Regional input-output modelling in Germany: The case of North Rhine-Westphalia

Kronenberg, Tobias and Többen, Johannes

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Johannes Többen & Tobias Kronenberg
Forschungszentrum Jülich

Abstract

The political system of Germany is characterized by strong federalist elements, which means that many important decisions of economic policy are made by the governments of the federal states or *Länder*. Unfortunately the statistical offices of the *Länder* do not produce regional input-output tables, claiming that they lack the resources (i.e. manpower) to do so. The lack of official input-output tables for the *Länder* forms a significant obstacle to the study of regional economic developments and hampers the ability of economists to provide well-informed advice to regional policy-makers. A similar situation prevails in many other European countries.

This paper attempts to meliorate the situation by describing the process of constructing a regional input-output table (RIOT) for North Rhine-Westphalia (NRW), the largest federal state in terms of GDP and population. A first approximation is produced by applying the CHARM method to the national input-output table on the basis of regional and national employment data. This first approximation is then improved upon by adding additional information from various sources, including the statistical office of NRW and the household survey of income and expenditure. We conclude that it is possible to construct a meaningful RIOT even when resources (time and money) are severely limited if the available information is used in an efficient manner.

Keywords

regional input-output table, nonsurvey method, hybrid method, location quotient.

1 Introduction

North Rhine-Westphalia (henceforth NRW) is one of the sixteen federal states that make up the Federal Republic of Germany. In terms of GDP and population, it is also the largest of the federal states. Due to the federal structure of Germany, its government has considerable influence over regional policymaking, including the fields of economic and environmental policy. In an attempt to use that influence, the current government has proposed a new law on climate conservation, which stipulates ambitious goals in terms of reducing greenhouse gas emissions. Specifically, the proposed law states that carbon dioxide emissions should be reducing by 25% in 2020 and by 80% in 2050, compared to the 1990 level. In order to achieve these aims, various policy measures will have to be undertaken, including, for example, a programme for the refurbishment of buildings. It seems natural to expect that these ambitious policy measures may unfold noticeable effects on the regional economy in terms of value added and employment, especially since NRW's economy was built upon coal mining, steelmaking and other heavy industry. In order to trace these effects, and also to assess the effectiveness of policy measures in terms of reducing emissions, the proposed law includes a requirement for monitoring the progress on a regular basis.

This raises the question of how to study the effects of such policy measures on regional employment, value added, and emissions. An accepted approach for such analyses is the application of regional input-output models (or multisectoral CGE models, which are after all extended input-output models with certain closure rules). Unfortunately, the construction of such models is hampered by the lack of official input-output tables for NRW. A similar situation prevails in the other federal states, as none of the statistical offices produces official input-output tables for individual federal states (the last one to do so was the statistical office of Baden-Württemberg in 1993). From a regional economics perspective, the lack of official input-output tables is deplorable because input-output models could be of great help in assessing the effects of policy measures on regional economies.

This paper aims at meliorating that situation by describing the process of constructing a regional input-output table (RIOT) for NRW. In principle, the same procedure can be applied to the other federal states as well. Since regional economists in many other countries also face the problem of constructing RIOTs based on limited statistical information, we hope that they are also interested in how the problem was addressed here for the case of NRW. In the recent past, a number of papers have discussed the problem of regionalising a national input-output table (NIOT) by means of nonsurvey methods (Bonfiglio, 2009; Bonfiglio and Chelli, 2008; Flegg and Tohmo, 2011; Kronenberg, 2009; Tohmo, 2004). The present paper contributes to that stream of literature and goes a step further by using not only a nonsurvey method but also drawing on other sorts of information, e.g. a supply table, a household survey on income and expenditure, and official statistics on international imports and exports. Thus, the resulting RIOT for NRW is not based on a pure nonsurvey approach but on a hybrid approach in the sense of Lahr (1993). The paper also discusses very specific problems that arise during the RIOT construction process, for example the distinction between industries and homogeneous branches.

The paper proceeds as follows. Section 2 provides some background on NRW and its government's climate policy. Section 3 lays out the notational conventions and definitions used in the mathematical parts of the paper. Section 4 describes the actual process of constructing the RIOT. Section 5 reports the results and draws some comparisons between the NIOT for Germany and the RIOT for NRW. Finally, Section 6 forms the conclusion.

2 Background and Motivation

NRW is Germany's largest state in demographic and economic terms, its population of 18 million and GDP of 522 billion € amounting to 22% of the corresponding national totals in 2010. Figure 1 shows a map of the region. NRW borders on three other federal states (Lower Saxony, Hesse and Rhineland-Palatinate) and two foreign countries (Belgium and the Netherlands). The capital of NRW is Düsseldorf; its largest city is Cologne with one million inhabitants. The grey-shaded area between Duisburg and Dortmund is the highly industrialised and densely populated Ruhr area (named after the river Ruhr). During the 19th century, this region became the industrial heartland of Germany due to the coal mines situated along the Ruhr valley and the steel-based industries which developed around them.

Figure 1: Map of NRW

Source: http://de.wikipedia.org/wiki/Nordrhein-Westfalen (accessed October 25, 2011)

Like many other "old" industrial regions, NRW has been experiencing a significant structural change in the past three decades. The coal mines can no longer compete with cheap coal imported from abroad, and the subsidies which have kept them alive until now are due to run out in the near future. Thus, coal mining and steel industry are currently in decline. However, there has not been a complete "de-industrialization" in NRW – many manufacturing industries continue to operate in the region.

Due to the federal structure of the German political system, the government of NRW and its parliament wield considerable influence over concerning economic, social and environmental policy in NRW. In the summer of 2011, for example, the government proposed a new law intended to reduce greenhouse gas emissions[1]. This law – which has yet to pass parliament before it can enter into force – sets forth certain policy goals, including a reduction of greenhouse gas emissions in NRW by 25 percent in 2020 and by 80 percent in 2050 (compared to 1990). It requires that the government (and future governments) set up a "climate protection plan" and explicitly states (§8) that continuous "monitoring" will be performed. This monitoring must include:

1) an up-to-date survey of greenhouse gas emissions in NRW
2) a depiction of the expected development of GHG emissions in NRW as well as an estimation of the effects of the individual measures of the climate protection plan and their contribution to the achievement of the climate protection goals as well as intermediate goals and sectoral interemediate goals
3) other aspects, e.g. macroeconomic repercussions including employment effects
4) a consideration of the effects of EU-funded measures
5) suggestions for the further development of the climate protection plan as well as the specification of new intermediate goals and sectoral goals
6) an overview over the effects of climate change on humans and the environment as well as the enacted adaptation measures in NRW.

This monitoring process could benefit tremendously from the application of macroeconomic models based on the input-output approach[2]. Such models are frequently used to estimate the effects of climate policy measures at the national level as well the effects of economic developments on GHG emissions (Kuckshinrichs *et al.*, 2010). In principle, they could also be used at the regional level. However, this would require a regional input-output table (RIOT) for NRW. Such a table is not available from official sources. Therefore, our aim in this paper is to show how a RIOT for NRW can be constructed from the available data. Once such a table is available, it can be used for a multitude of purposes. The work on this table was started before the climate conservation law entered into public discussion, and its relevance has only increased as a consequence of this law.

