Multiregional Input-Output Tables for Swedish Regions - today and tomorrow

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Abstract

In this article we describe an ongoing project at Statistics Sweden to develop a model for constructing multiregional input-output tables (MRIOTs) for Sweden. A prototype set of MRIOTs for 2018 has been constructed, which consists of 21 counties times 446 products, making up a table of 9366 x 9366 elements. The table was based on national data regionalized with the help of business surveys complemented by employment statistics, and interregional trade data. In the next phase micro data from Statistics Sweden and Government agencies as the Swedish Transport Administration will be used to construct a bottom up MRIOT.

The current project has also involved some novel analyses using the tables ranging from multilevel multiplier calculations to computations of value-added chains, and interregional freight and service trade. We have also constructed an environmental input-output model generating consumption-based GHG emissions per consuming county, i.e., carbon footprints for each county. This input-output model was coupled with data from the global MRIO database EXIOBASE to include imported emissions due to final consumption in Swedish counties.

Summary

This report on the validation, quality assurance, demonstration, and applications of the new MRIO-tables of Statistics Sweden was produced as part of Swedish development work to use interregional IO-tables for research, policy assessment, and planning. The work constitutes an increase in the level of ambition regarding the production of knowledge support concerning linkages among Swedish regional economies, and internationally, through trade in goods and services.

Questions on what policies will be effective to further develop Sweden's competitive edge, and to promote Swedish efforts to stall climate change in an ever more specialized international economy are at the center of the report. It was for long considered infeasible to address these questions with the help of interregional input-output analysis. The report shows that such an increase in the level of ambition is both motivated and possible, especially in Sweden with its well-developed economic statistics, and its acceptance that public policy should be evaluated using scientifically sound, and evidence-based methods.

The report also includes a couple of applications of the MRIO tables produced, among them estimates of consumption-based emissions per county in Sweden. This kind of data at a regional level has seen a rising demand the latest years from county boards as well as from municipalities, where the purpose is to inform regional and local environmental policy in order to decrease the carbon footprint at a regional and local level and being able to measure and follow up the development of these emissions.

A main result of the report is that there is reason to continue and further develop the development work on interregional input-output tables presented by Statistics Sweden. For this effort to be successful, it is necessary to add further resources for the collection of statistics, the development of quality-assured statistical products, and the demonstration of the strengths and weaknesses of these methods in relation to current practice.

A fundamental problem identified in the ongoing MRIO-project within Statistics Sweden, is that the regional level is subordinate to the national level as concerns the collection of statistics, and the establishment of economic accounts. National accounts are based on micro data without utilizing the geographic information contained in micro data. After that, the regional accounts are set up using top-down methods of various kinds.

It is shown that this may lead to consistency problems for both internal deliveries in the production system, and for final demand. Private consumption is taken as an example. The treatment of trade and transport margins is given as another example.

It is pointed out that additional synergies can be achieved through a further cooperation between ongoing development work in the government agencies[1], as to a coordination of collection of primary data for commodity trade and exports. These integration issues can be developed further in the third phase of the MRIO project.

It is also shown that the next phase of the Statistics Sweden project will benefit from focusing on linking the Swedish regional and national accounts with the international work on consolidated input-output analysis for groups of countries. It is noted that the Swedish accounts earlier have been subject to adjustments, for instance, within the OECD for them to work in analyzing global value chains, and global climate policies. Now adjustments have been made and it is within reach to make Sweden a role model when it comes to evaluating international and interregional policies within the same consolidated framework.

[1] Swedish Agency for Growth Policy Analysis, The Swedish Agency for Economic and Regional Growth, Transport Analysis and the Swedish Transport Administration

1. Introduction

This is a research report in connection with the project validation, quality assurance and demonstration of Statistics Sweden's MRIO tables, see also Berglund et al. (2021). The project has a long-standing background since the early 1970s when IO analysis was part of the methodology of the Swedish Long-Term Economic Assessment and in connected regional economic analysis. During this period, the first regular delivery surveys were carried out.

However, for many years long-term structural analyses with IO analysis were reduced in importance as it was considered that computing power formed an excessive task in trying to validate multiregional IO analyses using survey methodology. The growth of computing power and the expansion of the Internet have shown that this was a hasty conclusion. Now the knowledge of both goods and services trade ends up with the large network-based companies. Flow relationships needed to understand structural change become trade secrets that are not even in OECD reporting, see for example OECD (2013).

At the same time, studies increasingly confirm that interregional trade in goods and services within a country generally exceeds international trade. A large part of this trade relates to inputs and services that are further refined in another region, as shown, for example, in a previous study by Falck & Nordström (2016).

IO-analyses have for decades been a central area of regional science, but also an area where a big breakthrough has been awaited. The reason, of course, is the lack of data at such a detailed level that the analyses can become relevant to the understanding of an economy marked by an increasing specialization. Analyses based on aggregated data produce results at an aggregated level, while the detailed relationships are made invisible.

In contemporary MRIO models, interregional links can be treated differently and apply to different variables. It is common to distinguish between flows of factors of production such as labour and capital and flows of goods and services in production processes. We have reviewed how interregional trade is handled in some internationally renowned MRIO models. The review shows that this part of MRIO models is still a bottleneck. The large-scale development work done by Manfred Lenzen and his colleagues across Australia has focused on formal methods. A central concept is parent models, which involves collecting microdata from different sources in cloud-based systems according to standardized formats. From this parent model, daughter models are constructed by aggregation of data in different applications.

The Danish LINE model deals with interregional trade in a way that is partly equivalent to what is built up in Statistics Sweden's MRIO model, see Madsen & Jensen-Butler (2002). They propose that trade flows should be estimated with constraints on supply and demand in different regions with a gravitational approach based on distance and transport costs. The problem is that their approaches are not validated empirically. It can be noted that the Danish LINE model in many respects shares features with the Swedish Raps system.

One of the most well-developed MRIOT models has been built up by Geoffrey Hewings and his research team at the University of Urbana-Champaign, see for example Hewings et al (2017). Their system also does not have a clearly developed methodology for estimating interregional trade flows. Applications are built up with location quotients of different kinds and they spend much effort in linking trade to general equilibrium models.

One sophisticated model what was outlined by Boyce (2002) linking interregional input-output models and analysis of flows in multimodal transport networks. In the Swedish context, his model has features reminiscent to the work done by Erlander (1981) and Eriksson (1980). Their models use a combination of transportation costs and entropy metrics to estimate trade flows by transforming them into large-scale optimization problems.

From this review of international research, we can conclude that there has been a number of sophisticated modelling efforts but few of these focused on carefully validated empirical data in interregional trade.

It is against this background that one should see the current development project at Statistics Sweden and the present research report. The overall and long-term goal of the study is to promote a discussion about the importance of regional trade and value chains in Sweden at regional and national level using large-scale empirical estimations of MRIO tables.

Chapter 2 presents the ongoing MRIO project and discusses the quality of the MRIO project in terms of both process and method. The report conducts an initial discussion on the quality of the tables with a particular focus on interregional and international trade, private consumption, and the relationship between national and regional accounting data.

Chapter 3 is devoted to demonstrations of the content of the new MRIO tables in terms of interregional trade, Leontief multipliers and global value chains.

Chapter 4 discusses the application and applications of the MRIO tables. A discussion is held on how the new MRIO tables can contribute to new model approaches for regional scenarios and forecasts. An application to production-based versus consumption-based emissions at regional level in Sweden is also provided.

Chapter 5 contains conclusions and proposals for further work. One conclusion is that MRIO models with an explicit treatment of interregional trade are needed in a consolidated system in order to be able to examine measures in energy, environmental and climate policy.

2. Statistics Sweden's multiregional input-output tables

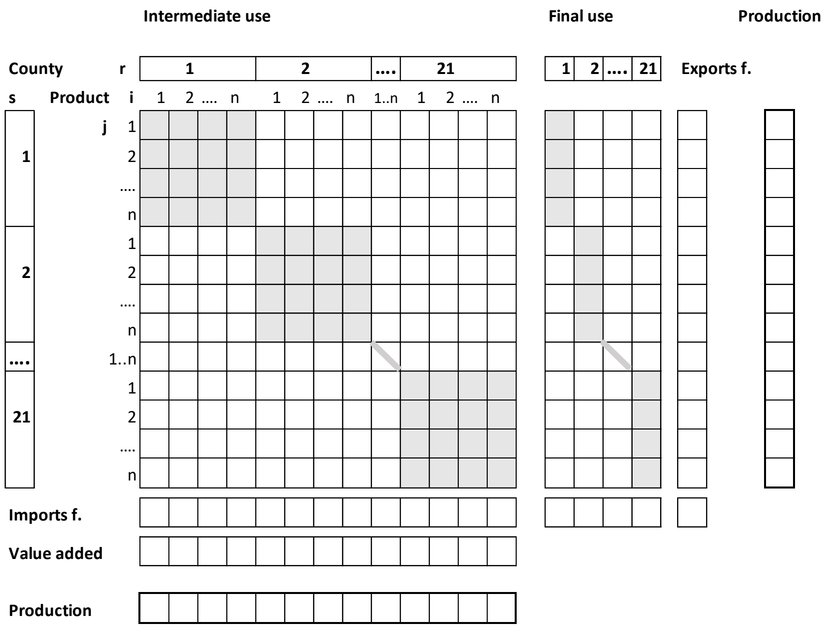
Statistics Sweden's (SCB) multiregional input-output tables (MRIOT) of counties in Sweden have been developed in phase two of a project that includes three phases. In Phase 1 (2018-2019), a model from the University of Sydney (Sydney model) was tested with open data. The development work in phase 2 (2020–2022) has not proceeded with the Sydney model, but the project has been carried out entirely within Statistics Sweden. At present MRIOT have been developed for year 2018, and tables for the years 2008-2017 are planned. After phase 3, Statistics Sweden will publish MRIOT on an annual basis.[2]

2.1 Structure of MRIO tables

The national IO tables in national accounts (NR) are produced from the supply and use tables in the annual GDP calculations. Production is estimated for about 400 products and 100 industries; household consumption is distributed for different purposes (COICOP); public consumption is distributed by sector, industry and function (COFOG), as well as investments.[3]

MRIOT for 21 counties is basically structured in the same way. Detailed MRIOT refers to more than 400 products (*n= 446)*. In the illustration of MRIOT in Figure 2.1 below, only product 1, 2 and *n* are highlighted; similarly, only three counties are marked, 1, 2 and 21; other products/counties are represented by dots. Shaded elements refer to deliveries within each county; other elements refer to deliveries to other counties and foreign exports (rows), respectively deliveries from other counties and foreign imports (columns).

Figure 2.1 Illustration of MRIOT for 21 counties and n products.



In Figure 2.1 production by product and county can be read in two ways. A row sum shows how the product is used as input in production and final use in all counties, as well as exports abroad. The column sum for the same product and county shows production cost divided into inputs from all counties and abroad as well as value added. The complete structure of MRIOT as shown in Figure 2.1 can be described by the equations below:

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[2] SCB (2019a).

