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Paper 126

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Regionalization of national input-output tables: empirical evidence on the use of the FLQ formula

Julia Kowalewski*

Abstract

This paper contributes to the ongoing debate about deriving the value of the exponent δ when using Flegg's location quotient (FLQ) formula which helps to simulate regional input-output tables. Using a survey-based regional input-output table, the empirical analysis provides evidence of an optimal δ for the German Federal of State Baden-Wuerttemberg. Furthermore, an extended formula (SFLQ) is introduced allowing for variation in δ by industry. Finally, this paper demonstrates the advantage of the SFLQ and finds evidence for a close relationship between the spatial concentration of an industry at the national level and its propensity to import goods and services from other regions.

Keywords: regional input-output table; non-survey method; empirical analysis

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1 Introduction

Estimating regional economic interdependencies as accurately as possible is a major task in regional science. Thus, regional input-output tables remain important and significant effort has resulted in a large number of approaches for their derivation. The construction of a regional input-output table can be carried out in three different ways: survey-based, semi-survey-based (hybrid or partial-survey) or non-survey-based. The feature that defines the difference between these methods is the degree of reliance upon the national input-output framework (Brand et al. 2000, p. 345). Survey-based regional input-output tables in Germany have been published by the State Office of Statistics of Baden-Wuerttemberg. Owing to financial limitations the data collection was stopped in 1993. Only a few researchers put much effort into conducting semi-survey-based input-output tables. In Germany, examples of semi-survey-based tables include those derived by Kronenberg (2010) for the Federal State of Mecklenburg-West-Pomerania, Oberhofer/Haupt (2001) for the city of Regensburg (Bavaria) or Staeglin (2001) for the city of Hamburg. Most commonly, researchers make use of non-survey methods, such as the commodity balance approach (e.g. Kronenberg (2009) for the Federal State of North-Rhine Westphalia), iterative procedures (e.g. Bergmann (2006) for a part of Lower Saxony) or location quotient approaches (e.g. Koschel et al. (2006) for the Federal State of Hessen).

It would be desirable to establish a standardized method, which is as accurate as possible and used consistently so that regional economic impacts are adequately assessed and results are comparable across regions. Thereby, non-survey-based estimations generally are the basis for hybrid approaches (e.g. Lahr 1993). Thus, the higher the accuracy of the initial regional input-output table, the better the starting conditions for hybrid approaches. The aim of the latter should be to include additional information in order to account for regional or industrial specifics, such as technological gaps between regions and the national average.

Literature dealing with comparisons of different non-survey methods already exists. In most cases, the accuracy of different location quotient methods is evaluated (e.g. Round 1978, Harrigan et al. 1980, Bonfiglio 2009). Recent studies show that the location quotient method developed by Flegg/Webber (1997) (FLQ) tends to outperform the other methods in estimating regional output multipliers and input coefficients (Tohmo 2004, Bonfiglio/Chelli 2008, and Bonfiglio 2009). In contrast to its predecessors, the FLQ formula simultaneously accounts for the size of the selling industry, the size of the purchasing industry and the size of the region.

However, the problem of choosing an appropriate value for the arbitrary parameter δ , which allows for adjusting regional import patterns, has limited the practical use of the formula. It has been shown that this element of flexibility in the FLQ formula helps to increase the accuracy of the regional input-output table, but there is still uncertainty about the ‘optimal’ value of δ .

Empirical investigations are necessary in order to provide at least a generally accepted interval for the value of the exponent and to decrease the uncertainty. Indeed, Flegg/Webber (1997 and 2000), and Flegg/Tohmo (2011) deliver empirical studies for Scotland as well as for Finnish regions, where survey-based input-output tables were available for comparison with estimated tables. Whether their results also hold for other countries, like Germany, is uncertain. As Flegg/Webber (1997) point out, a substantial amount of empirical work needs to be done in order to turn the FLQ formula into a widely used regionalization method. McCann/Dewhurst (1998) also call for further work on the robustness of the formula. Furthermore, the latter suggest that future work should analyse whether the relaxation of the assumption that the exponent in the FLQ formula is equal for all industries would result in more accurate regional input-output tables.

As a response to the above demands, this paper provides empirical evidence for the applicability of the FLQ formula to a German region. Thereby, the aim is to determine a reasonable value for δ through empirical analysis in order to estimate regional input coefficients and output multipliers. Furthermore, as it has not been done before, this paper analyses whether an industry-specific value for δ helps to produce more accurate simulation results and whether a general conclusion can be drawn for further applications of the formula. The analyses will be based on the survey-based input-output table for the German Federal State of Baden-Wuerttemberg (B-W) in 1993 and the respective national input-output table.

The rest of the paper is divided into five sections. Section 2 presents the FLQ formula as well as its most important predecessors. Subsequently, a summary of the empirical evidence on the value of δ is provided. In section 4 the data for the following analysis is explained. Section 5 describes the applied comparative statistics and shows their results. This section also analyses the advantage of an industry-specific δ and illuminates its explanatory factors. Section 6 concludes the paper.

