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BEYOND INTERMEDIATES: THE ROLE OF CONSUMPTION AND COMMUTING IN THE CONSTRUCTION OF LOCAL INPUT-OUTPUT TABLES

BY

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NO. 13-05

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

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Abstract

It is a well-established fact in the literature on simulating Input-Output tables that mechanical methods for estimating intermediate trade lead to biased results where cross-hauling is underestimated and Type-I multipliers are overstated. Repeated findings to this effect have led to a primary emphasis on advocating the accurate estimation of intermediate trade flows. This paper reviews previous research and argues for a qualification of the consensus view: When simulating IO tables, construction approaches need to consider spill-over effects driven by wage and consumption flows. In particular, for the case of metropolitan economies, wage and consumption flows are important if accurate Type-II multipliers are to be obtained. This is demonstrated by constructing an interregional Input-Output table, which captures interdependencies between a city and its commuter belt, nested within the wider regional economy. In addition to identifying interdependencies caused by interregional intermediate purchases, data on sub-regional household incomes and commuter flows are used to identify interdependencies from wage payments and household consumption. The construction of the table is varied around a range of assumptions on intermediate trade and household consumption to capture the sensitivity of multipliers.

JEL Codes: C67; R12; R15; R23.
Keywords: Input-Output; Location Quotients; Commuting; Consumption; Glasgow; Scotland.

1 Introduction

Input-Output (IO) tables offer a variety of applications, such as, for impact studies, key sector analysis, attribution of greenhouse gas emissions and simply as multisectoral economic accounts. Furthermore, they are frequently used as inputs into other modelling approaches, such as Social Accounting Matrices (SAMs) and Computable General Equilibrium (CGE) models. The best IO tables are produced based on extensive surveying by national/regional statistical agencies or international bodies. These are often constructed as part of the process of compiling national accounts and are resource intensive, well beyond the means of individual research or consultancy projects. Often an Input-Output table is not available for a desired geographic unit, and hence has to be simulated. In this case the academic literature favours using hybrid methods, which are attractive to use as they require much less primary data collection than full-blown surveying, while retaining significant accuracy (Lahr, 2003). However, for this the bottleneck is obtaining actual firm or sector level estimates of intermediate sales and/or purchases and the resources required are still not trivial. Therefore in practice researchers and consultants often fall back on mechanical methods, using secondary data sources to spatially disaggregate existing accounts, using Location Quotients (LQs).

Several authors (e.g. Harris & Liu 1998) have criticised the use of Location Quotients to construct local Input-Output. Instead, they typically advocate the use of hybrid approaches. Despite this clear methodological recommendation LQ-based IO tables continue to be applied. The expectation of wide spread primary data-collection is unfortunately not realistic given typical availability of resources[1]; therefore it is worth making further attempts to refine the use of location quotients.

Whereas previous work has emphasised refining the estimation of intermediate trade, this paper explores the relative importance of wage and consumption flows across boundaries, as driven by commuting and shopping trips. To examine this issue an interregional Input-Output 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 a location quotient approach, but augmented with a simple use of secondary data to capture interregional wage and consumption flows. Sensitivity analysis reveals the relative importance of specifying interregional wage and consumption flows at the metropolitan level. This is not surprising given the role of service sectors and extent of commuting in metropolitan economies in high income countries. The results support the existing consensus on the importance of accurately specifying intermediate trade, but suggest that accounting for wage and consumption flows can be equally important when working with Type-II multipliers.

The paper is structured as follows. The next section introduces the literature on simulating IO tables. The third section describes the Glasgow metropolitan economy and its interdependencies 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

[1] With notable exceptions such as the Scottish island economies: Eilean Siar, Shetland and Orkney.

assumptions about intermediate trade and wage and consumption flows. The sixth section concludes.

2 Previous research

There are a number of hybrid or partial survey approaches available for estimating Input-Output tables (see Miller & Blair (2009, Chapter 7) for an overview). These improve the accuracy of the estimates over purely mechanical approaches by drawing on actual observations to constrain the results. Typically they proceed in several steps (Lahr, 1993, p. 278). For example, we could start out with a location quotient based matrix of intermediate transactions for a local economy. To improve the accuracy of the estimates it would be possible to survey or conduct case studies of companies in the most important sectors to determine the total of intermediate sales (row sum) and purchases (column sum). Numerical approaches could then be applied to adjust the original matrix to conform to these more accurate control totals. Or as put more generally by Snickars & Weibull (1977) information about macro states can be used to inform estimates of micro states. As summarised by Lahr & de Mesnard (2004) there are a range of techniques available for reconciling partial observations with estimates. Within the context of Input-Output tables the RAS Technique is probably the most well-known of these (see Section 7.4 in Miller & Blair (2009)). As Lahr & de Mesnard (2004) point out these adjustment algorithms fall into broadly two categories: Scaling algorithms, of which RAS is one, and maximizing algorithms. Prominent examples of the latter are entropy maximisation principles (Wilson 1970) or Efficient Information Adding. Snickars & Weibull (1977) discuss the general principle and demonstrate its application to several spatial-economic problems. The approach is discussed further in the context of estimating interregional IO-tables by Batten (1982) and

Snickars (1979) demonstrates its application to estimating interregional trade within Sweden.

Notable past contributions have acknowledged the problem that at the metropolitan level local economies are strongly interdependent through commuting and shopping trips (Hewings et al 2001, Jun 1999, 2004, Madden 1985). Therefore, particular care needs to be taken when the boundaries of the study area cross functional boundaries (Hewings & Parr, 2007). Madden (1985) clearly lays out the theory for a multiregional metropolitan input-output model allowing for commuting and shopping trips. Its use is demonstrated for Nordrein-Westphalia in Germany, but the author does not elaborate on the data sources used. Hewings et al (2001) set out a theoretical structure for a 4-region metropolitan input-output model, which they apply to the Chicago economy. The database is constructed based on LQs in combination with commuting and shopping matrices. These models offer a number of advanced features. However, what data collection they involve is not clear and these have yet to be distilled into simple approaches, which could readily be implemented in practice, for example by resource constrained policy makers and consultants.

2.1 Location Quotients

The widespread use of the LQ approach for constructing regional Input-Output tables is primarily driven by pragmatic concerns. Detailed data are seldom available at the regional level to implement more accurate methods and collecting the primary data needed is typically beyond the means of the IO-users. Given this predicament a typical response is to draw on a published input output table pertaining to a larger geography and use employment based location quotients to estimate a local sub-section of that table. Implicitly by going down that route the researcher is accepting some rather bold assumptions. For these Harris & Liu (1998) refer to Norcliffe (1983, pp. 162-163), which identifies the main assumptions underlying the use of location quotients to identify the export base in export base models[2].

