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A Modification of the Cross-Industry Location Quotient for Projecting Sub-Territorial Input-Output Tables

Una modificación del cociente de localización interindustrial para la proyección de las tablas input-output subterritoriales

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Abstract

Economic accounts at sub-territorial level are projected primarily through Location Quotients (LQ). The degrees of sectoral specialisation at this level will therefore be key in spatial projections. This article advocates rectified use of the Cross-Industry Location Quotient (CILQ). Indirectly, the aim is to check to what extent CILQs are well exploited, given that they are the fundamental reference in other techniques. The input-output (IO) tables for the Euro 19 Area for 2010 and 2015 are taken as a reference for analysis purposes. A statistic is used to measure the degree of similarity between the accounting frameworks of ten countries in the Euro Area and their projections using CILQ, Flegg's formula, its augmented version, and the CILQ variant.

Keywords: Location quotients, AFLQ, CILQ, Non-survey method, Regional input-output tables.

Resumen

La proyección de cuentas económicas a nivel sub-territorial se establece primordialmente a través de cocientes de localización (LQ). Así, los grados de especialización sectoriales a dicho nivel actuarán como piezas clave en las proyecciones espaciales. En este artículo se reivindica un uso rectificado del Cross-Industry Location Quotient (CILQ). Indirectamente, se trata de comprobar hasta qué punto los CILQ están bien explotados, dado que son la referencia fundamental en otras técnicas. A efectos de análisis, se toman como referencia las tablas input-output (IO) del Área Euro 19 para los años 2010 y 2015. Se recurre a un estadístico para medir el grado de similitud entre los marcos contables de diez países de dicha área y sus proyecciones mediante el CILQ, la fórmula de Flegg, su versión aumentada y la variante del CILQ.

Palabras clave: cocientes de localización, AFLQ, CILQ, métodos non-survey; tablas input-output regionales.

JEL Classification / Clasificación JEL: C13, C67, R19.

1. Introduction

Implementing Input-Output (IO) analysis at sub-territorial level (almost always regional) can often be difficult due to the lack of accounting frameworks. An attempt is therefore made to avoid this pitfall by using non-survey techniques to design these frameworks. Economic accounts are normally available for a specific territory, which will be used as a reference when materialising the projections. At the same time, certain socio-economic magnitudes (production by industry, employment, or added value) are known for sub-territories with the same sectoral breakdown. A range of methodologies are used (Morrison and Smith 1974; Schaffer and Chu 1969; Bonfiglio and Chelli 2008), most notably location quotients (LQs). A range of studies highlight the utility of these quotients (Flegg and Webber 1997, 2000; Flegg, Webber and Elliott, 1995). It is therefore essential to know which LQ formulation is susceptible to being applied, and, at the same time, to look for adjustment techniques that can complement it (Lamonica et al., 2020) specifically, on the performance of the cross-entropy method (CE). However, it is not sufficiently clear which LQ will offer the best results. Indeed, (Bonfiglio and Chelli 2008; Jahn et al., 2020) show the superiority of Flegg's formula (FLQ) or its modified version (AFLQ), while (Zhao and Choi 2015) including Flegg's location quotient (FLQ; Lamonica and Chelli, 2018) lean towards other quotients. Moreover, other techniques found alongside the LQs should not be overlooked, such as Commodity Balance or one of its variants, the Cross-Hauling Adjusted Rationalization Method (Isard, 1953; Kronenberg, 2009; Flegg and Tohmo, 2013a). Indeed, use of LQs has been criticised as they are not able to quantify cross-hauling, Kronenberg (2009).

As with other estimation techniques, FLQ and AFLQ must be contrasted in order to ensure controlled use, especially with regard to processing available information. In this context, the different degrees of sectoral specialisation may be used in a distorted manner or not. The same is true for the proportion of the sub-territory (compared to the reference territory), which is considered a fundamental datum in the projections. The FLQ and AFLQ techniques include a parameter (delta) that performs a deviation on the sub-territorial size that must be limited within an interval, and its optimal value varies from one sub-territory to another (Kowalewksi 2015; Flegg and Tohmo 2016). Pereira-Lõpez et al. (2020) proposed a 2D-LQ, in which there are two parameters (alpha and beta) to be optimised. This technique and its extensions are more complex and require a certain amount of expertise (Pereira-López et al., 2022).

As regards the FLQ and AFLQ formulas, there is a constant search for the optimum value of delta according to the sub-territorial size. Due to a lack of information Flegg and Weber (2000) suggest a delta equal to 0.3. Bonfiglio (2009) argues that in FLQ, the parameter focuses on 0.3 with a 33% associated probability, and for AFLQ between 0.3 and 0.4 with a 38% probability. But the 0.3 value is not acceptable for all projections, and so, the search for the optimum value must be refined, Flegg y Thomo (2013). In this same vein, Lampiris et al., (2019) made contrasts for technical coefficient matrices, together with Leontief's inverse matrices, and they conclude that they are not satisfactory for values above 0.3. It can be said that this relatively simple way of projecting accounting frameworks is still apparent today, see Mardones and Silva (2022). With regard to 2D-LQ, (Pereira-López et al., 2021) give a range for the values of the Alpha and Beta parameters, although the corresponding recommendation still requires a larger number of contrasts using other databases.

However, the optimization processes must be accompanied by sensitivity analyses. Apart from the optima, it is necessary to know what occurs in their environment. The parameters are present in the formulations through the smoothing of the data (aggregated or disaggregated). It will be seen that the way in which the parameters are incorporated in the formulations is not a minor issue, as they condition, to varying degrees, the results obtained from the scarce information available. Everything would seem to indicate that the search for more efficient refinements in order to generate sub-territorial IO tables is becoming longer. In this regard, a method that uses a parameter differently to the FLQ and AFLQ techniques and is also better at limiting estimation errors is envisaged; in other words, a technique that is simpler, at least in appearance, will be recommended.

As for the structure of the article, following on from this introduction (section 1), section 2 provides a review of the formulation of the LQs. Section 3 sets out a methodological proposal. Section 4 describes the data used. Section 5 analyses the robustness of the aforementioned proposal based on 10 countries in the Euro 19 Area (EA-19) for 2010 and 2015. Finally, Section 6 provides an in-depth comparison between the proposed method and those commonly used, highlighting the main conclusions.

2. Review of location quotients

The IO method is often used to assess the impact of extrinsic changes in variables on a certain economy. Thus, when extrinsic changes occur in any element of aggregate demand—changes occurring in the short term are admitted—, "impact analysis" is generally used. Economic impact studies help to quantify the effect and the advantages for the economy and employment for any activity that is likely to cause a socioeconomic impact.

The Leontief model is built on the basis of the accounting relationship, which specifies that the total output of an economy must be equal to intermediate and final demand:

$$x = Xi + y \ , \tag{1}$$

where X is a square matrix of order that n represents the inter-industry flows in an economy, i is a column vector of n unit elements, x is the vector that represents total output, and y is the vector of final demand (net of imports).