2. Regionalization methods

2.1 The simple and the cross-industry location quotient

Regional input-output analyses require regional input-output tables. The regional modeller faces the problem that required data are often not available at the regional level. Thus, estimates about inter- and intraregional trade have to compensate for this lack of data. A common way to estimate regional coefficients is to regionalize the national input-output table using location quotients (LQs). The LQ methods are based on the assumptions that regional and national technologies are identical and that regional trade coefficients differ from the national input coefficients in the extent to which goods and services are imported from other regions. Let a_{ij}^N and a_{ij}^R be the national (N) and regional (R) input coefficients, i.e. the values of goods and services purchased by industry j from industry i divided by the total output of industry j in the nation and the region, respectively. The national input coefficient a_{ij}^N is then equal to the regional input coefficient a_{ij}^R plus the regional import coefficient m_{ij}^R . The regional input coefficients are estimated in the following way: $a_{ij}^R = a_{ij}^N \cdot q_{ij}$, where q_{ij} represents the degree of modification of the national coefficient. Different formulae that aim to estimate the value of q_{ij} have already been developed up to now.

In the empirical literature regional input-output tables are usually estimated by the simple LQ (SLQ) (e.g. Spoerri et al. 2007). The SLQ of industry i is defined by the following equation:

$$SLQ_i = \frac{E_{ir} / E_{.r}}{E_i / E_{..}} \quad (1)$$

with E_{ir} (E_i) the regional (national) employment in (the selling) industry i with $i = 1, \dots, n$ industries and $E_{.r}$ ($E_{..}$) total regional (national) employment. SLQ thereby reflects the relative importance of the regional industry i as compared with its national counterpart measured by employment. If $SLQ_i > 1$, it is assumed that the region is specialized in the specific industry. This implies that the regional industry is able to meet the regional demand requirements for its products or services and therefore the regional coefficient is assumed to be equal to the national coefficient ($a_{ij}^R = a_{ij}^N$). The same assumption holds if $SLQ_i = 1$. However, if $SLQ_i < 1$, it is assumed that the regional production is less than the national

average. Consequently, the industry needs to import from other regions to meet the whole regional demand requirements and $a_{ij}^R = a_{ij}^N \cdot SLQ_i$.

One of the first enhancements of the SLQ was the cross-industry location quotient (CILQ). The CILQ compares the share of the selling industry's employment of the region to the national with that of the purchasing industry in the region to the national:

$$CILQ_{ij} = \frac{E_{ir} / E_{jr}}{E_i / E_j} = \frac{SLQ_i}{SLQ_j} \quad (2)$$

with E_{jr} (E_j) the regional (national) employment in the purchasing industry. In the special case where $i = j$ in equation (2) the $CILQ_{ij}$ equals one. For this reason the SLQ 's are used to adjust the coefficients along the principal diagonal (Smith/Morrison 1974, p. 66). Consequently, if an industry in a region is small, the interregional trade is assumed to be higher than the national average. The allowance for a variable domestic (regional) share coefficient across the purchasing industries implies that each industry can simultaneously import and export, i.e. cross-hauling can occur (Harrigan et al. 1980, p. 930). The disadvantage of the CILQ is that it does not account for regional size.

2.1 Flegg's location quotients

Flegg et al. (1995) developed a new formula, which was reformulated later on by Flegg/Webber (1997) with respect to the specification of the parameter λ . The following formula will also be used in the further course of this paper:

$$FLQ_{ij} = CILQ_{ij} \cdot \lambda^* \quad (3)$$

$$\text{with } \lambda^* = [\log_2(1 + E_r / E_n)]^\delta \quad (4)$$

The FLQ incorporates the CILQ merits, i.e. it has a cross-industry foundation, and also accounts for the relative size of the region through λ^* ($0 \leq \lambda^* < 1$). In the case of $\lambda^* = 1$ FLQ_{ij} equals $CILQ_{ij}$. The value of λ^* increases monotonically with the size of the region so that a greater adjustment for imports is made in smaller regions. Thereby, an increase in regional imports implies a decrease in intraregional trade. Thus, the underlying assumption is

that any method, which correctly estimates total imports, would at the same time result in better estimates of input coefficients and output multipliers (McCann/Dewhurst 1998, p. 437).

The inclusion of the exponent δ ($0 \leq \delta \leq 1$) introduces an element of flexibility by altering the convexity of the function λ^* . A higher value of δ would lower the value of λ^* and thus, greater adjustments of regional imports are made. However, the choice of value for δ is considered to be an empirical matter.

The implementation of the FLQ formula is carried out similar to other location quotient formulae:

$$a_{ij}^R = \begin{cases} a_{ij}^N & \text{if } FLQ_{ij} \geq 1 \\ FLQ_{ij} \cdot a_{ij}^N & \text{if } FLQ_{ij} < 1 \end{cases} \quad (5)$$

McCann/Dewhurst (1998, p. 442) criticised that industrial specialization is not adequately taken into account with the above regionalization technique. Their main criticism is that regional specialization involves the creation of localization economies, which generally involve a greater degree of local subcontracting than in the case of a more diversified economic structure. Hence, their conclusion is that as the spatial scale of analysis falls, the observed input-output linkages will be stronger within and between industries, in which the region is specialized, and lower in the others. The extent of intraregional trade might even be higher than in the national average so that $a_{ij}^R > a_{ij}^N$.