It is clear that for employment to be used as a proxy for output there must be identical productivity per employee in each region in each industry so that a region's share of national employment accurately represents its share of national production. Furthermore, for similar reasons, there must be identical consumption per employee. Perhaps most importantly however, so as not to underestimate interregional trade, there must be no cross-hauling between regions of products belonging to the same industrial category. Given that these assumptions rarely hold, a number of authors have attempted firstly to estimate empirically the extent to which the breakdown of these assumptions will influence estimates for IO-accounts and secondly to come up with modifications of the LQ-approaches that might counter some of the inherent biases.

Various LQ methods have been suggested in the literature (Miller & Blair, 2009, pp. 349-360). In general LQ approaches adjust the national technical coefficient to take account of the potential for satisfying input needs locally. A regional Input-Output coefficient is a function of the location quotient and the national Input Output coefficient:

[2] Norcliee 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.

$$a_{ij}^{RR} = a_{ij}^{RR}\left(LQ_i^R, a_{ij}^N\right)$$

Where a_{ij}^{RR} is the regional IO technical coefficient, LQ_i^R is the location quotient and a_{ij}^N is the national technical coefficient[3].

2.1.1 Simple location quotient (SLQ)

The simple location quotient for sector i in region R is defined as:

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

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.

When the SLQ_i is greater than one (less than one), it can be inferred that sector *i* is more (less) concentrated in region R than in the nation as a whole. Where the location quotient is less than one the region is perceived to be less able to satisfy regional demand for its output, and the national coefficients are adjusted downwards by multiplying them by the location quotient for sector *i* in region R. Where the sector is more concentrated in the region than the nation at large (LQ_i>1), it is assumed that the regional sector has the same coefficients as the nation as a whole. Therefore for row *i* of the regional table:

$$a_{ij}^{RR} = \begin{matrix} a_{ij}^N SLQ_i^R & if \quad SLQ_i^R < 1 \\ a_{ij}^N & if \quad SLQ_i^R \geq 1 \end{matrix}$$

[3] Which shows the required input of commody i per unit of output of commodity j.

2.1.2 Cross industry location quotient

A criticism of the simple location quotient is that it does not take into account the relative size of the sectors engaged in intermediate transactions. The argument goes that if a sector which is relatively small locally is supplying a sector which is relatively big, this should imply a need for imports to satisfy intermediate demand, and vice versa. This is addressed with cross industry location quotients (CILC). The CILQ for sectors *i* and *j* can be defined as:

$$CILQ_{ij}^{R} = \frac{SLQ_i^R}{SLQ_i^R}\left[\frac{E_i^R / E_i^N}{E_j^R / E_j^N}\right]$$

Where sector *i* is assumed to be supplying inputs to sector *j*. As with the SLQ national coefficients are not adjusted if $CILQ_{ij}^{R} \geq 1$ as it is assumed that intermediate demand can be met within the economy.

2.1.3 Round's semi-logarithmic Location Quotient (RLQ)

Round (1978, p. 181) surmises that "following the basic notion of the location quotient, one could reasonably conjecture that the size of trading coefficient may be ascertained by some function of the relative size of the supplying sector, the relative size of the purchasing sector, and the overall size of the region relative to the nation as a whole". In order to incorporate all three of these measures in a location quotient, Round (1978) suggested a semilogarithmic quotient, which he defined as

$$RLQ_{ij}^{R} = SLQ_i^R / \log_2\left(1 + SLQ_j^R\right)$$

2.1.4 Flegg, Webber and Elliot's Location Quotient (FLQ)

Flegg, Webber and Elliot introduce the FLQ approach (Flegg *et al*, 1995), which is subsequently developed in Flegg *et al* (1997) and Flegg *et al* (2000). In this approach they modify the CILQ to incorporate a measure of the relative size of the region such that FLQ_{ij}^{R}=$(\lambda)CILQ_{ij}^{R}$, where $\lambda = \left\{\log_2\left[1 + \left(\mathrm{E^R}/\mathrm{E^N}\right)\right]\right\}^{\delta}$, where $0 \leq \delta \leq 1$. Then

$$a_{ij}^{rr} = \begin{matrix} FLQ_{ij}^{R} a_{ij}^{N} & if\ FLQ_{ij}^{R} > 1 \\ a_{ij}^{N} & if\ FLQ_{ij}^{R} < 1 \end{matrix}$$

The aim is to reduce national coefficients more for smaller regions, under the general expectation that smaller regions are more import intensive. The main difficulty with this method is that it requires an ad hoc assumption about the parameter δ. Initially, Flegg & Webber (1997) propose that an approximate value for δ=0.3 "would seem reasonable" (p. 798). However, subsequently efforts have been extended to select an appropriate parameter through empirical testing.

2.2 Empirical testing of alternative LQ methods

A number of studies have been undertaken to test the accuracy of hybrid and non-survey methods. See for example: Schaffer & Chu (1969); Smith & Morrison (1974); Round (1978); Harrigan *et al* (1980ab); Willis (1987); Harris & Liu (1998); Tohmo (2004); Stoeckl (2010); and Flegg & Tohmo (2011). The resulting consensus is that IO-tables constructed using location quotients produce multipliers that are systematically biased upwards. These tables tend to underestimate imports and exports and overestimate local intermediate transactions. This is primarily due to their failure to acknowledge cross-hauling (Harris & Liu, 1998). Secondly, when Type-II multipliers are used, an accurate identification of household consumption and labour income is critical for accurate multipliers (Lahr 1993, Richardson 1985).

Tohmo (2004) summarises the findings of five studies comparing multipliers derived from location quotients to survey based multipliers. These are Smith &

Morrison (1974), Harrigan *et al* (1980b), Flegg & Webber (1996) and Harris & Liu (1997) in addition to his own analysis. This reveals that it does not seem to make much difference whether the SLQ, CILC or the RLQ formulas are used. These methods produce multipliers that are on average biased upwards by 12-25%. An exception to this is the FLQ formula, which is able to recreate on average[4] the multipliers obtained from a surveyed Input-Output table. However, this depends on identifying the right adjustment parameter, which is not known *ex ante* but has to be deduced from comparison with surveyed tables *ex post*. Flegg & Tohmo (2011) discuss this issue in detail and test parameter values by simulating IO tables for 20 Finnish regions of various sizes.