[3] The published national IO tables refer to 65 products and 65 industries.

$$X_i^r = \sum_{s=1}^{21} \sum_{j=1}^{n} X_{ij}^{rs} + \sum_{s=1}^{21} \sum_{k=1}^{8} X_{ik}^{rs} + X_i^{rEx} \quad (1)$$

$$X_j^r = \sum_{s=1}^{21} \sum_{i=1}^{n} X_{ij}^{sr} + X_j^{Imr} + VA_j^r \quad (2)$$

where

X_i^r	production of product i in county r (use)
X_{ij}^{rs}	supply of product i from county r as input for producing product j in county s
X_{ik}^{rs}	supply of product i from county r for final use category[4] k in county s
X_i^{rEx}	foreign exports of product i from county r
X_j^r	production of product j county r (production cost)
X_j^{Imr}	foreign imports to product j in county r, $X_j^{Imr} = \sum_{i=1}^{n} X_{ij}^{Imr}$
VA_j^r	value added product j county r

The construction of MRIOT takes place in two stages. The first involves estimating supply S_i^r and use D_i^r by product and county:

$$S_i^r = X_i^r - X_i^{rEx} \quad (3)$$

$$D_i^r = \sum_{j=1}^{n} X_{ij}^r + \sum_{k=1}^{8} X_{ik}^r \quad (4)$$

where

S_i^r	supply of product in county r, i.e. production minus foreign exports
D_i^r	use of product in county r, i.e. intermediate use plus final use.

Data sources and methods for estimating the different components of supply and use are briefly described and discussed in section 2.2. When summing up to the national level supply equals use, $\sum_r S_i^r = \sum_r D_i^r$, but this balance does not apply at the county level.

In the second stage, interregional trade $\widehat{X_i^{rs}}$ is estimated. Data sources and methods are examined in section 2.3. The estimate of interregional trade is based on the assumption in the Chenery-Moses model, see also Oosterhaven & Hewings (2014), where the trade flows for product i are specified with respect to sending county r and receiving county s, while use in county s is not specified[5]. With this assumption, trade flows can be expressed with trade coefficients $\widehat{t_i^{rs}}$ indicating the proportion of the use of product in county s that comes from county r. Thus, equation (1) can be rewritten as

$$X_i^r = \sum_{s=1}^{21} \sum_{j=1}^{n} \widehat{t_i^{rs}} * X_{ij}^s + \sum_{s=1}^{21} \sum_{k=1}^{8} \widehat{t_i^{rs}} * X_{ik}^s + X_i^{rEx} \quad (5)$$

2.2 Supply, use and IO tables

2.2.1 Supply and use

The main data sources for estimating supply and use by product are the same as in NR, and we will here give a very brief account; after that the specific data sources for final use are described. For practical reasons most data sources are denoted with the Swedish acronyms.

For business, Statistics Sweden's central data sources are: Structural business statistics from Statistical Business Register (FEK), industrial goods production (IVP), industrial consumption of purchased goods (INFI), intermediate consumption of service enterprises (TFF). For the public sector the central data sources are the Financial Management Authority (ESV) and the Annual accounts for municipalities and county councils (RS).

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[4] In MRIOT, final use is divided into 8 categories.

[5] Moses (1955) admits that it is an imperfect assumption but that it is motivated by the fact "that it is impossible to implement statistically a model which applies separate trading patterns to each industry" (Moses, 1955, p. 810). This justification is still valid.

FEK contains detailed industry statistics for production, intermediate consumption and value added, among other things. For industries in mineral extraction and manufacturing, FEK is supplemented by statistics from IVP and INFI to allocate production and intermediate consumption respectively to products. Similarly, TFF is used for the service enterprises.

The detailed industry statistics are available for kind-of-activity units (KAU) within enterprises. These statistics are allocated to local units within a KAU by the share of the number of employees. The statistics for the local units are summarized to regional level, i.e. county.

Turning to the estimation of final use, in MRIOT it is divided into 8 categories: Household consumption, consumption by private non-profit organizations, public consumption, investments in the business sector, investments in the public sector, stocks, valuables and exports. Here we exclude non-profit organizations, stocks and valuables from the description.

Household consumption: NR's calculations are extensively documented in SCB (2019b) and SCB (2018). The calculations of household consumption are made partly for individual purposes separately and partly through a household consumption matrix (HCM). In total, HCM consists of 72 industry groups, and is based on the industry surveys in the business sector, with sales by detailed product group, which is carried out annually within the framework of FEK. This survey gives a complete picture of how sales are distributed among products in different industries in the business sector. Sales are also divided by customer category, which provides information about how much relates to sales to households.

Regarding the distribution by county, the following applies. With data for regional turnover statistics by industry, HCM (industry x product) is used for all regions. Regional turnover statistics are based on VAT data on legal units, which are distributed to establishments using the number of employees per establishment. The turnover is then summed up by county and the 72 industry groups that exist in HCM. Thereafter, a summary is made per COICOP group (the official classification of household consumption expenditure). HCM consists of 108 COICOP groups; household consumption will be calculated for a total of 151 different COICOP groups.

For groups not covered by the HCM, regional consumption is estimated with other sources. For example, *housing consumption* is estimated with data for the housing stock by county, divided into single-family houses and apartment buildings, and statistics, at the national level, on rent per square meter in apartment buildings. This data is used to estimate a value in use for single-family houses and apartment buildings per county that is consistent with the national data for each COICOP group. For holiday homes, the national data for consumption, i.e. the value in use of holiday homes, is distributed using data on the number of holiday homes per county.

Public consumption: Public consumption is estimated in the same way as in NR. The statistics from RS are specified by municipality or county. The statistics from ESV are distributed by county using, for example, regional statistics on wage sums for state authorities.[6]

Investments: Data on gross fixed capital formation for business and public authorities at the regional level is available in the regional accounts, which are official statistics linked to national accounts, NR. Data sources are FEK, Investment Surveys, RS and others.

Exports and imports: The statistics on Sweden's *foreign trade in goods* (UHV) are based on data collected by Statistics Sweden and The Swedish Customs. Data for trade with countries within EU are collected via VAT returns (Intrastat); data for non-EU countries comes from The Swedish Customs via the companies' import and export declarations (Extrastat). Foreign trade in goods reports statistics after border crossing. The regional distribution of UHV is made stepwise. In brief, data for entry, exit and commodity codes in UHV is first linked to FEK by organization number. In the second step the collected value is distributed in proportion to the number of employees in local units within a KAU.

[6] See SCB (2019b).

The statistics on Sweden's *foreign trade in services* (UHT) are based on a survey that Statistics Sweden conducts on behalf of the Riksbank, the Swedish central bank. It is a sample survey with the aim of making estimates of Sweden's UHT, distributed among other things across different service types. Selection objects, which are simultaneously data sources, are active companies that can be found in FEK. The UHT estimate base also includes transaction data that is not collected via selection. As with UHV, the distribution by county and industry is made proportional to the proportion of employees in local units.

2.2.2 IO-tables

Above we have given a brief account of data sources and methods to get the elements according to equation (3) and (4). The next two steps are compiling supply-use tables by county (SUT) and converting SUT to IO-tables by county (IOT).

SUT are defined product-by-industry. The supply table indicates by county how the production of n products is distributed among J industries, about 100 industries. The supply table is valued at basic prices. The use table indicates by county how the use of n products is divided into J industries and k categories of final use. The use table is valued at purchasers' prices, thus including trade and transport margins and taxes on products minus subsidies. The use includes imported products.

To compile SUT per product, use is valued at basic prices by excluding trade and transport margins and product taxes minus subsidies. Furthermore, the use of imported products is brought to separate tables. The resulting SUT are adjusted so that, when summarizing all counties, they are balanced and consistent with the tables at national level.

When converting SUT to IOT, either product-by-product or industry-by-industry tables can be created. For the regional IOT in MRIOT, product-by-product tables are applied, where all industry variables are converted to product.

2.2.3 Discussion

This section discusses possible improvements with respect to two main issues: Converting SUT to IOT and estimating household consumption.

First, about converting SUT to IOT, the IOT in MRIOT, product-by-product, is based on the so-called *industry technology assumption*, which means that each industry in each county has its own specific input structure regardless of the product mix. At the national level, Statistics Sweden also produces IOT industry-by-industry, based on the *assumption of fixed product sales structure*, which means that each product has its own specific sales structure regardless of which industry has produced the product. According to official manuals[7], these alternative assumptions represent model B and model D out of four basic models, A-D, for constructing IOT product-by-product and industry-by-industry, respectively. Essential parts of the discussion in the manuals are based on Thage (2005), former head of Denmark's national accounts, and here we reproduce the summary:

"In this paper it is argued that any type of SIOT <symmetric IOT> that can be compiled in practice depends heavily on industry related flows in the sense that the institutional characteristics of the industries are the main determinants of the data in the SIOT. In practice all input-output tables are deemed to be of the inter-industry type. On this background it is further argued that the compilation of SIOTs as industry-by-industry tables based on the assumption of fixed product sales structures (in the SNA terminology "industry technology") should be preferred. This type of table is not an approximation to a more ideal table but exists in its own right as part of "best practices" official statistics, fulfilling central quality criteria, including user needs."

[7] Eurostat (2008), United Nations (2018)

Thage (2005) is also a central reference for Yamano and Ahmad (2006), as to the reasons for Model D being used in the OECD database. Model D has long been used in Canada, Denmark, Finland, the Netherlands, Norway and the United States. In Sweden, work to develop IOT by Model D has resumed relatively recently. For many years, only IOT product-by-product have been developed, Model B.

Model D is based on fixed sales shares from *observed*[8] data, i.e., the industry's share of the total production of each product. The only assumption is that the purchase of a product from supplying industries is made in proportion to how the total production of the product is distributed. For example, if an industry *I* accounts for, say, 70 percent of the production of a specific product, then 70 percent of all purchases of that product are made from industry *I*, regardless of the purchases are for intermediate or final use. This assumption is a parallel to the assumption in the Chenery-Moses model, see section 2.1, where the trade coefficients indicate the percentage of the use of a product in county that comes from county *r*, regardless of use.

Thus, IOT in MRIOT could be improved by replacing product-by-product (Model B) by industry-by-industry (Model D). A disadvantage is that interregional trade is estimated at the product level. However, we believe that this inconsistency is outweighed by Model D providing a safer basis than Model B for estimating IOT. When estimating interregional trade flows by product, supply and use by industry can be assumed to relate to primary products.

The second main issue is concerning the estimation of household consumption in MRIOT, an issue of major importance for the quality of MRIOT, as this item accounts for almost half of total final use.

As for housing expenditures, the current estimates could be improved by taking the regional variation in rents into account. At present the estimated total housing expenditures per capita are lowest in the metropolitan county Stockholm and highest in the northern and rural county Jämtland. What contributes to this unreasonable result is the estimates of expenditures for secondary homes. These estimates are based on the county where secondary homes are located, and not the county of residence for the owners of secondary homes, which is aimed at. This brings us to a general problem when using regional turnover statistics for estimating regional household consumption. This data reflects where consumption takes place by county, and not consumption by county residents, which is aimed at. Previously, Statistics Sweden has produced estimates based on surveys on household expenditures. Such surveys are no longer used, as the quality of data is insufficient for the purpose of estimating the consumption of county residents. Obviously, regional turnover statistics cannot be used as a proper alternative.

