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 conventional non-survey methods produces biased results. This problem has led to a methodological recommendation that emphasises the accurate estimation of intermediate trade flows. This paper argues for a qualification of the consensus view: when simulating input-output (IO) tables, analysts need also to consider spill-over effects driven by wage and consumption flows. In particular, for metropolitan economies, capturing wage and consumption flows is essential to obtain accurate Type II multipliers. This is demonstrated by constructing an interregional IO table, which captures the interdependence between a city and its commuter belt, nested within the wider regional economy.

JEL Codes: C67; R12; R15; R23.
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1 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 based on extensive surveying by statistical agencies. However, an IO table is often unavailable for a desired geographic unit and has to be simulated. Many authors are critical of employing non-survey methods for this task (e.g. Harris and Liu, 1998). Hybrid methods are favoured, as they retain significant accuracy while requiring less primary data collection than would full surveying (Lahr, 1993). Although thoughtful streamlining of data requirements can reduce the cost of hybrid approaches (Boomsma and Oosterhaven, 1992), conducting surveys and consulting industry experts is still costly[1]. Therefore, practitioners often fall back on non-survey methods such as Location Quotients (LQs). Given this requirement for local IO tables with limited resources, it is useful to refine the use of LQs. Hitherto, most such efforts have focused on trade. However, given the prominent share of consumption in final demand, this approach is incomplete. This is especially so when LQs are 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 task is carried out via 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, yet suggest that accounting for wage and consumption flows is also important when working with Type II multipliers at a sub-regional scale.

[1] Boomsma and Oosterhaven (1992, p. 282, Footnote 5) point out that a bi-regional table (i.e. the region of interest and the rest of a host economy) can be constructed using 9 months of labour.

The paper is structured as follows. The next section introduces the literature on estimating IO tables, while Section 3 describes the Glasgow metropolitan economy and its interdependence with the rest of Scotland. Section 4 explains the construction of the baseline IO table. In Section 5, sensitivity analysis is carried out, whereby the table is re-estimated based on a range of assumptions about intermediate trade and wage and consumption flows. Section 6 concludes.

2 Non-survey and partial-survey methods for constructing IO tables

Where an IO table is unavailable, one can be simulated by using hybrid (partial-survey) approaches or non-survey methods such as location quotients (LQs). A comprehensive overview is provided in Miller and Blair (2009, Chapters 7-8). When using LQs, regional input coefficients are calculated as

$$a_{ij}^{RR} = a_{ij}^{NR} \times LQ_{ij}^{R} \qquad (1)$$

where a_{ij}^{NR} is the input coefficient determining the intermediate input requirement of sector j in region R from sector i in the whole of the national economy N and LQ_{ij}^{R} is an LQ[2]. This LQ captures the proportion of regional requirements of input *i* purchased from within region R. 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 LQ (SLQ), which is defined for sector i in region R as:

$$SLQ_i^R = \left[\frac{E_i^R / E^R}{E_i^N / E^N}\right] \qquad (2)$$

where E_i^R and E^R are employment in sector i and total employment in region R, and E_i^N and E^N are national employment in sector *i* and total national employment.

[2] It is assumed that $a_{ij}^{NR} = a_{ij}^{NN}$, so that the input requirements of the regional sector are the same as those 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 and Treyz (1986), a Regional Purchase Coefficient (RPC).

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

$$\mathrm{CILQ}_{\mathrm{ij}}^{\mathrm{R}} = {\mathrm{SLQ}_{\mathrm{i}}^{\mathrm{R}}} \Big/ {\mathrm{SLQ}_{\mathrm{j}}^{\mathrm{R}}} \tag{3}$$

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

$$FLQ_{ij}^{R} = (\lambda^{*})CILQ_{ij}^{R} \tag{4.a}$$

$$\lambda^{*} = \left\{\log_{2}\left[1 + \left(\mathrm{E}^{\mathrm{R}}/\mathrm{E}^{\mathrm{N}}\right)\right]\right\}^{\delta} \tag{4.b}$$

where $0 \leq \delta < 1$. 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] about the regions being examined, i.e. identical productivity, identical consumption and no cross-hauling of products from the same sector. In practice, these assumptions are unlikely to hold. Therefore, several authors have analysed the extent to which LQ-based estimates of regional input coefficients are biased (Schaffer and Chu, 1969; Smith and Morrison, 1974; Round, 1978; Harrigan et al., 1981; Willis, 1987; Harris and 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 an overestimation of local intermediate transactions (see Harris and Liu, 1998, for a detailed discussion). An exception is Stoeckl (2012), who explores the role of differences in productivity. Tohmo

[3] The approach was initially presented in Flegg et al. (1995) but a revised version, Flegg and Webber (1997), has become the default specification and is, for instance, presented in Miller and Blair (2009). This paper follows the convention of referring to the FLQ approach as that described in Flegg and Webber (1997). An augmented version is provided in Flegg and Webber (2000).