The academic debate on formulating appropriate location quotients is mostly concerned with finding the most appropriate method to counter the bias of overestimating regional multipliers (Flegg *et al*, 1995, Flegg & Webber, 1997, 2000, Brand 1997). However, McCann & Dewhurst (1998) point out that in some cases, particularly where strong regional specialization occurs, traditional LQ-approaches can actually underestimate local multipliers by over-estimating interregional trade. Flegg & Webber (2000) acknowledge this point in principle but argue that based on empirical testing this does not seem to be a significant concern in practice. Furthermore, the upward bias to multipliers derived from LQ-based IO-tables does not seem to be uniform across regions or sectors. For example Harris & Liu (1998) point out that this bias is more acute for traded sectors such as manufacturing than for services.

[4] Flegg *et al* (1995, p.548) point out that even if the systematic errors are removed, inaccuracies in individual coefficients are bound to remain.

Previous research has primarily focussed on the role of trade. This is certainly important, but ex ante it can be expected that the smaller the scale of the economy being examined, the more pertinent the role of wage and consumption flows across boundaries. For example, Roberts (2005) demonstrates the relative importance of households consumption in rural economies and Hewings et al (2001) demonstrate the relative importance of these effects in their IO-table of the Chicago Metropolitan Economy.

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[5]. 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. At its centre is the City of Glasgow, which 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.

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

		GLA	RST	ROS	SCO
Population	**000's**	580,690	1,555,374	2,980,836	5,116,900

[5] 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 Dunbartonshire, 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 Police, Strathclyde Fire and Rescue Service, and the Strathclyde Partnership for Transport, which runs public transport in the region

	% 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 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 Table 2) four out of every ten jobs in the city are taken by in-commuters, primarily originating from other parts of the Strathclyde region.

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 as there are in GLA. As is evident from Table 2 the lower job density in the RST region is explained by significant out-commuting to seek employment in Glasgow (40% of all those working in Glasgow come from the rest of the Strathclyde region). Furthermore, households in RST bring significant amounts of consumer spending to GLA as we shall see in Section 4.4.1.

Table 2 Origins and destinations of people who travel between Scottish addresses for work/study (headcount/column %). Own calculations, based on Fleming (2006, Table 16A, pp. 64-65).

		Place of work							
		GLA		RST		ROS		SCO	
Residence	GLA	246,938	59%	46,677	6%	4,743	0%	**298,360**	**11%**
Residence	RST	167,322	40%	727,112	93%	16,258	1%	**910,694**	**32%**
Residence	ROS	5,961	1%	6,335	1%	1,613,211	99%	**1,625,507**	**57%**
		420,221	**100%**	**780,125**	**100%**	**1,634,212**	**100%**	**2,834,560**	**100%**

4 Construction of the Input-Output table

The Scottish Input-Output tables for 2006 are disaggregated into three sub-regions. The process is presented schematically on the next page[6]. The IO-table has *i* intermediate sectors, *q* final demand sectors and *p* primary (i.e. value added categories) sectors. The notation is as follows (small bold cases for vectors and capital bold cases for matrices):

x = i-vector of outputs

Z = i x i - matrix-of intermediate demand

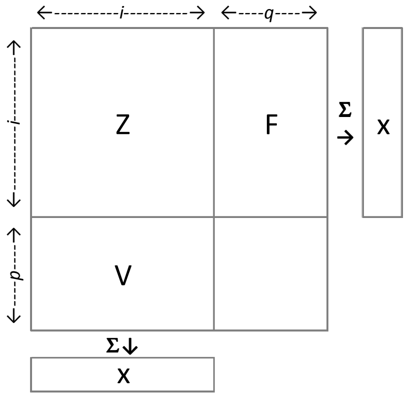
F = i x q - matrix-of final demand

V = p x i – matrix of primary costs

The superscripts indicate the spatial origin and destination of the matrix elements, with G representing Glasgow, W the rest of the Strathclyde region and S the rest of Scotland. The order follows the familiar row/column convention for matrix elements, for example the matrix $\mathbf{Z}^{\mathbf{WG}}$ contains the elements for the intermediate demand rows (origin) of the rest of Strathclyde region (W) and the intermediate expenditure column of Glasgow (G), which is the destination of the expenditures.

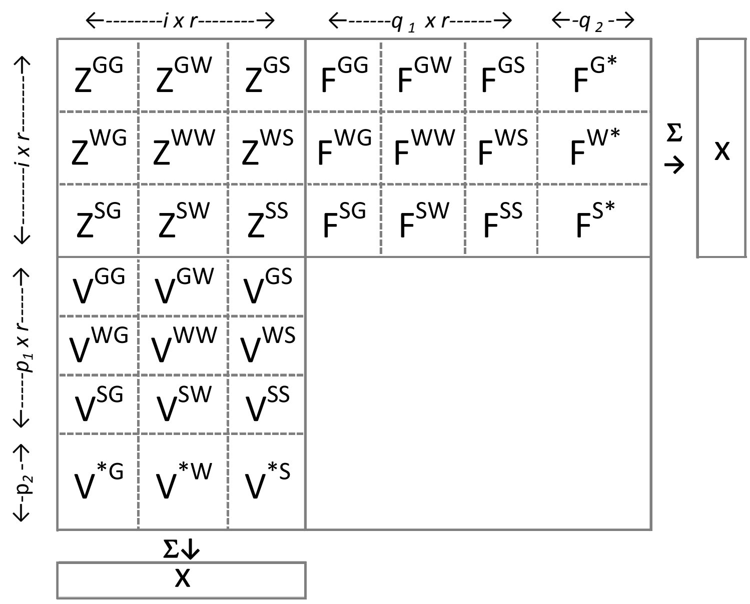
[6] The schematics are based on Oosterhaven & Stelder (2007), which provides an accessible introduction to interregional IO-models.

Figure 1 Single region IO-table for Scotland



For final demand and primary inputs the table is more complicated. The household consumption category of final demand has a region of origin and a region of destination. This q_1 category is represented by the interregional matrices $\mathbf{F}^{GG}$, $\mathbf{F}^{GW}$, $\mathbf{F}^{GS}$, $\mathbf{F}^{WG}$, $\mathbf{F}^{WW}$, $\mathbf{F}^{WS}$, $\mathbf{F}^{SG}$, $\mathbf{F}^{SW}$ and $\mathbf{F}^{SS}$. The q_2 final demand categories are not assigned a spatial origin (from within the interregional IO-accounts), e.g. government and capital formation (and export) final demand. These matrices are denoted as $\mathbf{F}^{G*}$, $\mathbf{F}^{W*}$, $\mathbf{F}^{S*}$.

