type II multipliers as an approximation of induced effects. However, in the context of disaggregating IO tables, the primary concern is the appropriate spatial attribution of these effects. For this an accurate identification of household consumption and labour income is critical (Lahr 1993, Richardson 1985). In particular at the metropolitan level, where local economies are strongly interdependent through commuting and shopping trips (Hewings et al 2001, Madden 1985, Madsen & Jensen-Butler 2005, Oosterhaven, 1981). Therefore, particular care needs to be taken when the boundaries of the study area cross functional boundaries (Hewings & Parr, 2007).

Oosterhaven (1981) constructs a 3-region IO table for the Netherlands, using commuting data from a census to inform interregional flows of wage income and a gravity model to estimate consumption flows across regional boundaries. This shows limited commuting but significant spillover of household final demand. Several subsequent studies have emphasised the potential discrepancy between place of work and place of consumption in IO models. Madden (1985) for Nordrein-Westphalia in Germany, Hewings et al (2001) in 4-region model of the Chicago economy and Jun (2004) sets out a general framework. These IO models offer a number of advanced features[[5]](#footnote-5). However, with the exception of Oosterhaven (1981), the practicalities of populating the commuting and shopping matrices are not detailed. In particular, it is not clear what assumptions are involved in converting shopping trips to values of interregional consumptions flows. Furthermore, these innovations have yet to be distilled into simple approaches that can be readily adopted in practice, such as by resource constrained policy makers and consultants.

# Glasgow City-region and the rest of Scotland

This paper focuses on Glasgow, which is the largest city in Scotland, with a city-region (comprising Glasgow (GLA) and the rest of Strathclyde (RST)) of approximately 2.1 million inhabitants[[6]](#footnote-6). GLA is a separate administrative unit but is economically interdependent with the RST and the Rest of Scotland (ROS). The ROS is identified as a residual, to allow the spatial boundaries of the study to conform to Scotland. The Strathclyde region is Scotland's largest population and economic centre, containing 41.7% of its population and 41.1% of total employment. The City of Glasgow is at its centre and is linked via an extensive suburban rail network to the rest of the Strathclyde region. Key economic and social indicators for these areas are given in .

Table 1 Key social and economic indicators for each IO-region in 2006.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | **GLA** | **RST** | **ROS** | **SCO** |
| **Population** |  | 580,690 | 1,555,374 | 2,980,836 | 5,116,900 |
| **% of total** | 11% | 30% | 58% | 100% |
| **Employment** | **FTEs** | 313,535 | 448,296 | 1,089,529 | 1,851,360 |
| **% of total** | 17% | 24% | 59% | 100% |
| **Gross Domestic Household Income Per Capita** | **£** | 11,968 | 12,975 | 13,319 | 13,071 |
| **% of average** | 92% | 99% | 102% | 100% |

Within Strathclyde the main focus is on the Glasgow City Council jurisdiction, which spans an area of 175 km2 and included 581 thousand inhabitants in 2006. Roughly 313 thousand full time equivalent jobs are found in Glasgow, which is approximately 17% of total employment in Scotland. This is a much larger share of Scotland-wide employment than Glasgow’s population share would suggest – to the extent that (as is illustrated in ) every second job in the city is taken by in-commuters, primarily originating from other parts of the Strathclyde region.

Table 2 Origins and destinations of people who travel between Scottish addresses for work (headcount/column %). Own calculations, based on flow data from 2011 UK census.

|  |  |  |
| --- | --- | --- |
|  |  | **Place of work** |
|  |  | **GLA** | **RST** | **ROS** | **SCO** |
| **Residence** | **GLA** | 157,278 | 49% | 36,799 | 9% | 11,234 | 1% | **205,312** | **10%** |
| **RST** | 137,774 | 43% | 375,908 | 87% | 30,627 | 3% | **544,310** | **28%** |
| **ROS** | 25,258 | 8% | 17,804 | 4% | 1,173,415 | 97% | **1,216,477** | **62%** |
|  |  | **320,310** | **100%** | **430,511** | **100%** | **1,215,276** | **100%** | **1,966,099** | **100%** |

Table 3 Origins and destinations of people who travel between Scottish addresses for shopping (column %). Based on 2007 Travel Survey.

|  |  |  |
| --- | --- | --- |
|  |  | **Residence** |
|  |  | **GLA** | **RST** | **ROS** |
| **Shopping destination** | **GLA** | 81% | 7% | 1% |
| **RST** | 15% | 91% | 1% |
| **ROS** | 4% | 2% | 98% |
|  |  | **100%** | **100%** | **100%** |
|  |  |  |  |  |

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The rest of the Strathclyde region (RST) has somewhat different economic characteristics than Glasgow (GLA). In terms of population it is approximately 3 times the size of Glasgow. However, there are only 1.4 times as many jobs in RST. The lower job density in RST is explained by significant out-commuting to seek employment in GLA. The sub-regions are not only linked through work, as residents undertake shopping trips across regional boundaries. The 2007 Scottish Household Survey contains a detailed travel habits survey. shows the composition of all shopping trips by residence and the shopping destination.

# Construction of the Input-Output table

The Scottish Input-Output table for 2006 is disaggregated into three sub-regions. The parent IO table, as illustrated in , has *i=j* intermediate sectors, *q* final demand sectors and *p* primary sectors[[7]](#footnote-7). The notation is as follows (small bold cases for vectors and capital bold cases for matrices):

**x** = i×1 and 1×j vectors of outputs.

**Z** = i × j matrix-of intermediate demand.

**F** = i × q matrix-of final demand.

**V** = p × jmatrix of primary costs.

Figure 1 Single region IO table for Scotland



The disaggregation process is carried out at the most disaggregated level possible (126 sectors) and is aggregated subsequently to simplify presentation. The disaggregation occurs in 4 stages:

1. Estimate sector gross output totals
2. Estimate input coefficients (A-matrices) and intermediate transactions (Z-matrices)
3. Estimate primary inputs
4. Estimate final demands and balance table

Data on employment by sector and NUTS 3 region are obtained from the 2006 Annual Business Inquiry (ABI) using the NOMIS data portal[[8]](#footnote-8). The IO sectors refer to specific Standard Industrial Classification (SIC) categories and therefore employment levels from the ABI can be matched to each sector. An outline of the resulting interregional IO table is presented in . This contains three sub-regions L. When analysing interactions across sub-regions it is useful to distinguish between the row and column region of the matrix. These are identified in superscripts using r and s. The order follows the familiar row/column convention for matrix elements, where r represents rows and s represents columns. The sub-regions are labelled as follows: G represents Glasgow, W the rest of the Strathclyde region and B the rest of Scotland. For example the matrix **ZWG** contains the elements for the intermediate demand rows (origin of the demand) of the rest of Strathclyde region (W) and the intermediate expenditure column of Glasgow (G), which is the destination of the expenditures.