[1] The draft version of the *Gesetz zur Förderung des Klimaschutzes in Nordrhein-Westfalen* is available online at http://www.umwelt.nrw.de/klima/pdf/gesetz_klimaschutz_nrw.pdf (accessed 9 November 2011).
[2] This includes the "textbook" input-output model as well as more elaborate models (e.g. CGE models).

3 Conventions and Definitions

The RIOT for NRW will be constructed according to the same format at the corresponding input-output table for Germany provided by the Federal Statistical Office (Destatis). The layout of this table is illustrated in Figure 2. For vectors, matrices and scalars we adopt the usual conventions. That is, vectors and matrices are printed in bold type, whereas scalars (including the individual elements of vectors and matrices) are printed in italic type.

Figure 2: Layout of the input-output table

		Branches 1	Branches 2	Interm. use	Final use: Households	Final use: Others	Final use: Exports	Total use
Products	1	$Z_{1,1}$	$Z_{1,2}$	Z_1^D	c_1	d_1	e_1	u_1
	2	$Z_{2,1}$	$Z_{2,2}$	Z_2^D	c_2	d_2	e_2	u_2
Interm. consumption		Z_1^U	Z_2^U					
Primary inputs (Value added)		v_1	v_2					
Output		x_1	x_2					
Imports of similar products		m_1	m_2					
Total Supply		s_1	s_2					

Source: authors' illustration

The full-scale input-output table for Germany distinguishes 71 products and the same number of homogeneous branches. For illustrative purposes, Figure 2 shows a simplified version with only two products and two homogeneous branches. A homogeneous branch is an artificial construct which, by assumption, produces only one type of output, and that output is a homogenous product. Naturally, reality is more complicated, with many firms producing a variety of products. Therefore, a distinction has to be made between a homogenous branch and an industry, which is a group of similar firms producing various products. The difference between industries and homogenous branches will play an important role in section 4.1.

The core of the input-output table is the interindustry transactions matrix **Z**. It includes both domestically produced products and imported products. That is, $Z_{1,1}$ represents the total value of products of type 1 used by branch 1, regardless of the origin of those products. The column sums of this matrix, Z_1^U and Z_2^U, denote the total intermediate consumption of the two branches. Below that, the value added by each industry, v_1 and v_2, is recorded[3]. The sum of intermediate consumption and

[3] Value added is the sum of the compensation of employees (i.e. wages and social security contribution), net operating surplus (i.e. profits), consumption of fixed capital (i.e. depreciation) and net taxes on production. For the sake of simplicity, net taxes on products are ignored in Figure 2.

value added is output, denoted by x_1 and x_2. The second row from the bottom shows imports of both products. Note that the row is labelled “imports of **similar** products”. That is, m_1 is the value of imported products of type 1, not the value of products imported for use by branch 1. Finally, the sum of domestic production and imports of each product is defined as the total supply of that product, denoted by s_1 and s_2.

Along each row, we can see how the products of a certain type were used. The row sums of **Z**, denoted by Z_1^D and Z_2^D, represent the total use of each product for intermediate consumption by all branches. Further to the right, we can see final consumption expenditure by households (c_1 and c_2), exports (e_1 and e_2), and “other final use” (d_1 and d_2). The latter includes final consumption expenditure by government and non-profit institutions serving households (NPISH) as well as gross capital formation (i.e. investment). The sum of intermediate use and final use is total use (u_1 and u_2).

4 The Construction Process

The construction process consisted of four steps. First, we estimated regional output by branch, using data on employment by industry to construct a regional supply table. Second, we estimated primary inputs and intermediate use of commodities by invoking the equal technology assumption and adjusting the estimates on the basis of superior information. Third, we estimated the final of commodities, drawing upon a household survey of consumption expenditure. Finally, we estimated regional imports and exports using the CHARM approach and adjusting the nonsurvey estimates to be compatible with the official statistics on foreign trade. Each of these four steps is described in the following.

4.1 Estimation of regional output by branch

The estimation of the intermediate and primary inputs within the hybrid approach incorporates a national input-output and a national supply table as well as data of output, value added and wages on national and regional level.

The first step in the construction of the RIOT is the estimation of regional output by branch. Since the latest input-output table is published for 2007 all other data also refer to 2007. However, a problem arises because the data that are available at the regional level are classified by economic activity according to the WZ classification, whereas the data from the national input-output accounts are classified by products according to the CPA classification. A car manufacturer, who also owns a bank, in order to provide financial services to car buyers, shall serve as an illustrative example: According to the classification in economic activities the activities of this bank are related to the sector “motor vehicles”, because the main activity of a car manufacturer is to produce cars, whereas the same bank is related to the sector “financial services” according to the classification in products.

Therefore, we cannot directly use our regional data as a basis for the RIOT; we first have to “convert” the data from industries (WZ classification) to products/branches (CPA classification). This can be done by means of a regional supply table. Thus, before we move on toward the actual RIOT, we make a detour and estimate the regional output from the supply table. Figure 3 shows a simplified supply table with two products and two economic activities. In the full-scale supply table for Germany, which is also provided by Destatis, the columns *j* are structured in 59 industries, whereas the rows *i* are divided in 71 products.

Figure 3: The layout of the supply table

		Industries 1	Industries 2	Total output without company internal deliveries (CPA)
Products	1	$r_{1,1}$	$r_{1,2}$	$\bar{x}_1$
	2	$r_{2,1}$	$r_{2,2}$	$\bar{x}_2$
Total output (WZ)		r_1	r_2	

Source: authors' illustration

Ideally, we would use data on regional and national output by industry to construct the regional supply table. However, regional output data is not available at the 59-sector classification; it is only available at a 16-sector classification. Therefore, we use the compensation of employees as the basis for the regionalisation procedure. This data is available at the same 59-sector classification at the regional and national level. The national supply table can be regionalized by multiplying each column *j* with wage quotients for each economic activity $\boldsymbol{t_j}$:

$$(1)\quad \boldsymbol{r_j^r} = \frac{\boldsymbol{w_j^r}}{\boldsymbol{w_j^n}} \boldsymbol{r_j^n}$$

where the indices *r* and *n* indicate variables related to the regional and the national level and w_j denotes the compensation of employees in industry *j*. The column totals must be equal to the official output data and the row totals (denoted by $\overline{\boldsymbol{x_1}}$ and $\overline{\boldsymbol{x_2}}$) are our estimates of regional output by product. This is already very close to what we need for out RIOT. However, a small problem remains: The output figures in the supply table do not include intra-company deliveries, but the input-output table does. In most cases this is not important, but in certain branches (e.g. agriculture) the share of intra-company deliveries is quite significant. We then use data on regional output by industry to correct for this.

The data on regional output (as mentioned above) is only available for a 16-industry disaggregation. For this reason the column totals have to be aggregated on the same level of detail, in order to compare the estimated values with the official data. The estimated outputs are adjusted by multiplying each column of the supply table with a quotient from the estimated output and the output from the official data $\boldsymbol{\tilde{r}_j^r}/\boldsymbol{r_j^r}$, where $\boldsymbol{\tilde{r}_j^r}$ denotes the regional output from the official data. Before the row totals of the supply table can flow into the regional input-output table, the company-internal deliveries on the regional level have to be estimated and added to the estimated output. Assuming that the share of company-internal deliveries in output on the regional and national level is equal the regional output is estimated as:

$$(2)\quad \boldsymbol{x_j^r} = \boldsymbol{\bar{x}_\imath} * \left(\boldsymbol{1} + \frac{\boldsymbol{l_j^n}}{\boldsymbol{x_j^n}}\right) \qquad (7)$$

Where $\boldsymbol{l_j^n}$ denotes the monetary value of company-internal deliveries on the national level. As a result, we have a regional estimate of output by product at the same 71-sector level as in the national IOT. This estimate is fully consistent with the official data on output by industry for NRW.