Flegg/Webber (2000) responded that regional specialization is already reflected by the FLQ formula as long as $a_{ij}^R \leq a_{ij}^N$. This is because regional specialization would lead to an increase in SLQ_i and hence in $CILQ_{ij}$ and FLQ_{ij} (p.565). However, they provided a modification of the FLQ formula, which allows for $a_{ij}^R > a_{ij}^N$ in case of regional specialization:

$$AFLQ_{ij} = \begin{cases} FLQ_{ij} \cdot \left[\log_2(1 + SLQ_j) \right] & \text{for } SLQ_j > 1 \\ FLQ_{ij} & \text{for } SLQ_j \leq 1 \end{cases} \quad (6)$$

2.3 Improving the FLQ formula

The FLQ formula is subject to the strong assumption that the value of the exponent δ is equal for all industries. An improved formula which allows for a variation in δ_j across industries is applied in the following empirical analysis. The industry-specific FLQ (SFLQ) is defined as

$$SFLQ_{ij} = CILQ \cdot [\log_2(1 + E_{i,r} / E_{..})]^{\delta_j} \quad (7)$$

The variation in δ_j implies that industrial specifics determine the propensity to import. Accordingly, the question arises, which characteristics lead to higher or lower interregional trade. Thus, the aim of the following empirical analysis is, firstly, to identify optimal industry-specific values of δ_j . Secondly, it will be checked if industries with a high or a low value of δ_j have common characteristics. This is the central precondition for a transfer of the SFLQ to other regions.

3. Empirical evidence

Empirical evidence on the relative success of the FLQ formula compared to its predecessors (LQ and CILQ) is provided by Flegg/Webber (1997), Flegg/Webber (2000), Tohmo (2004), Bonfiglio (2009), or Flegg/Tohmo (2011). Therein, it is found that the SLQ and the CILQ have a tendency to underestimate imports systematically. Most of these studies also find that the FLQ outperforms the AFLQ in accuracy of the estimation of output multipliers and input coefficients (Flegg/Webber 2000, Flegg/Tohmo 2011). The main obstacle for a widespread use of the FLQ formula is that the choice of a value for the exponent δ remains an empirical matter. The ‘best’ value would be the one that produces estimates equal to the actual input coefficients and output multipliers. Unfortunately, only little empirical research on the value of δ has been produced so far. This is mainly owing to scarcity of regional survey-based input-output tables for comparison with estimated tables.

Flegg/Webber (1997) applied their formula to Scotland, as they could use a survey-based input-output table of the year 1989 for verification. A value of $\delta = 0.3$ turned out to be reasonable. Their later study (Flegg/Webber 2000), on the other hand, indicates that a value of $\delta = 0.2$ delivers higher accuracy of results. A more comprehensive study of 20 Finnish regions for the year 1995 by Flegg/Tohmo (2011, p. 18) found that a value of $\delta = 0.25$ produced acceptable estimates of industrial multipliers for most of the regions using the FLQ formula. Thereby, they observed a tendency for the required value of δ to rise with regional

size. While the smallest regions (with 0.7 % of total employment) need a value of $\delta = 0.15$, some of the larger regions (with 8.2 % of total employment) require $\delta = 0.35$. From their findings they develop a regression equation with δ being the independent variable and regional size measured in output (R), regional propensity to import from other regions divided by the mean value of this propensity for all regions (P) and the survey-based average use of intermediate inputs (including imports) (I) as explanatory variables (Flegg/Tohmo 2011, p. 11):

$$\ln \delta = -1.8379 + 0.33195 \ln R + 1.5834 \ln P - 2.8812 \ln I + e \quad (8)$$

Using the AFLQ formula a somewhat higher value of δ was required to produce satisfactory estimates, i.e. a value around $\delta = 0.3$. Similar results were provided by Bonfiglio (2009). The most precise estimation with the FLQ formula was found using a value of $\delta = 0.3$, i.e. $\delta = 0.3$ produced the closest multipliers to the ‘true’ multipliers. Regarding the AFLQ formula, he found that a value of $\delta = 0.36$ is appropriate and the AFLQ becomes superior to the FLQ formula in producing more accurate simulation results (Bonfiglio 2009, p. 122).

4. Data base

Input-output table of Baden-Wuerttemberg

The subsequent estimations are based on the input-output table of Germany for the year 1993 which was generated by the Federal Statistical Office of Germany. It includes 58 commodities, which represent the supplying industries, as well as 58 branches of production, which represent the industries or purchasing industries. For comparison with the non-survey based results the regional input-output table, distinguishing between 27 industries of B-W for the year 1993, is used. This is provided by the State Office of Statistics of B-W. From 1972 to 1993 regional input-output tables for B-W had been estimated nearly every two years. In order to estimate imports from other federal states in Germany the external dependence of each product group on a very low aggregation level was assessed.

The input-output system of B-W was completely integrated into national accounting. Basic data for the input-output table (production values, value added, sum of intermediates of branch of production, domestic final demand aggregates) were taken from the social product accounting (Sozialproduktsberechnung). Furthermore, specific information about commodity flows came from the goods traffic statistics (Gütertransportstatistiken) (Kaiser 1995).

Both, national and regional tables display the respective domestic production, i.e. imports are shown separately. Furthermore, values are shown as factory prices, which are denominated in

'Deutsche Mark'. Table 1 presents an aggregated version of the official industry-by-industry input-output table of B-W.