We propose another approach where the estimation of the counties' total household consumption is based on a consumption function. There is extensive research and literature on how such functions should be specified and calculated. A specification of great interest is presented in National Institute of Economic Research (2017), where national household consumption depends on disposable income, real and financial wealth, the Gini coefficient and the age structure of the population. This general consumption function has been estimated with quarterly data for the period 1996:2-2017:1. All parameters are statistically significantly different from zero, which as the National Institute of Economic Research writes, gives an indication of which factors, in addition to the commonly used ones, affect household consumption. There are good conditions for adapting this function to estimate household consumption at regional level. For all variables, there are time series statistics by county. The question of the appropriate method for such adaptation remains to be analyzed.

The household consumption by product can be based on the adjusted distribution according to the data of regional turnover statistics. Adjustments are needed since the budget share of a product in county's turnover cannot be assumed to be completely proportional to the budget

[8] In contrast, Model B is based on input structure assumptions that cannot be substantiated by observed statistical data.

share for the county's residents. A better alternative, of course, would be a distribution based on data on revealed consumption patterns for the county's residents. For example, it seems technically possible to use data for card transactions, indicating the purchases per purpose made by cardholders in each county.[9]

2.3 Interregional trade

In section 2.2 we have described how IOT per product (i = 1...,n) and county (r = 1...,21) have been developed. This data provides the restrictions when estimating matrices for interregional trade flows by product, to get the multiregional tables, MRIOT. The sum of flows from county r must be equal to production minus exports in county r; the sum of flows to county r must be equal to the sum of use in county r, see equation (3) and (4). The matrix of interregional trade per product is estimated by balancing an à priori matrix against these restrictions.

An appropriate à priori matrix shows a trading pattern that we have knowledge of, à priori, based on observed and estimated trade flows. At a detailed level with n products there are no suitable à priori matrices. Interregional trade is therefore estimated stepwise:

1. Restrictions for product i are summed to aggregate I. At this level, à priori matrices are estimated based on observed and estimated trade flows.
2. The à priori matrices from step 1 are balanced.
3. Balanced matrices from step 2 are applied as à priori matrices when balancing matrices for products at the detailed level, $i \in I$.

When the balanced matrices in step 3 are summed up to aggregate level, the resulting matrices will be better substantiated than the balanced matrices in step 2.

2.3.1 Commodity groups

For commodity groups, à priori matrices are based on estimated consignments of goods according to the commodity flow survey 2016, VFU[10]. For the same purpose, data from VFU is used as input to the Swedish Transport Administration's modelling of freight transport[11]. VFU is a sample survey, and the estimated consignments of goods are point estimates with more or less large confidence intervals. For the time being, however, we accept this uncertainty and consider the point estimates as the best available à priori knowledge of trade flows.

However, the trade flows from VFU do not provide complete à priori matrices. VFU does not report flows in all relationships where positive trade flows ($X_I^{rs} > 0$) can be expected from restrictions on supply in county r ($X_I^r > 0$) and use in county s ($D_I^s > 0$). In these cases, the observations from VFU are supplemented by estimated flows. This supplement is currently based on information from an à priori matrix for all commodity groups.

Table 2.1 below exemplifies an à priori matrix. The table shows the pattern of trade in 2016 according to VFU, for the aggregate of all goods. It should be mentioned that the table refers to consignments of goods not only from goods-producing industries, but also from wholesale and retail trade. The matrix must be balanced to give a picture of the total trade in goods consistent with the restrictions.

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9 From what we understand, Statistics Sweden has an ongoing project with commission to develop a design that makes extensive use of alternative data sources, such as cash register and card data.
10 See https://www.trafa.se/kommunikationsvanor/varufloden/
11 See Anderstig et al (2015) and Edwards et al (2019).

Table 2.1 Origin and destination of goods shipments 2016, total for all product groups.

Tabell 10b. Avgående inrikes varusändningar 2016 fördelat på start och mål. Totalt, värde i miljoner SEK[1]
Table 10b. Outgoing domestic consignments 2016 by origin and destination. Total, value in millions SEK

Till tabellförteckning

Från län / *County of origin*	**Till län** / *County of the recipient* 01	03	04	05	06	07	08	09	10	12	13	14	17	18	19	20	21	22	23	24	25	**Totalt**	Därav inom länet (%)
01 Stockholms län	85 294	8 529	5 638	7 279	3 541	4 151	3 190	948	1 001	11 615	6 108	25 455	3 426	5 630	5 126	7 293	2 751	2 882	1 510	5 493	2 617	**199 478**	43
03 Uppsala län	9 391	3 308	443	510	393	278	552	98	84	806	595	1 324	328	654	650	1 083	799	254	178	433	219	**22 379**	15
04 Södermanlands län	6 793	427	6 223	1 847	2 011	722	409	83	128	2 137	442	5 379	2 085	4 573	1 992	811	451	415	151	688	1 646	**39 413**	16
05 Östergötlands län	5 081	1 006	2 297	13 157	2 833	614	2 461	282	388	3 915	1 058	6 934	1 196	1 761	2 804	908	1 395	904	257	461	269	**49 983**	26
06 Jönköpings län	9 679	1 315	1 833	6 495	18 335	2 520	3 246	133	1 322	8 943	4 431	17 319	1 346	3 186	2 592	1 642	1 128	1 697	1 111	1 170	948	**90 391**	20
07 Kronobergs län	8 328	485	574	3 528	3 194	3 123	2 511	94	991	2 240	1 670	3 210	417	674	632	624	436	323	198	432	507	**34 189**	9
08 Kalmar län	3 209	557	366	1 591	3 353	1 611	7 504	112	598	4 243	551	5 886	441	497	658	144	7 243	128	203	289	767	**39 952**	19
09 Gotland län	431	10	17	26	49	27	87	1 823	4	138	5	34	8	13	52	22	10	7	1	6	51	**2 820**	65
10 Blekinge län	1 736	641	101	1 112	1 513	767	905	49	4 377	3 395	714	5 631	328	520	403	606	181	16	271	68	221	**23 556**	19
12 Skåne län	25 603	3 773	2 081	6 675	5 475	5 136	3 552	339	3 867	60 374	10 625	23 878	1 705	5 083	7 728	3 647	1 940	1 365	975	1 609	976	**176 406**	34
13 Hallands län	4 975	1 467	785	1 562	2 385	1 556	1 427	48	977	7 918	10 411	13 300	686	729	1 121	1 040	894	276	237	430	127	**52 353**	20
14 Västra Götalands län	36 646	3 672	3 327	9 890	8 640	3 999	3 298	889	3 434	24 689	11 258	104 254	5 977	12 305	5 044	4 490	3 866	2 266	1 255	2 693	2 953	**254 845**	41
17 Värmlands län	1 272	276	294	792	475	241	506	5	417	669	203	2 884	6 741	2 181	903	461	454	133	98	202	395	**19 601**	34
18 Örebro län	6 275	4 744	920	1 698	1 148	1 283	504	64	210	2 964	1 013	9 537	1 864	9 076	1 758	1 614	846	465	353	995	645	**47 976**	19
19 Västmanlands län	8 526	3 207	3 256	1 738	737	1 515	271	160	344	2 146	1 284	7 464	738	2 441	10 219	3 040	1 041	765	340	2 236	319	**51 789**	20
20 Dalarnas län	5 237	435	823	1 447	1 267	389	723	6	85	2 361	653	4 883	995	4 047	2 775	7 787	3 285	1 871	1 478	4 545	1 488	**46 578**	17
21 Gävleborgs län	3 001	561	283	579	503	97	559	20	54	2 239	443	2 679	773	1 184	2 535	2 704	6 352	595	217	378	102	**25 861**	25
22 Västernorrlands län	1 081	1 020	180	630	569	265	454	11	34	1 089	375	3 422	254	1 067	262	1 007	1 582	16 217	1 669	1 151	1 328	**33 665**	48
23 Jämtlands län	412	113	17	97	491	36	28	8	16	192	36	683	25	172	141	346	616	1 027	2 890	249	52	**7 648**	38
24 Västerbottens län	2 895	461	127	442	765	61	42	2	471	5 501	108	2 648	127	76	450	554	1 846	8 617	659	13 645	6 117	**45 614**	30
25 Norrbottens län	811	64	672	51	81	33	57	4	4	471	146	937	40	213	173	7 364	176	467	107	6 992	9 741	**28 603**	34
Totalt	**226 676**	**36 073**	**30 259**	**61 147**	**57 759**	**28 423**	**32 286**	**5 178**	**18 806**	**148 044**	**52 127**	**247 741**	**29 501**	**56 083**	**48 015**	**47 187**	**37 291**	**40 692**	**14 157**	**44 166**	**31 489**	**1 293 099**	-
därav inom länet (%)	38	9	21	22	32	11	23	35	23	41	20	42	23	16	21	17	17	40	20	31	31	-	31

[1] Konfidensintervall saknas i denna tabell på grund av utrymmesskäl. Kontakta Trafikanalys om konfidensintervall önskas.

Sveriges officiella statistik

Source: VFU (2016).

Balancing is performed by a simple RAS-procedure, resulting in a matrix that preserves as far as possible the trading pattern of the initial matrix, given the restrictions on supply and demand. The theoretical basis of the RAS method can be described in several ways; for example, the solution will be the same as when applying the 'minimum information principle'.[12] The balanced matrix can be described with the core components of a traditional gravity model:

$$X^{rs} = X^r D^s d^{rs\,(\alpha^{rs})} \qquad (6)$$

where

X^{rs} = trade flow from region r to region s
X^r = supply region r
D^s = use region s
d^{rs} = distance between r and s
α^{rs} = distance parameter, calculated

As a measure of distance between r and s, we start from a measure of so-called "effective" distance:[13]

$$d^{rs} = \sum_{k\in r}\left(\frac{y^k}{y^r}\right)\sum_{l\in s}\left(\frac{y^l}{y^s}\right) d^{kl} \qquad (7)$$

where

d^{rs} road distance between county r and county s
d^{kl} road distance between municipality k and municipality l
y gross regional product (GRP)

This measure is thus a weighted average of road distances between municipalities, with the municipalities' share of GRP in each county as weights. The weighted average of the municipalities' share of the county's GRP can be assumed to give an acceptable picture of the intraregional distribution of goods consumption but gives a partly skewed picture of the intraregional distribution of goods production. For county r, GRP is therefore replaced by the value added of commodity-producing industries. In the corresponding measure for services, GRP is replaced by the value added of the service-producing industries in the business sector.