Figure 2 Interregional Input-Output table for three regions (r = 3)



The disaggregation process is carried out at the most disaggregated level permitted by the Scottish IO tables (126 sectors)[7] and occurs in 4 stages:

1. Estimate sector gross output totals
2. Estimate technical 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]. The IO sectors in the Scottish IO-table refer to specific Standard Industrial Classification (SIC) categories and therefore employment levels from the ABI can be matched to each IO-sector.

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 input output table:

$$x_i^R = x_i^N \left[\frac{E_i^R}{E_i^N} \right]$$

Where x_i^R refers to output of sector *i* in region *R* and x_i^N refers to output of sector *i* in Scotland. Similarly, E_i^R and E_i^N denote employment in sector *i* in region *r* and Scotland, respectively.

[7] However, to simplify presentation sectors are aggregated subsequently.

[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.

4.2 Step 2: Technical coefficients (A-Matrices) and intermediate transactions (Z-Matrices)

The share of intermediate purchases sourced locally are estimated using FLQ's, based on δ=0.3[9]. Using this method it is possible to estimate the elements in the diagonal technical coefficient matrices, i.e. the A-matrices where the origin and destination of demand coincide with the same region ($\mathbf{A}^{\mathbf{O=D}}$). These are the: $\mathbf{A}^{\mathbf{GG}}$**,** $\mathbf{A}^{\mathbf{WW}}$**,** $\mathbf{A}^{\mathbf{SS}}$**.** This leaves the issues of estimating the off-diagonal matrices of technical coefficients, where the origin and destination of intermediate demand is not within the same region ($\mathbf{A}^{\mathbf{O\neq D}}$). In a two region setting this would be straightforward as the off-diagonal elements are a residual of the national technological coefficient less the diagonal elements. In a three region setting, however, the residual between the technical requirements of a sector i, denoted by the national technical coefficient a_{ij}^{N} and what it sources of it locally $a_{ij}^{O=D}$ has to be divided up between the two other regions 1 and 2, so that $a_{ij}^{N} - a_{ij}^{O=D} = \sum_{D=1}^{2} a_{ij}^{O\neq D}$. To disaggregate $\sum_{D=1}^{2} a_{ij}^{O\neq D}$ this residual is divided pro-rata among the two D regions based on sectoral employment shares of sector i in each of the regions so that for each region[10]:

$$a_{ij}^{O\neq D} = \left(\frac{E_i^D}{\sum_{D=1}^{2} D_i^D}\right)\sum_{D=1}^{2} a_{ij}^{O\neq D} = \left(\frac{E_i^D}{\sum_{D=1}^{2} D_i^D}\right)\left(a_{ij}^{N} - a_{ij}^{O=D}\right)$$

[9] This is chosen as the central value for δ as this is recommended by Flegg & Webber (1997) and testing by Flegg & Tohmo (2010) and Bonfiglio (2009) find the best results for intermediate transactions tend to be based on δ values clustered within an interval of 0.2-.03 and 0.25-.0.35, respectively.

[10] Another possibility would be to make strict assumptions about the spatial direction of intermediate flows based on the role of each sub-region in a regional hierarchy (see Robison 1997, Robison & Miller 1991, 1988). This approach is appropriate when analysing interdependencies between relatively simple economies, for which supply chain relationship are known. Such as for the case of rural lumber and sawmill economies, where industrial structure is dominated by few industries and supply chain relationships are transparent (Robison & Miller, 1991). However, no such obvious trade hierarchy is evident for the sub-regions considered here.

Once all the technical coefficient matrices have been derived they can be multiplied with the sectoral gross outputs estimated in section 3.3.3.1 to obtain the $\mathbf{Z}^{\mathbf{OD}}$ matrices of interregional intermediate transactions.

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

For estimating the primary inputs of industrial sectors in input matrices $\mathbf{V}^{*\mathbf{G}}$, $\mathbf{V}^{*\mathbf{W}}$ and $\mathbf{V}^{*\mathbf{S}}$ the firms in the sub-regions are assumed to have the same needs for inputs as Scottish firms in general, such that:

$$P_{ji}^{R} = P_{ji}^{N}\left[\frac{E_{i}^{R}}{R_{i}^{N}}\right]$$

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

For one category of primary inputs, the compensation of labour, the spatial origin is explicitly identified. Drawing on the commuting data presented in Table 2 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 originate, such that:

$$P_{ji}^{R} = P_{ji}^{N}\left[\frac{E_{i}^{R}}{R_{i}^{N}}\right]\left[\frac{\sum E^{RO}}{\sum E^{R}}\right]$$

where $\sum E^{RO}$ is the aggregate employment in region R by origin O and $\sum E^{R}$ is the aggregate employment in region R. 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. Where this is not possible final demand is attributed to each sub-region on a *pro rata* basis in line with the respective region's share of overall employment for the sector in question. Finally the spatial allocation of exports to the Rest of the UK (RUK) and the Rest of the World (ROW) is determined as a residual item that also balances the input-output table. A summary of these methods is provided in the table below.

Table 3 Overview of disaggregation approaches by final demand category.

	Total value £m	% of total final demand	Disaggregation method	Data source
Final consumption expenditure				
Households	36,002	28.2%	Secondary data	ONS GDHI
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

Households in the sub-regions are taken to exhibit the same sectoral consumption pattern as households in Scotland as a whole. However, working within an interregional framework it is necessary to determine not only the level of household demand, but also its spatial origins and destinations. To achieve this two different data sources are used to proxy household final demand by origin and destination. The first step is to use employment shares to spatially disaggregate household demand in Scotland, such that:

$$HFD(D)_i^R = HFD_i^N \left[\frac{E_i^R}{E_i^N}\right]$$

where $HFD(D)_i^R$ is Household Final Demand by destination for sector *i* in region *R*, HFD_i^N is the Household Final Demand for sector *i* in Scotland as a whole (*N*), 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*).

Aggregate household demand by origin is proxied using data on Gross Domestic Household Income (GDHI) by NUTS3 sub-regions published by the ONS (ONS, n.d. b):

$$HFD(O)_i^R = HFD_i^N \left[\frac{GDHI^R}{GDHI^N}\right]$$

where $HFD(O)_i^R$ represents Household Final Demand by origin for sector *i* in region *R* and HFD_i^N is the Household Final Demand in Scotland as a whole (*N*). $GDHI^R$ and $GDHI^N$ represent GDHI in region *R* and in Scotland as a whole (*N*).