Table 1 Aggregated input-output table of B-W 1993 in million German Marks, industry-by-industry

| Output to industry j Input from industry i | Agriculture, Forestry, Animal Husbandry, Fisheries | Manufacturing industry | Trade, Mail Services | Transport | Financial Intermediation, Insurance and Pension Funding | Hotels and Restaurants | Health and Veterinary Services | Other Services, State, Private Organisations | Final Demand | Gross Production Value |
|---|--|------------------------|----------------------|-----------|---|------------------------|--------------------------------|--|--------------|------------------------|
| Agriculture, Forestry, Animal Husbandry, Fisheries | 614 | 4,091 | 22 | 1 | 12 | 69 | 41 | 555 | 3,267 | 8,672 |
| Manufacturing industry | 1,030 | 73,978 | 3,084 | 1,876 | 861 | 2,249 | 762 | 16,366 | 327,726 | 427,932 |
| Trade, Mail Services | 231 | 13,150 | 1,785 | 408 | 539 | 496 | 269 | 3,987 | 48,435 | 69,300 |
| Transport | 127 | 5,043 | 531 | 224 | 218 | 172 | 48 | 1,160 | 9,488 | 17,011 |
| Financial Intermediation, Insurance and Pension Funding | 67 | 1,596 | 348 | 283 | 17,852 | 76 | 82 | 1,859 | 12,048 | 34,211 |
| Hotels and Restaurants | 12 | 2,187 | 605 | 507 | 194 | 6 | 7 | 1,501 | 8,257 | 13,276 |
| Health and Veterinary Services | 135 | 126 | 35 | 21 | 55 | 3 | 133 | 10,943 | 4,362 | 15,813 |
| Other Services, State, Private Organisations | 303 | 44,758 | 10,391 | 1,763 | 6,507 | 1,982 | 1,905 | 38,455 | 156,107 | 262,171 |
| Intermediates from Production in B-W | 2,519 | 144,929 | 16,801 | 5,083 | 26,238 | 5,053 | 3,247 | 74,826 | 569,690 | 848,386 |
| Foreign Imports | 626 | 44,904 | 1,904 | 957 | 969 | 871 | 506 | 5,985 | | |
| Imports from other Federal States in Germany | 1,197 | 60,800 | 2,116 | 2,214 | 4,649 | 1,535 | 700 | 13,252 | | |
| Total Intermediates | 4,342 | 250,633 | 20,821 | 8,254 | 31,856 | 7,459 | 4,453 | 94,063 | | |
| Value Added | 4,330 | 177,299 | 48,479 | 8,757 | 2,355 | 5,817 | 11,360 | 168,108 | | |
| Gross Production Value | 8,672 | 427,932 | 69,300 | 17,011 | 34,211 | 13,276 | 15,813 | 262,171 | | |

Employment data

Employment data for Germany and its federal states is published by the German Employment Agency (2011). Additionally, employment data for B-W has been provided by the State Office of Statistics of Baden Wuerttemberg (1994). In regional models employment often serves as a proxy for output because output data are not normally available at a highly disaggregated level. It is assumed that output and employment are in a close relationship. The present case of B-W confirms this assumption as output has a correlation of 0.802 with employment and 0.711 with value added.

The employment data used in the analyses follow the industrial classification of 1973 (WS73) and are classified in 21 sectors of economic activity. Table 2 shows the industry classification and number of employees in B-W and Germany in 1993 and the corresponding location quotients, which reflect regional industry-specific specialization if $SLQ_i > 1$. Hence, in 1993 the share of B-W in total employment in Germany was 13.4 percent. The federal state was specialized in the following industries: (1) Electro and Precision Engineering, Ironware, (2) Manufacture of Textiles, Apparel and Leather, (3) Manufacture of Steel, Machinery and

Motor Vehicles, Office Machinery, (4) Manufacture of Wood, Paper and Printing Industry, (5) Manufacture of Plastic Products, Rubber and Asbestos, (6) Manufacture of Iron and Metal, Foundry, Steel Forming, (7) Financial Intermediation, Insurance and Pension Funding, and (8) Health and Veterinary Services.

Table 2 Industry structure of B-W

| Sector | Baden- Wuerttemberg | Germany | Location Quotient |
|--|------------------------|-------------------|----------------------|
| Agriculture, Forestry, Animal Husbandry, Fisheries | 29,393 | 415,408 | 0.53 |
| Energy Industry, Water Supply, Mining | 36,530 | 579,272 | 0.47 |
| Chemical Industry, Manufacture of Petroleum | 68,946 | 670,812 | 0.77 |
| Manufacture of Plastic Products, Rubber and Asbestos | 74,427 | 433,146 | 1.28 |
| Quarrying for Stone and Earths, Fine-Ceramics, Glass | 43,716 | 394,011 | 0.83 |
| Manufacture of Iron and Metal, Foundry, Steel Forming | 82,451 | 557,368 | 1.10 |
| Manufacture of Steel, Machinery and Motor Vehicles, Office Machinery | 554,796 | 2,996,477 | 1.38 |
| Electro and Precision Engineering, Ironware | 420,402 | 1,893,189 | 1.65 |
| Manufacture of Wood, Paper and Printing Industry | 166,200 | 933,463 | 1.33 |
| Manufacture of Textiles, Wearing Apparel and Leather | 88,603 | 478,316 | 1.38 |
| Manufacture of Foodstuffs, Drinks and Tobacco | 102,059 | 852,633 | 0.89 |
| Construction | 259,706 | 2,283,301 | 0.85 |
| Trade | 484,782 | 3,869,552 | 0.93 |
| Mail Services | 38,094 | 331,512 | 0.86 |
| Transport | 109,687 | 1,274,523 | 0.64 |
| Financial Intermediation, Insurance and Pension Funding | 154,013 | 1,067,030 | 1.08 |
| Hotels and Restaurants | 137,568 | 1,095,050 | 0.94 |
| Health and Veterinary Services | 239,500 | 1,764,572 | 1.01 |
| Other Services | 429,083 | 3,679,342 | 0.87 |
| State | 241,089 | 2,294,749 | 0.78 |
| Private Organisations without Pecuniary Reward | 76,718 | 725,184 | 0.79 |
| Sum | 3,837,763 | 28,588,910 | |