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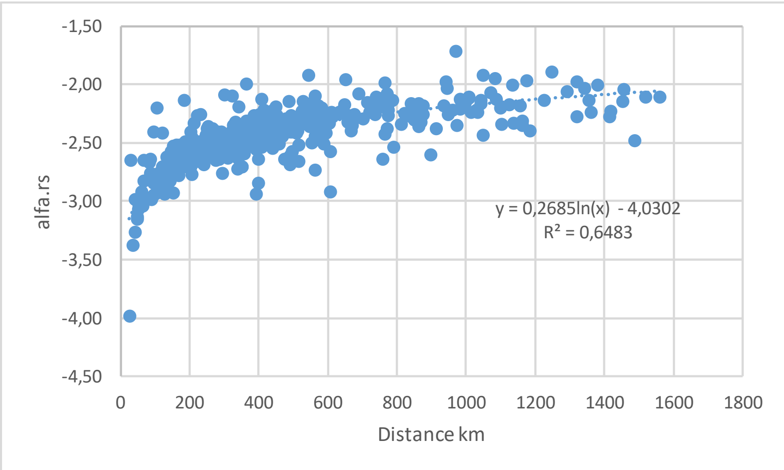
12 See for example Bacharach (1970), Snickars and Weibull (1977) and Snickars (1978).
13 See Head and Mayer (2002).

Thus, we can solve for the distance parameter α^{rs}, given supply X^r, use D^s, and distance d^{rs} that generates the trade flow X^{rs}.

$$\alpha^{rs} = \frac{\log\left(\frac{X^{rs}}{X^r D^s}\right)}{\log\left(d^{rs}\right)} \qquad (8)$$

This parameter value is lowest within each county and tends to increase with the distance between counties. If we interpret the parameter as merely an expression of the distance sensitivity, the pattern is according to expectations. Intraregional trade often refers to goods with low commodity values (KSEK per ton) and high distance sensitivity, such as gravel and stone. Conversely, trade at longer distances often refers to goods with high commodity values and low distance sensitivity, such as machinery and pharmaceuticals. The parameter does not only reflect distance sensitivity, but it also expresses the influence of *all* factors that generate the trade flow X^{rs}, given X^r, D^s and d^{rs}. The parameter values can best be interpreted as "matching indicators", i.e. how well the supply of specific goods from region *r* matches the use in region *s*, conditioned by the distance. However, we can note that the parameter value varies relatively clearly with the distance, see Figure 2.2. This illustrates what was mentioned above, that trade at longer distances tends to refer to goods with high commodity values and low distance sensitivity.

Figure 2.2 Parameter value and distance, all flows, aggregates $\boldsymbol{\alpha^{rs}}$



The à priori matrices for the aggregates of commodity groups *I* are estimated with observed flows from VFU, supplemented by estimated flows for the relationships where data from VFU are missing. The method is described in equations (9) to (11).

$\widehat{X_I^{rs}}$ = w*$X_I^{rs}[1]$ + (1-w) * $\widehat{X_I^{rs}}[2]$ (9)

Final estimated flows are weighted averages of $X_I^{rs}[1]$, which are observed flows from VFU, and $\widehat{X_I^{rs}}[2]$, which are estimated flows. For relationships *r-s* that have observed flows from VFU we estimate $\widehat{X_I^{rs}}[2]$

$$\widehat{X_I^{rs}}[2] = X_I^r D_I^s d^{rs(\alpha_I^{rs})} \qquad (10a)$$

For relationships *r-s* that lack observed flows from VFU we estimate $\widehat{X_I^{rs}}[2]$

$$\widehat{X_I^{rs}}[2] = X_I^r D_I^s d^{rs(\widehat{\alpha^{rs}})} \qquad (10b)$$

where $\widehat{\alpha^{rs}}$ is calculated using the estimated correlation in Figure 2.2.

The weights in (9) are determined (calibrated) to minimize the following error indicator *F*:

$$F_s = \sum_s |\sum_r \boldsymbol{X_I^{rs}} - \sum_r \widehat{X_I^{rs}}| / \sum_r \sum_s \boldsymbol{X_I^{rs}}$$

$$F_r = \sum_r |\sum_s \boldsymbol{X_I^{rs}} - \sum_s \widehat{X_i^{rs}}| / \sum_r \sum_s \boldsymbol{X_I^{rs}}$$

$$F = 0{,}5 * F_s + 0{,}5 * F_r \quad (11)$$

where the restrictions are marked in bold. This minimization[14] is also applied to calibrate $\widehat{X_I^{rs}}[2]$ in equation (10).

What is described above is the method for estimating à priori matrices for the 13 aggregates of commodity groups reported in Table 2.2. After RAS balancing, these matrices are used as à priori matrices when balancing the corresponding 225 matrices at the detailed commodity group level. When these are summed up to the corresponding aggregates, the resulting matrices will be better substantiated than the balanced matrices of the aggregates, as mentioned above. The reason is that for detailed commodity groups the number of theoretically possible trade flows is limited by the fact that in several counties there is no local production, see also McDougall(1999) and Anderstig et al, (2021).

2.3.2 Service groups

For service groups, the task of estimating à priori matrices is more complicated, for two reasons. The first is that we lack observed data, corresponding to VFU. The second is that trade in services is of different kinds, depending on the product/industry to which the service relates. Appropriate data and methods are therefore varying with the type of trade.[15]

An established grouping of trade in services can be found in *the General Agreement on Trade in Services (GATS),* the framework used in the WTO negotiations on the liberalization of international trade in services. According to GATS, trade in services can be divided into four categories as follows:[16]

1.	Cross-border trade	Service crossing the border between region *r* and *s* *Example: Telecommunications services*
2.	Consumption outside the region:	Households/companies in region *s* consume services in region *r* *Example: Hotel and restaurant services*
3.	Delivery outside the region:	Companies in region *r* deliver on-site service in region *s* *Example: Consulting services, Construction*
4.	Establishment of branch outside the region:	Companies in region *r* establish branch in region *s*

This classification is used to categorize interregional trade in services, except for category 4. This category is irrelevant here since production is estimated for local units, irrespective of where the parent company is located. Mixed categories are also relevant. This applies mainly to services that may belong to both category 1 and category 3, such as consultancy services that can be provided both through ICT and through on-the-spot activities.

At detailed product level, categories 1-3 comprise a total of 221 products, of which about half are in category 1, cross-border trade. For this category, we can assume that distance sensitivity is negligible. However, for categories 2 and 3, consumption and delivery outside the region, we can assume that distance sensitivity is relatively high. When estimating the à priori matrices at the aggregate level for these categories, representative products are used for each category. The estimate is carried out by calibrating the estimated relationship between the calculated parameter value α^{rs}, developed in the same way as in equation (8), and commuting distance.

For category 1, cross-border trade, the matrices are directly estimated at a detailed level. For categories 2 and 3, consumption and supply outside the region, the à priori matrix is estimated for representative products *I*.

$$\widehat{X_I^{rs}} = k_I X_I^r D_I^s d^{rs(\widehat{\alpha^{rs}})} \quad (12)$$

[14] The minimization of the error indicator is inspired by Sargento et al (2012).

[15] The definition of which products/industries included is given from NR; Services includes SPIN 33-96. In the literature, on the other hand, the distinction between goods and services is a contentious issue; see Brousolle (2014).

[16] The argument is based on Francois and Hoekman (2010).

$\widehat{X_I^{rs}}$ = estimated trade flow from region r to region s
k_I = calibration factor
X^r = supply region r
D^s = use region s
d^{rs} = distance between r and s
$\widehat{a^{rs}}$ = distance parameter, calibrated

The majority of all commuting trips take place at shorter distances than 100 km. The distance sensitivity (travel time sensitivity) of commuting trips is higher than for shopping trips, category 2, and business trips, category 3. The calibration factor k_I and calibration of $\widehat{a^{rs}}$ aim to minimize the error indicator according to equation (11).

For category 1, cross-border trade, distances and transport costs are assumed to be irrelevant. At present we do not have access to any other factors than supply and use to estimate trade flows. Thus, we can only guess what the pattern of trade looks like. If we only have information on supply and use, S_i^r , D_i^s , the statistically most likely pattern of trading is

$$\widehat{X_i^{rs}} = \frac{S_i^r * D_i^s}{\sum_r S_i^r} \qquad (13)$$

For the time being, this is the basic model for estimating trade flows for category 1.

As mentioned above, we can assume relatively high distance sensitivity for services in categories 2 and 3, consumption and delivery outside the region. In order to estimate à priori matrices at the detailed service group level for categories 2 and 3, the main principle is the same as when estimating the matrices at the detailed commodity group level. That is, the matrices at the aggregate level, RAS-balanced matrices for representative products, are used as à priori matrices in RAS balancing the corresponding 113 matrices at the detailed level.

However, for services at a detailed level within categories 2 and 3, we can assume that many services are characterized by what in literature is called "proximity burden", see, for example, Hellmanzik & Schmitz (2016), services that require proximity between producer and consumer. An obvious example of such local services is pre-school education. The operational definition of such local services is that use is very close to supply in most counties

$$1\text{-}\varepsilon < \frac{D_i^r}{S_i^r} < 1\text{+}\varepsilon \qquad (14)$$

For local services, the matrices are first balanced with restrictions on supply S_{i-}^r and use D_{i-}^r excluding the diagonal elements $\widehat{X_i^{rr}}$, i.e, $S_{i-}^r = S_i^r - \widehat{X_i^{rr}}$ and $D_{i-}^r = D_i^r - \widehat{X_i^{rr}}$ where $\widehat{X_i^{rr}} = \min\ (S_i^r, D_i^r)$. Then $\widehat{X_i^{rr}}$ is added to the diagonal elements.

2.3.3 Discussion

We will here very briefly discuss some possible improvements with respect to the à priori matrices. As for commodity groups, current à priori matrices, based on data from the commodity flow survey VFU, have two main shortcomings. First, the use of point estimates disregard large confidence intervals for reported flows.

Second, for relations where no trade flows are reported in VFU, flows are estimated by using the relationship between distance and distance parameter for the aggregate of all trade flows. This means that the variation of the distance parameter between commodity groups is neglected.

The second problem could feasibly be handled by statistical estimation of a gravity model for each commodity group I, corresponding to equation (6). For relations where observed flows are missing the estimation is based on simulated data $\hat{X}_I^{rs}$, e.g., from equation (9). The distance parameter in equation (10b), $\widehat{a^{rs}}$, is then replaced by the estimated distance parameter, specific for each commodity group.

The first problem could tentatively be handled in the following way. Start with a matrix where X_I^{rs} are the point estimates from observed flows in VFU, and $\hat{X}_I^{rs}$ are estimates according to equation (10b). Construct a search procedure by which the matrix elements are randomly adjusted in order to minimize the error indicator according to equation (11). This minimization should be weakly constrained by the 95% confidence intervals.

While trade in goods is estimated using à priori matrices based on VFU, there are no corresponding à priori matrices available for trade in services. Furthermore, while all trade in goods is associated with transport costs, the equivalent does not apply to all trade in services.

On the other hand, trade in services for groups in categories 2 and 3, consumption and delivery of services outside the region, are associated with transport costs, i.e. travel costs. In MRIOT travel cost sensitivity has been estimated in simplified terms based on an à priori matrix based on recorded commuting, which has subsequently been calibrated for representative products for each service group.