If assuming no interregional flow of household demand, either of the disaggregation approaches introduced above could have been used directly. Under such an approach only the matrices on the diagonal would be used for household demand, i.e. $\mathbf{F}^{\mathbf{GG}}$, $\mathbf{F}^{\mathbf{WW}}$ and $\mathbf{F}^{\mathbf{SS}}$. However, to estimate to what extent household demand flows between the sub-regions the two estimates HFD(D) and HFD(O) are used as control totals for the matrix of interregional household final demand. The sum of each column $\mathbf{F}^{\mathbf{*R}}$ equals the sum of HFD(D) for each sector *i* of a particular sub-region and the sum of each row $\mathbf{F}^{\mathbf{R*}}$ equals the sum of HFD(O) for each sector *i* in sub-region *r.*

The next step is to arrange the elements in the interregional household final demand matrix so as to conform to these control totals. To determine the amount of interregional flow of household demand for each sector *i* in each region *R* I subtract HFD(O) from HFD(D):

$$IHFD_i^R = HFD(D)_i^R - HFD(O)_i^R$$

Determining the interregional flow of household demand between the three regions for each sector is straightforward, as there are either two regions of origin but only one destination or only one origin and two destinations. This approach estimates the net-flow of household consumption between regions. As information about cross-hauling of household consumption is not available local Type-II multipliers are likely to be somewhat overstated and conversely interregional spill over effects understated. However, accounting for the net-flows is a significant improvement over not assuming any interregional consumption flows.

Table 4 Household final demand in Scotland. Origin and destination by sub-region.

	HHFD estimated from GDHI data (HFD(O))		HHFD from employment share (HHFD(D))		HHFD from (to) other regions	
GLA	3,820.4	10.4%	7,158.2	19.5%	3,337.9	9.1%
RST	11,092.8	30.2%	7,674.6	20.9%	-3,418.1	-9.3%
ROS	21,851.3	59.4%	21,931.6	59.7%	80.2	0.2%
Total (SCO)	**36,764.5**	**100%**	**36,764.5**	**100%**	**0.0**	**0%**

Table 4 shows this calculation for each region on aggregate. This reveals that Glasgow is a net-exporter of goods and services that satisfy household final demand in the rest of the Strathclyde, while the rest of Scotland is largely self-contained. In fact, almost a third of household final demand in the rest of

Strathclyde gets spent in Glasgow, suggesting strong spill-over effects in terms of Type-II multipliers.

4.4.2 Government demand

The disaggregation of government final demand by sub-region draws on regional government accounts (Hillis, 1998) and public sector employment by sub-region to construct weights, which in turn are used to disaggregate the local and central government final demand columns from the Scottish IO-table[11].

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%
SCO (total)	100.0%	100.0%

Table 5 reveals the breakdown of central- and local government expenditures in each of the 3 IO-regions. Local government expenditures are relatively larger in GLA and RST, whereas the converse holds for ROS where central government expenditures are a relatively larger share.

4.4.3 NPISHs, Tourist Demand and Gross Capital Formation

For the disaggregation of NPISHs (Non Profit Institutions Serving Households), Tourist Demand and the Gross Capital Formation final demand categories a simple

[11] The latest year the regional government accounts (Hillis, 1998) refer to is 1998. This was a one-off publication. Therefore it has to be 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 South Western Scotland, broken down by each IO region. Government expenditures in the other three NUTS 2 regions (North Eastern Scotland, Eastern Scotland and Highlands and Islands) are attributed directly to ROS.

approach is used. It is assume that demand for each sector is proportional to the share of Scotland-wide employment in that sector found in Glasgow, such that:

$$F_i^R = F_i^N \left[\frac{E_i^R}{E_i^N} \right]$$

where F_i^R is a final demand (of an unspecified category) for sector *i* in region *r*, F_i^N is the final demand (of the same category) for sector *i* in Scotland as a whole (*N*), 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*).

4.4.4 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 starting point in this process is determining the shares of total exports of a sector that go to the RUK and ROW. For this it is assumed that the RUK/ROW breakdown of exports at the Scottish level hold at the sub-regional level. Then 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 the previously determined weights for RUK and ROW exports for sector *i*. This concludes the disaggregation process.