Technical coefficients are defined as:

$$a_{ij} = \frac{x_{ij}}{x_j} \ , \tag{2}$$

where x_{ij} is the total sector sales i to sector j (or the intermediate consumption of the sector i by the sector j, while x_j represents the total production of the sector j. The technical coefficient a_{ij} measures the amount of product i that the sector requires j to produce one product unit. Therefore, the technical coefficient matrix, A, is $n \times n$ in size, where n is the number of sectors (branches) of the economic activity. Given that the flows could be domestic (d) or imported (m, $x_{ij} = x_{ij}^d + x_{ij}^m$, the technical coefficients can be disaggregated $a_{ij} = a_{ij}^d + a_{ij}^m$.

By using these coefficients, we can build a basic demand model to obtain the production.

$$x = Ax + y \tag{3}$$

So that:

$$x = (I - A)^{-1} \ y \tag{4}$$

where $(I\text{-}A)^{-1}$ is the so-called Leontief inverse matrix, which is, together with A, the basic statistical tool used to develop the IO models.

From the above development, we can see that it is essential to have accounting information for an economy under analysis, although this is not always the case.

The main benefit of LQs is that they can easily quantify the amount of regional requirements for a certain sector in a specific region with information that is available almost in real time. Yet, projections can affect intermediate flows, coefficients and even multipliers. The focus here will be on technical coefficients. Here we mention the most common LQs that stand out due to their simplicity, even though we are aware that there are other basic variants or more complicated generalizations.

Jensen, Mandeville and Karunaratne (2017) admit that the regional technical coefficients (a_{ij}^R) correspond to rectifications with the national coefficients (a_{ij}^N) by way of a multiplicative effect:

$$a_{ij}^{R} = a_{ij}^{N} LQ_{ij}, \quad i, j = 1, 2, \ldots, n. \tag{5}$$

The $\boldsymbol{i}$ y $\boldsymbol{j}$ subscripts refer to the supplying and purchasing sectors, respectively. Apart from that, $\boldsymbol{a_{ij}^{R}}$ is defined as the regional input amount $\boldsymbol{i}$ that is required to produce a unit of the product $\boldsymbol{j}$ and the generic factor $\boldsymbol{LQ_{ij}}$ is associated to the participation of the corresponding industry within the regional trade.

A restriction is imposed upon the regional technical coefficients, given by the following criterion:

$$\begin{aligned} a_{ij}^{R} &= a_{ij}^{N} LQ_{ij}, & \text{if } LQ_{ij} < 1 \\ a_{ij}^{R} &= a_{ij}^{N}, & \text{if } LQ_{ij} \geq 1 \end{aligned} \tag{6}$$

Therefore, if the region is self-sufficient, the regional coefficient is exactly the same as the national intermediate consumption matrix. On the other hand, if the region is a net importer, the regional coefficient will be lower than the national one (Miller and Blair, 2009).

The Simple Location Quotient (SLQ) is the most basic formulation, in which the relative weight of a certain sectoral magnitude (production, employment or added value) of a sub-territory is simply compared to its relative weight in the territory. Analytically we have

$$SLQ_i = \frac{x_i^R / x^R}{x_i^N / x^N} = \frac{x_i^R / x_i^N}{x^R / x^N} = \frac{wx_i^R}{wx^R}, \tag{7}$$

where x_i^R is production (not necessarily) of sector i in region R, x^R is production in region R, x_i^N is production in the sector i in the whole country (N), and x^N is production in the country. Therefore, wx_i^R represents the weight of the production of sector i in the total production of the sector; and wx^R corresponds to the participation of the production of region R in the total production of the country. It therefore indicates whether the sector can be self-sufficient or an exporter, or whether the sector imports from the other regions.

The Cross-Industry Location Quotient (CILQ) considers the relative importance of the selling industry with respect to the purchasing industry, as shown below:

$$CILQ_{ij} = \frac{SLQ_i}{SLQ_j} = \frac{wx_i^R}{wx_j^R}, \tag{8}$$

where the subscript j refers to purchasing sectors.

Given that the formulation above excludes, for the sake of simplification, the size of the region in the process, Flegg and Webber (1997), proposed the FLQ method, which is defined as follows:

$$FLQ_{ij} = CILQ_{ij}\left[log_2\left(1+\frac{X^R}{X^N}\right)\right]^{\delta}, 0<\delta<1 \tag{9}$$

The effect of region size is usually abbreviated as:

$$\lambda = \left[log_2\left(1+\frac{X^R}{X^N}\right)\right]^{\delta}. \tag{10}$$

The δ parameter is a quotient associated with interregional imports and λ functions as a corrective element for CILQ. Following the standard procedure, the regional technical coefficients a_{ij}^R are the result of corrections on the national coefficients a_{ij}^N, namely:

$$\begin{aligned} a_{ij}^R &= a_{ij}^N \cdot FLQ_{ij} \quad & if\ FLQ_{ij} \leq 1 \\ a_{ij}^R &= a_{ij}^N & if\ FLQ_{ij} > 1 \end{aligned} \tag{11}$$

However, FLQ does not adequately address those scenarios in which regional industries are more specialised than national industries, McCann and Dewhurst (1998). This led to Flegg and Webber (2000) performing rectifications (semi-logarithmic smoothing) by columns for those sectors that are specialist buyers. This resulted in the Augmented FLQ:

$$AFLQ_{ij} = \begin{cases} FLQ_{ij} \cdot log_2\left(1+SLQ_j\right), & if\quad SLQ_j > 1 \\ FLQ_{ij}, & if\quad SLQ_j \leq 1 \end{cases} \tag{12}$$

This technique is therefore the one used most extensively in spatial IO projections.

3. A modification of Cross-industry location quotient

Initially, the aim is to rewrite the LQs in order to find simplifications that suggest or favour the design of methodological alternatives.

Rectifications via CILQ can be expressed as

$$a_{ij}^R = \begin{cases} \frac{SLQ_i}{SLQ_j}a_{ij}^N = \frac{wx_i^R}{wx_j^R}a_{ij}^N, & if\ wx_i^R \leq wx_j^R. \\ a_{ij}^N, & if\ wx_i^R > wx_j^R. \end{cases} \tag{13}$$

or, once certain simplifications have been made, an alternative expression emerges:

$$a_{ij}^R = \begin{cases} x_i^R d_{ij}^N \frac{1}{x_j^R}, & if\quad wx_i^R \leq wx_j^R. \\ a_{ij}^N, & if\quad wx_i^R > wx_j^R. \end{cases} \tag{14}$$

Hence, it can be seen how a large number of national quotients are not rectified, and the projection for the remaining ones simply consists of taking advantage of the structure (by rows) of the distribution quotients in order to estimate a (regional) consumption matrix and then calculate the technical coefficients. The corrections made are therefore proportional to production of the regional sectors, without differentiating degrees of specialisation.