With what data could these à priori matrices be improved? One potential source of data is the national travel surveys RVU that have been conducted for several years. Unlike VFU, RVU cannot be used to estimate trading for specific product groups. However, RVU contains data for two case types that could potentially become the basis for à priori matrices for representative products, namely purchase trips for category 2, and business trips for category 3. Prior to a third phase of MRIOT, the authorities Traffic Analysis and the Swedish Transport Administration should be encouraged to thoroughly investigate if and how this potential data source can be used.

The same question as above can also be asked with regard to category 1, cross-border trade: With what data could these à priori matrices be improved? As we have described above the basic model of cross-border trade contains no factors other than supply in region r and use in region s, i.e. there is assumed to be no specific cost associated with trade in the r-s relationship. The à priori matrix is by definition balanced. In order to find alternatives to this simple basic model, it may be appropriate to first divide cross-border trade into two subcategories, transport and services trade based on ICT.

Transport, i.e. transport services, relates to freight transport and passenger transport. For freight transport, it is not so much a question of estimating an à priori matrix, but of distributing transport margins on the basis of balanced matrices for the trade in goods. It is again a task that requires close cooperation with Traffic Analysis and the Swedish Transport Administration. For passenger transport, the task is to obtain traffic data from transport operators and responsible authorities to estimate à priori matrices.

ICT-based trade in services can be divided into two categories, (a) communications services (telecommunications), (b) services that can be distributed to varying degrees on ICT-based trade and/or trade based on business travel, such as consultancy. For category (a) it should be examined whether, in the same way as for passenger transport, there is access to traffic data as a basis for an alternative to the simple basic model.

For category (b) there is no database to estimate how trade in services is distributed between ICT-based trade and trade based on business travel. Here is our proposal that Traffic Analysis should periodically carry out surveys, serving as a supplement to RVU and VFU. For the part of services trade in category (b) that can be estimated to be ICT-based, the question is whether there are better alternatives than the simple basic model for estimating à priori matrices? Hellmanzik & Schmitz (2016) present a study of international trade in services where they examine with a gravity model how trading patterns are affected by factors that represent 'virtual proximity'. It is of interest to examine in more detail whether and how this approach can be applied to interregional trade in services.

3. Some calculations with the new MRIO model

We start from the outline of the MRIO model as developed within the Statistics Sweden work, see Figure 2.1. Calculations have been performed with a 21x21 model that is set up according to this figure. Its successive steps have been estimated according to the Chenery-Moses model, applied to interregional trade flows estimated using the methodology presented in section 2 above. The calculations have included the production of regional and interregional input-output tables, the production of their Leontief inverses and the calculation of multipliers for each industry aggregate and county.

The continued calculations will be based on IO matrices for each county and the estimated pattern of trade per product group (aggregate of products). For each county there is a regional IO matrix corresponding to the national one marked in bold in Figure 2.1 above. The regional IO matrices differ from the national one since the composition of products within each product group varies between counties.

The full interregional table is built on county-specific trade patterns for each of the 446 products. These trade patterns are related to how transport costs differ between county relations. As a measure of transport costs, we use the kilometer distances between different counties. Transport distances have a similar structure for the industries, as we have seen in previous sections.

3.1 Demonstrations of interregional trade patterns

A central issue for MRIO is how the different counties are connected via interregional trade. The modelling of this trade is at the heart of the approach. It is therefore important from a quality point of view to highlight what the trading patterns look like. In a first figure we show the proportion of deliveries that come from your own county, see Figure 3.1.

Figure 3.1 below shows the intraregional share of the deliveries from each county for each of the 21 product group aggregates. The shares differ between around 30 percent for mining and manufacturing to more than 80 percent for construction. Many of the product group aggregates in the analysis are services. For those typical intraregional trade shares are around 2/3.

Figure 3.1 Intraregional delivery shares for counties in 2018.

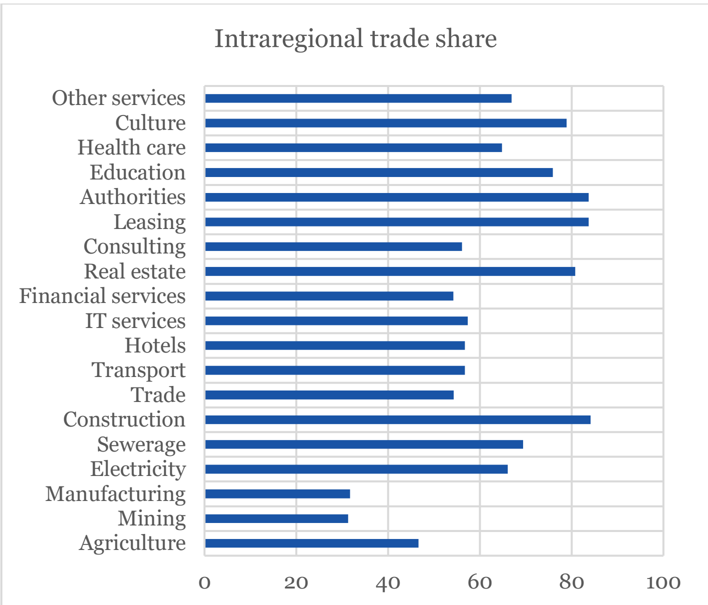


Figure 3.2 shows the trade pattern for each of the 21 counties rather than for the 21 product group aggregates. This time we look at the interregional trade component. The figure shows that the Stockholm AB-region is the most self-contained one for both exports and imports. The F county

(Kronoberg County) in south central Sweden has the highest export and import shares. The difference between export and import shares is generally rather small also for the northern counties of Västerbotten and Norrbotten (AC and BD).

Figure 3.2 Export and import shares from and to counties in 2018.

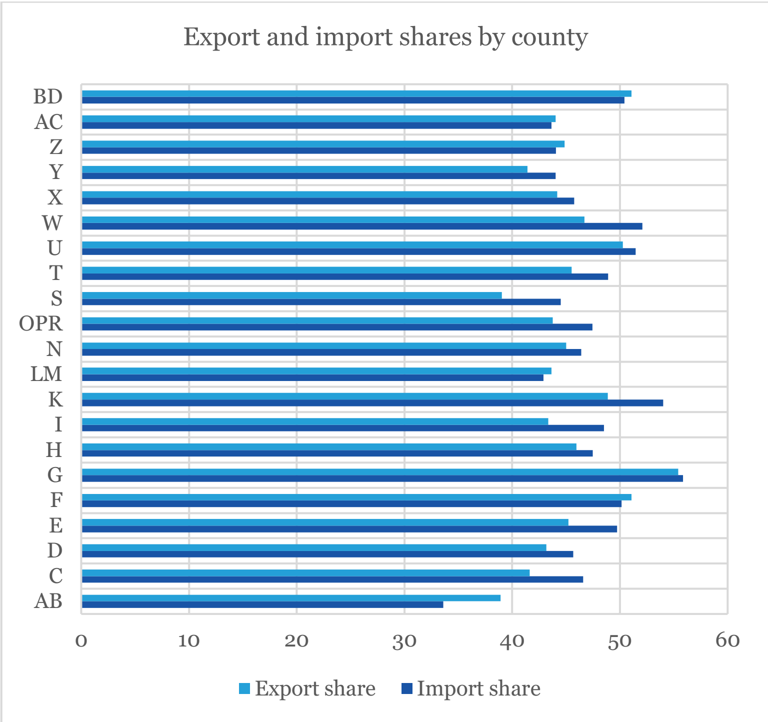


Figure 3.3 shows similar information for the distribution across the geographical dimension. The import shares differ between 33 percent for county AB and 56 percent for county F.

Figure 3.3 Interregional import shares for Swedish counties in 2018.

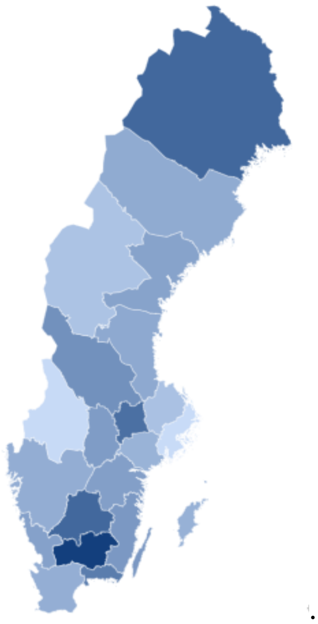
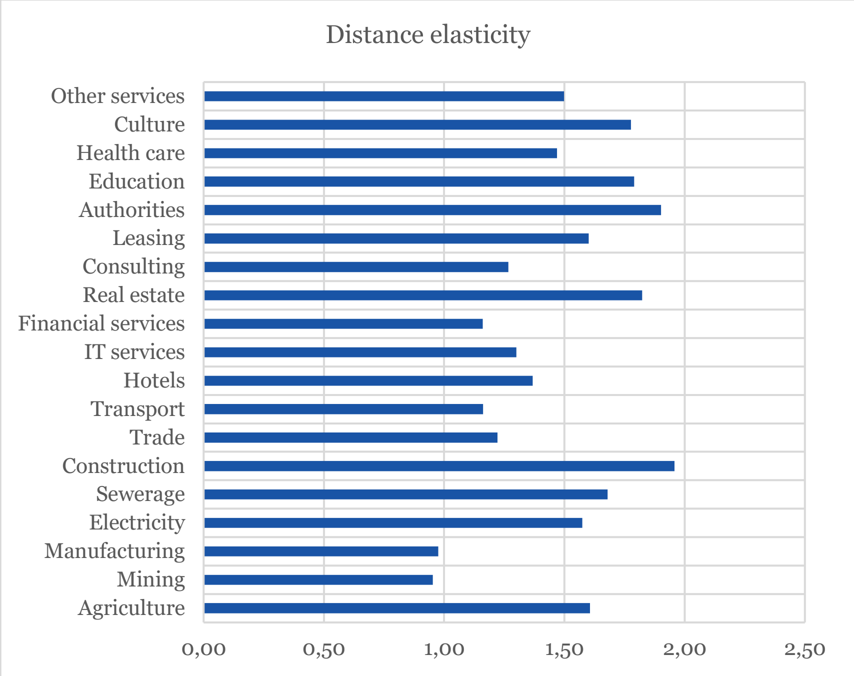


Figure 3.4 Distance elasticities for interregional trade for each commodity group in 2018.