[4] Norcliffe identifies four 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.

(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 IO table (Tohmo, 2004).

The difficulty with the FLQ is that it requires selecting an appropriate value for the parameter δ, which is not known *ex ante* but has to be inferred from comparison with surveyed tables *ex post*[5]. Based on analysis of IO tables for Scotland and Peterborough in England, Flegg and Webber (1997) propose that an approximate value for δ = 0.3 "would seem reasonable" (p. 798). Flegg and 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 analysis, they recommend a value between 0.25 and 0.3. A similar result is obtained by Bonfiglio and Chelli (2008), using a Monte Carlo approach and Flegg et al. (2016) suggest a value of 0.3 - 0.4. The weight of evidence therefore supports the original Flegg and Webber (1997) recommendation of δ = 0.3. However, there are some single-region studies that suggest both lower and higher values. For instance, Flegg and Webber (2000) find a lower value δ = 0.15 based on analysis of Scotland. However, as pointed out by Flegg and Tohmo (2013a), this is likely to reflect the fact that the Scottish input coefficients often surpassed corresponding UK coefficients. Similarly, Kowalewski (2013), finds the best results for the German federal state of Baden-Wuerttemberg are 0.11 ≤ δ ≤ 0.17. Conversely, Bonfiglio (2009), based on a study of the Marche region in Italy, suggests a much 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 by Flegg and Tohmo (2013a, pp. 707-708), who argue that it is unclear that the gravity models yield results superior to the FLQ.

[5] Flegg and Tohmo (2016) argue that given the underperformance of other LQs vis-à-vis the FLQ, analysts should focus on choosing an appropriate value for δ.

Furthermore, they require 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 and Tohmo, 2013b). However, this method is not appropriate for the present case study, as CHARM estimates technical coefficients, as opposed to intraregional input coefficients.

2.1 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 LQ-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 and de Mesnard (2004) point out, these fall into broadly two categories: scaling algorithms (e.g. the well-known RAS (Miller and Blair (2009, Section 7.4)), and maximizing algorithms, e.g. entropy-maximisation approaches (Wilson, 1970).

Several templates have been proposed for deriving hybrid IO tables (Miller and Blair, 2009, p. 373). A widely applied example 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 and Oosterhaven, 1992). This builds on the observation that firms are generally better informed about the spatial destination of their output than they are about the spatial origin of their inputs. Focusing 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 and 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 is available, it may 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 and Escobedo-Cardeñoso, 2011).

2.2 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 as 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 fact biases Type II multipliers upwards. Similarly, this procedure assumes that all marginal income is spent and it 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 and Oosterhaven, 1986). Even so, 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-à-vis SAM multipliers. However, in the context of disaggregating IO tables, the primary concern is the appropriate spatial attribution of these effects. For this purpose, an accurate identification of household consumption and labour income is critical (Lahr, 1993; Richardson, 1985). This is especially so at the metropolitan level, where local economies are strongly interdependent through commuting and shopping trips (Hewings et al., 2001; Madden, 1985; Madsen and Jensen-Butler, 2005; Oosterhaven, 1981). Therefore, particular care needs to be taken when the boundaries of the study area cross functional boundaries (Hewings and 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 table shows limited commuting vis-à-vis the rural Northern Region but active commuting vis-à-vis the densely populated Rijnmond region and significant spill-over of household final demand between all regions. Several subsequent studies have emphasised the potential discrepancy between place of work and place of consumption in IO models, such as: Madden (1985) for Nordrein-Westphalia in Germany and Hewings et al. (2001) in a 4-region model of the Chicago economy, while Jun (2004) sets out a general framework. These IO models offer several advanced features[6]. Nonetheless, with the exception of Oosterhaven (1981), the practicalities of populating the commuting and shopping matrices are not detailed. In particular, it is unclear what assumptions are involved in converting shopping trips into 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.