Flegg's formula makes further rectifications to the cells by introducing a scale λ associated with regional size, which, by definition, takes values below 1. In principle, λ could take values between 0.80 and 0.90, as a result of applying its formula according to the different regional sizes and the values of the exponents δ (which vary depending on size). The following projection would therefore be formalised:

$$a_{ij}^R = \begin{cases} \lambda\left(x_i^R d_{ij}^N \dfrac{1}{x_j^R}\right), & if \ \dfrac{wx_i^R}{wx_j^R} \leq \dfrac{1}{\lambda}. \\ a_{ij}^N, & if \ \dfrac{wx_i^R}{wx_j^R} > \dfrac{1}{\lambda}. \end{cases} \tag{15}$$

The FLQs do not actually offer significant changes compared to the CILQs since they only reduce the rectified cells in a linear manner, although there are more of them than when applying the CILQs, and their number will increase at lower values of λ.

The AFLQ technique introduces a small but transcendental difference by giving $SLQ_j>1$ specific treatment. Applying semi-logarithmic smoothing gives $1<log_2(1+SLQ_j)<SLQ_j$. The distance between $log_2(1+SLQ_j)$ and SLQ_j increases as we move away from 1, bringing an end to the proportionality. This means that

$$a_{ij}^R = \begin{cases} \lambda\left(x_i^R d_{ij}^N \dfrac{1}{x_j^R}\right) log_2(1+SLQ_j), & if \ \dfrac{wx_i^R}{wx_j^R} \leq \dfrac{1}{\lambda} \ and \ SLQ_j \geq 1. \\ \lambda\left(x_i^R d_{ij}^N \dfrac{1}{x_j^R}\right), & if \ \dfrac{wx_i^R}{wx_j^R} \leq \dfrac{1}{\lambda} \ and \ SLQ_j < 1. \\ a_{ij}^N \ log_2(1+SLQ_j), & if \ \dfrac{wx_i^R}{wx_j^R} > \dfrac{1}{\lambda} \ and \ SLQ_j \geq 1. \\ a_{ij}^N, & if \ \dfrac{wx_i^R}{wx_j^R} > \dfrac{1}{\lambda} \ and \ SLQ_j < 1. \end{cases} \tag{16}$$

The fact that $SLQ_j \geq 1$ does not imply that $\frac{wx_i^R}{wx_j^R} \leq \frac{1}{\lambda}$, while the fact that $SLQ_j<1$ does not imply that $\frac{wx_i^R}{wx_j^R} > \frac{1}{\lambda}$. It is therefore necessary to distinguish between the four scenarios.

In summary, working with SLQ without applying any type of smoothing brings simplifications that make information on regional size disappear, meaning the degree of specialisation of the different productive sectors is lost. In Flegg's formula, regional size is, to some extent, respected through the value of the λ parameter. It should be remembered that this parameter is determined by regional size and by the exponent that affects semi-logarithmic smoothing, since the exponent must vary in accordance with regional size in order to obtain reasonable values in the projections. In essence, for AFLQ there are rectifications by columns that break their proportionality, although it is also true that there are multiple smoothings that achieve a similar effect.

The FLQ formula and its extended version have a peculiarity that conditions them: the use of a single parameter that has a homogeneous (linear) impact on the CILQs. Moreover, the formulation of the CILQs is the basis for subsequent proposals. This is where a methodological doubt arises, as the incidence of SLQs by rows and columns has a direct, inverse relationship, which, in turn, can be reciprocal, depending on the values of the SLQs, at least by columns. In certain cases, these direct, inverse relationships, without any distortion, imply simplifications in the formulas that lead to over-simple rectifications (which, a priori, might be appropriate). Introducing exponential smoothing in the CILQ formulation for $SLQ_j>1$ is therefore proposed. This variant can be abbreviated as ACILQ. A parameter, γ, is introduced by way of exponent, reflecting a variation in the formulation:

$$CILQ_{ij}\left(\gamma\right) = SLQ_i\left(SLQ_j\right)^{-\gamma}. \tag{17}$$

This means that the ACILQ projection will be

$$a_{ij}^R = \begin{cases} SLQ_i a_{ij}^N \left(SLQ_j\right)^{-1}, & if \quad SLQ_j \leq 1. \\ SLQ_i a_{ij}^N \left(SLQ_j\right)^{-\gamma}, & if \quad SLQ_j > 1. \end{cases} \tag{18}$$

According to Jensen, Mandeville and Karunaratne (2017), the rectification does not apply if $CILQ_{ij}(\gamma)>1$. This idea of not rectifying the technical coefficients of the reference territory upwards is maintained in the preceding formulations, with the sole exception of some cells in AFLQ, when applying the multiplication of $log_2\left(1+SLQ_j\right)$ on FLQ_{ij} for $SLQ_j>1$. Pereira-López et al. (2020), in a different context (for domestic coefficients), provide upward corrections, albeit controlled by adapting the hyperbolic tangent function.

The question is whether this formulation provides better results than the particular case (CILQ) in which γ is equal to 1. The values of this parameter are not limited, although it is understood that they will take values close to the particular case. Obviously, when the degrees of specialisation by columns are much higher than 1, this would have an exaggerated effect on the associated rectifications, meaning they must be treated in a manner consistent with the others. In short, the idea put forward by Flegg in relation to rectifications by columns should not be underestimated, and, to a certain extent, is reflected in this proposal.

4. Data sources

The robustness tests for the specified formulas for 10 countries in the Euro 19 Area (EA-19) will subsequently be formalised. The database containing the symmetric matrices of total flows at basic prices with 64x64 products was downloaded from Eurostat for this purpose (https://ec.europa.eu/eurostat/web/esa-supply-use-input-tables/data/database) [naio_10_cp1700]. The IO tables (2010 and 2015) were then selected for ten countries, namely Austria, Belgium, Estonia, France, Germany, Italy, Latvia, Slovakia, Slovenia and Spain. It should be noted that 10 selected countries represented 84.39% of the production of the EA-19 (Austria 3.06%, Belgium 4.22%, Estonia 0.17%, France 19.89%, Germany 26.79%, Italy 17.42%, Latvia 0.21%, Slovakia 0.85%, Slovenia 0.39% and Spain 11.40%). Their production volume was 83.79% in 2015: (Austria 3.27%, Belgium 4.33%, Estonia 0.21%, France 19.79%, Germany 28.27%, Italy 15.99%, Latvia 0.24%, Slovakia 0.96%, Slovenia 0.38% and Spain 10.35%). The aforementioned extraction is based on the European System of Accounts (ESA) 2010 classification system, specifically the Classification of Product by Activity (CPA) 2008.