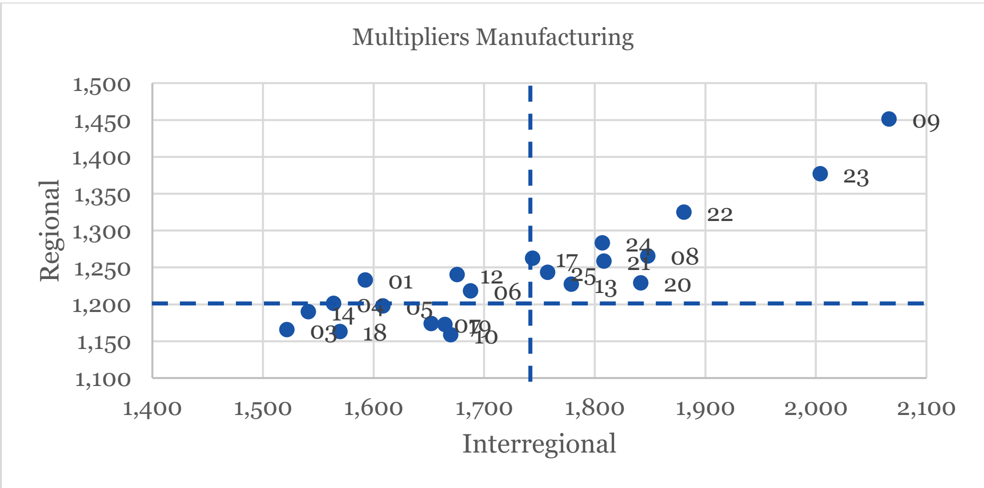
We have made calculation of the distance elasticities for the interregional trade patterns for each of the 21 product group aggregates. The result of these estimations, which have been made using the methods in earlier chapters, shows a varying pattern. Elasticities are small for mining and manufacturing and high for construction. The pattern differs between service commodity groups, which real estate services and public authorities exhibiting high elasticities.

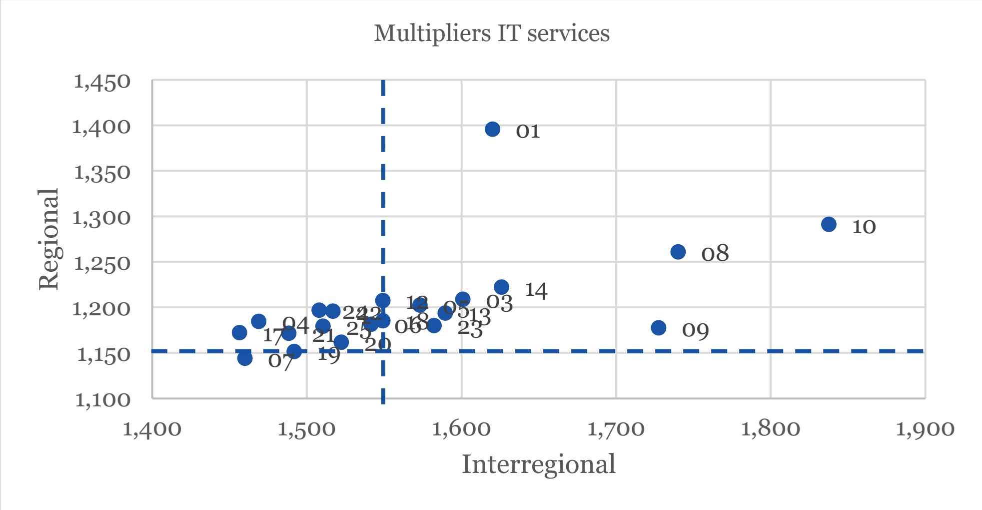
3.2 Demonstrations of Leontief multipliers

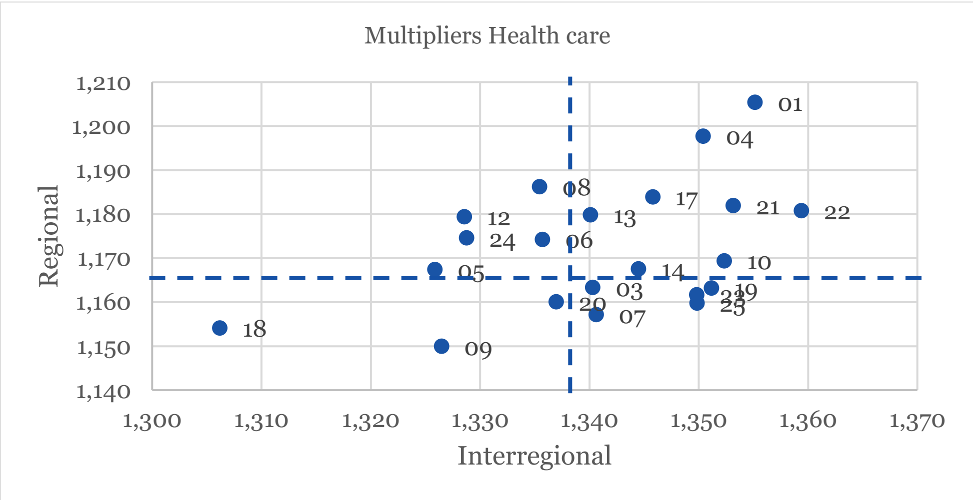
We have also derived Leontief multipliers both for the regional linkages and for the interregional linkages. We provide examples for a selection of three commodity groupings in Figure 3,5.

We see from Figure 3.5 that interregional multipliers vary more between counties than regional ones, and especially for IT services.

Figure 3.5 Regional and interregional multipliers for manufacturing (top), IT services (middle) and health care (bottom) in 2018 (counties are indicated below bottom figure).







Note: Note that the scales differ between the figures. Region notations: Stockholm 1, Uppsala 3, Södermanland 4, Östergötland 5, Jönköping 6, Kronoberg 7, Kalmar 8, Gotland 9, Blekinge 10, Skåne 12, Halland 13, Västra Götaland 14, Värmland 17, Örebro 18, Västmanland 19, Dalarna 20, Gävleborg 21, Västernorrland 22, Jämtland 23, Västerbotten 24, Norrbotten 25

In conclusion we present the combination of regional and interregional multipliers for each county. The regional multipliers are based on the regional IO coefficients for each county, isolated from the other counties. The second set of multipliers is based on the interregional coefficients for each county.

In Figure 3.5 we have drawn lines that cross the average of each multiplier. If a county is located in the upper right quadrant, it will have both regional and interregional effects greater than the average. In addition, the figure shows how great the effects are. Thus, there are four quadrants where the lower left one shows counties with small multipliers in both dimensions and the upper right one with large multipliers in both dimensions.

Several factors help explain why the multipliers for individual counties vary in the way that Figure 3.5 shows. An important factor was addressed in the introduction of the chapter, namely how the cost of production is divided into input products and value added. The greater the proportion of input products, the higher the multiplier. The relatively low interregional multipliers of metropolitan counties have to do with the fact that they are just metropolitan counties. With large regional markets, it follows that they can buy inputs from suppliers in their own county.

One might ask whether the results of the calculation examples we report stand up when using a more disaggregated approach. Such calculations are important expected results of the MRIO project. These analyses will not be more disaggregated geographically, but both because of varying transport costs and varying sector compositions a more detailed commodity group analysis is likely to affect the results.

A review of the thinking behind analyzes of upstream (purchasing) and downstream (selling) value chains can be done by following Wang et al (2017). There, the central concept is APL, average production length, which is a measure of the relative position of a production stage in an industry and region, in relation to the start and end point of the value chain. Their measure is a development of previous attempts by, for example, Antras et al (2012) to handle upstream and downstream linkages in a uniform way.

To carry out the analyses, a theoretical reasoning is needed, see Wang et al (2017), Johnson & Noguera (2012), Borin et al. (2021) and Baldwin et al. (2022). It is based on the interaction between production, value added and indirect effects. A total gross production is induced in a supply chain based on a value-added package that starts in an industry and a county. The package goes through a number of production stages where it creates new gross production values. The more complex the processing process is, the more times the package creates new gross production values. The process ends when the package is purchased by the final customer. The length of the production chain measured in number of processing steps can then be calculated. The average length of the processing chain for the package is obtained by summing over end-user industry and county.

The analysis points to the value of using an interregional approach. Anything else would be surprising given how important the supply of goods and services across the county border has become in the specialized economy. The first impression of these figures is how clearly the counties are grouped into four categories in four fields according to the level of multipliers. In conclusion, it is clear that only regional IO tables do not capture the interdependences that exist within the production system. This points to the value of Statistics Sweden's ongoing MRIO project with its interregional analyses.

3.3 Demonstrations using network theory

You can also analyze interregional value chains by using network theory, see, for example, Cerina el al (2014). In their study, this was done for international value chains, but such analyses can also be applied at regional level.

In graph theory and network analysis, the measure *betweenness centrality* is used to measure a node's position on a network. It is a way to capture what influence a node has over the flow of information between nodes given a certain set of network connections. The algorithm calculates the shortest routes through the network between all pairs of nodes.

As an illustration for this application, Figure 3.6 and Figure 3.7 are included, for Sweden as a whole, using an aggregation of all sectors and for all 21 sectors for Jönköping County. In the figures, the thickness of the links is proportional to the size of the value-added package.

The first figure shows the domination of the three metropolitan areas in the Swedish interregional trade pattern. The main source of the domination they has as central nodes in the service production system. Another observation is that some regions are more peripheral than others. We see the regions of the north in these peripheral positions but also regions in southeast Sweden. One can note the more central positions of Östergötland and Jönköping county.

Figure 3.6 Network analysis of a model with interregional flow data aggregated across all sectors.

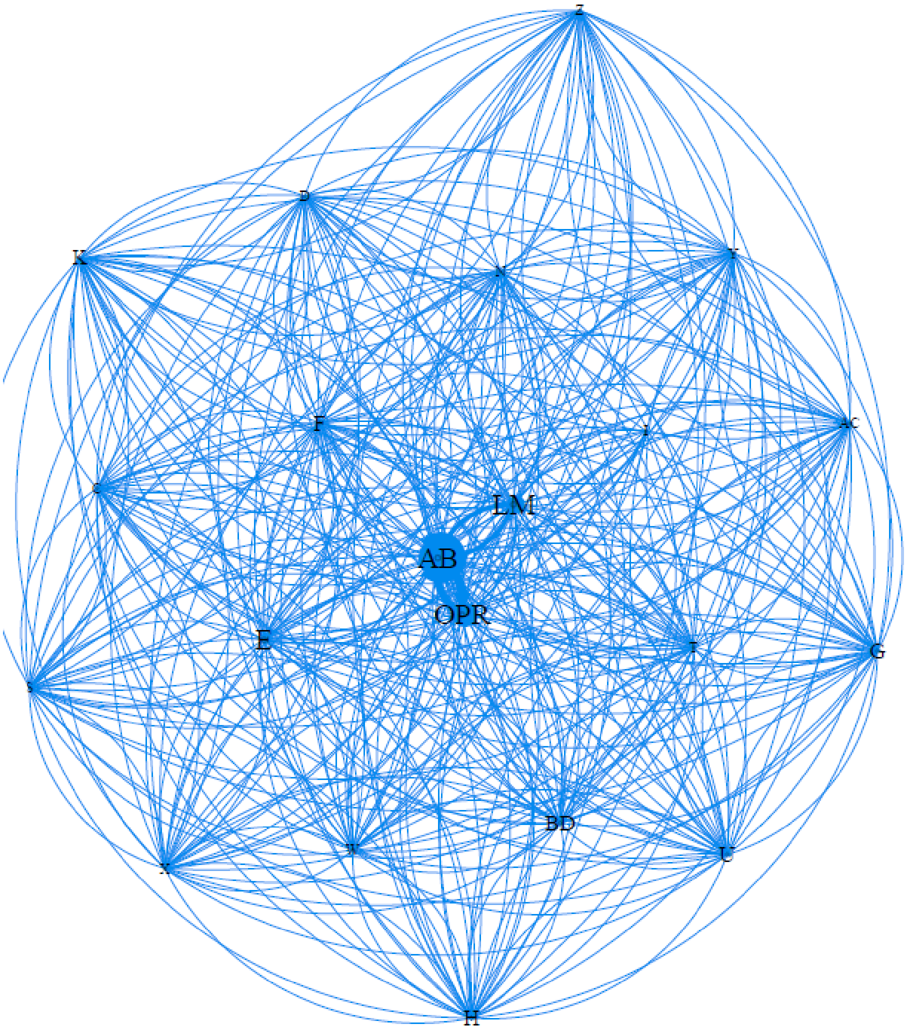
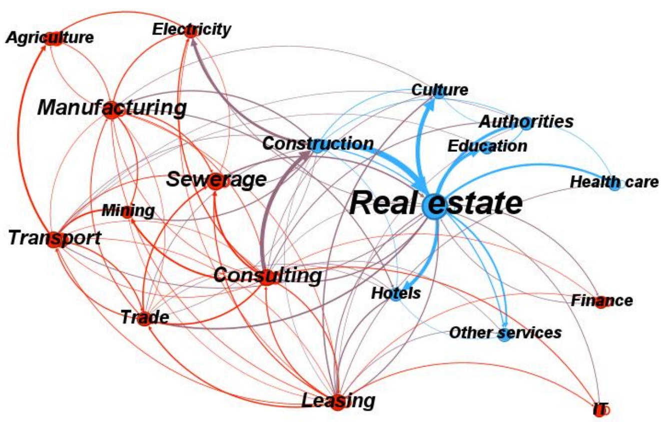