4.2 Estimation of primary inputs and intermediate use

The next step in the construction procedure consists of the estimation of regional value added and regional compensation of employees. Data on both are available, but they are classified according the WZ system and for only 60 sectors. In order to "translate" this data into our classification (CPA, 71 sectors), we adopt the following approach. At first we calculate the regional value added on the 60-sector level by multiplying the regional value added data $\boldsymbol{v}_j^{r,WZ}$ with a correction term:

$$(3)\quad \tilde{\boldsymbol{v}}_j^{r,CPA} = \boldsymbol{v}_j^{r,WZ} * \frac{v_j^{n,CPA}}{v_j^{n,WZ}}\,.$$

We assume that the ratio of value added $\boldsymbol{v}_j^{n,CPA}/\boldsymbol{v}_j^{n,WZ}$ classified in CPA and WZ on the national level is equal to ratio on the regional level. In cases where the value added of an economic activity exceeds the value added of a product on the national level $\boldsymbol{v}_j^{n,CPA}/\boldsymbol{v}_j^{n,WZ} < \mathbf{1}$ and, hence, the value added of the same product on the regional level decreases in comparison to the data. Thus, $\boldsymbol{v}_j^{n,CPA}/\boldsymbol{v}_j^{n,WZ} > \mathbf{1}$ causes a correction in the opposite direction. As this estimation yields value added for only 60 sectors because of the data limitations, the estimated value added must be disaggregated in 71 sectors. The only data that are available in an appropriate structure are employment data. Value added of those sectors that possess a higher level of aggregation in data than needed for the input-output table is allocated to the subsectors via their share in employment. The estimation of the compensation of employees is conducted in the same fashion as the estimation of the value added.

Given that, we are able to estimate the remaining properties of the value added namely the [net] operating surplus $\boldsymbol{\pi}_j^r$, the net taxes on production t_j^r and the consumption of fixed capital $\boldsymbol{\alpha}_j^r$. Since the value added and the compensation of employees are already known, the difference between both must be allocated to $\boldsymbol{\pi}_j^r$, $\boldsymbol{t}_j^r$ and $\boldsymbol{\alpha}_j^r$. Because of lacking information about the regional values of these components, we assume that their share in gross value added is the same as on the national level.

$$(4)\quad \boldsymbol{\pi}_j^r = \left(\boldsymbol{v}_j^r - \boldsymbol{w}_j^r\right) * \frac{\boldsymbol{\pi}_j^r}{[\boldsymbol{v}_j^n - \boldsymbol{w}_j^n]}$$

$$(5)\quad \boldsymbol{t}_j^r = \left(\boldsymbol{v}_j^r - \boldsymbol{w}_j^r\right) * \frac{\boldsymbol{t}_j^r}{[\boldsymbol{v}_j^n - \boldsymbol{w}_j^n]}$$

$$(6)\quad \boldsymbol{\alpha}_j^r = \left(\boldsymbol{v}_j^r - \boldsymbol{w}_j^r\right) * \frac{\boldsymbol{\alpha}_j^r}{[\boldsymbol{v}_j^n - \boldsymbol{w}_j^n]}$$

In a final step the estimation of the interindustry matrix is conducted. Total intermediate consumption of branch *j* is equal to the difference between the output and value added of that branch: $\boldsymbol{z}_j^{u,r} = \boldsymbol{x}_j^r - \boldsymbol{v}_j^r$. We assume the structure of the intermediate inputs on the regional level to be equal to those on the national level[4]. The elements of the interindustry matrix are then given by:

$$(7)\quad \boldsymbol{z}_{i,j}^r = \boldsymbol{z}_{ij}^n * \frac{z_j^{u,r}}{z_j^{u,n}}$$

[4] Note that we do not assume equal input-output coefficients in the region and the nation. We do assume that the share of each intermediate input in total intermediate use of branch *j* is the same. This might be called the "weak" version of the equal technology assumption.

After this step the primary and intermediate inputs of our regional input-output table are estimated and we move on to the estimation of the final domestic use.

4.3 Estimation of regional final use

Final use of products is sub-divided into final consumption of households and NPISH, final consumption of government, gross capital formation (including stock variations), and exports. The latter will be dealt with in section 4.4. Here, we first consider the final consumption of households, then move on to the other components of final use.

Due to the crucial role of consumption of private households, the estimation of these is based on micro data from the income and expenditure survey (*Einkommens- und Verbrauchsstichprobe* – henceforth EVS), which was conducted by the statistical offices in 2003. The remaining components of the final domestic use, which are of lower importance in quantitative terms, are simply estimated by scaling down the corresponding columns of the national IOT, using the shares of NRW in the national totals.

The participants of the EVS allocate their expenditures over a period of three months on 133 groups of intended use according to the SEA classification standard (the German version of the international COICOP standard). As the participation is voluntary, note that these data are a quoted sample, because the return rates differ considerably over population groups. For this reason data of a single household must be weighted with an expansion factor, which indicates the number of households that are represented by a pooled household. The average of an intended use over all households is calculated afterwards. The structure of the expenditures may be expressed in the form of consumption coefficients $\boldsymbol{\gamma^m}$

(8) $\boldsymbol{\gamma^m} = \frac{\boldsymbol{c^m}}{\boldsymbol{c}},$

where $\boldsymbol{m}$ denotes the intended use, $\boldsymbol{c}$ denotes the total consumption of a household and $\boldsymbol{c^m}$ denotes the expenditure of a household for an intended use $\boldsymbol{m}$. The expenditures for the whole economy are then estimated by multiplying the consumption coefficients, with the number of households $\boldsymbol{H}$ and the total consumption of an average household $\boldsymbol{c}$.

(9) $\boldsymbol{C^m} = \boldsymbol{\gamma^m c H}.$

Lehmann (2004) observed that consumption of private households based on data of the EVS is likely to be underestimated for various reasons. For example, when people fill out their questionnaire they may not remember all the instances in which expenditures were made[5]. It is therefore necessary to proceed with an adjustment via correction coefficients (denoted by DQ^m) that denote the share of estimated expenditures for an intended use $\boldsymbol{m}$ based on EVS data in the consumption of the national social accounting. Thus we assume that the degree of deviation on the regional and the national level is the same.

As mentioned above, the EVS data are structured according to the SEA classification. In order to integrate the consumption of private households into the RIOT, it is necessary to convert the data into the CPA classification. This is done by making use of the consumption interdependence table,

[5] This applies in particular to expenditure on gastronomic services and cigarettes.

which is published by Destatis[6]. Because this table contains only 41 categories of intended use, we must aggregate the estimated expenditures first. Figure 4 shows a simplified version of the consumption interdependence table.

The elements of this table may be interpreted as follows: If the product group 1 denotes agricultural products and the intended use 1 stands for foods, then $\boldsymbol{V_{1,1}}$ is the monetary value of agricultural products that are used as food.