Figure 2 Interregional Input-Output table for three regions.



The household consumption category of final demand has a region of origin and a region of destination. This is represented by the i×1 vector **hrs**. Sales to the *q*final demand categories are not assigned a particular spatial destination (within the interregional IO table), i.e. final demand from government, capital formation and exports to the rest of the UK and the rest of the World. These matrices are denoted as **Fr\***. Similarly for primary inputs, Compensation of Employees flows from the place of work to the place of residence, as denoted by the 1×j vectors **lrs**. The *p*primary input categories (primarily other value added and imports from the rest of the UK and the rest of the World) are not assigned a spatial origin (i.e. the primary costs are not assigned a spatial destination). These matrices are denoted as **V\*s**.

## Step 1: Sector gross output totals for GLA-RST-ROS

To derive gross output totals by industrial sector and sub-region, employment is used to disaggregate output levels from the Scottish input-output table:

$$x\_{i}^{L}=x\_{i}^{N}\left[\frac{E\_{i}^{L}}{E\_{i}^{N}}\right]$$

Where $x\_{i}^{L}$ refers to output of sector *i* in region *L* and $x\_{i}^{N}$ refers to output of sector *i* in Scotland. Similarly, $E\_{i}^{L}$and $E\_{i}^{N}$ denote employment in sector *i* in region *L* and Scotland, respectively.

## Step 2: Intermediate inputs

The share of intermediate purchases sourced locally are estimated using FLQ’s, based on δ=0.3. This follows the recommendation of Flegg & Webber (1997), which is supported by the work of Flegg & Tohmo (2013a) as is summarised in section 2. Using this method it is possible to estimate the elements in the diagonal input-coefficient matrices, that is: **AGG**, **AWW**, **ABB.** This leaves the issues of estimating the off-diagonal matrices of input coefficients. This proceeds sequentially. The LQ is used to disaggregate the residual input that was not sourced locally into inputs sourced from an adjacent region and a residual that is attributed to the farthest region.

Illustrating this process for Glasgow we obtain the coefficients for inputs by Glasgow industries sourced in Glasgow as $a\_{ij}^{GG}=a\_{ij}^{N}×FLQ\_{ij}^{G}$. Not all intermediate inputs can be sourced locally and therefore we are left with a residual $a\_{ij}^{ρG}=a\_{ij}^{N}-a\_{ij}^{GG}$. This needs to be split up to determine how much is sourced from each of the remaining sub-regions: The coefficients for inputs into Glasgow production sectors that are sourced from RST are defined as $a\_{ij}^{WG}= a\_{ij}^{ρG}×FLQ\_{ij}^{W}$. This conveniently leaves the inputs sourced from the ROS as a residual: $a\_{ij}^{BG}= a\_{ij}^{ρG}-a\_{ij}^{WG}$.

The same procedure is applied to inputs for RST production sectors. What is not obtained locally is obtained from Glasgow, using the FLQ to adjust for the supply capacity of Glasgow sectors, and the residual is obtained from the ROS. Similarly, for the ROS, the next port of call is the RST and the residual is sourced from Glasgow. Once all the input coefficient matrices have been derived they can be multiplied with the sectoral gross outputs estimated in section 3.3.3.1 to obtain the **Zrs** matrices of interregional intermediate transactions.

## Step 3: Sector primary inputs for GLA-RST-ROS

The matrices **V\*G**, **V\*W** and **V\*B** show the q primary inputs required for each sector j in each region L. However, as the \* indicates, no specific origin is assigned to these inputs. It is assumed that industrial sectors in the sub-regions have the same requirements for primary inputs as production sectors in Scotland as a whole. This permits an estimation of the elements of these matrices by adjusting the national-level primary input requirement, such that:

$$p\_{qj}^{\*s}=p\_{qj}^{N}\left[\frac{E\_{j}^{s}}{E\_{j}^{N}}\right]$$

Where p stands for primary input of source *q* (imports, other valued added, etc.) into sector *j*, in region *s* and in Scotland (*N*) and *E* stands for employment in sector *j* in in region s and Scotland (*N*).

For one category of primary inputs, the compensation of labour, the spatial origin is explicitly identified. The share of commuters in the local labour supply is used as a proxy for the share of wages flowing to the sub-region where the commuters reside, such that:

$$l\_{j}^{rs}=l\_{j}^{N}\left[\frac{E\_{j}^{s}}{E\_{j}^{N}}\right]c^{rs}$$

where crs is a scalar that represents the share of employment in region s provided by workers living in region r. This is calculated based on the 2011 census data presented in . By using these data it is implicitly assumed that commuters are spread equally across sectors and that commuters get equally compensated as local workers.

## Step 4: Final demand totals and balancing

Wherever possible, published data are used to identify the level of a particular final demand category in each region. A summary of the methods used is provided in and detailed in subsequent sub-sections.