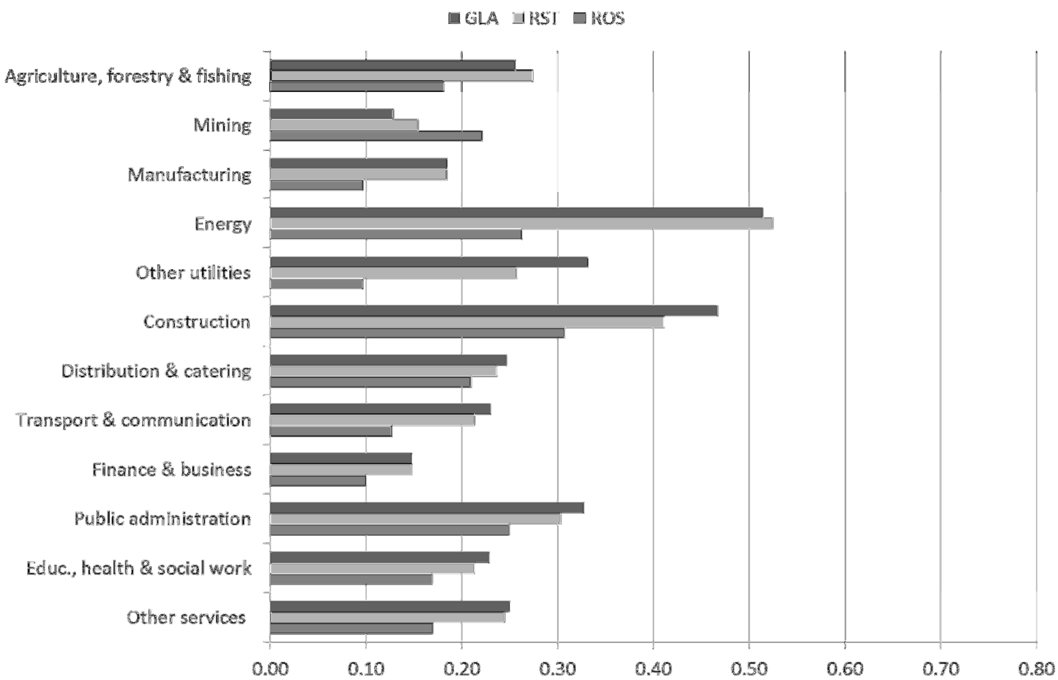
4.5 3-region IO-table

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	Knock on effects GLA	RST	ROS	SCO	Direct effect	Knock on effects GLA	RST	ROS	SCO
GLA	Agriculture, forestry & fishing	1	0.38	0.06	0.19	**1.64**	1	0.54	0.16	0.31	**2.00**
	Mining	1	0.39	0.03	0.10	**1.52**	1	0.56	0.14	0.19	**1.89**
	Manufacturing	1	0.20	0.05	0.14	**1.39**	1	0.40	0.17	0.25	**1.82**
	Energy	1	0.41	0.11	0.41	**1.93**	1	0.49	0.17	0.51	**2.17**
	Other utilities	1	0.38	0.05	0.29	**1.71**	1	0.48	0.11	0.39	**1.98**
	Construction	1	0.24	0.14	0.32	**1.71**	1	0.43	0.27	0.49	**2.19**
	Distribution & catering	1	0.08	0.07	0.18	**1.32**	1	0.32	0.23	0.33	**1.88**
	Transport & communication	1	0.24	0.07	0.16	**1.47**	1	0.47	0.22	0.30	**2.00**
	Finance & business	1	0.19	0.04	0.11	**1.34**	1	0.38	0.16	0.22	**1.76**
	Public administration	1	0.10	0.09	0.23	**1.42**	1	0.35	0.26	0.41	**2.01**
	Educ., health & social work	1	0.12	0.07	0.16	**1.35**	1	0.47	0.28	0.37	**2.12**
	Other services	1	0.29	0.07	0.18	**1.54**	1	0.52	0.22	0.33	**2.07**
RST	Agriculture, forestry & fishing	1	0.03	0.33	0.24	**1.61**	1	0.13	0.50	0.37	**2.00**
	Mining	1	0.03	0.32	0.13	**1.47**	1	0.15	0.53	0.25	**1.93**
	Manufacturing	1	0.03	0.24	0.16	**1.43**	1	0.14	0.45	0.28	**1.87**
	Energy	1	0.11	0.40	0.41	**1.93**	1	0.17	0.49	0.52	**2.18**
	Other utilities	1	0.04	0.45	0.22	**1.70**	1	0.11	0.57	0.32	**1.99**
	Construction	1	0.07	0.30	0.34	**1.71**	1	0.20	0.50	0.51	**2.21**
	Distribution & catering	1	0.05	0.09	0.19	**1.33**	1	0.20	0.36	0.35	**1.92**
	Transport & communication	1	0.04	0.28	0.17	**1.50**	1	0.19	0.54	0.32	**2.05**
	Finance & business	1	0.04	0.19	0.11	**1.34**	1	0.17	0.42	0.24	**1.83**
	Public administration	1	0.07	0.12	0.23	**1.42**	1	0.23	0.39	0.41	**2.04**
	Educ., health & social work	1	0.05	0.15	0.17	**1.36**	1	0.26	0.53	0.39	**2.18**
	Other services	1	0.06	0.28	0.19	**1.52**	1	0.20	0.54	0.35	**2.09**
ROS	Agriculture, forestry & fishing	1	0.04	0.14	0.42	**1.60**	1	0.09	0.20	0.71	**2.00**
	Mining	1	0.10	0.12	0.31	**1.53**	1	0.16	0.19	0.65	**1.99**
	Manufacturing	1	0.03	0.06	0.44	**1.53**	1	0.08	0.11	0.76	**1.95**
	Energy	1	0.13	0.13	0.66	**1.92**	1	0.17	0.17	0.84	**2.18**
	Other utilities	1	0.04	0.05	0.62	**1.72**	1	0.08	0.09	0.84	**2.01**
	Construction	1	0.10	0.20	0.40	**1.70**	1	0.17	0.28	0.75	**2.21**
	Distribution & catering	1	0.08	0.13	0.11	**1.32**	1	0.16	0.20	0.55	**1.91**
	Transport & communication	1	0.05	0.08	0.34	**1.46**	1	0.11	0.15	0.77	**2.03**
	Finance & business	1	0.05	0.05	0.27	**1.37**	1	0.10	0.10	0.63	**1.84**
	Public administration	1	0.11	0.14	0.17	**1.42**	1	0.19	0.22	0.63	**2.04**
	Educ., health & social work	1	0.07	0.10	0.18	**1.35**	1	0.16	0.20	0.82	**2.18**
	Other services	1	0.07	0.10	0.38	**1.55**	1	0.14	0.17	0.81	**2.12**

The interregional Type-I and Type-II multipliers are shown in a disaggregated format in Table 6, revealing the direct effect upon the host region and the knock on effects for each of the 3-regions[12] and Scotland as a whole. For example, for Public Administration in Glasgow the total Scotland-wide Type-II output multiplier is 2.01. This is composed of the direct effect upon the host region GLA (1) in addition to knock impacts upon GLA (0.35), RST (0.26) and ROS (0.41). 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. A graphical exposition of this point is provided in Figure 3.

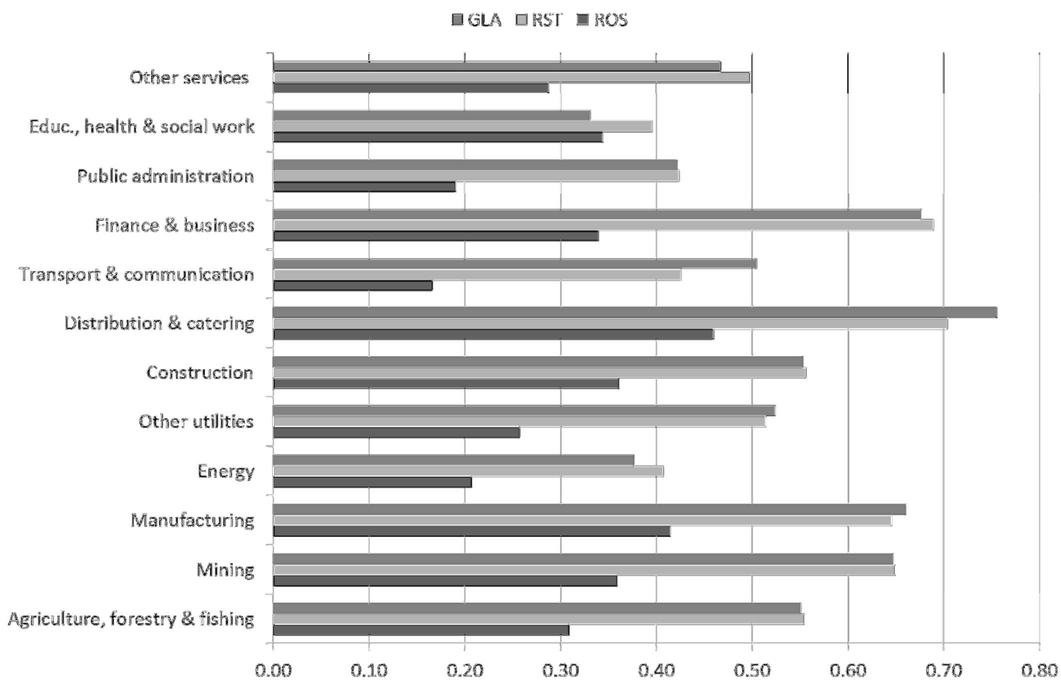
Figure 3 knock-on effects that spill over to other regions by sector and host-region.