5. Empirical analysis

5.1 Performance of the FLQ formula

The FLQ is used to regionalize the input-output table of Germany, 1993, according to Formula (5) using different values for the exponent δ . Thereby, values in the range of $0 \leq \delta \leq 1$ are applied in steps of 0.001. Several statistics are applied afterwards in order to ascertain which value for δ delivers the most accurate results with respect to input coefficients and output multipliers. A detailed description of the motivation for using the applied criteria can be found in Flegg/Tohmo (2011, p. 9, 13-14). The results are compared to alternative LQ-based formulae for the examination of the relative success of the FLQ formula.

Regional output multipliers

Output multipliers are highly relevant for regional impact analyses. Thus, their accuracy is of great importance for regional analysts and policy makers. The following statistics are applied to assess the accuracy of the estimated industrial output multipliers:

$$\mu_1 = (1/n) \sum_j |\hat{p}_j - p_j| / p_j \quad (9)$$

$$\mu_2 = (1/n) \sum_j |\hat{p}_j - p_j| \quad (10)$$

$$\mu_3 = 100 \sqrt{\sum_j (\hat{p}_j - p_j)^2 / \sum_j p_j^2} \quad (11)$$

$$sd = \left[(1/n) \sum_j \left\{ \left(|\hat{p}_j - p_j| / p_j \right) - \mu_1 \right\}^2 \right]^{0.5} \quad (12)$$

$$\mu_4 = (100/n) \sum_j (\hat{p}_j - p_j) / p_j \quad (13)$$

$$\mu_5 = 100 \sum_j e_j (\hat{p}_j - p_j) / p_j \quad (14)$$

where \hat{p}_j is the estimated type I output multiplier of industry j , i.e. the column sum of the simulated Leontief inverse, p_j is the corresponding survey-based multiplier of industry j with $n = 21$ industries, and e_j is the employment share of industry j in total employment in B-W.

Formulae (9) to (12) account for the absolute deviation of the estimated from the actual multipliers. The first two criteria, μ_1 and μ_2 , represent the mean absolute proportional deviation and the mean absolute deviation, respectively. μ_3 is the Theil's index of inequality and sd (standard deviation) measures dispersion in the absolute proportional errors. Formulae (13) and (14) have the ability to measure bias. While μ_4 weights each industry equally, μ_5 accounts for the relative industry size. The disadvantage of both formulae is that positive and negative errors can average out to zero (Flegg/Tohmo 2011, p. 9).

Table 3 shows the results of the applied criteria for the FLQ as well as the AFLQ, the SLQ, and the CILQ. For the FLQ and the AFLQ the values of δ which minimize the respective criterion are presented. The results show that the FLQ outperforms the other LQ-methods with respect to almost all criteria. With respect to dispersion and bias of the estimated multipliers, the accuracy of the AFLQ is similar to the FLQ, although the AFLQ requires a higher value of δ ($\delta \approx 0.2$). The FLQ requires a value of $0.11 \leq \delta \leq 0.17$ in order to produce most accurate results.

Table 3 Assessment of accuracy of estimated output multipliers

| Criterion | Method | | | |
|-------------------|------------------------------|------------------------------|-------|-------|
| | FLQ | AFLQ | SLQ | CILQ |
| $\mu_1 \cdot 100$ | 5.20 ($\delta = 0.14$) | 6.34 ($\delta = 0.16$) | 11.2 | 10.9 |
| $\mu_2 \cdot 100$ | 8.24 ($\delta = 0.13$) | 9.84 ($\delta = 0.14$) | 16.8 | 16.3 |
| μ_3 | 1.89 ($\delta = 0.11$) | 2.1 ($\delta = 0.15$) | 3.24 | 2.94 |
| sd | 0.057 ($\delta = 0.16$) | 0.057 ($\delta = 0.20$) | 0.101 | 0.083 |
| μ_4 | 0.002 ($\delta = 0.17$) | 0.002 ($\delta = 0.21$) | 11.2 | 10.9 |
| μ_5 | 0.001 ($\delta = 0.14$) | 0.002 ($\delta = 0.19$) | 11.4 | 9.1 |

Regional input coefficients

The examination of regional input coefficients can help to identify the sources of errors and provide insights into problematic industries. The following statistics will be used to evaluate the accuracy of the estimated coefficients:

$$\gamma_1 = \frac{100}{n^2 - z} \sum_{i,j} (\hat{a}_{ij} - a_{ij}) \quad (15)$$

$$\gamma_2 = \frac{100}{n^2 - z} \sum_{i,j} (\hat{a}_{ij} - a_{ij})^2 \quad (16)$$

$$\gamma_3 = \left(\sum_{i,j} |\hat{a}_{ij} - a_{ij}|^2 \right)^{0.5} \quad (17)$$

$$\gamma_4 = \sum_{i,j} |\hat{a}_{ij} - a_{ij}| / \sum_{ij} a_{ij} \quad (18)$$

$$\gamma_5 = \frac{100}{n} \sum_j |\hat{s}_j - s_j| \quad (19)$$

Thereby, a_{ij} is the survey-based and \hat{a}_{ij} the respective estimated input coefficient. s_j (\hat{s}_j) is the column sum of the survey-based (estimated) input coefficients and z represents the number of cells for which $a_{ij} = 0$.