Figure 4: The structure of the consumption interdependence table

Expenditures of private households...		intended use				
		1	2	...	$\widetilde{m}$	sum
	1	$V_{1,1}$	$V_{1,2}$	...	$V_{1,\widetilde{m}}$	C_1
	2	$V_{2,1}$	$V_{2,2}$	...	$V_{2,\widetilde{m}}$	C_2
product groups	⋮	⋮	⋮	⋱	⋮	⋮
	n	$V_{n,1}$	$V_{n,2}$	...	$V_{n,\widetilde{m}}$	C_n
	sum	C^1	C^2	...	$C^{\widetilde{m}}$	$\bar{C}$

Source: authors' illustration

In order to proceed with the conversion, we define a consumption allocation quotient $v_{i,m}$:

$$(10)\ \boldsymbol{v_{i,m}} \equiv \frac{\boldsymbol{V_{i,m}}}{\boldsymbol{C^m}} <=> \boldsymbol{V_{i,m}} = \boldsymbol{v_{i,m} C^m}$$

Obviously the private consumption structured in product groups can be estimated by summing up the elements of a row; hence in combination with (10) we receive

$$(11)\ C_i = \sum_{m=1}^{\widetilde{m}} v_{i,m} C^m.$$

By applying (11) we can compute household's consumption according to the CPA classification.

A final adjustment is necessary because the EVS 2003 data are likely to be lower than the actual consumption expenditure in 2007. We adjust for this effect by multiplying the consumption of each product with the growth rate the total consumption within this time, which is calculated from the consumption data in the national accounts.

4.4 Estimation of imports and exports

The estimation of imports and exports is a crucial problem that has been extensively discussed in the literature on regional and interregional input-output modelling (Boomsma and Oosterhaven, 1992; Flegg and Webber, 1997; Flegg and Webber, 2000; Flegg *et al.*, 1995; Hewings, 1971; Hewings and Jensen, 1986; Kronenberg, 2009; Oosterhaven, 1984; Richardson, 1985; Round, 1972; Round, 1978;

[6] For a more detailed discussion of these tables, see Kronenberg (2011).

Schaffer and Chu, 1969). For sovereign states, reliable trade statistics are available because customs authorities collect information on the amount and type of products being shipped across international borders and submit these data to the statistical offices. For subnational regions, by contrast, such trade statistics are generally not available. Therefore, regional input-output modellers often have to produce their own estimates of regional imports and exports. There are various ways of doing this with different strengths and weaknesses. Considering the trade-off between the limitations of pure nonsurvey methods and the cost of collecting data, a reasonable compromise appears to be the hybrid approach suggested by Lahr (1993).

One of the criticisms that has been directed at the nonsurvey methods is that they insufficiently account for the size of regional trade (Harris and Liu, 1998; Tohmo, 2004). Richardson (1985) laments that popular methods like Location-Quotient (LQ) or Commodity Balance (CB) approaches are prone to overestimate regional multipliers, because they ignore the simultaneous exportation and importation of commodities, which is known as cross-hauling. Recent evidence suggests that the FLQ method performs better than the traditional approaches that were subject to Richardson's critique. However, for the present study we choose to adopt the CHARM method because it has been shown to generate satisfactory results for other German *Länder* (Kronenberg, 2009; Kronenberg, 2010). In the following, we provide a brief outline of this approach[7].

The CHARM approach is based on a formal definition of cross-hauling:

(12) $q_i = v_i - |b_i| = (e_i + m_i) - |(e_i - m_i)|$,

where $\boldsymbol{q_i}$ denotes cross-hauling, $\boldsymbol{v_i} \equiv \boldsymbol{e_i} + \boldsymbol{m_i}$ denotes the sum of exports e_i and importsm_i or rather the trade volume and $\boldsymbol{b_i} \equiv \boldsymbol{e_i} - \boldsymbol{m_i}$ denotes the trade balance of a commodity *i*.

Traditional nonsurvey methods can only account for the net exports $(\boldsymbol{e_i} - \boldsymbol{m_i})$ and are usually based on the assumption that each industry is either export- or import oriented, which causes either $\boldsymbol{e_i}$or $\boldsymbol{m_i}$ to be set equal to zero and, according to equation (1), cross-hauling not to occur (Kronenberg, 2009). Norcliffe (1983) argues that cross-hauling is the main problem that must be solved to increase the accuracy of non-survey methods.

Particularly two reasons for the occurrence of cross-hauling are dominant in the literature. The first one is related to the geographical size of region. Firms that are located at the frontier of a region are likely to operate on markets on the opposite side of the border. Since smaller regions have longer frontiers in relation to their geographical space, more firms are affected and, hence, cross-hauling is more important. This argument is given by Flegg et al. (1995) with regard to the regional size in their FLQ formula. Apart from that, product heterogeneity is frequently mentioned as a reason for the occurrence of cross-hauling. In accordance with Harris and Liu (1998) cross-hauling appears especially in those industries where "product differentiation and brand preference is important" [p. 853]. This argument is based on an empirical investigation by Norcliffe (1983), who compared estimations of the regional trade volume of several LQ with survey-data on regional trade. He found that LQ-methods considerably underestimate the trade volume of industries that produce heterogeneous commodities like cars or furniture, whereas the estimates for homogeneous commodities e.g. fishery products are almost in accordance with survey-data. Isserman (1980) suggests to implement non-survey methods using data on a very high level of disaggregation, where

[7] For a more extensive presentation, see Kronenberg (2009).

product groups are relatively homogeneous. However, in many countries sufficiently detailed data are simply not available. CHARM therefore includes product heterogeneity as a variable explicitly in the procedure of estimating regional trade.

The first steps of the regionalization procedure are carried out analogically to the traditional CB approach. For a more detailed description see e.g. Miller and Blair (2009). CHARM allows for the estimation of cross-hauling explicitly by assuming that cross-hauling $\boldsymbol{q_i}$ is a function of product heterogeneity h_i, domestic production $\boldsymbol{x_i}$, total intermediate use $\boldsymbol{z_i^d}$ and final domestic use $\boldsymbol{d_i}$, thus $\boldsymbol{q_i} = \boldsymbol{q_i}(\boldsymbol{h_i}, \boldsymbol{x_i}, \boldsymbol{z_i^d}, \boldsymbol{d_i})$. The estimation of product heterogeneity $\boldsymbol{h_i}$ requires, then, a specific functional from that must be consistent with some requirements. Kronenberg (2009) assumes cross-hauling to be proportional to the sum of domestic production $\boldsymbol{x_i}$ and total use $\boldsymbol{z_i} + \boldsymbol{d_i}$ with the degree of product heterogeneity $\boldsymbol{h_i}$ as the factor of proportion[8]:

(13) $q_i = h_i(x_i + z_i + d_i)$.

Substituting (12) into (13) and solving for $\boldsymbol{h_i}$ yields:

(14) $h_i = \frac{v_i - |b_i|}{x_i + z_i + d_i}$.

Since product heterogeneity is a characteristic of a commodity and not of geographical location, it is reasonable to assume that product heterogeneity on the regional level equals its counterpart on the national level for each commodity i. Given that assumption, $\boldsymbol{h_i}$ may be estimated from data of the national input-output table. Substituting the estimated product heterogeneity $\boldsymbol{h_i}$ into equation (2) combined with the values of $\boldsymbol{d_i}$, $\boldsymbol{z_i^d}$ and $\boldsymbol{x_i}$ from the regional input-output table yields an estimation of the regional degree of cross-hauling.