3 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[7]. 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

[6] An alternative approach is taken by Madsen and Jensen-Butler (2005), who 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.

[7] This is a wide definition of Glasgow city region that encompasses 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.

extensive suburban rail network to the rest of the Strathclyde region. Key economic and social indicators for these areas are given in Table 1.

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 km^2 , and had 580,690 inhabitants in 2006. 313,535 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 Table 2) 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 %). Source: 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 %). Source: 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%**

The rest of the Strathclyde region (RST) has somewhat different economic characteristics than Glasgow (GLA). In terms of population, it is approximately three 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. Table 3 shows the composition of all shopping trips by residence and the shopping destination.

4 Construction of the IO table

The Scottish IO table for 2006 is disaggregated into three sub-regions. The parent IO table, as illustrated in **Figure 1**, has *I = j* intermediate sectors, *q* final demand sectors and *p* primary sectors[8]. The notation is as follows (small bold cases for vectors and capital bold cases for matrices):

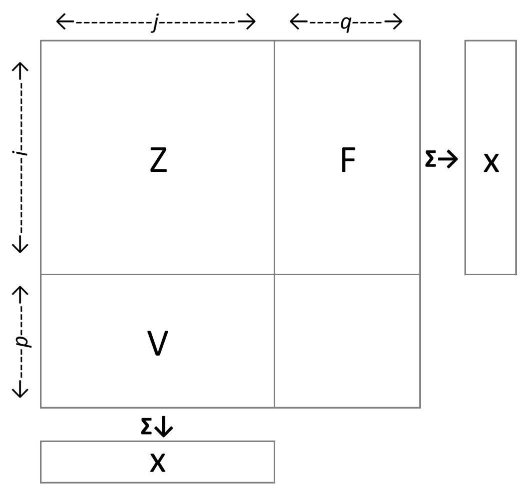
x = i × 1 and 1 × j vectors of outputs.

Z = i × j matrix of intermediate demand.

F = i × q matrix of final demand.

V = p × j matrix of primary costs.

Figure 1 Single- region IO table for Scotland.



[8] The schematics are based on Oosterhaven and Stelder (2007), which provides an accessible introduction to interregional IO models.

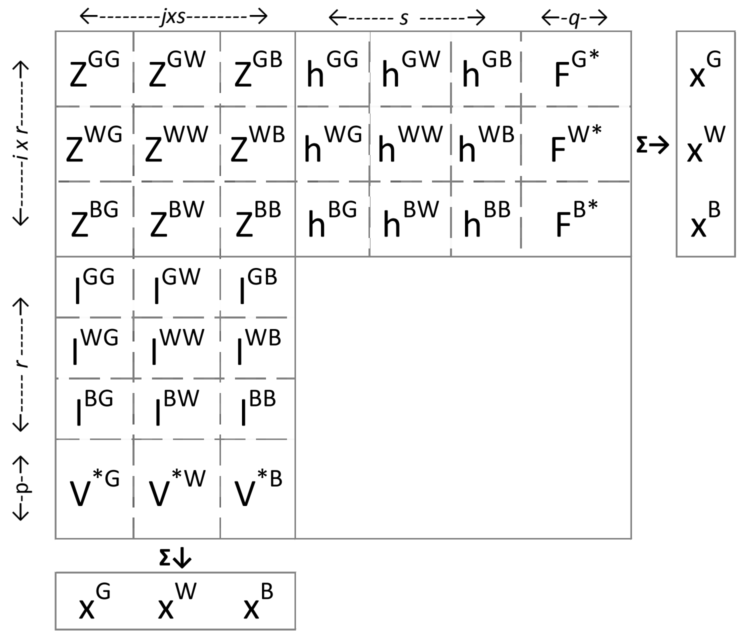
The disaggregation process is carried out at the most disaggregated level possible (126 sectors) and is aggregated subsequently to simplify presentation. The disaggregation occurs in four stages:

1. Estimate sectoral 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[9]. The IO sectors refer to specific Standard Industrial Classification (SIC) categories, so employment levels from the ABI can be matched to each sector. An outline of the resulting interregional IO table is presented in Figure 2. 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 $\mathbf{Z}^{\mathbf{WG}}$ 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.