5. Analysis

Having the projections of the sub-territorial IO tables under control is essential. More specifically, it is necessary to check whether the proposed modification is usable. To this end, the Standardised Total Percentage Error (STPE) was used in the graphical analysis. Its formulation is as follows:

$$STPE = 100 \sum_{i=1}^{n}\sum_{j=1}^{n}\left|\tilde{a}_{ij}^{R} - a_{ij}^{R}\right| / \sum_{i=1}^{n}\sum_{j=1}^{n} a_{ij}^{R} \qquad (19)$$

where a_{ij}^{R} represents the sub-territorial true quotients and $\tilde{a}_{ij}^{R}$ is the sub-territorial estimated quotient; n is the number of the products/sectors. This statistic globally calculates the relative distance between the estimated quotients and the true quotients (Jalili, 2000; Jackson and Murray, 2004; Bonfiglio 2005; Flegg et al., 2016; Lampiris et al., 2019).

With a view to strengthening graphic analysis, the results obtained through four other statistics used extensively in this area are also shown in the Annex. Specifically, these other statistics are Mean Absolute Difference (MAD), Mean Absolute Percentage Error (MAPE), Standard Deviation of the Mean Absolute Difference (SD-MAD), and Theil's Index (U). The MAD calculates the difference in absolute value between the estimated quotient and the true quotient, dividing it by the total number of matrix elements in order to obtain the absolute mean of the distances (Morrison and Smith, 1974; Bonfiglio 2005; Bonfiglio and Chelli, 2008; Miller and Blair, 2009; Kowalewksi 2015; Wiebe and Lenzen 2016; Lamonica and Chelli 2018; Lampiris et al., 2019; Lamonica, Recchioni, Chelli and Salvati, 2020) specifically, on the performance of the cross-entropy method (CE). MAPE is practically the mean of STPE (Oosterhaven, van der Knijff and Eding, 2003) relatively uncharted territory of nonsurvey versus impact studies by means of a series of simulations. The base case is provided by a very detailed five region survey of both the forward and the backward impacts of the energy-distribution sector in the four northern provinces of the Netherlands. To deal adequately with the two-sided dependence between a firm or sector and a region, as opposed to using the traditional gross (Mīnguez, Oosterhaven and Escobedo, 2009; Miller and Blair, 2009; Lampiris et al., 2019; Flegg and Tohmo, 2019; Jahn, Flegg and Tohmo 2020). SD-MAD is the standard deviation from the absolute mean of the distances between the estimated quotient and the true quotient (Lamonica and Chelli, 2018). Theil's inequality index allows the overall distance ratio to be estimated (Jalili, 2000; Lahr and Stevens, 2002; Bonfiglio 2005; Flegg and Tohmo, 2013b; Kowalewksi 2015; Flegg et al., 2016; Flegg and Tohmo, 2019; Lampiris et al., 2019; Jahn et al., 2020; Towa et al., 2020) because of its ability to capture economic and environmental impacts at other geographical levels. Yet, such analyses are hindered by the lack of subnational IO tables. Furthermore, the lack of physical product and waste flows in what is known as a "hybrid" table prevents a range of consumption-based and circular-economy-type analyses. We demonstrate the development of a multiregional hybrid IOT (MRHIOT).

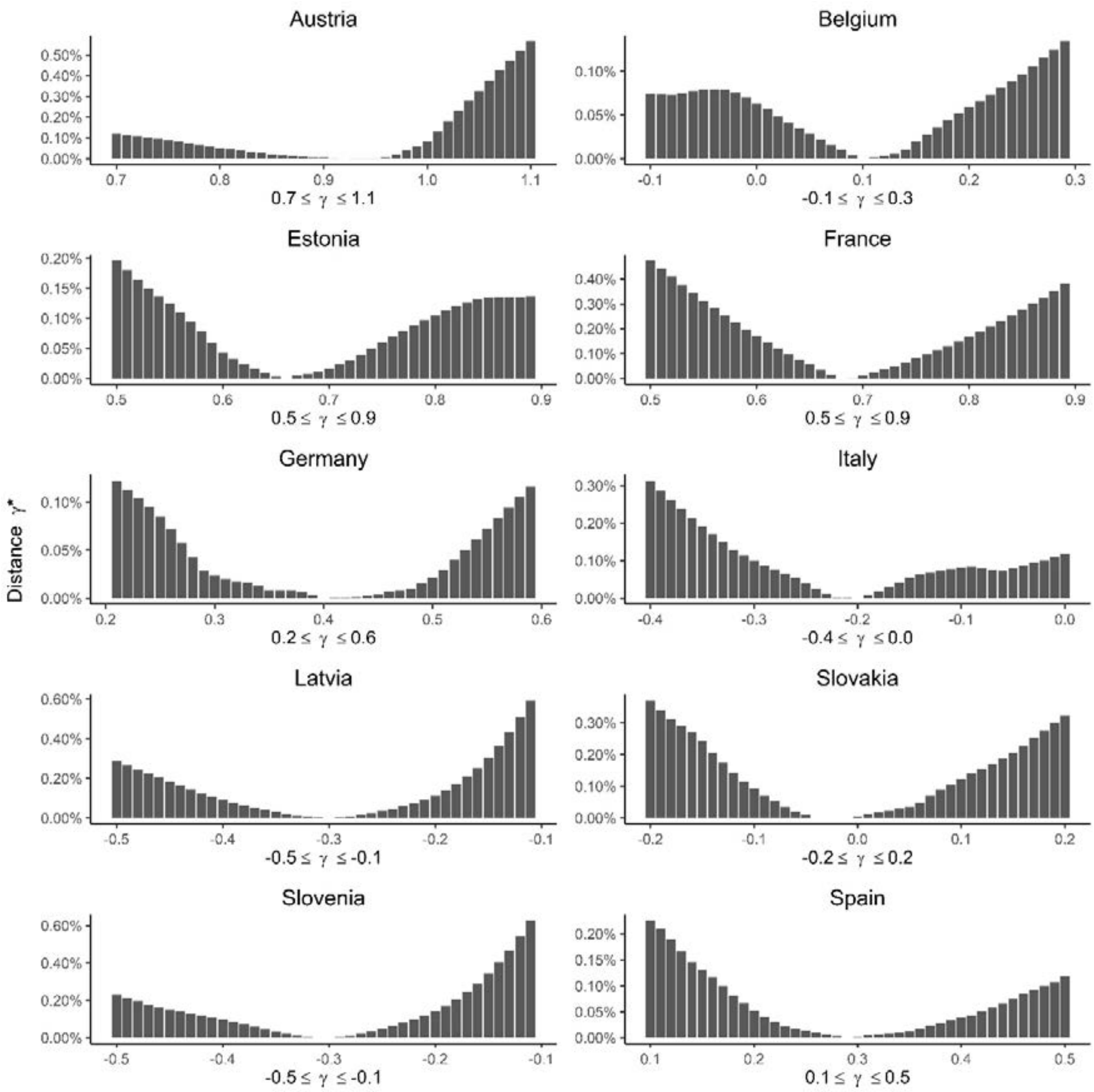
The STPE can be used to globally quantify the degree of similarity between the estimated matrices of the technical coefficients (by means of CILQ, FLQ, AFLQ and ACILQ) and true matrices. The matrices in this study are contrasted element by element, unlike others that focus only on sums by rows or columns. It is understood that working with sum vectors (by rows or columns) is inexact since errors can be offset easily, at least for technical coefficients.