Table 4 Overview of disaggregation approaches by final demand category.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | **Total value £m** | **% of final demand** | **Disaggregation method** | **Data source** |
| **Final consumption expenditure** |   |   |   |   |
|   | **Households** | 36,002 | 28.2% | Secondary data | ONS GDHI, Census commuting data, shopping trips data from Scottish Household Survey.  |
|   | **NPISHs** | 2,472 | 1.9% | Pro rata | Based on employment share from ABI |
|   | **Tourist Exp** | 1,816 | 1.4% |
|   | **Central Government** | 17,106 | 13.4% | Secondary data | Regional Government Accounts Hillis (1998) |
|   | **Local Government** | 10,662 | 8.4% |
| **Gross capital formation** |  |  |  | Based on employment share from ABI |
|   | **GFCF** | 8,701 | 6.8% | Pro rata |
|  | **Valuables** | 36 | 0.0% |
|   | **Change in Inventories** | 184 | 0.1% |
| **Exports** |  |  |  | Control total from Scottish IO but spatial dispersion determined as a balancing item |
|   | **RUK** | 33,297 | 26.1% | Residual |
|   | **RoW** | 17,394 | 13.6% |
|  |  | **127,669** | **100%** |  |  |

### Household demand

The single region IO table for Scotland provides an ix1 vector of household consumption demand $h^{N}$**.** In order to capture interregional spillover of household final demand it is necessary to disaggregate it into an $ri×s$matrix of household final demand by origin and destination $H^{rs}$**.** This can be portioned into a 3×3 matrix of i×1 vectors $h^{rs}$showing household final demand by place of destination (r) and origin (s):

$$H^{rs}=\left|\begin{matrix}\begin{matrix}h\_{ }^{GG}&h\_{ }^{GW}&h\_{ }^{GB}\\h\_{ }^{WG}&h\_{ }^{WW}&h\_{ }^{WB}\\h\_{ }^{BG}&h\_{ }^{BW}&h\_{ }^{BB}\end{matrix}\end{matrix}\right|$$

This is achieved by using data for shopping trips as a first approximation for consumption flows in line with convention in the literature (see Section ). The matrix is then balanced using a RAS procedure.

Households in the sub-regions are taken to exhibit the same consumption pattern as households in Scotland as a whole. However, population varies between them, as does the average disposable income (see ) and households shop outside their local area. Therefore the level of household final demand will vary across the sub-regions. The vector of final demand of households shopping in region I and residing in region J is estimated as:

$$h\_{ }^{rs}=h\_{ }^{N}×d\_{ }^{rs}$$

Where $d\_{ }^{rs}$ is a scalar that's defined as:

$$d\_{ }^{rs}=y^{s}×t^{rs}=\frac{Y^{s}}{\sum\_{s}^{}Y^{s}}×\frac{T^{rs}}{\sum\_{r}^{}T^{rs}}$$

where $y^{s}$ is share of region s in total Gross Disposable Household Income in Scotland and $t^{rs}$ is the share of all shopping trips by residents in region s to region r. These coefficients are calculated based on information in Tables 2 and 3.

Assuming a uniform spatial distribution of consumption over all sectors is problematic, as supply conditions vary across regions. For instance, Glasgow’s demand for agricultural outputs outstrips the supply of the indigenous sector several times over. In this case, the relative frequency of shopping trips clearly understates the degree to which Glasgow households satisfy their demand in other sub-regions. Therefore a RAS procedure is used to balance the $H\_{ }^{rs}$matrix.

RAS requires control totals for column and row sums. Ys is used for column sums, whereas employment shares in each region are used to derive row totals:

$$\sum\_{s}^{}h\_{i}^{rs}=h\_{i}^{N}\left[\frac{E\_{i}^{r}}{E\_{i}^{N}}\right]$$

where $h\_{i}^{rs}$is the final demand of households in region s for the output of sector i in region r, $h\_{i}^{N}$ is household final demand for sector *i* in Scotland as a whole$ E\_{i}^{r}$ is the FTE employment in sector *i* in region rand $E\_{i}^{N}$ is the FTE employment in sector *i* in Scotland as a whole (*N*).

### Government demand

Data from regional government accounts (Hillis, 1998) and public sector employment by sub-region are used to disaggregate government final demand by sub-region[[9]](#footnote-9). These data are used to construct weights, which in turn are used to disaggregate the local government and central government final demand columns from the Scottish IO table. Table 5 reveals the breakdown of government expenditures in each of the 3 sub-regions. Local government expenditures are relatively larger in GLA and RST, whereas the converse holds for ROS.

Table 5 Breakdown of central- and local government expenditures by IO region.

|  |  |  |
| --- | --- | --- |
| **Sub-region** | **Central** | **Local** |
| **GLA** | 17.1% | 19.1% |
| **RST** | 23.2% | 25.9% |
| **ROS** | 59.7% | 55.1% |
| **Total** | 100.0% | 100.0% |

### NPISHs, Tourist Demand and Gross Capital Formation

For the disaggregation of the q final demand categories NPISHs (Non Profit Institutions Serving Households), Tourist Demand and the Gross Capital Formation it is assumed that demand for each sector is proportional to the share of total employment in that sector found in each sub-region, such that:

$$f\_{qi}^{L}=f\_{qi}^{N}\left[\frac{E\_{i}^{L}}{E\_{i}^{N}}\right]$$

where $F\_{qi}^{L}$ is a final demand of category q, for sector *i,* in region L; $F\_{qi}^{N}$ is the final demand of category q, for sector *i,* in Scotland as a whole (*N*);$ E\_{i}^{L}$ is the FTE employment in sector *i,* in region L;and $E\_{i}^{N}$ is the FTE employment, in sector *i*,in Scotland as a whole (*N*).

### Exports and balancing

As the 3-region table is a disaggregation of the balanced Scottish IO table, it should by definition balance if constrained to each sector’s row and column total. Therefore there is no need to apply an adjustment procedure, as the IO table conforms to the accounting identity that column sum must equal row sums. As there is least information available for spatial distribution of RUK and ROW exports this is chosen as a balancing row. The total exports of sector *i* in region *r* is determined as that sector’s estimated gross output, less intermediate demand and less all the final demands estimated so far (i.e. everything but exports). This estimate for total exports is then attributed to RUK and ROW exports, using weights for RUK and ROW exports for sector *i,* based on the Scottish IO table[[10]](#footnote-10). This concludes the disaggregation process.

## 3-region IO table

The interregional multipliers are shown in a disaggregated format in . The multipliers reveal the direct effect upon the host region and the knock-on effects for each of the 3 regions and Scotland as a whole. For example, for Public administration in Glasgow the total Scotland-wide Type I output multiplier is 1.43. This is composed of the direct impact upon the host region GLA (1) in addition to indirect impacts upon GLA (0.10), RST (0.10) and ROS (0.23). In this case more than three quarters of the indirect impacts are incurred outside the host region. Conversely, some sectors are much more locally contained. For instance Finance & Business in ROS, where the total indirect impacts amount to 0.37, of which approximately three quarters are incurred locally. When combined, the effects on individual regions add up to the multiplier for Scotland as a whole (SCO) [[11]](#footnote-11). From the multipliers, it is clear that interregional intermediate trade (indirect effects as gauged by the Type I multiplier) drives significant spill-over effects, but that this varies across sectors and sub-regions. Type II multipliers additionally account for induced effects. These are calculated using the standard approach, as outlined in Miller and Blair (2009, p. 34-41) imposing a 1-for-1 relationship between wage income and consumption.