[9] 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 FTE job.

Figure 2 Interregional IO table for three regions.



The household consumption category of final demand has a region of origin (*s*) and a region of destination (*r*). This is represented by the i×1 vector $\mathbf{h}^{rs}$. Sales to the remaining *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 $\mathbf{F}^{r*}$. Similarly, for primary inputs, compensation of employees flows from the place of work (*s*) to the place of residence (*r*), as denoted by the 1×j vectors $\mathbf{I}^{rs}$. The remaining *p* primary input categories are not assigned a spatial dimension. These matrices are denoted as $\mathbf{V}^{*s}$.

4.1 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 IO table:

$$x_i^L = x_i^N \left[\frac{E_i^L}{E_i^N}\right] \tag{5}$$

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.

4.2 Step 2: Intermediate inputs

The share of intermediate purchases sourced locally is estimated using FLQs, based on δ = 0.3. This follows the recommendation of Flegg and Webber (1997), which is supported by the work of Flegg and Tohmo (2013a), as summarised in Section 2. Using this method, it is possible to estimate the elements in the diagonal input-coefficient matrices, that is: $\mathbf{A}^{GG}$, $\mathbf{A}^{WW}$, $\mathbf{A}^{BB}$**.** This leaves the issue of estimating the off-diagonal matrices of input coefficients. This proceeds sequentially. The FLQ 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 $\mathrm{a}_{\mathrm{ij}}^{\mathrm{GG}} = \mathrm{a}_{\mathrm{ij}}^{\mathrm{N}} \times \mathrm{FLQ}_{\mathrm{ij}}^{\mathrm{G}}$. Not all intermediate inputs can be sourced locally and therefore we are left with a residual $\mathrm{a}_{\mathrm{ij}}^{\rho\mathrm{G}} = \mathrm{a}_{\mathrm{ij}}^{\mathrm{N}} - \mathrm{a}_{\mathrm{ij}}^{\mathrm{GG}}$. 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 $\mathrm{a}_{\mathrm{ij}}^{\mathrm{WG}} = \mathrm{a}_{\mathrm{ij}}^{\rho\mathrm{G}} \times \mathrm{FLQ}_{\mathrm{ij}}^{\mathrm{W}}$. This conveniently leaves the inputs sourced from the ROS as a residual: $\mathrm{a}_{\mathrm{ij}}^{\mathrm{BG}} = \mathrm{a}_{\mathrm{ij}}^{\rho\mathrm{G}} - \mathrm{a}_{\mathrm{ij}}^{\mathrm{WG}}$.

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 by the sectoral gross outputs estimated in section 3.3.3.1 to obtain the $\mathbf{Z}^{rs}$ matrices of interregional intermediate transactions.

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

The matrices $\mathbf{V}^{*G}$, $\mathbf{V}^{*W}$ and $\mathbf{V}^{*B}$ 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 do 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:

$$v_{qj}^{*S} = v_{qj}^{N}\left[\frac{E_j^S}{E_j^N}\right] \tag{6}$$

where v stands for primary input of source *q* (imports, other valued added, etc.) into sector *j*, in region *s* and in Scotland (*N*). *E* stands for employment in sector *j* in region *S* and in 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 these commuters reside, such that:

$$l_j^{rs} = l_j^{N}\left[\frac{E_j^S}{E_j^N}\right]c^{rs} \tag{7}$$

where c^{rs} is a scalar that represents the share of employment in region *s* provided by workers living in region *r*. This calculation is based on the 2011 census data presented in **Table 2**. By using these data, it is implicitly assumed that commuters are spread equally across sectors and that commuters get equally compensated as local workers.

4.4 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 Table 4 and detailed in subsequent sub-sections.

Table 4 Overview of disaggregation approaches by final demand category.