12 For ease of exposition the sectors were aggregated from 126 to 12 for each sub-region, after the spatial disaggregation had been carried out.

When incorporating induced effects, using the Type-II multipliers, a greater degree of interregional interdependency is revealed. Figure 4 is identical to Figure 3 and drawn in the same scale to facilitate comparison This reveals the increase in interregional spill-overs of knock-on effects, once induced effects are accounted for in addition to indirect effects. Again, the individual sub-regions differ in the extent to which host-region demand stimuli spill over to the other regions. In this regards GLA and RST are clearly more open than the larger ROS.

Figure 4 Type-II knock-on effects that spill over to other regions by sector and host-region.



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 influence the nature of induced impacts.

5.1 Intermediate transactions

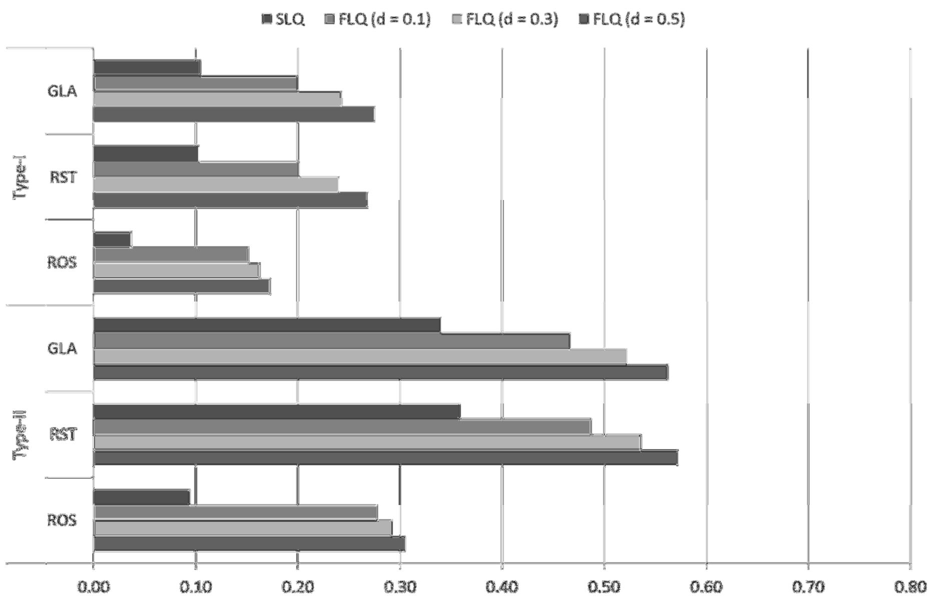
The IO-table is estimated using alternative LQs. The FLQ formula is used under a range of δ parameters and compared to a version of the IO-table estimated using SLQs. Three parameter values are chosen. To simplify the presentation of results the industrial sectors are aggregated into 1 sector for each region. These are presented in Table 7. Which shows these aggregate multipliers broken down into their constituent components: direct effect, local knock-on effect and interregional knock-on effect.

Table 7 Spatial decomposition of aggregate multipliers by sub-region

		Type I			Type II		
		Direct	Local	Inter-regional	Direct	Local	Inter-regional
GLA	**SLQ**	1	0.33	0.10	1	0.59	0.34
	FLQ (d = 0.1)	1	0.24	0.20	1	0.47	0.47
	FLQ (d = 0.3)	1	0.19	0.24	1	0.41	0.52
	FLQ (d = 0.5)	1	0.16	0.28	1	0.37	0.56
RST	**SLQ**	1	0.35	0.10	1	0.64	0.36
	FLQ (d = 0.1)	1	0.25	0.20	1	0.51	0.49
	FLQ (d = 0.3)	1	0.22	0.24	1	0.46	0.54
	FLQ (d = 0.5)	1	0.19	0.27	1	0.43	0.57
ROS	**SLQ**	1	0.44	0.04	1	0.92	0.09
	FLQ (d = 0.1)	1	0.32	0.15	1	0.72	0.28
	FLQ (d = 0.3)	1	0.31	0.16	1	0.71	0.29
	FLQ (d = 0.5)	1	0.30	0.17	1	0.70	0.31

A graphical summary of these results is presented Figure 5 below. The horizontal bars identify the interregional component of the multiplier of the aggregate sector in each region, based on estimates using alternative LQ specifications. 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 (δ=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 vary the outcome, but this sensitivity is much less distinct than the initial choice between SLQ and FLQ. Furthermore, there is a clear qualitative distinction between results obtained in the smaller more open sub-regions of GLA and RST, vis-á-vis the larger and more self-contained ROS. In the latter case spill-over effects are much less distinct, 16p in the pound for the baseline assumptions, but only 4p based on SLQs.

Figure 5 Knock-on impacts that spill over across sub-regional boundaries under alternative LQ-formulas.



As expected, the Type-II multipliers reveal larger spill-over effects. For example, based on the base case assumption a £1 of final demand stimulus in Glasgow will result in 52p of knock-on impacts in the other two sub-regions. Again, these spill-over effects are much stronger for the smaller sub-regions.

5.2 Household incomes and expenditures

As is detailed in section 4.3 and 4.4.1 this paper adopts a simple method to allow for interregional flows of wages and consumption. For comparison the table was re-estimated using a typical LQ-type approach, where all employment is assumed to be local and all household consumption is assumed to occur locally. The results indicate that allowing for these drivers of spill-over effects, is important when looking at smaller geographical units. Figure 6 reveals that under 'origin-destination' assumptions for wages and consumption each £1 of final demand stimulus in GLA and RST leads to spill-over effects of 52 and 54p respectively. Whereas, under the 'standard' assumptions, these spill-over impacts would be reduced to 42p and 39p respectively. However, for the larger ROS the specification of the income and expenditures of the household sector is not important.