Gross exports and imports are then calculated by solving the definitions of trade volume $\boldsymbol{v_i} \equiv \boldsymbol{e_i} + \boldsymbol{m_i}$ and $\boldsymbol{b_i} \equiv \boldsymbol{e_i} - \boldsymbol{m_i}$ for $\boldsymbol{e_i}$ and $\boldsymbol{m_i}$, which yields:

(15) $\boldsymbol{e_i} = \frac{\boldsymbol{v_i} + \boldsymbol{b_i}}{\boldsymbol{2}}$
(16) $\boldsymbol{m_i} = (\boldsymbol{v_i} - \boldsymbol{b_i})/\boldsymbol{2}$.

$\boldsymbol{b_i}$ is simply given through its definition as the difference of output $\boldsymbol{x_i}$ and total domestic use $\boldsymbol{z_i} + \boldsymbol{d_i}$ from the regional input-output table, whereas the trade volume $\boldsymbol{v_i}$ may be obtained through solving (1) for $\boldsymbol{v_i}$, which yields $\boldsymbol{v_i} = \boldsymbol{q_i} + |\boldsymbol{b_i}|$.

Following these steps yields a regional input-output table based on CHARM as a pure non-survey method. However, these first-round estimates can be improved by using additional data from the foreign trade statistics. These data are available from the statistical office of NRW. We define $\tilde{\boldsymbol{e}}_i$ as the exports and $\widetilde{\boldsymbol{m}}_j$ as the imports from the foreign trade data. The difference is that our first-round estimates refer to NRW's total imports from both foreign countries and other regions in Germany, whereas the official trade data refer only to imports from foreign countries. The same holds true for exports. Naturally, our estimates have to be reconcilable with the official trade statistics.

Four cases can be distinguished by comparing foreign trade data and estimated trade pattern:

[8] Note that this assumption involves some degree of arbitrariness. Equation (13) might also involve a nonlinear component, if that is deemed more appropriate.

- Both estimated exports and imports are greater than the exports and imports from the foreign trade statistic. $\boldsymbol{e_i} > \boldsymbol{\tilde{e}_i}$ and $\boldsymbol{m_j} > \boldsymbol{\widetilde{m}_j}$. In this case no adjustment is necessary.
- Both estimated exports and imports are smaller than the exports and imports from the foreign trade data meaning that $\boldsymbol{e_i} < \boldsymbol{\tilde{e}_i}$ and $\boldsymbol{m_j} < \boldsymbol{\widetilde{m}_j}$.This case concerns the manufacturing of non-metallic mineral products and manufacturing of motor vehicles.
- $\boldsymbol{e_i} < \boldsymbol{\tilde{e}_i}$ and $\boldsymbol{m_j} > \boldsymbol{\widetilde{m}_j}$ so only the estimated exports deceed those from the foreign trade data. Forestry, other mining and the manufacturing of communication equipment are hit by this case.
- $\boldsymbol{m_j} < \boldsymbol{\widetilde{m}_j}$ and $\boldsymbol{e_i} > \boldsymbol{\tilde{e}_i}$ meaning that only the estimated imports are lower than the imports from the foreign trade data. This case concerns the mining of coal as well as the manufacturing of textiles, wearing apparel and coke.

The first case requires no adjustment, since our estimations are consistent with the foreign trade data. On the contrary it is obvious that our estimations have to be adjusted in the three other cases, since we expect the total trade volume to exceed the total foreign trade considerably. Hence, we proceed with a new estimation of trade pattern that explicitly incorporates the foreign trade data, thereby the new estimates must fulfil two conditions: $\boldsymbol{e_i} > \boldsymbol{\tilde{e}_i}$ and $\boldsymbol{m_j} > \boldsymbol{\widetilde{m}_j}$ must hold and the ratio of the new exports and imports must be such that the identity $\boldsymbol{u} \equiv \boldsymbol{s}$ is retained.

Generally the imports and exports of a region can be divided into the trade with other federal states ($\boldsymbol{\breve{e}_i}$ resp. $\boldsymbol{\breve{m}_j}$) and trade with foreign countries ($\boldsymbol{\tilde{e}_i}$ resp. $\boldsymbol{\widetilde{m}_j}$), such that

(17) $e_i = \tilde{e}_i + \breve{e}_i$
(18) $m_j = \widetilde{m}_j + \breve{m}_j$.

Furthermore the trade balance of the trade with the other federal states is given as

(19) $\boldsymbol{\breve{b}_i} = \boldsymbol{\breve{e}_i} - \boldsymbol{\breve{m}_j} = \boldsymbol{b_i} - \boldsymbol{\widetilde{b}_i}$,

whereby $\boldsymbol{\widetilde{b}_i} = \boldsymbol{\tilde{e}_i} - \boldsymbol{\widetilde{m}_j}$ can be calculated from foreign trade data and $\boldsymbol{b_i} = \boldsymbol{z_j^u} + \boldsymbol{n_j} - \boldsymbol{z_i^d} - \boldsymbol{d_i}$ is predetermined, as the identity $u \equiv s$ would be violated otherwise. The trade volume of the trade with other federal states can be written as

(20) $\boldsymbol{\breve{v}_i} = \boldsymbol{\breve{e}_i} + \boldsymbol{\breve{m}_j} = |\boldsymbol{\breve{b}_i}| + \boldsymbol{\breve{q}_i}$

where $\boldsymbol{\breve{q}_i}$ denotes the degree of cross-hauling on the level of regional trade. The trade balance is given through equation (19), but we neither have information about the degree of cross-hauling on the regional level nor do we know the regional trade volume. As a consequence of this problem we have to assume that the degree of regional cross-hauling equals the degree of cross-hauling that we observe in the trade with foreign countries. Such an assumption is surely questionable, but due to the lack of more information, it is one way to calculate trade pattern according to the two conditions we have mentioned above.

On the analogy of (15) and (16), substituting (19) in (20) and solving for $\boldsymbol{\breve{e}_\iota}$ and $\boldsymbol{\breve{m}_\iota}$ yields the regional exports and imports:

(21) $\breve{e}_i = \frac{\breve{v}_i + \breve{b}_i}{2}$

(22) $\breve{m}_j = \frac{\breve{v}_i - \breve{b}_i}{2}$.

Substituting (21) and (22) into (17) and (18) yield an estimation of the total imports and exports for those product groups with requirement for amendment. As a result, we have acquired estimates of total imports and exports for each commodity which are consistent with the official data on imports and exports from and to other countries. Combined with the results of the previous steps, we now have all the data we need to complete the RIOT for NRW.

5 Results

As discussed in the previous section, the first step in our RIOT construction process consisted of the estimation of a supply table for NRW. The result of this estimation is reported in Table 1. Since the fully table is too large for reproduction on a sheet of paper, Table 1 displays an aggregated version of the table with 16 products and 16 industries[9]. The results show that it makes sense to go through the procedure of estimating a regional supply table. Although most of the value of output is recorded on the diagonal of the table (indicating cases where a firm from industry X is producing commodities of type X), there are some notable exceptions. For example, the manufacturing industry (D) produced manufactured products worth 349,451 million EUR, but its total output is worth 367,765 million EUR, which means that roughly five percent of its output did not consist of manufactured products. In a similar fashion, firms in the mining industry (C) produced a total output worth 3,169 million EUR, but only 80 percent (2,537 million EUR) of this output was actually mining products. Furthermore, there are some significant differences between the output figures including and excluding intra-firm deliveries. This is mostly notable for agricultural products (A), where total output excluding intra-firm deliveries amounted to only 7,323 million EUR, whereas total output including intra-firm deliveries amounted to 9,158 million EUR. This indicates that a lot of agricultural products are produced and consumed within the same firm.