Final consumption expenditure	Total value £m	% of final demand	Disaggregation method	Data source
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				
GFCF	8,701	6.8%	Pro rata	Based on employment share from ABI
Valuables	36	0.0%		
Change in Inventories	184	0.1%		
Exports				
RUK	33,297	26.1%	Residual	Control total from Scottish IO but spatial dispersion determined as a balancing item
RoW	17,394	13.6%		
	127,669	**100%**		

4.4.1 Household demand

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

$$\boldsymbol{H}^{\boldsymbol{rs}} = \begin{vmatrix} \boldsymbol{h}^{\boldsymbol{GG}} & \boldsymbol{h}^{\boldsymbol{GW}} & \boldsymbol{h}^{\boldsymbol{GB}} \\ \boldsymbol{h}^{\boldsymbol{WG}} & \boldsymbol{h}^{\boldsymbol{WW}} & \boldsymbol{h}^{\boldsymbol{WB}} \\ \boldsymbol{h}^{\boldsymbol{BG}} & \boldsymbol{h}^{\boldsymbol{BW}} & \boldsymbol{h}^{\boldsymbol{BB}} \end{vmatrix} \tag{8}$$

This is achieved by using data for shopping trips as a first approximation for consumption flows, as is conventional in the literature (see Section 2.2). The matrix is then balanced using a RAS procedure.

Households in the sub-regions are taken to exhibit the same consumption pattern as those in Scotland as a whole. However, population varies between them, as does the average disposable income (see Table 1) 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 *r* and residing in region *s* is estimated as:

$$\boldsymbol{h}^{rs} = \boldsymbol{h}^{N} \times d^{rs} \tag{9}$$

where d^{rs} is a scalar that's defined as: $d^{rs} = y^{s} \times t^{rs} = \frac{Y^{s}}{\sum_{s} Y^{s}} \times \frac{T^{rs}}{\sum_{r} T^{rs}}$, where y^{s} is the 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 from 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 $\boldsymbol{H}^{rs}$matrix. RAS requires control totals for column and row sums. Y^{s} 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 *r*, and E_{i}^{N} is the FTE employment in sector *i* in Scotland as a whole (*N*).

4.4.2 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. 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.

4.4.3 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:

$$f_{qi}^{L} = f_{qi}^{N}\left[\frac{E_i^L}{E_i^N}\right] \tag{10}$$

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*).

4.4.4 Exports and balancing

As the 3-region table is a disaggregation of the balanced Scottish IO table, it balances by definition 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 the spatial distribution of RUK and ROW exports, this is chosen as a balancing row. The total exports of sector *i* in region *r* are determined as that sector's estimated gross output, less intermediate demand and less all the final demands estimated so far (i.e. all 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]. This concludes the disaggregation process.

4.5 3-region IO table

The interregional multipliers are shown in a disaggregated format in Table 5. The multipliers reveal the direct effect upon the host region and the knock-on effects for each of the three regions and for 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) plus indirect impacts upon GLA (0.10), RST (0.10) and ROS (0.23). In this case, more than three quarters of the indirect impacts occur outside the host region. Conversely, some sectors are much more locally

[10] For this it is assumed that the RUK/ROW breakdown of exports at the Scottish level holds at the sub-regional level.

contained. For instance, Finance and Business in ROS, where the total indirect impacts amount to 0.37, of which approximately three quarters occur locally. When combined, the effects on individual regions add up to the multiplier for Scotland as a whole (SCO) [11].

Table 5 Type I and Type II interregional multipliers in the interregional GLA-RST-ROS IO table.

		Type I multiplier					Type II multiplier				
	Sector	Direct effect	Indirect effects				Direct effect	Indirect and induced effects			
			GLA	RST	ROS	SCO		GLA	RST	ROS	SCO
GLA	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**
RST	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**
ROS	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**

From the multipliers, it is clear that interregional intermediate trade (indirect effects as gauged by the Type I multiplier) generates significant spill-over effects, yet this magnitude varies across sectors and

[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 (see Miller and Blair (2009, Ch. 4.9.2., pp. 165-167)).

sub-regions. Type II multipliers additionally account for induced effects. These are calculated using the standard approach, as outlined in Miller and Blair (2009, pp. 34-41) imposing a 1-for-1 relationship between wage income and consumption.

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 and 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 over into GLA and RST amount to 0.09 and 0.14 or to just under 20% of overall multiplier effects. A similar pattern emerges for Distribution and Catering, Transport and Communications, Finance and 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 0.11spilling over into RST and ROS, respectively. For the same sector in ROS, induced effects amount to 0.25 of the overall multiplier effects of 1.18. However, more than half of these (0.16) occur locally in ROS.

5 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 influences the nature of induced impacts.