Table 6 Type I and Type II interregional multipliers in the interregional GLA-RST-ROS Input-Output table.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Sector** | **Type I multiplier** |  | **Type II multiplier** |
|  | **Direct effect** | **Indirect effects** |  | **Direct effect** | **Indirect and induced effects** |
|  | **GLA** | **RST** | **ROS** | **SCO** |  | **GLA** | **RST** | **ROS** | **SCO** |
| **G L A** | Agriculture, Forestry & Fishing | 1 | 0.38 | 0.09 | 0.17 | **1.64** |   | 1 | 0.49 | 0.20 | 0.32 | **2.02** |
| Mining | 1 | 0.39 | 0.08 | 0.05 | **1.52** |  | 1 | 0.51 | 0.20 | 0.20 | **1.91** |
| Manufacturing | 1 | 0.21 | 0.11 | 0.07 | **1.38** |  | 1 | 0.34 | 0.25 | 0.25 | **1.84** |
| Energy | 1 | 0.42 | 0.29 | 0.21 | **1.92** |  | 1 | 0.48 | 0.37 | 0.32 | **2.17** |
| Other Utilities | 1 | 0.37 | 0.26 | 0.07 | **1.70** |  | 1 | 0.46 | 0.35 | 0.18 | **1.98** |
| Construction | 1 | 0.25 | 0.19 | 0.28 | **1.71** |  | 1 | 0.38 | 0.34 | 0.49 | **2.20** |
| Distribution & Catering | 1 | 0.08 | 0.06 | 0.19 | **1.33** |  | 1 | 0.25 | 0.23 | 0.42 | **1.90** |
| Transport & Communication | 1 | 0.24 | 0.15 | 0.08 | **1.47** |  | 1 | 0.41 | 0.32 | 0.29 | **2.02** |
| Finance & Business | 1 | 0.19 | 0.07 | 0.08 | **1.34** |  | 1 | 0.32 | 0.21 | 0.25 | **1.78** |
| Public Administration | 1 | 0.10 | 0.10 | 0.23 | **1.43** |  | 1 | 0.27 | 0.28 | 0.48 | **2.03** |
| Educ., Health & Social Work | 1 | 0.12 | 0.08 | 0.15 | **1.35** |  | 1 | 0.36 | 0.32 | 0.47 | **2.15** |
| Other Services  | 1 | 0.29 | 0.12 | 0.13 | **1.54** |   | 1 | 0.45 | 0.29 | 0.35 | **2.09** |
| **R S T** | Agriculture, Forestry & Fishing | 1 | 0.08 | 0.34 | 0.19 | **1.61** |  | 1 | 0.17 | 0.47 | 0.35 | **2.00** |
| Mining | 1 | 0.07 | 0.32 | 0.08 | **1.47** |  | 1 | 0.18 | 0.49 | 0.26 | **1.93** |
| Manufacturing | 1 | 0.06 | 0.24 | 0.12 | **1.42** |  | 1 | 0.17 | 0.40 | 0.30 | **1.87** |
| Energy | 1 | 0.18 | 0.41 | 0.33 | **1.92** |  | 1 | 0.24 | 0.49 | 0.45 | **2.18** |
| Other Utilities | 1 | 0.07 | 0.44 | 0.19 | **1.70** |  | 1 | 0.14 | 0.54 | 0.32 | **1.99** |
| Construction | 1 | 0.10 | 0.30 | 0.31 | **1.72** |  | 1 | 0.22 | 0.47 | 0.52 | **2.21** |
| Distribution & Catering | 1 | 0.04 | 0.10 | 0.19 | **1.33** |  | 1 | 0.19 | 0.30 | 0.43 | **1.92** |
| Transport & Communication | 1 | 0.09 | 0.29 | 0.12 | **1.50** |  | 1 | 0.23 | 0.49 | 0.33 | **2.05** |
| Finance & Business | 1 | 0.05 | 0.20 | 0.10 | **1.34** |  | 1 | 0.17 | 0.37 | 0.29 | **1.83** |
| Public Administration | 1 | 0.05 | 0.12 | 0.25 | **1.43** |  | 1 | 0.20 | 0.34 | 0.50 | **2.04** |
| Educ., Health & Social Work | 1 | 0.05 | 0.15 | 0.16 | **1.37** |  | 1 | 0.26 | 0.45 | 0.48 | **2.19** |
| Other Services  | 1 | 0.09 | 0.28 | 0.15 | **1.52** |   | 1 | 0.24 | 0.49 | 0.37 | **2.09** |
| **R O S** | Agriculture, Forestry & Fishing | 1 | 0.05 | 0.14 | 0.41 | **1.60** |  | 1 | 0.11 | 0.22 | 0.67 | **1.99** |
| Mining | 1 | 0.18 | 0.05 | 0.30 | **1.53** |  | 1 | 0.25 | 0.14 | 0.59 | **1.98** |
| Manufacturing | 1 | 0.04 | 0.06 | 0.43 | **1.53** |  | 1 | 0.10 | 0.13 | 0.71 | **1.95** |
| Energy | 1 | 0.10 | 0.18 | 0.64 | **1.92** |  | 1 | 0.14 | 0.23 | 0.80 | **2.18** |
| Other Utilities | 1 | 0.05 | 0.05 | 0.61 | **1.72** |  | 1 | 0.09 | 0.11 | 0.81 | **2.01** |
| Construction | 1 | 0.07 | 0.25 | 0.39 | **1.71** |  | 1 | 0.15 | 0.35 | 0.71 | **2.20** |
| Distribution & Catering | 1 | 0.04 | 0.17 | 0.11 | **1.32** |  | 1 | 0.13 | 0.29 | 0.50 | **1.91** |
| Transport & Communication | 1 | 0.05 | 0.08 | 0.33 | **1.46** |  | 1 | 0.13 | 0.19 | 0.71 | **2.03** |
| Finance & Business | 1 | 0.03 | 0.07 | 0.26 | **1.37** |  | 1 | 0.10 | 0.15 | 0.58 | **1.84** |
| Public Administration | 1 | 0.04 | 0.21 | 0.16 | **1.42** |  | 1 | 0.14 | 0.33 | 0.57 | **2.04** |
| Educ., Health & Social Work | 1 | 0.04 | 0.14 | 0.18 | **1.35** |  | 1 | 0.15 | 0.28 | 0.73 | **2.17** |
| Other Services  | 1 | 0.06 | 0.12 | 0.37 | **1.55** |   | 1 | 0.14 | 0.22 | 0.75 | **2.11** |