The main objective, of course, was to estimate the actual RIOT for NRW, which is reproduced in Table 2. Again, the full table is too large to be printed on paper, so Table 2 shows only an aggregated version. An important feature of the RIOT for NRW is that it is fully consistent with the official results of the statistical offices. That is, the total figures for value added and the major components of regional final use (consumption of households and government; capital formation) are equal to the results from the official statistics.

[9] Note that the full-size table is not of the symmetric type, it includes 59 industries and 71 products. The 16 sector breakdown follows the usual CPA 2002 convention, which is reproduced in the appendix.

Table 1: Aggregated regional supply table

Sector	Industries																Output (excl. intra-firm deliveries)	Output (incl. intra-firm deliveries)
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P		
Products A	7.323	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.323	9.158
B	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	11
C	0	0	2.537	180	0	42	8	0	18	0	0	0	0	0	0	0	2.785	4.152
D	14	0	68	349.451	650	949	1.944	111	211	0	210	0	7	19	0	0	353.635	396.182
E	0	0	352	505	33.134	0	0	0	0	0	0	0	0	0	0	0	33.991	34.987
F	67	0	10	466	2.229	36.436	0	4	484	0	55	44	0	0	157	0	39.952	39.952
G	0	0	30	9.840	6	121	90.058	121	221	34	23	0	0	0	285	0	100.738	100.738
H	15	0	12	509	0	99	41	12.986	8	0	0	0	0	10	0	0	13.680	13.680
I	51	0	3	191	496	38	622	0	54.890	0	0	0	0	0	0	0	56.291	56.291
J	0	0	1	0	0	0	0	0	32	47.797	0	0	0	0	0	0	47.830	47.830
K	58	0	157	6.053	2.514	116	859	97	802	897	167.974	86	46	41	112	0	179.813	179.813
L	0	0	0	0	0	0	0	0	0	0	0	38.132	0	0	0	0	38.132	38.132
M	0	0	0	0	0	0	0	0	0	0	0	0	26.159	0	0	0	26.159	26.159
N	0	0	0	0	0	0	0	0	0	0	0	0	0	49.460	0	0	49.460	49.460
O	0	0	0	570	246	0	0	38	0	0	0	0	0	0	38.076	0	38.930	38.930
P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.830	1.830	1.830
Total	7.527	11	3.169	367.765	39.276	37.802	93.533	13.356	56.667	48.728	168.262	38.262	26.212	49.530	38.630	1.830	990.560	1.037.305

Source: author's calculations

Table 2: Aggregated RIOT for NRW

Sector	Intermediate use																Total interm. use	Final use			Total final use	Total use
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P		House-holds	Other	Exports		
A	1.454	0	15	7.474	0	0	3	149	12	1	147	234	13	162	32	0	9.697	4.542	1.328	1.550	7.420	17.117
B	0	1	0	51	0	0	0	10	0	0	0	0	0	7	0	0	70	76	1	33	110	180
C	78	0	611	15.003	3.302	303	113	11	10	15	36	117	25	42	39	0	19.705	1.488	1.015	2.725	5.228	24.933
D	2.097	2	1.389	194.716	2.945	11.498	3.979	2.190	4.980	361	2.974	2.524	623	4.062	1.682	0	236.019	74.264	34.184	263.719	372.167	608.186
E	183	0	370	6.723	8.958	68	919	228	388	163	434	324	333	472	353	0	19.916	7.574	30	9.580	17.185	37.100
F	45	0	98	1.037	507	1.935	332	87	361	148	4.370	632	195	526	356	0	10.630	889	29.976	191	31.056	41.686
G	549	1	198	14.995	570	2.113	3.886	718	1.321	84	490	581	185	1.212	752	0	27.655	50.157	6.340	20.278	76.775	104.430
H	0	0	9	265	6	41	232	7	240	72	125	204	20	34	143	0	1.398	14.556	0	1.035	15.591	16.989
I	47	1	107	9.797	1.189	267	12.259	136	16.806	733	1.164	889	561	244	603	0	44.803	16.909	601	6.952	24.462	69.265
J	169	0	40	3.339	575	772	1.602	244	1.092	15.988	4.614	715	277	674	904	0	31.005	19.707	0	3.423	23.130	54.135
K	1.268	0	544	33.866	2.633	5.510	14.198	1.486	5.575	10.626	31.221	2.892	656	3.550	3.649	0	117.673	59.160	9.174	14.481	82.815	200.489
L	24	0	45	921	1.594	205	159	37	103	44	616	617	32	128	181	0	4.707	1.059	34.083	184	35.326	40.033
M	7	0	2	447	35	49	128	16	108	76	1.036	219	2.277	42	74	0	4.515	2.836	19.182	0	22.017	26.532
N	68	0	0	45	0	0	25	12	0	0	4	50	31	1.067	40	0	1.342	13.923	33.818	377	48.118	49.460
O	81	0	150	3.351	196	216	1.326	319	550	337	3.730	919	168	865	5.204	0	17.411	16.629	5.739	726	23.094	40.505
P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.710	0	120	1.830	1.830
Interm. consumption	6.069	5	3.579	292.030	22.510	22.979	39.161	5.648	31.544	28.648	50.960	10.916	5.396	13.088	14.011	0	546.545	285.480	175.470	325.374	786.324	1.332.869
Net taxes on products	205	0	57	2.484	420	304	734	364	1.302	2.058	1.297	1.661	618	1.729	1.069	0	14.303	31.636	9.080	-33	40.683	54.986
Value added	2.884	6	516	101.668	12.057	16.670	60.842	7.667	23.445	17.123	127.557	25.555	20.145	34.643	23.850	1.830	476.458					
Output	9.158	11	4.152	396.182	34.987	39.952	100.738	13.680	56.291	47.830	179.813	38.132	26.159	49.460	38.930	1.830	1.037.305					
Imports of similar products	7.958	169	20.780	212.004	2.113	1.733	3.692	3.309	12.973	6.305	20.675	1.901	374	0	1.576	0	295.563					
Total supply	17.117	180	24.933	608.186	37.100	41.686	104.430	16.989	69.265	54.135	200.489	40.033	26.532	49.460	40.505	1.830	1.332.869					

Source: author's calculations

As one of the main reasons for using a hybrid approach is to avoid a systematic overestimation of regional output multipliers due to the underestimation of regional trade, we draw a comparison between import shares and output multipliers on the regional and the national level as well as between results from a nonsurvey estimation procedure with CHARM and the hybrid approach. For reasons of clearness we present our aggregated on a level of 16 sectors denoted with capitals from A to P. Note that a loss detail comes along with especially in the case of manufacturing industries, we therefore mention if values of single industries differ significantly from aggregated values.