5.1 Intermediate transactions

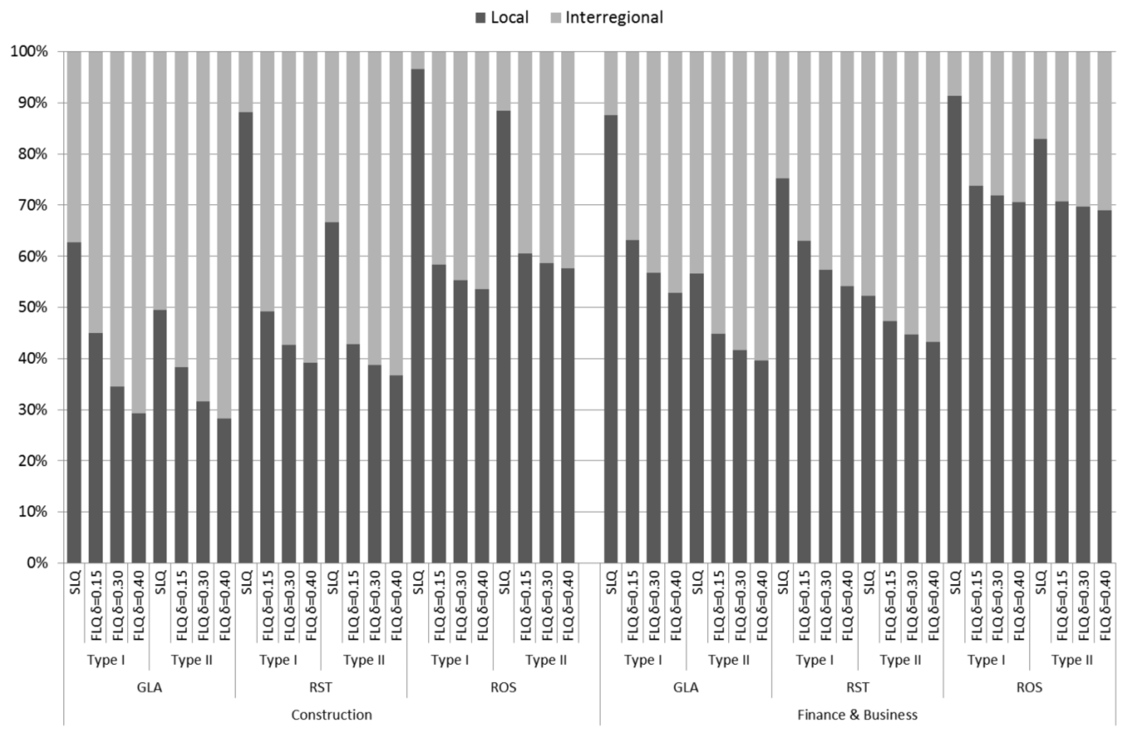
The IO table is estimated using alternative LQs. The FLQ formula is used for a range of δ values and compared with a version of the IO table estimated using SLQs. The upper and lower values of δ chosen here follow Flegg and Tohmo (2013a), who test the appropriateness of δ values in the range 0.15 - 0.4 for 20 regions in Finland. To simplify the presentation of results, the industrial sectors are aggregated into a single sector for each region, to identify the extent to which indirect (and, where appropriate, induced effects) impact locally or in other sub-regions. Table 6 shows aggregate multipliers broken down into their constituent components: direct effect, local effect and interregional effect.

Table 6 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 $\delta = 0.3$, 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 δ does change the outcome. As the value of δ rises, less input is sourced locally and the local multiplier effect falls, whereas the opposite occurs with the interregional effect. However, 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, the spill-over effects are noticeably smaller than those for the smaller regions under all approaches. These results are in line with the stated aim of the FLQ formula, i.e. to allow for the higher 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 final demand stimulus in Glasgow of £1 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.