Figure 3.7 Network analysis of a model with 21 industry aggregates and 21 counties with data for 2018. Example given for Jönköping County.



Note: The graph has been constructed for intermediate flows greater than the average.

The Jönköping County economy has become separated into two parts through the network analysis. The manufacturing part of the economy has a complex network of interactions. For the service part, the figure clearly shows the importance of business services in the country and especially the real estate commodity group.

The results of this calculation example indicate that a corresponding analysis for the hundreds of industries included in the MRIO project should be able to provide new insights into the interregional relationships. Corresponding analyses for international data can be found, for example, in Cerina et al (2014). We have complemented our MRIO analyses with calculations using global data from the IO tables constructed by Ivanova el al. (2019) and Thissen et al. (2019). However, these results will be reported elsewhere.

4. Application and use of MRIO

4.1 Introduction

In previous chapters, a review has been made of various components of ongoing development work to create a new generation of MRIO tables. It has been noted that Swedish regional statistics can be used in new ways to build accounting systems that include interregional trade by using sources in the field of transport statistics. Economic flows and their counterparts in delivered ton-kilometers are central to socio-economic calculations of investments in transport and communication systems. In the present chapter, we point to some areas of application where the MRIO tables may have particular interest.

4.2 Regional development work

Regulation (2017:583) on regional growth work states, among other things, that

"*Whoever is responsible for regional growth work shall (...) develop and define a strategy for the county's development (regional development strategy) and coordinate efforts to implement the strategy*" (§7).

"The regional development strategy shall be drawn up on the basis of an analysis of the specific conditions for sustainable regional growth and development in the county. The analysis shall take into account functional regional relationships both within, within, across county and national borders, as well as to different types of rural areas and urban areas" (§9) (our italics).

A review of a number of current regional development strategies and their documentation reports in some of the largest counties (Västra Götaland, Skåne, Östergötland) indicates that functional regional connections within the counties have a given place in the regional development strategies. Functional relationships across county and national borders are given much less attention. Twenty years after the 'regionalisation' of regional policy, regional development strategies give the impression of being relatively intraregional documents in which the regions' relations and dependencies with the outside world play an obscure role.

The endogenous growth theory and the EU's strategic work have also had a major influence on this development. The reporting on global value chains, GVC, has meant that the focus is raised to external relations, so that networks and agglomeration can also be considered as complements to external economies of scale.

The reasons for this may, of course, be several, but one explanation is likely to lie in the fact that, with the exception of commuting statistics, in many areas there has been a lack of data on regions' trade and other exchanges with each other. In the absence of detailed data on external relations, which MRIO tables could offer, regions have had to concentrate on internal strategies.

Another important regional development area is the regions' climate and energy strategies. A crucial reason why both Region Skåne, Västra Götaland Region and the Swedish Environmental Protection Agency are co-financiers in the MRIO project is that there is a great demand for models and methods to quantify the consumption-based emissions and follow up on the goals of this in the regional strategies.

4.3 Regional analysis and forecasting system (Raps)

Raps is a system of models for population, labour market, regional economy and housing market – models for individual regions as well as a multiregional model for all counties, see also Swedish Agency for Economic and Regional Growth (2017). Since Raps was launched in the late 1990s, the multiregional model has served as a model tool for, among other things, regional analyses and forecasts in connection with all long-term investigations, and to generate input to the Swedish Transport Administration's models for passenger and freight transport in connection with all national plans for transport infrastructure.

Integrating MRIO with Raps enables significant improvements, especially on three essential points. First, Raps becomes a sharper modeling tool. The regional economy model is now based on the national IO table. Through MRIO, the model can be built up with region-specific IO tables that reflect how IO dependencies vary between regions. Furthermore, with region-specific data for final use, supply balances are significantly better estimated than with the allocation keys currently in use.

The second point is that MRIO-Raps opens up completely new analysis opportunities, with important policy implications. With current model tools, the multiplier effects of a larger investment can be estimated within the region where the investment takes place, while the effects in other regions, through the trade generated by the investment, cannot be estimated. MRIO makes it possible to estimate how the impact of an investment in a region is spread to specific regions in several stages. Because Raps is a system of models, it will also be possible to estimate how the region's labour and housing markets provide the conditions for potential multiplier effects.

The third point concerns the special importance of MRIO-Raps in improving inputs to the Swedish Transport Administration's passenger and freight transport models, Sampers and Samgods. We have previously mentioned that the Swedish Transport Administration uses matrices for commodity trading, PWC matrices, which are based on VFU data. At present, the restrictions on these matrices, i.e. supply and use by region and commodity group, are estimated using national data allocated to regions using employment data. MRIO, which is based on regionally specific micro data provides significantly more reliable estimates.

4.4 Consumption-based emissions at a regional level

Another important application of MRIO tables is calculation of consumption-based emissions at a regional level. Consumption-based emissions are already calculated at a national level, at a national level at national level, see SCB (2022) and Palm et el. (2019), see also Almström et al. (2018). With the MRIO table of Swedish counties that has been produced in this project, it is possible to estimate the emissions that for instance inhabitants in Stockholm County generates in the county itself, in other counties in Sweden and in other parts of the world, and it is also possible to estimate the distribution of where these emissions arise per county in Sweden and per country in the world.

The input–output model used for this purpose can be described by the following equation where the consumption-based emissions in region r are calculated as

$$e_r = \hat{s}Ly_d^r + q(A_mLy_d^r + y_m^r) + f_r \qquad (15)$$

and where

e_r is the footprint in region r, each e_r is in itself a vector of where in Sweden the emissions occur in the production of which products,

$\hat{s}Ly_d^r$ is the emissions that arise in Sweden due to the consumption in region r (s is the production-based emissions per product and county, L is the Leontief-inverse of the MRIO table),

$q(A_mLy_d^r + y_m^r)$ is the emissions that arise abroad due to the consumption in region r (q is the emission mulitpliers that describes the amount of emissions generated due to the imports of one SEK worth of a given product, A_m is the input matrix of imported products as a share of the production value per product),

f_r is the direct emissions from households per region r.

The model is completely analogous to the input–output model used at the national level, with the difference that the consumption vector y now constitutes 21 different consumption vectors y_r, one for each county, each of them in turn containing a domestic part y_d and an imports part y_m.

In the figures below, some tentative results from the model are displayed. Figure 4.1 shows production-based versus consumption-based emissions per capita, per county and Figure 4.2 shows the consumsumption-based emissions of Stockholm county, and where in Sweden the domestic part of these emissions arise.

Figure 4.1 Production-based (blue bars) versus consumption-based (orange bars) emissions per capita, per county 2018.

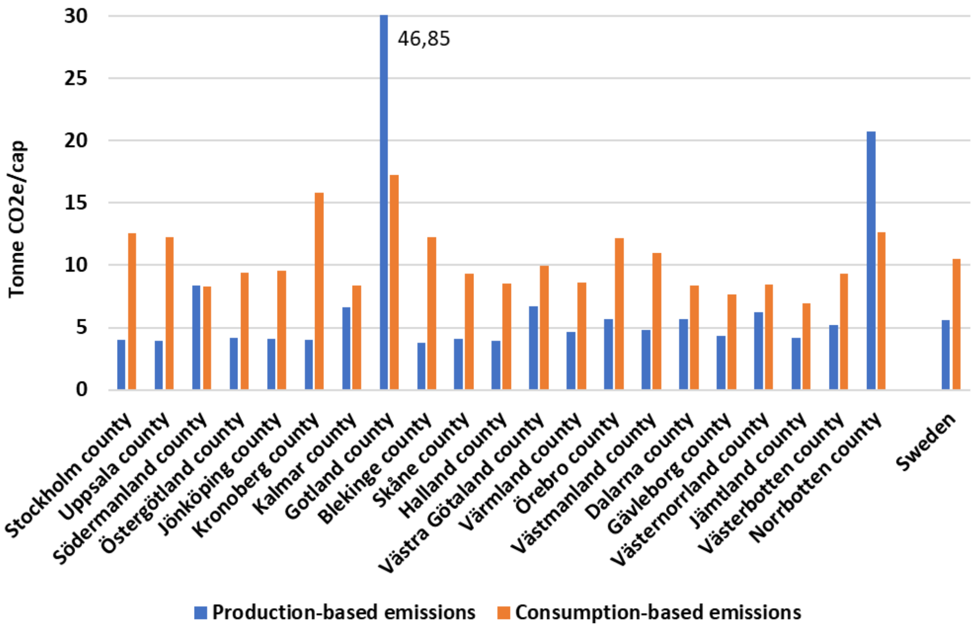
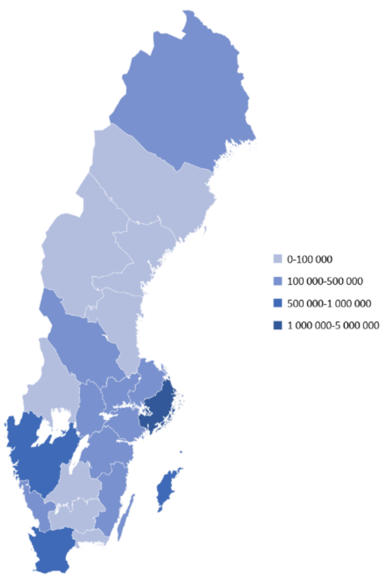


Figure 4.2 Consumption-based emissions of Stockholm county and how these emissions are distributed over the counties in Sweden. Note that direct emissions from households (e.g. emissions from driving car) is not included here.