When incorporating induced effects, using the Type II multipliers, a greater degree of interregional interdependence is revealed. As can be expected two general patterns emerge from the multipliers. The induced spill-over effects tend to be bigger for the smaller regions and for service sectors. For instance, looking at Education, Health & Social work in Glasgow indirect and induced effects amount to 1.15. Thereof, induced effects in RST amount to 0.24 (0.32-0.08) and 0.32 (0.47-0.15) in ROS. That is just under half of overall multiplier effects. Looking at the same sector in ROS, the induced effects that spill into GLA and RST amount to 0.09 and 0.14 or just under 20% of overall multiplier effects. A similar pattern emerges for Distribution & Catering, Transport & Communications, Finance & Business, Public administration and Other Services. Conversely, looking at a capital intensive sector like Energy, induced effects are much more subdued. For the Energy sector in Glasgow multiplier effects in Scotland as a whole amount to 1.17. Thereof, 0.25 is an induced effect, with 0.06 impacting locally and 0.08 and 0.11 spilling over into RST and ROS, respectively. For the same sector in ROS, induced effects amount to 0.25 of overall multiplier effects of 1.18. However, more than half of these (0.16) are incurred locally in ROS

# Alternative specifications and sensitivity of multipliers

Sensitivity analysis is conduced around two dimensions: the approach used to estimate intermediate trade, which influences the extent of indirect knock-on impacts; and the treatment of wages and household consumption, which influence the nature of induced impacts.

## Intermediate transactions

The IO table is estimated using alternative LQs. The FLQ formula is used under a range of δ parameters and compared to a version of the IO table estimated using SLQs. The upper and lower level of δ chosen here follows Flegg & Tohmo (2013a), which tests the appropriateness of δ values in the range 0.15-0.4 for 20 regions in Finland. To simplify the presentation of results the industrial sectors are aggregated into 1 sector for each region to identify the extent to which indirect (and where appropriate induced effects) impact locally or in other sub-regions. shows aggregate multipliers broken down into their constituent components: direct effect, local multiplier effects and interregional multiplier effects.

Table 7 Spatial decomposition of aggregate multipliers by sub-region

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  | **Type I** |  | **Type II** |  |
|  |  |  | **Direct** | **Indirect** |  | **Direct** | **Indirect & induced** |  |
|  |  |  | **Local** | **Inter-regional** |  | **Local** | **Inter-regional** |  |
| **GLA** | **SLQ** |  | 1 | 0.33 | 0.10 |   | 1 | 0.49 | 0.46 |   |
| **FLQ** (δ=0.15) |  | 1 | 0.22 | 0.21 |  | 1 | 0.38 | 0.57 |  |
| **FLQ** (δ=0.3) |  | 1 | 0.19 | 0.24 |  | 1 | 0.35 | 0.61 |  |
| **FLQ** (δ=0.4) |  | 1 | 0.18 | 0.26 |  | 1 | 0.33 | 0.63 |  |
| **RST** | **SLQ** |  | 1 | 0.35 | 0.10 |   | 1 | 0.55 | 0.45 |   |
| **FLQ (δ=0.15)** |  | 1 | 0.24 | 0.21 |  | 1 | 0.44 | 0.56 |  |
| **FLQ (δ=0.3)** |  | 1 | 0.22 | 0.24 |  | 1 | 0.41 | 0.59 |  |
| **FLQ (δ=0.4)** |  | 1 | 0.20 | 0.25 |   | 1 | 0.40 | 0.60 |   |
| **ROS** | **SLQ** |  | 1 | 0.44 | 0.04 |   | 1 | 0.84 | 0.16 |   |
| **FLQ (δ=0.15)** |  | 1 | 0.31 | 0.16 |  | 1 | 0.67 | 0.33 |  |
| **FLQ (δ=0.3)** |  | 1 | 0.30 | 0.17 |  | 1 | 0.66 | 0.34 |  |
| **FLQ (δ=0.4)** |  | 1 | 0.30 | 0.17 |   | 1 | 0.65 | 0.35 |   |

Looking at the Type I multipliers, the difference between the estimated results under the SLQ and the FLQs is striking. For example in GLA, under the base case assumption of FLQ (=0.3), for every £1 of final demand stimulus locally there would be an interregional spill-over effect of 24p, whereas under the SLQ this would only be 10p. Varying the δ parameter does change the outcome, but this sensitivity is much less distinct than the initial choice between SLQ and FLQ. Results obtained in the smaller more open sub-regions of GLA and RST are similar. For the more self-contained ROS a qualitatively identical result is obtained, i.e. there is a step change from SLQ to FLQs. However, spill-over effects are less distinct under all the approaches. These results are in line with the stated aim of the FLQ formula, i.e. to allow for the additional import propensity of smaller regions. Given the nature of the adjustment formula, as detailed by Flegg and Webber (2007), the relatively smallest regions are the most sensitive to the selection of the δ value. As the regions become relatively larger estimates under different δ values become more closely grouped together.

As expected, the Type II multipliers reveal larger spill-over effects. For example, under the base-case assumption, a £1 of final demand stimulus in Glasgow results in 61p of indirect- and induced impacts in the other sub-regions. Again, these spill-over effects are much stronger for the smaller sub-regions.

Figure 3 Local and spill-over effects for indirect and induced effects for two sectors under alternative LQ-formulas.