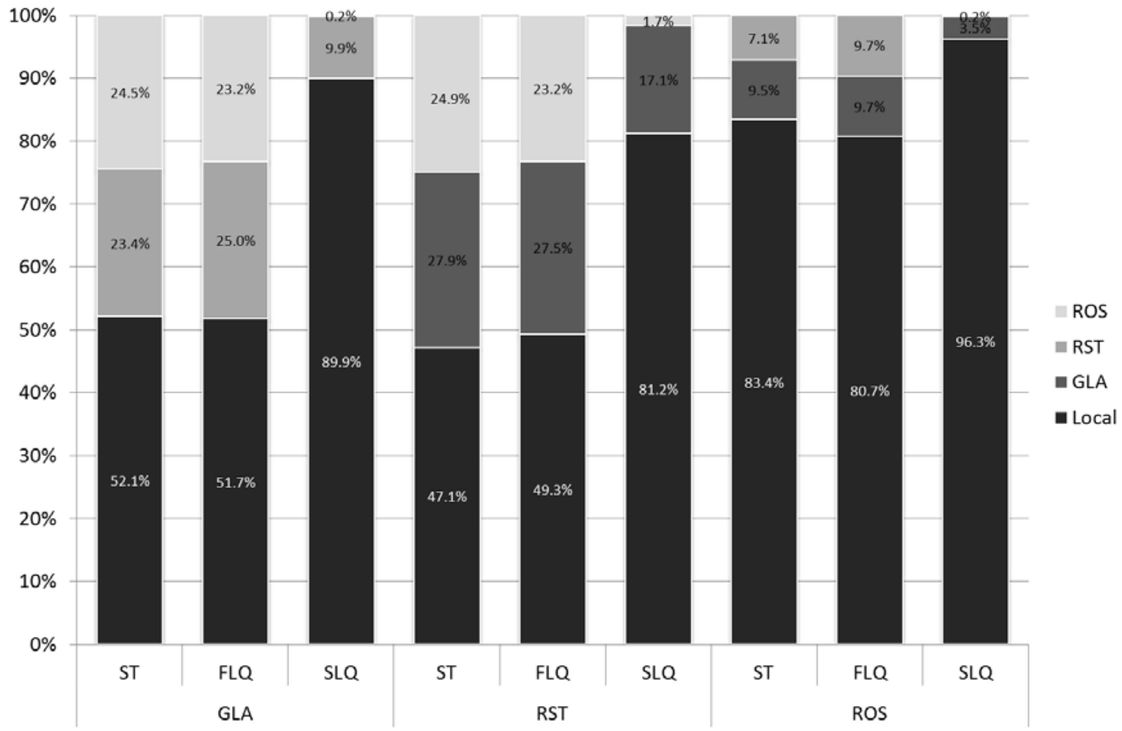
Within the aggregate economies of each region there are differences between sectors and the outcomes for these sectors vary with the assumptions adopted. This is explored in Figure 3 for two contrasting sectors, Construction and Finance and Business. Both sectors are labour intensive and therefore support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

5.2 Household incomes and expenditures

As is detailed in Section 4.3 and 4.4.1, data on local gross disposable household income, shopping trips and commuting are used to determine the flows of wages and consumption. This approach, referred to here as the Shopping Trip (ST) approach, is in line with past work on metropolitan IO tables, as is summarised in Section 2.2. When sufficient data are unavailable, researchers are likely to fall back on LQs to estimate the spill-over of household final demand. Therefore, 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 4.2.

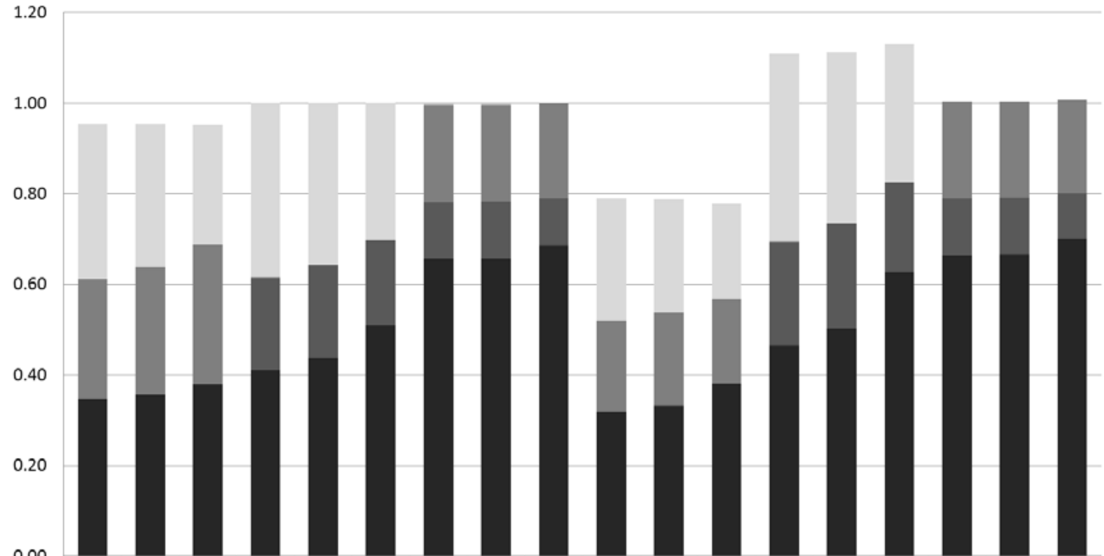
As shown in Figure 4, across all three sub-regions, the ST and FLQ approaches give similar results in terms of the share of household final demand that goes to local sectors. The SLQ implies predominantly local household consumption for all three sub-regions. However, the contrast is marked in GLA and RST, where the local share of household final demand jumps from approximately half under ST and FLQ to 89.9% and 81.2% under the SLQ in GLA and RST, respectively. The RST is slightly more open in terms of household consumption than is GLA, with over 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.