5. Conclusions

Knowledge of how regional economies are interrelated and with the rest of the world is crucial for an evidence-based climate and growth policy, but also for understanding how changes in global value chains affect Swedish regions. It is also important to understand how establishments, such as those that are now being built up in northern Sweden can affect the rest of Sweden.

There needs to be a grouping of stakeholders that drives the development of unified MRIO tables. The project has shown in-depth knowledge needs to ensure the quality of the work and its results. This must be done in collaboration between authorities, universities and international research expertise. It is of great importance that the continued MRIO project is not only built on publication of statistics and databases but also on model developments.

The work has brought Sweden closer to the research front in interregional input-output analysis. There is a need for continued development work on increasing the element of survey methods. Previous work has meant that data has been used that has been developed for other primary issues than interregional and international trade.

The MRIO project has used a database for 2018 to test the different components. It is important that time series are created. The difficulty will be to make updates to VFU data and data for trade in services to make the MRIO tables empirically anchored in external survey data.

One possible way forward for the development of MRIO tables is to use the work carried out within the framework of VFU by estimating MRIO matrices and PWC matrices at the same time through an in-depth collaboration between Transport Analysis and Statistics Sweden. For the years in which no VFU is implemented the MRIO matrices can be updated by RAS balancing.

Statistics Sweden now has its own software, programmed in R, that can well compete with the infrastructure of leading countries such as Australia and Canada. Contacts have been created with international IO work. It is important that even stronger contacts be established with these international networks in the upcoming phase of the project.

References

Almström, P, Anderstig, C & Sundberg, M, 2018, Effects on sectors and regions of a carbon tax increase in Sweden – analysis with an SCGE model. Paper presented at the Nordic Regional and Local Economic Model Symposium, Copenhagen

Anderstig, C, Berglund, M, Edwards, H & Sundberg, M, 2015, PWC Matrices: new method and updated Base Matrices, Final Report, https://www.trafikverket.se/contentassets/d7cf7d727fb2488aab9fa9d24387c7c8/externa-rapporter/2015/pwc_matrices___new_method_and_updated_base_matrices.pdf

Anderstig, C, Snickars F, Westin, J & Westlund, H, 2023, Multiregional Input-Output Tables for Swedish Regions- Trade Modelling Comparisons, CERUM Report No 76/2023

Antràs P, Chor D, Fally T & Hillberry R, 2012, Measuring the Upstreamness of Production and Trade Flows. The American Economic Review: Papers & Proceedings, 2012, 102(3): 412-416

Bacharach, M, 1970, Biproportional Matrices and Input-Output Change. Cambridge University Press, Cambridge, Mass.

Baldwin, R, Freeman, R & Theodorakopoulos, A, 2022, Horses for Courses: Measuring Foreign Supply Chain Exposure, Working Paper 30525. http://www.nber.org/papers/w30525, NBER

Berglund, M, Björneskog, L & Gerner, A, 2021, Multiregional input-output tables of Sweden, phase two. Project plan 2020-10-09, Statistics Sweden (unpublished PM)

Borin, A, Mancini, M & Taglioni, D, 2021, Countries and Sectors in Global Value Chains. Policy Research Working Paper 9785, Development Research Group, World Bank

Boyce, D, 2002, Combined Model of Interregional Commodity Flows on a Transportation Network. I Hewings, G, Sonis, M & Boyce, D (eds), Trade, Networks and Hierarchies: Modeling Regional and Interregional Economies. Advances in Spatial Science, Springer, 29-40

Brousolle, D, 2014, Service, Trade in Services and Trade of Services Industries, Journal of World Trade 48(1), 31-58

Cerina, F, Zhu, Z, Chessa, A & Riccaboni, M, 2014, World Input-Output Network. IMT LUCCA EIC WORKING PAPER SERIES 06 © IMT Institute for Advanced Studies Lucca

Edwards, H, Anderstig, C, Pettersson, D & Huelsz-Prince A, 2019, Samgods PWC-matriser 2016 och 2040, https://www.trafikverket.se/contentassets/ab220f9016154ef7a8478555560bb280/2020/samgods_pwc-matriser_2016_och_2040.pdf

Eriksson, J, 1980, A note on solution of large sparse maximum entropy problem with linear equality constraints. Mathematical Programming, 18, 146-154

Erlander, S, 1981, Entropy in linear programs. Mathematical Programming, 21, North-Holland, 137-151

Eurostat, 2018, Eurostat Manual of Supply, Use and Input-Output Tables, https://ec.europa.eu/eurostat/documents/3859598/5902113/KS-RA-07-013-EN.PDF/b0b3d71e-3930-4442-94be-70b36cea9b39

Falck, S & Nordström, H, 2016, Regional trade and the importance of interregional and global value chains for Swedish counties. Tillväxtanalys.PM 2016:02

Francois, J & Hoekman, B, 2010, Services Trade and Policy, Journal of Economic Literature 48, September 2010: 642–692

Head, K & Mayer, T, 2002, Illusory Border Effects: Distance Mismeasurement Inflates Estimates of Home Bias in Trade, CEPII, Working Paper No 2002-01, Paris, www.cepii.fr

Hellmanzik, C & Schmitz, M, 2016, Gravity and international services trade: the impact of virtual proximity. Paper presented at the FREIT LETC conference, Izola

Hewings, G, Gyoo Yoon, S, Park, S, Kim, T J, Kim, K & Kratena, K, 2017, Unraveling the Household Heterogeneity in Regional Economic Models: Some Important Challenges. I Jackson, R and Schaeffer, P (eds.), Regional Research Frontiers, vol. 2, Advances in Spatial Sciences, Heidelberg, Springer

Ivanova, O, Kancs, D & Thissen, M, 2019, Regional Trade Flows and Input-Output Data for Europe, European Commission, JRC118892

Johnson, R & Noguera, G, 2012, Accounting for intermediates: Production sharing and trade in value added. Journal of International Economics, Volume 86, Issue 2, 224-223

Madsen, B & Jensen-Butler, C, 2002, Regional Economic Modeling in Denmark: Construction of an Interregional SAM with Data at High Levels of Disaggregation Subject to National Constraints. I Trade, Networks and Hierarchies: Modeling Regional and Interregional Economies. Advances in Spatial Science, Springer, 29-40

McDougall, R, 1999, Entropy Theory and RAS are Friends. GTAP Working Papers 5-14, Purdue University

Moses, L, 1955, The stability of Interregional Trading Patterns and Input-Output Analysis, The American Economic Review Vol. 45, No. 5 (Dec., 1955), pp. 803-826

National Institute of Economic Research, 2017, Consumption, population and prosperity, Deepening the economic situation December 2017, https://www.konj.se/download/18.21a15ba916066d05ff68023e/1513691661325/Konsumtionen,%20befolkningen%20och%20v%C3%A4lst%C3%A5ndet_dec2017.pdf

OECD, 2013, Communications Outlook 2013. https://doi.org/10.1787/comms_outlook-2013-en

Oosterhaven, J & Hewings, G, 2014, Interregional Input–Output Models. I Fischer, M & Nijkamp, P (eds), Handbook of Regional Science, DOI 10.1007/978-3-642-23430-9_43, Springer

Palm, V, Wood, R, Berglund, M, Dawkins, E, Finnveden, G, Schmidt, S & Steinbach, N, 2019, Environmental pressures from Swedish consumption a hybrid multi-regional input-output approach, Journal of Cleaner Production, Vol. 228, p. 634-644

Sargento, A, Ramos, R & Hewings, G, 2012, Inter-Regional Trade Flow Estimation Through Non-Survey Models: An Empirical Assessment. Economic Systems Research, Taylor & Francis Journals, vol. 24, no 2, 173-193

SCB, 1972, Input-Output tables for Sweden 1968, Statistical Messages N 1972:44, http://share.scb.se/ov9993/data/historisk%20statistik/Statistiska%20meddelanden%20(SM)%201963-2001%2FN_1972%2FN197244.pdf

SCB, 1987, Input-Output tables for Sweden 1980, http://share.scb.se/ov9993/data/publikationer/statistik/nr/nr0101/1980a01/nr0101_1980a01_sm_n031987.pdf

SCB, 2018, Quarterly National Accounts Inventory, Sources and methods in the Swedish National Accounts, https://www.scb.se/contentassets/767986f40d23499facc8e6f6e5234a06/_sources-and-methods-in-the-swedish-national-accounts_.pdf

SCB, 2019a, A multiregional input–output model over Sweden using the virtual laboratory model [SCB:s diarienummer Dnr U 2018/1592]

SCB, 2019b, Sweden GNI Inventory March 2016, (Revised August 2019), https://www.scb.se/contentassets/c89bb85e14184e92a4d5e4eec5ce4b98/sweden-gni-inventory---2016---august-2019.pdf

SCB, 2022, Greenhouse gas emissions from Swedish consumption decreased in 2020, Statistical news from Statistics Sweden 2022-09-29
https://www.scb.se/en/finding-statistics/statistics-by-subject-area/environment/environmental-accounts-and-sustainable-development/system-of-environmental-and-economic-accounts/pong/statistical-news/environmental-accounts--environmental-pressure-from-consumption-2020/

Snickars, F & Weibull, J, 1977, A minimum information principle – theory and practice. Regional science and urban economics, vol 7, no 1-2, pp 137-168

Snickars, F, 1978, Construction of interregional input-output tables by efficient information adding. I Bartels, CPA & Ketellapper, RH (eds), Exploratory and explanatory statistical analysis of spatial data, Springer, Dordrecht, 73-112

Thage, B, 2005, Symmetric Input-Output Tables: compilation issues. Paper presented at the 15th International conference on Input-Output techniques, Beijing. www.iioa.org/conferences/15th/pdf/thage.pdf.

Thissen, M, Ivanova, O & Husby, T, 2019, The Importance of the Network: Consistent Interregional Trade and Transport flows between European NUTS2 regions. Working Paper, PBL Netherlands Environmental Assessment Agency

Swedish Agency for Economic and Regional Growth, 2017, Regional Economy in Raps 5.0, https://tillvaxtverket.se/download/18.489389311653c3b5cc82616d/1534497626109/Regionalekonomi%20i%20Raps%205.pdf

United Nations, 2018, Handbook on Supply and Use Tables and Input-Output Tables with Extensions and Applications, Department of Economic and Social Affairs, Statistics Division, Studies in Methods, Handbook of National Accounting, Series F No.74, Rev.1

Wang, Z, Wei, S-J, Yu, X & Kunfu, Z, 2017, Characterizing global value chains: Production length and upstreamness. Working Paper 23261, NBER

Yamano, N, & Ahmad, N, 2006, The OECD Input-Output Database: 2006 Edition. OECD Science, Technology and Industry Working Papers, 2006/8. Paris: OECD https://www.oecdlibrary.org/docserver/308077407044.pdf?expires=1641662013&id=id&accname=guest&checksum=F1DFFDFDC490180E7549C100E024F0CB