For practical purposes, the technical coefficients have been generated at sub-territorial level using the techniques considered. The choice was made to use the sectoral outputs, rather than the employment or added value vector, in accordance with Flegg and Tohmo (2019).

The initial focus is on ACILQ, in order to then compare it to the preceding techniques. Although no detailed description is provided, it is indicated that the quality of the approximations of the matrices subject to comparison is cardinal. The Annex shows that larger countries perform better than smaller ones, which is reasonable given that productive structures increasingly resemble the reference area as their proportion increases. For example, the STPEs for France, Germany, Italy and Spain are lower than those for the other six countries examined for both 2010 and 2015. This pattern can be seen for the different statistics. The indicated values correspond to the optimal values reached for the different techniques, although it should be noted that the behaviour of the functions, which depend on the parameters associated with the LQs, is similar for the different statistics. Obviously, the differences come from the differing way they are standardised.

Figures 1 and 2 show the errors (expressed as percentages) when deviating from the optimal value of the ACILQ technique parameter, γ^*, for the ten countries studied (2010 and 2015, respectively). In both figures it can be seen that the corresponding curves are convex (or practically convex) around γ^*. A comparison of the graphs for each country between 2010 and 2015 shows that the differences are minimal, especially for the larger countries. Latvia and Slovenia, sub-territories with negligible weight within EA-19, show minimum values for parameters distant from each other. Unlike the CILQ, here only

Figure 1. Sensitivity analysis of ACILQ using STPE for ten EA-19 countries in 2010

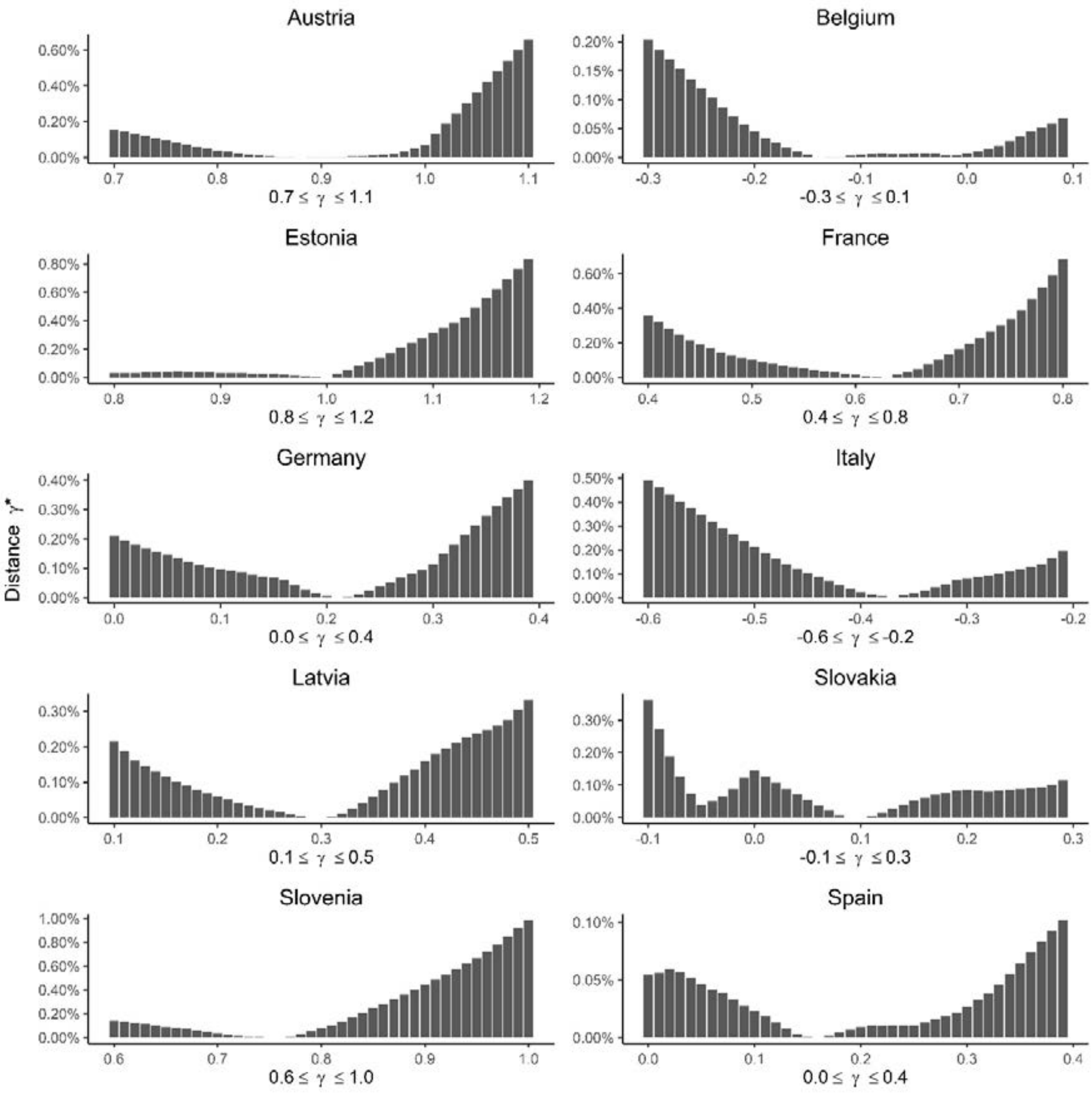


Source: Own elaboration, based on EUROSTAT data [naio_10_cp1700] certain columns are smoothed (with a parameter to be optimised), precisely in order to avoid pronounced rectifications due to $SLQ_j>1$.

The results would indicate that Flegg's nuance (applied to CILQ) is consistent. In fact, it is shown for the different cases studied here that rectifications in accordance with the value given by the simple LQ do not guarantee the optimal value. The only exception is Estonia for 2015, which admits a γ^* value close to 1. In all other cases the values are less than 1, or even negative.