Formula (15) measures the bias of the estimation results. In addition, Formula (16) accounts for dispersion and is, therefore, a strong measure for the accuracy of the estimated input coefficients. Formula (17), the Euclidean metric difference, expresses the distance between the estimated and actual input coefficients by putting higher weight on higher deviations. In contrast to the above formulae, γ_4 measures the mean absolute deviation as a percentage of the mean of the actual input coefficients. Finally, Formula (19) compares the column sums of estimated and actual coefficients. The advantage of comparing column sums is that they can give a first insight into problematic industries. This is accompanied by the disadvantage that positive and negative coefficients can cancel each other out.

Table 4 shows that, in general, the FLQ results are superior to the coefficients estimated by the other LQ-methods, although the difference in accuracy is not as high as for the output multipliers. However, the FLQ outperforms the SLQ and the CILQ in minimizing bias and dispersion by using a value of $\delta = 0.17$ and $\delta = 0.15$, respectively. Similar accuracy can be achieved with the AFLQ and a value of $\delta = 0.2$ and $\delta = 0.17$, respectively. The Euclidean metric difference and the mean absolute deviation are minimized with a value $\delta = 0.15$ and $\delta = 0.10$, respectively. The degree of accuracy with respect to these criteria is, however, similar to the other LQ-methods. In contrast, the column sums achieve the highest accuracy with the FLQ and a value of $\delta = 0.12$. Thereby, the highest overestimations of column sums are found in the Manufacture of Iron and Metal, Foundry, Steel Forming by 79%, in Agriculture by 44% and Transport by 30%. High underestimations were found in Trade (19%), Manufacture of Foodstuff, Drinks, Tobacco (17%) and Financial Intermediation, Insurance, Pension Funding (12%).

Table 4 Assessment of accuracy of estimated input coefficients

| Criterion | Method | | | |
|------------|------------------------------|------------------------------|-------|-------|
| | FLQ | AFLQ | SLQ | CILQ |
| γ_1 | 0.000 ($\delta = 0.17$) | 0.000 ($\delta = 0.20$) | 0.315 | 0.313 |
| γ_2 | 0.024 ($\delta = 0.15$) | 0.025 ($\delta = 0.17$) | 0.027 | 0.027 |
| γ_3 | 0.323 ($\delta = 0.15$) | 0.327 ($\delta = 0.17$) | 0.340 | 0.343 |
| γ_4 | 0.338 ($\delta = 0.10$) | 0.342 ($\delta = 0.11$) | 0.336 | 0.342 |
| γ_5 | 4.40 ($\delta = 0.12$) | 5.23 ($\delta = 0.11$) | 7.04 | 6.52 |

5.2 Industry-specific exponent

The following analysis is divided into three steps. Firstly, the ‘optimal’ value of δ_j for each industry is identified and implemented in the SFLQ formula. The value, which produces the lowest absolute deviation of the simulated from the actual output multipliers in the respective industry, is regarded as ‘optimal’. Secondly, the test statistics introduced above are also applied to the simulation results of the SFLQ in order to compare its performance to the results of the FLQ formula. Thirdly, it is checked if industries with a high or a low value of δ_j , respectively, have common characteristics. This is the central precondition for a transfer of the results to other regions.

Table 5 presents the industry-specific values of δ_j which produce the lowest absolute deviation of estimated output multipliers according to the criterion μ_2 . The optimal values range between $\delta_j = 0.43$ for Manufacture of Iron and Metal, Foundry, Steel Forming and $\delta_j = 0.03$ for Trade.

In order to examine the relative success of the SFLQ, Formulae (9) to (14) and (15) to (19) for output multipliers and input coefficients, respectively, are applied as criteria for the accuracy of the estimation results. The results are shown in Table 6 for output multipliers and Table 7 for input coefficients.

Table 5 Industry-specific exponents

| Industry | δ_j |
|--|------------|
| Manufacture of Iron and Metal, Foundry, Steel Forming | 0.4320 |
| Agriculture, Forestry, Animal Husbandry, Fishery | 0.4130 |
| Energy Industry, Water Supply, Mining | 0.3840 |
| Transport | 0.3010 |
| Manufacture of Steel, Machinery and Motor Vehicles, Office Machinery | 0.2250 |
| Manufacture of Textiles, Wearing Apparel and Leather | 0.2070 |
| Mail Services | 0.1910 |
| Construction | 0.1730 |
| Manufacture of Plastic Products, Rubber and Asbestos | 0.1650 |
| Private Organisations without Pecuniary Reward | 0.1580 |
| Chemical Industry, Manufacture of Petroleum | 0.1510 |
| Manufacture of Wood, Paper and Printing Industry | 0.1390 |
| Other Services | 0.1324 |
| Quarrying for Stone and Earths, Fine-Ceramics, Glass | 0.1302 |
| State | 0.1222 |
| Hotels and Restaurants | 0.1140 |
| Electro and Precision Engineering, Ironware | 0.0991 |
| Health and Veterinary Services | 0.0977 |
| Financial Intermediation, Insurance and Pension Funding | 0.0730 |
| Manufacture of Foodstuffs, Drinks and Tobacco | 0.0396 |
| Trade | 0.0289 |