Figure 6 Comparison of the interregional knock-on impacts of aggregate sectors, based on a 'standard' treatment of household incomes/expenditures and an origin-destination specification.

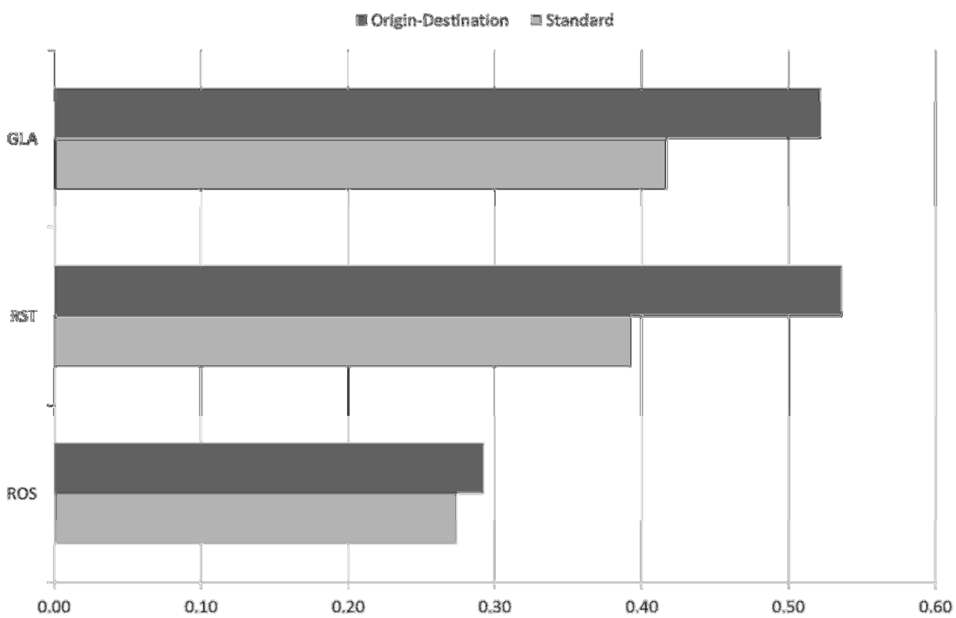
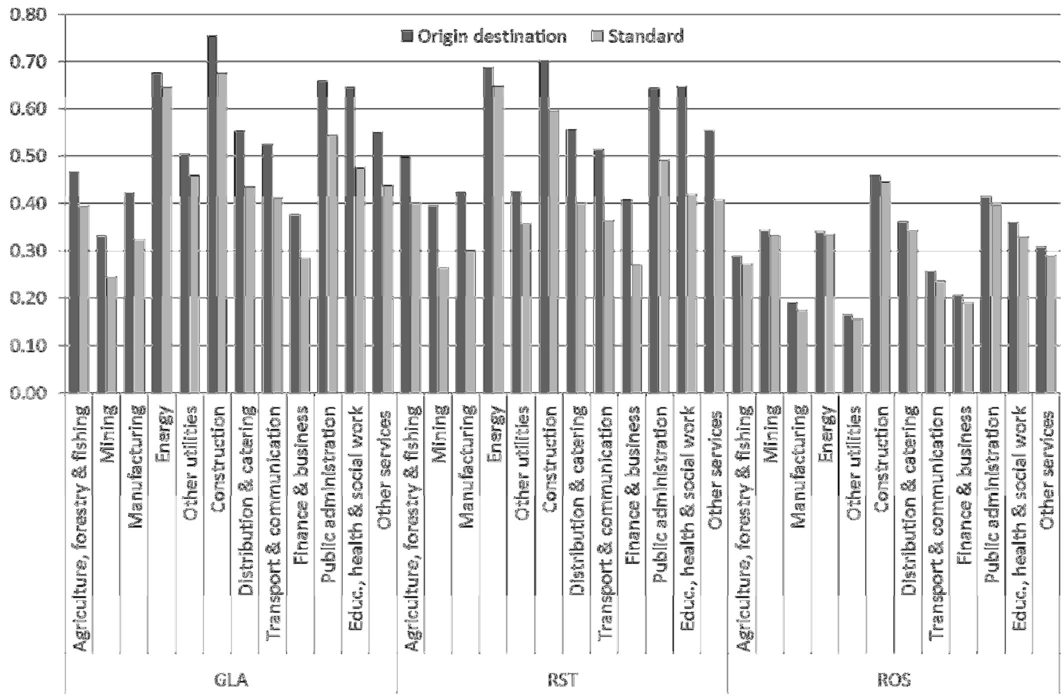


Figure 7 Presents the same comparison disaggregated to 12 sectors in each sub-region. This suggests that an accurate treatment of the household is most important for those sectors that are most labour intensive.

Figure 7 Comparison between the interregional component of the multiplier based on a 'standard' treatment of household incomes-expenditures and an origin-destination treatment acknowledging interregional commuter and consumption flows.



6 Conclusions

This paper explores the sensitivity of multipliers to assumptions adopted when constructing local Input-Output tables using non-survey methods. The official Scottish IO-table is spatially disaggregated 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. Once the base case has been established sensitivity analysis is conducted around two dimensions: the specification of intermediate inputs and the flow of wages and household consumption. The analysis supports existing finding in the literature that accurate estimation of intermediate trade is important if multipliers are not to be overstated. However, it further argues that researchers need also to think about accurate estimation of wage and consumption flows if Type-II multipliers are not to be overstated (and spill over effects underestimated when working a multi-region context). This is particularly important when working at smaller scales where commuting and shopping trips occur beyond the study area. Glasgow exemplifies this situation with 40% of jobs taken by in-commuters and conversely, about a quarter of all household consumption in its wider city-region is spent within the city. However, these concerns are not urgent when looking at larger geographical areas, such as is exemplified by results for the rest of Scotland.

The results clearly 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 highly desirable to verify them through empirical testing. However, this is not possible for the case of Glasgow, 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.

The interregional IO table features a simple mechanism that utilises secondary data to capture wage and consumption flows over regional boundaries. This is a significant improvement over conventional approaches but still suffers weaknesses, 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. A possible solution might be making use of data on card payments, which are stored in great detail, and occasionally made accessible to academic researchers.

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