As a general guideline, it can be stated that parameter γ is not very sensitive, i.e. the errors detected are not high in those cases in which they do not match the overall minimum (with the optimal parameter being unknown). This characteristic is of vital importance, as parameter δ (associated with FLQ

Figure 2. Sensitivity analysis of ACILQ using STPE for ten EA-19 countries in 2015

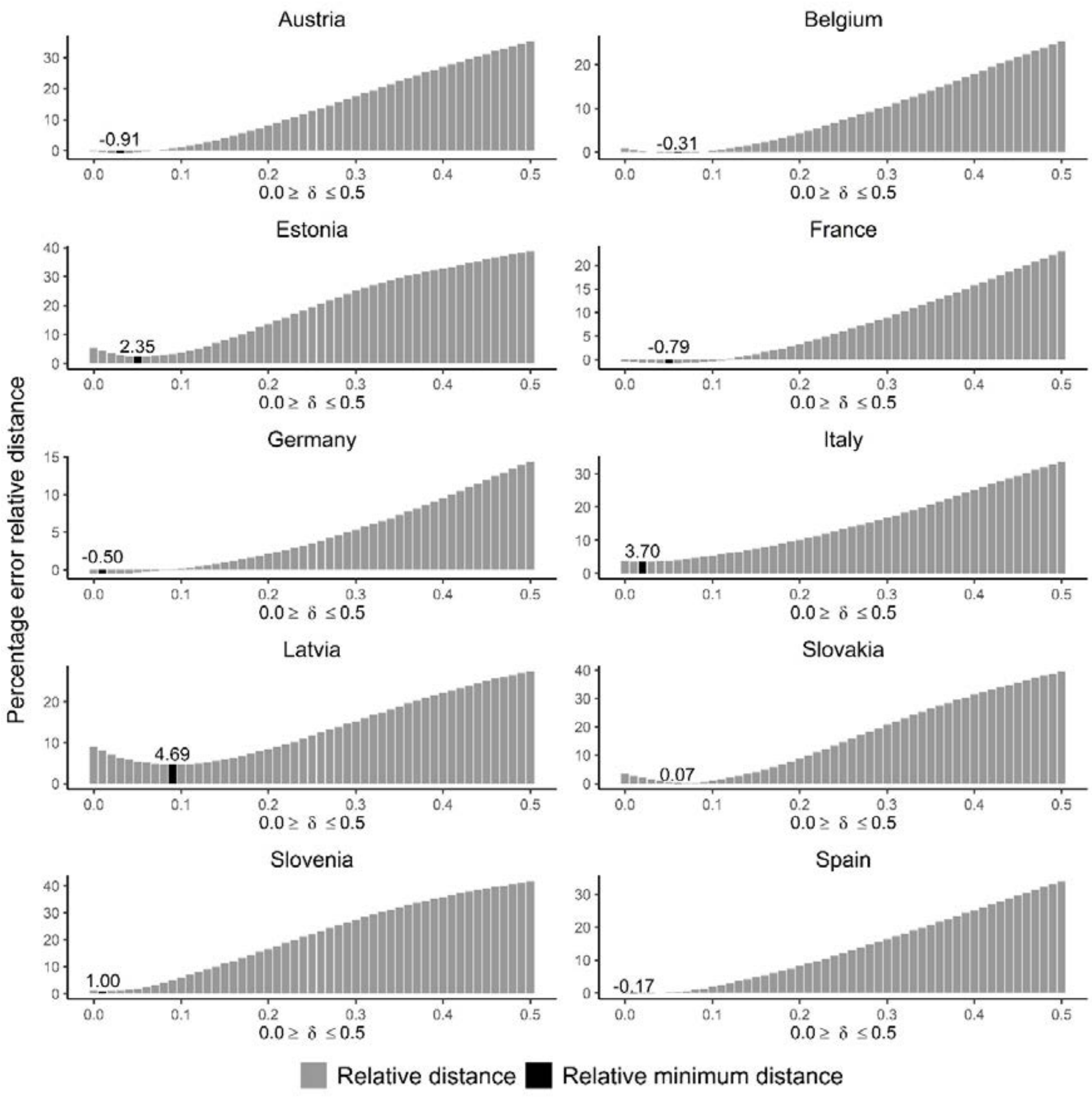


Source: Own elaboration, based on EUROSTAT data [naio_10_cp1700] and AFLQ techniques) does not behave in this way. A comparison between γ^* and the values of δ will then be carried out. The function performed by parameter γ in the formulation explains the reduced values (in percentage terms) of the ordinate axis. Acting on certain columns in a controlled manner therefore does not produce significant errors.

6. Discussion and conclusions

This final section compares the parameters of the AFLQ and ACILQ methods, with a view to identifying lines to follow in future LQ formulations. In particular, the goal is to see both the role played by the smoothings used, and also which variables they should act on in order to avoid working with sensitive

Figure 3. Relative distance between ACILQ (γ^*) and AFLQ (δ) in percentages for 2010