Within the aggregate economies of each region there are differences between sectors and the outcomes for these sectors vary in turn depending on the assumptions adopted. This is explored in Figure 3 for two contrasting sectors, Construction and Finance & Business. Both sectors are labour intensive and therefore drive significant impacts. However, the Construction sector also requires significant intermediate inputs and therefore has far stronger indirect impact than Business & finance. Therefore, it is not surprising that for Construction the spatial breakdown of the multiplier is more sensitive to the method used to allocate intermediate expenditures. The case of the sector in GLA shows some sensitivity to the δ value, not just the selection between SLQ and FLQ. The sector is very open. In the base case, around a third of the indirect impacts occur locally, whereas about two thirds under SLQ. This range is compressed for the Type II multipliers, where commuting and shopping trips mean that even under SLQ only about half of multiplier impacts are incurred locally. Conversely, Finance & business chimes with the aggregate results, in that there is a step change from SLQ to FLQ and then little variation across δ values. Again, this contrast is reduced under Type II multipliers, where the spill-over of induced effects dilutes the effects of alternative LQ methods.

## Household incomes and expenditures

As is detailed in section and , data on local gross disposable household income, shopping trips and commuting are used to determine the origin and destination flows of wages and consumption. This approach is in line with past work on metropolitan IO tables as is summarised in section (in comparison this is referred to as the Shopping Trip (ST) approach). In cases where data on shopping trips are not available, it is likely that researchers will fall back on location quotients to estimate spill over of household final demand. Therefore, to analyse the sensitivity of the interregional multipliers to household specification, the table was re-estimated using the FLQ and SLQ, respectively, to attribute household final demand across sub-regions in an identical way to the spatial attribution of intermediate demand described in section .

As can be seen from , across all three sub-regions the ST and FLQ approaches deliver similar results in terms of the share of household final demand that goes to local sectors. The SLQ implies predominantly local household consumption for all three sub-regions. However, the contrast is marked in GLA and RST where the local share of household final demand jumps from approximately half under ST and FLQ to 89.9% and 81.2% under SLQ in GLA and RST respectively. The rest of the Strathclyde region is slightly more open in terms of household consumption than is Glasgow, with slightly more than half of household final demand being spent outside the sub-region under both ST and FLQ approaches. The ROS is clearly different, with 83.4% and 80.7% of household final demand being incurred locally under the ST and FLQ approaches, respectively. This suggests that for large sub-regions such as the ROS the overall outcome is less sensitive to the treatment of household final demand.

Figure 4 Origin and destination of household final demand under different approaches.



Given the sensitivity of household final demand in GLA and RST to the estimation approach, it is interesting to see how this is reflected in the Type II multipliers. It should be noted, however, that household final demand is not equally important across the 3 sub-regions, as Glasgow has high employment relative to population and vice versa for RST. A graphical representation of the multipliers with and without commuting is provided in Figure 5. The ST column for each sub-region represents the default specification in the IO table. For indirect and induced effects with commuting ST produces the smallest local impacts and the largest spill-over effects across all three sub-regions and vice versa for SLQ. Results are the most sensitive for RST, where household expenditures are a larger share of final demand than elsewhere.

Looking at the right-hand side of the diagram, it is clear that not allowing for commuting significantly alters the nature of the multipliers, reducing impacts from stimulus to GLA and inflating impacts from stimulus to RST. This occurs as the ratio of labour income to household final demand varies across the two sub-regions. In Glasgow, there is disproportionate compensation of employees relative to household final demand, and therefore changes in wage income trigger relatively small changes in household consumption. The converse is the case in the RST where the household sector is large relative to local wage income and therefore ignoring commuting suggests and overly sensitive link between wage income and household expenditures.

Figure 5 Indirect and induced effects for each sub-region based on ST, FLQ, and SLQ approaches with and without commuting.



Looking at aggregate multipliers, it is clearly important to account for interregional wage and consumption spill-over effects. From this vantage point the ST and FLQ approaches provide very similar results. However, the results are also very similar at the level of individual sectors. Table 8 presents interregional Type-II multipliers calculated using the FLQ approach allowing for commuting. These are compared to the default multipliers (calculated using an ST approach with commuting) by calculating the percentage deviation of the FLQ multipliers from the ST-based multipliers. Relative to the ST multipliers the FLQ multipliers tend to overestimate local indirect and induced effects in GLA and RST (local impact highlighted in grey). This effect is negligible for the ROS, amounts to less than 1% for Glasgow but is on the order of 1-2% for most RST sectors. Primarily this is at the expense of spill-over effects in the ROS. These are small differences so that on balance the two approaches ST and FLQ can be concluded to produce similar results.