Table 6 Assessment of accuracy of estimated output multipliers, SFLQ

| Criterion | SFLQ |
|------------------|-------------|
| μ_1 | 1.13 |
| μ_2 | 1.65 |
| μ_3 | 0.314 |
| sd | 0.014 |
| μ_4 | 0.489 |
| μ_5 | -0.107 |

Table 7 Assessment of accuracy of estimated input coefficients, SFLQ

| Criterion | Method |
|------------------|---------------|
| γ_1 | 0.000 |
| γ_2 | 0.014 |
| γ_3 | 0.245 |
| γ_4 | 0.314 |
| γ_5 | 1.17 |

Owing to the chosen criterion for an optimal value of δ_j , the absolute (relative) deviation of the estimated multipliers is lower compared to the FLQ estimates (Table 3). Also with respect to dispersion the SFLQ outperforms the FLQ. In contrast, bias is higher with the SFLQ

formula than with the FLQ. This is because negative and positive deviations average out to zero. It follows from Table 5 that a value of $\delta = 0.15$ in the FLQ formula would overestimate output multipliers in ten industries and at the same time underestimate ten multipliers. Turning to the input coefficients, the SFLQ estimates are superior to the FLQ estimates with respect to all applied criteria.

From this it follows that if one would know the determinants of the value of δ_j , one could transfer the method to other regions and increase the accuracy of simulated input-output tables. Following the argumentation of McCann/Dewhurst (1998) regional specialization would lead to an increase in interregional trade and a decrease in imports. Thus, one would expect a higher SLQ_j to be accompanied by a lower value of δ_j , which would additionally (to the FLQ formula) dampen regional imports. Further explanatory content might be found in the relationship between industrial concentration at the national level and the industry's propensity to import from other regions. The concept of industrial concentration differs from the concept of regional specialization. While concentration describes how an industry is distributed across all regions in the nation, regional specialization relates a region's share in an industry to the national average. The assumption made here is the more a sector is concentrated in space, the higher the regional propensity to import goods or services of this industry. The degree of concentration of industry j is measured by the coefficient of localization, which is defined as:

$$CL_j = \frac{1}{2} \sum_r \left| \frac{E_{jr}}{E_j} - \frac{E_r}{E} \right| \quad (20)$$

Thus, the coefficient measures the deviation of the distribution of industry j across the German federal states from the distribution of total employment (Joseph 1982, p. 443). The regression approach presented below is used to analyse the explanatory content of specialization and concentration on the value of δ_j . Furthermore, it includes the share of imports in total industrial intermediate inputs (IM_j) and the share of value added in total output in Germany (VA_j) as explanatory variables. The idea is that an industry, which has a high propensity to import from foreign countries, might also tend to import a higher amount of intermediates from countries within Germany than other industries. The values of the four explanatory variables are presented in Table 8.

Table 8 Values of the explanatory variables

| Industry | CL_j | SLQ_j | IM_j | VA_j |
|--|--------|---------|--------|--------|
| Agriculture, Forestry, Animal Husbandry, Fisheries | 0.312 | 0.527 | 0.132 | 0.499 |
| Energy Industry, Water Supply, Mining | 0.254 | 0.470 | 0.168 | 0.471 |
| Chemical Industry, Manufacture of Petroleum | 0.235 | 0.766 | 0.284 | 0.396 |
| Manufacture of Plastic Products, Rubber and Asbestos | 0.165 | 1.280 | 0.181 | 0.442 |
| Quarrying for Stone and Earths, Fine-Ceramics, Glass | 0.167 | 0.827 | 0.111 | 0.447 |
| Manufacture of Iron and Metal, Foundry, Steel Forming | 0.289 | 1.102 | 0.132 | 0.402 |
| Manufacture of Steel, Machinery and Motor Vehicles, Office Machinery | 0.101 | 1.379 | 0.147 | 0.384 |
| Electro and Precision Engineering, Ironware | 0.152 | 1.654 | 0.169 | 0.475 |
| Manufacture of Wood, Paper and Printing Industry | 0.127 | 1.326 | 0.160 | 0.424 |
| Manufacture of Textiles, Wearing Apparel and Leather | 0.186 | 1.380 | 0.217 | 0.384 |
| Manufacture of Foodstuffs, Drinks and Tobacco | 0.089 | 0.892 | 0.141 | 0.282 |
| Construction | 0.112 | 0.847 | 0.088 | 0.461 |
| Trade | 0.057 | 0.933 | 0.085 | 0.676 |
| Mail Services | 0.133 | 0.856 | 0.130 | 0.792 |
| Transport | 0.134 | 0.641 | 0.137 | 0.515 |
| Financial Intermediation, Insurance and Pension Funding | 0.102 | 1.075 | 0.030 | 0.042 |
| Hotels and Restaurants | 0.066 | 0.936 | 0.116 | 0.438 |
| Health and Veterinary Services | 0.044 | 1.011 | 0.104 | 0.696 |
| Other Services | 0.062 | 0.869 | 0.061 | 0.690 |
| State | 0.181 | 0.783 | 0.057 | 0.500 |
| Private Organisations without Pecuniary Reward | 0.073 | 0.788 | 0.083 | 0.711 |

The applied linear regression is defined as follows:

$$\delta_j = \alpha + \beta_1 CL + \beta_2 SLQ_j + \beta_3 IM_j + \beta_4 VA_j + e_j \quad (21)$$

where α is a constant term, and e is a residual. The method of ordinary least squares is used to estimate the model parameters β_1 , β_2 , β_3 , and β_4 . With an R^2 of 0.67 the estimation shows that the only variable, which has a significant impact on the value of δ_j is the coefficient of localization with $\beta_1 = 1.13$ (t-value: 3.89). Hence, the more an industry is concentrated in Germany, the higher the respective δ_j and the higher the propensity to import from other regions.