A graphical representation of Type II multipliers with and without commuting is provided in Figure 5. For indirect and induced effects with commuting, the default specification (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 GLA, there is disproportionate compensation of employees relative to household final demand, so 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, so that ignoring commuting suggests an 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.



	Commuting									No Commuting								
	GLA			RST			ROS			GLA			RST			ROS		
	ST	FLQ	SLQ	ST	FLQ	SLQ	ST	FLQ	SLQ	ST	FLQ	SLQ	ST	FLQ	SLQ	ST	FLQ	SLQ
ROS	0.34	0.32	0.27	0.38	0.36	0.30				0.27	0.25	0.21	0.41	0.38	0.31			
RST	0.27	0.28	0.31				0.22	0.21	0.21	0.20	0.21	0.19				0.21	0.21	0.21
GLA				0.20	0.21	0.19	0.13	0.13	0.10				0.23	0.23	0.20	0.13	0.12	0.10
Local	0.35	0.36	0.38	0.41	0.44	0.51	0.66	0.66	0.69	0.32	0.33	0.38	0.46	0.50	0.63	0.66	0.67	0.70

The ST and FLQ approaches provide very similar results in terms of aggregate multipliers. However, the findings are also similar for individual sectors. Table 7 presents interregional Type II multipliers where FLQs were used to attribute household final demand and their percentage deviation from the default multiplier. These multipliers estimate slightly larger local indirect and induced effects in GLA and RST (local impact highlighted in grey), at the expense of spill-over effects in the ROS. These are small differences, so that on balance the two approaches used to attribute household final demand, namely ST and FLQ, produce similar results.

Table 7 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%

6 Conclusions

This paper has demonstrated the use of non-survey approaches for constructing interregional Input-Output (IO) tables and explored the sensitivity of multipliers to the assumptions adopted in the process. An IO table was constructed for a city region and its host regional economy using non-survey methods. Location Quotients (LQs) were used to disaggregate spatially the official Scottish IO 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 were 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 IO 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-regional 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 LQs used. The FLQ formula suggested far more interregional spill-over effects than did the simple LQ, which is in line with the stated aims of the FLQ approach. The choice of value for the δ parameter of the FLQ was 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 IO literature, which employs 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 (Glasgow and Rest of Strathclyde).

Interregional wage and consumption flows were far less important for the largest Rest of Scotland sub-region. This finding suggests 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 were remarkably similar to those obtained using the FLQ. Irrespective of the specification of household consumption, it is important to allow for the effects of commuting on the interregional flow of wage income, as failing to do so leads to biased estimates of the overall impact of the sectors in a particular region.

The results indicate that researchers should adopt a wider stance than solely focusing on trade when constructing local IO tables. Given that these results are based on simulation, it would be desirable to verify them through empirical testing. However, 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, so are unsuitable to test for the impact of commuting and shopping trips. However, opportunities may arise in other circumstances with the proliferation of local IO tables, perhaps by applying spatial projection.

Allowing for spill-over of household consumption and wage income enhances conventional approaches, yet this is still limited by lack of data. In particular, it would be useful to obtain sector-specific commuting intensities and a more detailed picture of interregional flows of household consumption. The first of these could be achieved with further disaggregation of census results, whereas the latter does not have an obvious solution short of extensive primary data collection. A possible solution might be by making use of big-data sources, such as card payment databases, which are occasionally accessible to academic researchers.

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