Table 3: Comparison of import shares at the regional and the national level

	NRW			Differences	
Sector	**Hybrid**	**Nonsurvey**	**National**	**Hybrid-Nonsurvey**	**NRW-National**
A	46.49%	37.92%	28.69%	8.57%	17.80%
B	93.85%	86.72%	51.70%	7.13%	42.15%
C	83.35%	78.82%	80.41%	4.53%	2.94%
D	34.86%	30.17%	28.60%	4.69%	6.26%
E	5.70%	7.04%	5.95%	-1.34%	-0.25%
F	4.16%	1.43%	1.55%	2.73%	2.61%
G	3.54%	1.13%	1.12%	2.41%	2.42%
H	19.48%	18.97%	8.16%	0.51%	11.32%
I	18.73%	12.79%	11.25%	5.94%	7.48%
J	11.65%	11.34%	6.34%	0.31%	5.31%
K	10.31%	8.40%	4.65%	1.91%	5.66%
L	4.75%	7.60%	0.47%	-2.85%	4.28%
M	1.41%	3.20%	0.00%	-1.79%	1.41%
N	0.00%	0.00%	0.00%	0.00%	0.00%
O	3.89%	3.57%	2.78%	0.32%	1.11%
P	0.00%	0.00%	0.00%	0.00%	0.00%
Total	22.17%	18.49%	16.40%	3.68%	5.77%

Source: author's calculations

Table 3 presents a comparison of the import shares. Apart from electricity, gas and water supply, financial intermediation and other community, social and personal services the dependence on imports is significantly higher on the regional level. Due to aggregation Table 3 does not display the whole scale of differences in import quotas. This affects especially manufacturing, where the differences amount to more than 25% for industries like manufacturers of motor vehicles, other vehicles or electronic products.

The inclusion of superior data causes the total regional import share to increase by 3.5%, which may mostly be attributed to the manufacturing industry that accounts for more than 70% of the whole regional imports. In the light of regional conditions the estimates of fishery (B) and electricity, gas and water supply (E) seem to be more reasonable, since NRW does not border on any sea and almost one third of Germany's gross electricity production is located in this region. The same is true for the import share of education services (M). Some smaller regions are expected to be more dependent on imports than the nations they belong to, these results go confirm with our expectations.

Table 4 Comparison of export shares on the regional and the national level

	NRW			Differences	
Sector	**Hybrid**	**Nonsurvey**	**National**	**Hybrid-Nonsurvey**	**NRW-National**
A	9.06%	8.50%	9.25%	0.56%	-0.19%
B	18.39%	19.57%	25.69%	-1.18%	-7.30%
C	10.93%	5.61%	2.94%	5.32%	7.99%
D	43.36%	39.69%	37.69%	3.67%	5.67%
E	25.82%	11.81%	8.17%	14.01%	17.65%
F	0.46%	0.08%	0.08%	0.38%	0.38%
G	19.42%	21.33%	13.86%	-1.91%	5.56%
H	6.09%	5.73%	6.47%	0.36%	-0.38%
I	10.04%	11.35%	14.80%	-1.31%	-4.76%
J	6.32%	10.84%	5.69%	-4.52%	0.63%
K	7.22%	8.33%	5.43%	-1.11%	1.79%
L	0.46%	0.44%	0.57%	0.02%	-0.11%
M	0.00%	0.00%	0.00%	0.00%	0.00%
N	0.76%	0.76%	0.00%	0.00%	0.76%
O	1.79%	1.23%	0.77%	0.56%	1.02%
P	6.54%	4.76%	0.00%	1.78%	6.54%
Total	24.41%	21.87%	20.07%	2.54%	4.34%

Source: author's calculations

Table 4 shows the export shares (i.e. exports as a share of regional output) for the 16 products categories. These results also suggest that the use of superior data on international exports has improved the overall accuracy of the RIOT. For example, with the pure nonsurvey procedure we estimate an export share of 11.81% for electricity, gas and water (product category E), whereas the hybrid procedure suggests a value of 25.82%. In general, the hybrid procedure leads to higher export shares than the pure nonsurvey procedure. Consequently, it should also produce lower regional output multipliers. These are reported in Table 5.

Table 5: Comparison of output multipliers on the regional and the national level

	NRW			Differences	
Sector	Hybrid	Nonsurvey	National	Hybrid-Nonsurvey	NRW-National
A	1.586	1.622	1.780	-0.036	-0.194
B	1.048	1.048	1.405	0.000	-0.357
C	1.238	1.324	1.208	-0.086	0.030
D	1.831	1.959	1.944	-0.128	-0.113
E	2.062	2.011	1.951	0.051	0.111
F	1.938	1.889	1.994	0.049	-0.056
G	1.610	1.619	1.678	-0.009	-0.068
H	1.555	1.575	1.663	-0.020	-0.108
I	1.780	1.785	1.916	-0.005	-0.136
J	1.899	1.942	1.937	-0.043	-0.038
K	1.391	1.363	1.420	0.028	-0.029
L	1.448	1.456	1.472	-0.008	-0.024
M	1.315	1.307	1.329	0.008	-0.014
N	1.435	1.455	1.452	-0.020	-0.017
O	1.553	1.552	1.581	0.001	-0.028
P	1.000	1.000	1.000	0.000	0.000

Source: author's calculations

Compared to the results of our non-survey estimates the hybrid approach delivers, in general, far lower output multipliers. This is particularly true in the cases of manufacturing (D), financial intermediation (J), public administration (L) and health and social work (N). A comparison between the national and regional multipliers shows that the former are generally larger than the latter, as should be expected. The only exceptions are mining products (C) and electricity, gas and water (E), where the regional multipliers are larger than their national counterparts. As already mentioned above, a large share of Germany's electricity generation and particularly hard coal and lignite mining is located in North Rhine-Westphalia. It is therefore plausible that output multipliers of these sectors are greater than the national ones, which indicates a strong overrepresentation.

A related observation can be made with respect to the input-output coefficients describing the production technology. At the regional level, the input-output coefficient of mining products in the production of electricity, gas and water is somewhat larger than at the national level. This reflects a different electricity generation mix, which is still dominated by hard coal and lignite in NRW. Other regional input-output coefficients also differ from their national counterparts. For example, the input of agriculture (A) in manufacturing is lower in NRW, reflecting the fact that NRW's manufacturing industry is dominated by steel and iron products, whereas food products play a much smaller role.