5.3 Summary of empirical results

In summary, the statistical measures for the conventional LQ methods showed that the highest accuracy of output multipliers and input coefficients is produced by the application of the FLQ formula. Nevertheless, with a higher value of δ , the AFLQ was able to produce results of a similar accuracy as the FLQ. While the FLQ requires a value in the interval $0.11 \leq \delta \leq 0.17$, the AFLQ performed best in the interval $0.11 \leq \delta \leq 0.21$. As Flegg/Tohmo (2011) mentioned, the difference results from the definition of the AFLQ formula. For a given SLQ_i , $CILQ_{ij} (= SLQ_i / SLQ_j)$ varies inversely to the specialization term ($\log_2(1 + SLQ_j)$), which dampens the impact on variations of SLQ_j (p. 13).

The results differ from the findings of Flegg/Tohmo (2011) who found the most accurate multipliers and coefficients for Finnish regions with the FLQ formula and a value of $\delta = 0.25$. A value of $\delta = 0.15$ delivered accurate results only for small regions, such as Ahvenanmaa with 0.6 % of total output in Finland (Flegg/Tohmo 2011, p. 7). The application of their regression equation (see Formula (8)) to the case of B-W, for which $R = 14.38$ and $I = 0.4972$, yields a value of $\delta = 0.28$. Thereby, it had to be assumed that $P = 1$ as for German regions (except B-W) information about the propensity to import from other regions is not available. Hence, for verifying this equation, i.e. to derive a value of $0.11 \leq \delta \leq 0.17$ for B-W, it would have to be assumed that the industries in B-W have a relatively low propensity to import from other regions compared to other German regions. A good reason for this assumption is that B-W, similar to the region Ahvenanmaa in Finland, is characterized by a relatively low degree of specialization (all industries). The Herfindahl index is 0.085 for Ahvenanmaa (Flegg/Tohmo 2011, p. 7) and 0.084 for B-W compared to an average value of 0.091 for Finish as well as German regions. Thus, B-W is – compared to other German regions – characterized by a more diversified industrial structure which might support intraregional trade because it offers a larger variety of goods and services.

The assumption that the spatial distribution of industrial activity plays a key role in interregional trade propensities is underlined by the analysis of a sector-specific δ_j . The analysis showed that the optimal value of δ_j differs substantially between industries. While some industries, such as the Manufacture of Iron and Metal, Foundry, Steel Forming, require values of $\delta_j > 0.3$, other industries produce most accurate results with a value of $\delta_j < 0.1$, for example Trade and Manufacture of Foodstuff, Drinks and Tobacco.

Including the optimal value for each industry into the SFLQ formula reduces not only the absolute variations in output multipliers but also the accuracy of the estimated input coefficients. Thereby, the level of δ_j is mainly driven by the industry's degree of concentration at the national level. The more an industry is spatially concentrated, the more imports of intermediate goods and services from other federal states are needed for the regional production.

6. Conclusion

The aim of this paper was to contribute to the ongoing debate about the FLQ formula developed by Flegg/Webber (1997). Several empirical studies showed that the formula overcomes specific problems of previous regionalization methods based on the location

quotient. However, as Flegg/Webber (1997, p. 803) noted the specification of the exponent δ represents the main obstacle to its widespread use. In order to reduce the uncertainty about the 'optimal' value of δ , empirical evidence is necessary. Therefore, the present paper provides an empirical analysis for Germany, which has been lacking in the literature so far. It is based on a survey-based input-output table of the German Federal State of B-W for the year 1993. The comparison of the survey-based and the simulated coefficients and multipliers allow the conclusion that a value of $0.11 \leq \delta \leq 0.17$ would produce most accurate input coefficients and output multipliers for B-W. This value seems to be relatively low compared to earlier studies which found optimal values of $0.2 \leq \delta \leq 0.3$. A possible explanation is the spatial distribution of economic activity. B-W has a relatively diversified industrial structure offering a great variety of goods and services. This might lower the need of the local industries to import from other German regions. A verification of this hypothesis would require data on the propensity to import of the other German federal states which are not available from statistical offices or other data sources.

However, the assumption is supported by the application of the SFLQ formula developed in this paper. The approach relaxes the assumption of a single value of δ for all industries. The analyses of the SFLQ showed that the optimal value of the exponent varies drastically between industries. The applied regression approach revealed that the most promising explanatory factor for δ_j is the degree of industrial concentration on the national level. The results show that there is a tendency for higher concentrated industries to require a higher value of δ_j in the SFLQ formula. It would be desirable for future work to investigate whether this approach is transferable to other regions and to provide more empirical evidence on the relationship between an industry's value of δ_j and its spatial distribution as well as other industry-specific characteristics.

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