Table 8 Type-II multipliers estimated using an FLQ specification of households and their % deviation from the default Type-II multipliers.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | **Sector** | **FLQ** |  | **% deviation of FLQ and ST multipliers** |
|  |  | **Direct effect** | **Indirect and induced effects** |  | **Direct effect** | **Indirect and induced effects** |
|  |  | **GLA** | **RST** | **ROS** | **SCO** |  | **GLA** | **RST** | **ROS** | **SCO** |
| **GLA** | 1 | Agriculture, forestry & fishing | 1.00 | 0.50 | 0.21 | 0.31 | 2.02 |   | 0.0% | 1.5% | 5.5% | -5.7% | -0.0% |
| 2 | Mining | 1.00 | 0.52 | 0.21 | 0.18 | 1.91 |  | 0.0% | 1.6% | 6.3% | -10.6% | -0.0% |
| 3 | Manufacturing | 1.00 | 0.35 | 0.26 | 0.23 | 1.84 |  | 0.0% | 2.8% | 5.9% | -9.7% | -0.0% |
| 4 | Energy | 1.00 | 0.49 | 0.38 | 0.30 | 2.17 |  | 0.0% | 0.7% | 2.0% | -3.5% | -0.0% |
| 5 | Other utilities | 1.00 | 0.46 | 0.36 | 0.16 | 1.98 |  | 0.0% | 1.1% | 2.9% | -8.5% | -0.0% |
| 6 | Construction | 1.00 | 0.39 | 0.35 | 0.46 | 2.20 |  | 0.0% | 2.2% | 4.1% | -4.5% | -0.0% |
| 7 | Distribution & catering | 1.00 | 0.26 | 0.25 | 0.40 | 1.90 |  | 0.0% | 4.7% | 7.2% | -6.6% | -0.0% |
| 8 | Transport & communication | 1.00 | 0.42 | 0.34 | 0.26 | 2.02 |  | 0.0% | 2.8% | 5.6% | -10.1% | -0.0% |
| 9 | Finance & business | 1.00 | 0.33 | 0.22 | 0.22 | 1.78 |  | 0.0% | 2.8% | 6.6% | -9.2% | -0.0% |
| 10 | Public administration | 1.00 | 0.28 | 0.29 | 0.46 | 2.03 |  | 0.0% | 4.3% | 6.3% | -6.0% | -0.0% |
| 11 | Educ., health & social work | 1.00 | 0.38 | 0.35 | 0.42 | 2.15 |  | 0.0% | 4.6% | 7.6% | -8.9% | -0.0% |
| 12 | Other services  | 1.00 | 0.46 | 0.31 | 0.32 | 2.09 |  | 0.0% | 2.5% | 5.9% | -8.2% | -0.0% |
| **RST** | 13 | Agriculture, forestry & fishing | 1.00 | 0.18 | 0.49 | 0.33 | 2.00 |   | 0.0% | 1.3% | 3.7% | -5.6% | 0.0% |
| 14 | Mining | 1.00 | 0.19 | 0.51 | 0.23 | 1.93 |  | 0.0% | 1.5% | 4.7% | -9.9% | 0.0% |
| 15 | Manufacturing | 1.00 | 0.18 | 0.42 | 0.27 | 1.87 |  | 0.0% | 1.5% | 5.4% | -8.1% | 0.0% |
| 16 | Energy | 1.00 | 0.24 | 0.50 | 0.44 | 2.18 |  | 0.0% | 0.6% | 1.7% | -2.1% | 0.0% |
| 17 | Other utilities | 1.00 | 0.14 | 0.55 | 0.30 | 1.99 |  | 0.0% | 1.1% | 2.2% | -4.3% | 0.0% |
| 18 | Construction | 1.00 | 0.22 | 0.49 | 0.50 | 2.21 |  | 0.0% | 1.2% | 4.3% | -4.4% | 0.0% |
| 19 | Distribution & catering | 1.00 | 0.19 | 0.33 | 0.40 | 1.92 |  | 0.0% | 1.7% | 9.1% | -7.2% | 0.0% |
| 20 | Transport & communication | 1.00 | 0.24 | 0.51 | 0.30 | 2.05 |  | 0.0% | 1.5% | 5.6% | -9.2% | 0.0% |
| 21 | Finance & business | 1.00 | 0.18 | 0.40 | 0.26 | 1.83 |  | 0.0% | 1.7% | 6.5% | -9.4% | 0.0% |
| 22 | Public administration | 1.00 | 0.21 | 0.37 | 0.47 | 2.04 |  | 0.0% | 1.6% | 8.3% | -6.2% | 0.0% |
| 23 | Educ., health & social work | 1.00 | 0.27 | 0.49 | 0.43 | 2.19 |  | 0.0% | 1.8% | 9.0% | -9.4% | 0.0% |
| 24 | Other services  | 1.00 | 0.24 | 0.51 | 0.34 | 2.09 |   | 0.0% | 1.5% | 5.6% | -8.2% | 0.0% |
| **ROS** | 25 | Agriculture, forestry & fishing | 1.00 | 0.11 | 0.22 | 0.67 | 1.99 |  | 0.0% | 0.0% | 0.0% | -0.0% | -0.0% |
| 26 | Mining | 1.00 | 0.25 | 0.14 | 0.59 | 1.98 |  | 0.0% | 0.3% | -0.4% | -0.0% | -0.0% |
| 27 | Manufacturing | 1.00 | 0.10 | 0.13 | 0.72 | 1.95 |  | 0.0% | -0.2% | -1.4% | 0.3% | -0.0% |
| 28 | Energy | 1.00 | 0.14 | 0.23 | 0.80 | 2.18 |  | 0.0% | 0.2% | 0.5% | -0.2% | -0.0% |
| 29 | Other utilities | 1.00 | 0.09 | 0.11 | 0.81 | 2.01 |  | 0.0% | -0.1% | -0.9% | 0.1% | -0.0% |
| 30 | Construction | 1.00 | 0.15 | 0.35 | 0.70 | 2.20 |  | 0.0% | 0.2% | 0.6% | -0.3% | -0.0% |
| 31 | Distribution & catering | 1.00 | 0.13 | 0.28 | 0.50 | 1.91 |  | 0.0% | -0.1% | -0.2% | 0.1% | -0.0% |
| 32 | Transport & communication | 1.00 | 0.13 | 0.18 | 0.72 | 2.03 |  | 0.0% | -0.2% | -1.2% | 0.3% | -0.0% |
| 33 | Finance & business | 1.00 | 0.10 | 0.15 | 0.58 | 1.84 |  | 0.0% | -0.3% | -1.2% | 0.4% | -0.0% |
| 34 | Public administration | 1.00 | 0.14 | 0.33 | 0.57 | 2.04 |  | 0.0% | -0.1% | 0.0% | -0.0% | -0.0% |
| 35 | Educ., health & social work | 1.00 | 0.15 | 0.28 | 0.74 | 2.17 |  | 0.0% | -0.4% | -1.1% | 0.5% | -0.0% |
| 36 | Other services  | 1.00 | 0.14 | 0.22 | 0.75 | 2.11 |   | 0.0% | -0.1% | -0.6% | 0.2% | -0.0% |

# Conclusions

This paper has demonstrated the use of non-survey approaches for constructing interregional input-output tables and explored the sensitivity of multipliers to the assumptions adopted in the process. An input-output table was constructed for a city-region and its host regional economy using non-survey methods. Location Quotients were used to spatially disaggregate the official Scottish Input-Output table to identify interdependencies between the largest city, Glasgow, its wider city-region in the rest of the Strathclyde region and the wider regional economy in the rest of Scotland. Secondary data was used as available to constrain results. In particular, data on commuting and shopping trips were used to inform spatial distribution of household wage income and consumption expenditures, in line with the metropolitan Input-Output tradition.