Table 6 Technological coefficients on the regional and the national level

Regional technological coefficients

Sector	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
A	0.159	0.000	0.004	0.019	0.000	0.000	0.000	0.011	0.000	0.000	0.001	0.006	0.000	0.003	0.001	0.000
B	0.000	0.113	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C	0.009	0.002	0.147	0.038	0.094	0.008	0.001	0.001	0.000	0.000	0.000	0.003	0.001	0.001	0.001	0.000
D	0.229	0.152	0.334	0.491	0.084	0.288	0.039	0.160	0.088	0.008	0.017	0.066	0.024	0.082	0.043	0.000
E	0.020	0.013	0.089	0.017	0.256	0.002	0.009	0.017	0.007	0.003	0.002	0.008	0.013	0.010	0.009	0.000
F	0.005	0.011	0.024	0.003	0.014	0.048	0.003	0.006	0.006	0.003	0.024	0.017	0.007	0.011	0.009	0.000
G	0.060	0.061	0.048	0.038	0.016	0.053	0.039	0.052	0.023	0.002	0.003	0.015	0.007	0.025	0.019	0.000
H	0.000	0.002	0.002	0.001	0.000	0.001	0.002	0.000	0.004	0.002	0.001	0.005	0.001	0.001	0.004	0.000
I	0.005	0.111	0.026	0.025	0.034	0.007	0.122	0.010	0.299	0.015	0.006	0.023	0.021	0.005	0.015	0.000
J	0.018	0.004	0.010	0.008	0.016	0.019	0.016	0.018	0.019	0.334	0.026	0.019	0.011	0.014	0.023	0.000
K	0.138	0.009	0.131	0.085	0.075	0.138	0.141	0.109	0.099	0.222	0.174	0.076	0.025	0.072	0.094	0.000
L	0.003	0.002	0.011	0.002	0.046	0.005	0.002	0.003	0.002	0.001	0.003	0.016	0.001	0.003	0.005	0.000
M	0.001	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.006	0.006	0.087	0.001	0.002	0.000
N	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.001	0.022	0.001	0.000
O	0.009	0.007	0.036	0.008	0.006	0.005	0.013	0.023	0.010	0.007	0.021	0.024	0.006	0.017	0.134	0.000
P	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Taxes	0.022	0.013	0.014	0.006	0.012	0.008	0.007	0.027	0.023	0.043	0.007	0.044	0.024	0.035	0.027	0.000
Value Added	0.315	0.501	0.124	0.257	0.345	0.417	0.604	0.560	0.416	0.358	0.709	0.670	0.770	0.700	0.613	1.000
Output	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

National technological coefficients

Sector	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
A	0.157	0.000	0.003	0.021	0.000	0.000	0.000	0.011	0.000	0.000	0.001	0.006	0.000	0.003	0.001	0.000
B	0.000	0.111	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C	0.008	0.002	0.150	0.033	0.089	0.007	0.001	0.001	0.000	0.000	0.000	0.003	0.001	0.001	0.001	0.000
D	0.211	0.149	0.182	0.484	0.075	0.287	0.048	0.161	0.090	0.007	0.017	0.064	0.024	0.082	0.042	0.000
E	0.018	0.013	0.055	0.015	0.238	0.002	0.010	0.017	0.007	0.003	0.002	0.008	0.013	0.010	0.009	0.000
F	0.005	0.011	0.011	0.002	0.012	0.046	0.004	0.006	0.006	0.003	0.025	0.016	0.007	0.011	0.009	0.000
G	0.056	0.060	0.028	0.037	0.014	0.053	0.039	0.053	0.025	0.002	0.003	0.015	0.007	0.025	0.020	0.000
H	0.000	0.002	0.001	0.001	0.000	0.001	0.002	0.000	0.004	0.001	0.001	0.005	0.001	0.001	0.004	0.000
I	0.005	0.109	0.048	0.025	0.028	0.007	0.114	0.010	0.303	0.015	0.006	0.023	0.022	0.005	0.017	0.000
J	0.017	0.004	0.011	0.009	0.014	0.019	0.017	0.018	0.021	0.326	0.025	0.018	0.011	0.014	0.021	0.000
K	0.129	0.009	0.128	0.088	0.066	0.134	0.151	0.109	0.099	0.207	0.169	0.075	0.025	0.072	0.093	0.000
L	0.003	0.002	0.009	0.002	0.042	0.005	0.002	0.003	0.002	0.001	0.003	0.016	0.001	0.003	0.004	0.000
M	0.001	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.007	0.006	0.087	0.001	0.002	0.000
N	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.001	0.022	0.001	0.000
O	0.008	0.006	0.020	0.008	0.005	0.005	0.015	0.023	0.009	0.007	0.020	0.023	0.006	0.018	0.142	0.000
P	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Taxes	0.022	0.013	0.012	0.006	0.012	0.008	0.007	0.027	0.024	0.041	0.008	0.044	0.024	0.035	0.028	0.000
Value Added	0.353	0.511	0.340	0.268	0.403	0.425	0.588	0.558	0.408	0.385	0.714	0.677	0.769	0.699	0.607	1.000
Output	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Source: author's calculations

Finally, Table 7 reports the results of the procedure described in section 4.3, where we computed the final consumption of households based on EVS micro data. The table shows that the consumption structure (i.e. the shares of each product category in total consumption spending) differs to a certain extent in NRW from the national structure. For example, the share of manufacturing products is 0.50% larger, whereas the share of transport, storage and communication (I) is 0.56% smaller. This indicates that the use of regional consumption survey data also contributes to an improvement of overall table accuracy.

Table 7 Consumption structure on the regional and the national level

	NRW		National		
Sector	**Mio. €**	**Share (%)**	**Mio. €**	**Share (%)**	**Difference**
A	4,542	1.59%	16,133	1.39%	0.20%
B	76	0.03%	334	0.03%	0.00%
C	1,488	0.52%	7,061	0.61%	-0.09%
D	74,264	26.01%	296,268	25.51%	0.50%
E	7,574	2.65%	33,854	2.91%	-0.26%
F	889	0.31%	3,594	0.31%	0.00%
G	50,157	17.57%	201,055	17.31%	0.26%
H	14,556	5.10%	63,150	5.44%	-0.34%
I	16,909	5.92%	75,247	6.48%	-0.
J	19,707	6.90%	78,317	6.74%	0.16%
K	59,160	20.72%	238,022	20.49%	0.23%
L	1,059	0.37%	4,506	0.39%	-0.02%
M	2,836	0.99%	13,998	1.21%	-0.22%
N	13,923	4.88%	55,788	4.80%	0.08%
O	16,629	5.83%	67,169	5.78%	0.05%
P	1,710	0.60%	7,070	0.61%	-0.01%
Total	285,480	100.00%	1,161,566	100.00%	

6 Conclusion

In federal states like Germany many important decisions regarding economic-, energy- or environmental policy are made by regional governments. Therefore, regional economists are dependent on reliable information about the regional economy under study to be able to give professional advice to regional decision makers, because the regional effects of political decisions have to be understood properly. Although there is a vast literature criticising traditional non-survey methods, they are often used applied in economic policy consulting, due to the lack of regional input-output tables from official sources, as these methods are quick and easy to use.

The aim of this paper was to show how a RIOT for one of Germany's federal states can be constructed with a reasonable endowment of time and money, using the case of NRW as an example. Our findings suggest that a hybrid approach using superior data with respect to household consumption and international trade produces better results than a pure nonsurvey approach. Our experience suggests that if the available information sources are used in an efficient manner, it is possible to construct a RIOT that yields plausible results in terms of output multipliers. The problems of pure nonsurvey methods, which tend to underestimate regional trade and overestimate regional output multipliers, are not insurmountable. Of course, this does not render surveys useless – we believe that a regional survey of firms in selected industries could still contribute to even better accuracy. However, the procedure outlined in this paper appears to offer a reasonable compromise between accuracy and cost.

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7

Appendix

Table 8 Sector codes and description

Sector code	Description
A	Agriculture, hunting, forestry
B	Fishing
C	Mining and quarrying
D	Manufacturing
E	Electricity, gas and water supply
F	Construction
G	Wholesale and retail trade, repair services
H	Hotels and restaurants
I	Transport, storage and communication
J	Financial intermediation
K	Real estate, renting and business support activities
L	Public Administration, compulsory social security
M	Education
N	Health and social work
O	Other community, social and personal services
P	Activities of households