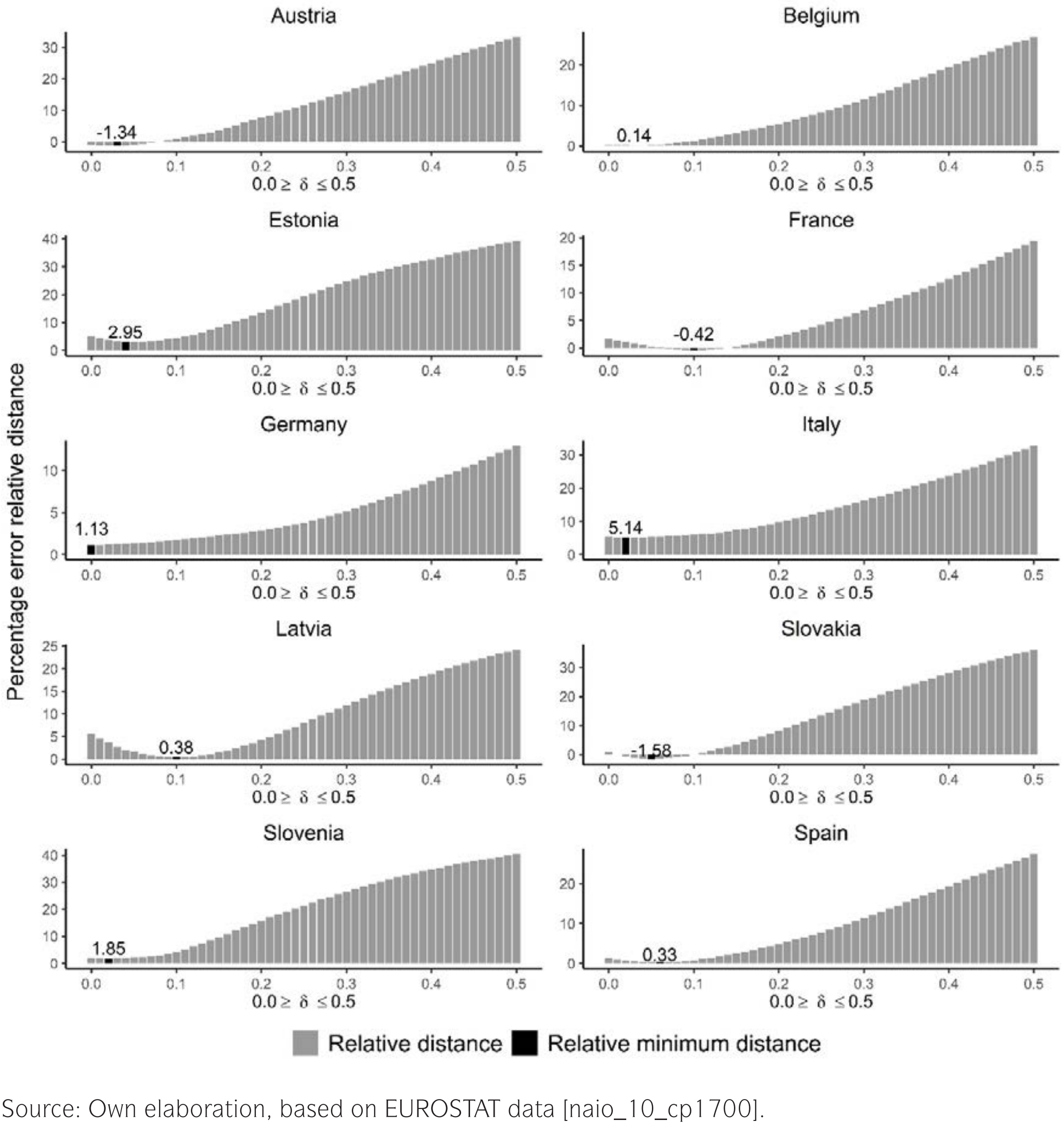


Source: Own elaboration, based on EUROSTAT data [naio_10_cp1700].

parameters. In accordance with the Annex, projections using CILQ, FLQ and AFLQ for the countries studied show a certain inverse relationship between territorial size and distances between true and estimated matrices. The ranking (from best to worst) of the initial methods, namely AFLQ, FLQ, and, finally, CILQ, is also ratified. The FLQ and CILQ techniques are therefore ruled out for this comparison.

As seen, AFLQ includes the parameter δ. The optimal value of this parameter has been discussed extensively, and logically varies according to the size of the sub-territory, since the aim is to find a moderately limited λ which depends on δ. Lampiris et al. (2019), for example, tested these techniques for several EU countries. Their results allow us to affirm that AFLQ provides better results

Figure 4. Relative distance between ACILQ (γ^*) and AFLQ (δ) in percentages for 2015



Source: Own elaboration, based on EUROSTAT data [naio_10_cp1700].

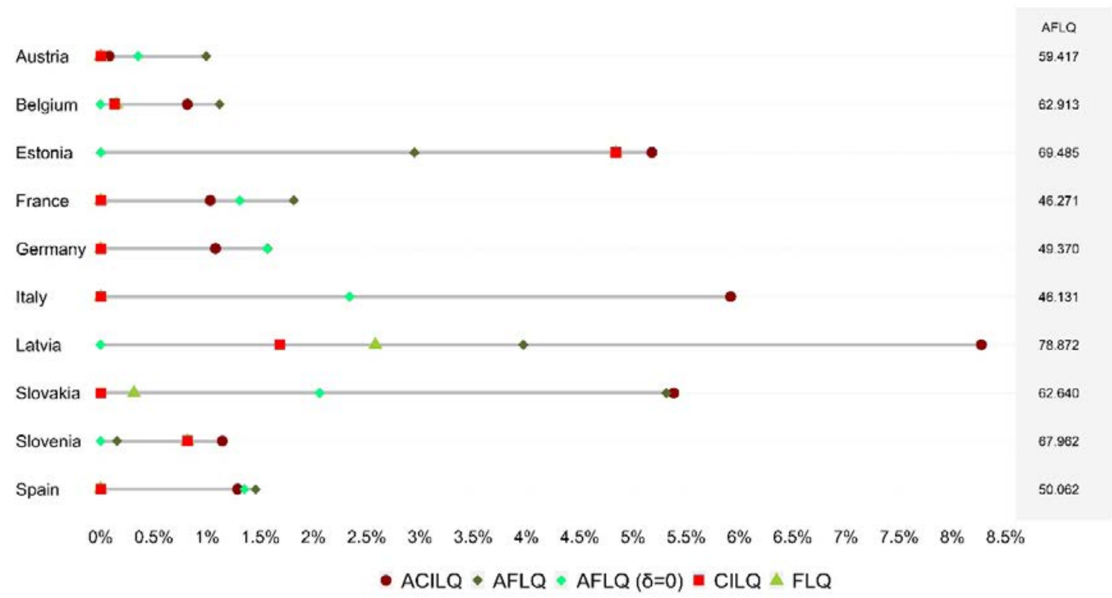
for δ values from 0.1 to 0.3, while for values higher than 0.3 the results are not satisfactory. These results are similar to those in this application; see the Annex.

Rigour would demand that we compare the sensitivity of δ (associated with the AFLQ method) to γ^*. Figures 3 and 4 therefore show the relative distances measured through the STPE between the ACILQ (γ^*) and the function given by AFLQ (δ).

The values of the γ^* environment do not significantly worsen the estimates. These figures also show that the AFLQ curves are convex in character, and present almost asymptotic behaviour as δ tends toward 1. Indeed, even the basic CILQ guarantees fewer errors when δ exceeds 0.25. Although FLQ curves are not shown, it should be noted that they practically converge with the AFLQ curves, since they are very similar formulations. There are also some quite small intervals in which the FLQ and AFLQ techniques improve CILQ projections. They should therefore be rejected once the corresponding ends of the intervals are exceeded. Obviously, the AFLQ parameter is much more sensitive than the proposed formulation, as can be seen by simply observing the values of the ordinate axes.

It is also appropriate to compare the STPE obtained by the LQs analysed. The reason for presenting the position of superiority in relation to the technique that presents a lower STPE is shown in Figures 5 and 6. For easier interpretation of the improvement percentages, the associated STPE value related to the modified Flegg formula, which is the most demanded technique, is provided for each country. It is obvious that higher statistic values increase the likelihood