Sensitivity analysis was conducted around two dimensions: the specification of intermediate inputs and the flow of wages and household consumption. The results support previous findings that the accurate estimation of intermediate trade is important if multipliers are not to be overstated. The results further suggest that accurate estimation of wage and consumption flows are important if Type II multipliers are not to be overstated (and spill-over effects underestimated when working in a multi-region context). This is particularly important when working at smaller scales where commuting and shopping trips occur beyond the study area.

For intermediate trade, the key distinction was found to be between the types of location quotients used. The FLQ formula suggested far more interregional spill-over effects than the simple location quotients, which is in line with the stated aims of the FLQ approach. The choice of parameter for the FLQ is of secondary importance in this regard.

In order to capture wage and consumption flows over regional boundaries, the interregional IO table features a simple mechanism based on the metropolitan input-output literature that utilises secondary data on commuting and shopping trips. The results showed that the specification of wage and consumption flows is important for the sub-regions within the city-region. Type II multipliers for the smaller sub-region of Glasgow City are less sensitive than for the larger sub-region in the Rest of Strathclyde. This occurs as local households are a more important source of final demand in the latter. Interregional wage and consumption flows were far less important for the larger Rest of Scotland sub-region. Suggesting that accurately estimating the spill over of induced effects becomes less critical the larger the region being analysed. When comparing alternative approaches for estimating interregional consumption flows, results based on shopping trips are remarkably similar to those obtained using FLQ location quotients. Irrespective of the specification of household consumption, it is important to allow for the effects of commuting on interregional flow of wage income, as the alternative leads to a biased estimation of the overall impact of the sectors in a particular region.

The results indicate that researchers must adopt a wider stance than solely focussing on trade when constructing local level IO tables. Given that these results are based on simulation it would be desirable to verify them through empirical testing. However, this is not possible for the case of Glasgow and its city-region as a fully surveyed benchmark table is lacking. There are several local economy tables available for Scottish sub-regions but these are based on small island economies and therefore not suitable to test for the impact of commuting and shopping trips when using non-survey methods to estimate local level IO tables. However, opportunities may arise in other circumstances with the proliferation of local level input-output tables, perhaps applying spatial projection.

Allowing for spillover of household consumption and wage income is a significant improvement over conventional approaches but still has limitations, which would require more detailed data to address. In particular it would be useful to obtain sector specific commuting intensities and more detailed picture of interregional flows of household consumption. The first of these could be achieved with further disaggregation of census results but the latter does not have an obvious solution short of extensive primary data collection, such as through detailed expenditure diaries. A possible solution might be making use of big-data sources, such as card payment databases, which are occasionally made accessible to academic researchers.

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1. Boomsma & Oosterhaven (1992, p. 282, Footnote 5) point out that a bi-regional table (i.e. region of interest and rest of host economy) can be constructed using 9 months of labour. [↑](#footnote-ref-1)
2. It is assumed that $a\_{ij}^{NR}=a\_{ij}^{NN}$ so that the input requirements of the regional sector are the same as that of the national sector. Furthermore, these input coefficients exclude imports from abroad and should therefore not be confused with technical coefficients. Regional and national propensities to import foreign goods are assumed to be the same. The LQ can be seen as a self-sufficiency trade coefficient or, as put by Stevens & Treyz (1986), a Regional Purchase Coefficient (RPC). [↑](#footnote-ref-2)
3. The approach was initially presented in Flegg, Webber & Elliott (1995) but a revised version (Flegg and Webber (1997) has become the default specification and is for instance presented in Miller & Blair (2009). This paper follows the convention of referring to the FLQ approach as that described in (Flegg & Webber, 1997). An augmented version is provided in Flegg & Webber (2000). [↑](#footnote-ref-3)
4. Norcliffe identifies 4 main assumptions. However, his fourth assumption is not relevant in the context of IO-accounts, as it is for estimating export base models, and is hence omitted here. [↑](#footnote-ref-4)
5. An alternative approach is taken by Madsen & Jensen-Butler (2005), which construct an interregional Social Accounting Matrix for Denmark that separately identifies; the place of production for production activities; place of residence for institutions; marketplace for commodities; and marketplace for factors. [↑](#footnote-ref-5)
6. This is a wide definition of Glasgow city-region encompassing the whole of the former Strathclyde Regional Council (SRC) area outside Glasgow. This includes the council areas of East and West Dunbartonshire, Helensburgh and Lomond, East, North and South Ayrshire mainland, Inverclyde, East Renfrewshire and Renfrewshire, North and South Lanarkshire. The SRC was abolished in 1996 but many public services in the area are still provided at the Strathclyde level, such as Strathclyde Fire and Rescue Service and the Strathclyde Partnership for Transport. [↑](#footnote-ref-6)
7. The schematics are based on Oosterhaven & Stelder (2007), which provides an accessible introduction to interregional IO models. [↑](#footnote-ref-7)
8. The ABI provides headcount numbers of full time and part time workers. To obtain estimates of full time equivalent (FTE) employment, part time workers are taken to be holding on average one third of a full time equivalent job. [↑](#footnote-ref-8)
9. The latest year the regional government accounts (Hillis, 1998) refer to is 1998. This was a one-off publication. Therefore it assumed that the spatial distribution of government activities within Scotland has not changed significantly since then. These accounts reveal central and local government expenditures at NUTS2 level. The NUTS2 area South West Scotland includes Glasgow and what is designated as the Rest of Strathclyde (RST) in this IO table – in addition to the relatively small NUTS3 area of Dumfries & Galloway, which is attributed to the Rest of Scotland. Therefore government expenditures in the NUTS 2 region SW-Scotland has to be disaggregated into expenditures in GLA, RST and ROS. This is done using public sector employment in the NUTS 2 area, broken down by each IO region. Government expenditures in the other three NUTS 2 regions are attributed directly to ROS. [↑](#footnote-ref-9)
10. For this it is assumed that the RUK/ROW breakdown of exports at the Scottish level hold at the sub-regional level. [↑](#footnote-ref-10)
11. Because of the spatial-disaggregation the multipliers for individual sectors in individual sub-regions are not identical. However, their weighted average adds up to the original single-region multiplier. It is well known that any changes to the structure of an IO table will cause slight changes in individual multipliers as discussed by Miller & Blair (2009, Ch. 4.9.2., pp. 165-167). [↑](#footnote-ref-11)