Figure 5. Ranking of LQ techniques for ten EA-19 countries for 2010

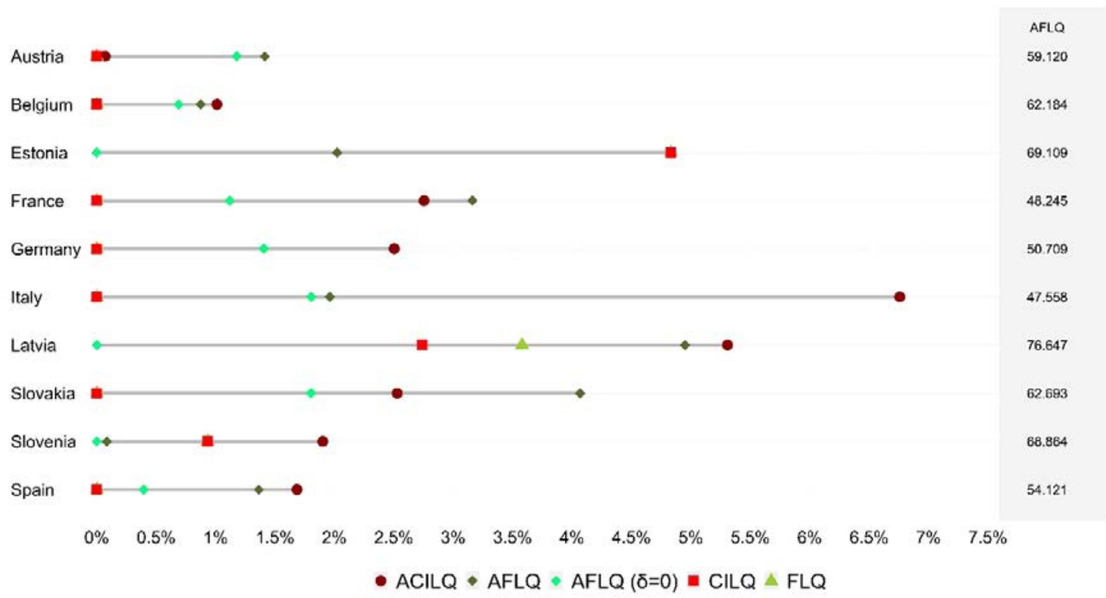


Source: Own elaboration, based on EUROSTAT data [naio_10_cp1700].

of reducing errors in the projections. For example, for 2010 Latvia presents some more pronounced deviations than the other nine countries, meaning its graph is understandable. Although quite a large number of countries have been included in the study, it would appear that the non-survey projections start to be questionable as of a (minimum) territorial portion, which in turn is understandable.

The AFLQs for δ equal to 0 are also noteworthy. Focusing on this aspect is considered the correct approach, as it implies not taking regional size into account. Checking the positions between AFLQ and this particular case is likely to prove revealing. Indeed, this non-rectification, given by λ equal to 1, hardly worsens the results in all countries studied here. As is known, smoothing is practised for certain columns when taking AFLQ as a basis, while ACILQ is used to seek an optimal value through the parameter that rectifies the degrees of specialisation greater than 1. The optimal value does not match the rectification value obtained by semi-logarithmic smoothing, although in certain cases it is quite close. For example, Germany shows better AFLQ for δ equal to 0 than ACILQ for 2010, meaning the upward rectifications, as allowed by AFLQ, are adequate in this case. The idea put forward by Jensen et al. (2017) could therefore also be reviewed. The ACILQ technique is not always the dominant one, although it makes a significant difference in the overall calculation. For example, the ACILQ for Austria does not stand out in the two rankings, although all LQs provide very similar values for STPE, as the improvements do not reach 2%.

Figure 6. Ranking of LQ techniques for ten EA-19 countries for 2015



Source: Own elaboration, based on EUROSTAT data [naio_10_cp1700].

There is an enormous amount of research focused on finding the optimal δ The results achieved here, while of great interest, therefore invite us to reconsider the regional IO projection tasks. Regional size is a clear conditioning factor in the different projections, but in this case qualifies each of the degrees of sectoral specialisation through the CILQ. This presents a dilemma, in the sense of whether it is enough to compute it in the sectoral specialisation degrees, or, to the contrary, it should be considered again at global level (according to Flegg's formulation).

All these optimisation processes start from the same basic information, but the design of the formulas requires more solid robustness measurements. The statistics used in this area are global measurements that need to be reinforced with control from quotient to quotient in order to detect any deviations (up or down) which would skew the results obtained through the multipliers associated with the projections.

It is clear that ACILQ provides moderately acceptable estimates in relation to previous LQs (CILQ, FLQ and AFLQ), meaning this technique can be used without the need to resort to more complex ones. As long as additional information is available, it is advisable to conclude the generation of IO tables with adjustment processes. Multi-regional IO frameworks are expected to be devised in the future. The multi-regional format is essential for designing and implementing policies; although, creating it is quite difficult. In this sense, we believe that this method of calculating rectification quotients is favorable when calculating prior matrices upon which complex adjustments could subsequently be made in order to create multi-regional frameworks. RAS generalizations, such as KRAS or Path-RAS, could be understood as tools which are complementary to the presented proposal. So the combination of the simplest LQs with complex adjustment techniques will, without a doubt, be a perfect tool for creating multi-regional frameworks.

In short, the main goal of this article was to detect any weaknesses in commonly used LQ techniques. The associated formulas have been rewritten to detect simplifications that, in practice, lead to a certain waste of available information. It is seen that the review of the CILQ, through the idea exploited by Flegg in his modified formula, provides acceptable results. It is understood that this contributes to a debate –in all likelihood disingenuous– in this scientific field. In other words, it is a question of seeing whether it will be opportune to focus on searching for more complicated LQs or, to the contrary, it is advisable to revise the initial formulas in order to exploit them efficiently. The two approaches are not incompatible, although it is clear that simple procedures ensure a greater number of users of the IO methodology.

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Annex

Table 1. Evaluation through STPE of the IO table projections for EA-19 countries (2010 and 2015)

	STPE									
	2010					2015				
Countries	CILQ	FLQ	AFLQ	AFLQ (	ACILQ	CILQ	FLQ	AFLQ	AFLQ (	ACILQ
Austria	60.0131	60.0131	59.4169*	59.8021	59.9648	59.9677	59.9677	59.1202*	59.2625	59.9257
		(0.00)	(0.03)	(0.00)	(0.92)		(0.00)	(0.03)	(0.00)	(0.88)
Belgium	63.5424	63.5308	62.9130*	63.6248	63.1072	62.7317	62.7317	62.1840	62.3004	62.0977*
		(0.01)	(0.06)	(0.00)	(0.10)		(0.00)	(0.03)	(0.00)	(-0.14)
Estonia	68.1329	68.1329	69.4853	71.5968	67.8906*	67.1265*	67.1265	69.1092	70.5343	67.1265
		(0.00)	(0.05)	(0.00)	(0.66)		(0.00)	(0.04)	(0.00)	(1.00)
France	47.1259	47.1259	46.2712*	46.5103	46.6407	49.8202	49.8202	48.2449*	49.2630	48.4481
		(0.00)	(0.05)	(0.00)	(0.68)		(0.00)	(0.10)	(0.00)	(0.63)
Germany	50.1567	50.1567	49.3700*	49.3730	49.6159	51.4315	51.4315	50.7090	50.7090	50.1443*
		(0.00)	(0.01)	(0.00)	(0.40)		(0.00)	(0.00)	(0.00)	(0.21)
Italy	47.2351	47.2351	46.1308	46.1308	44.4402*	48.5098	48.5098	47.5579	47.6341	45.2315*
		(0.00)	(0.00)	(0.00)	(-0.20)		(0.00)	(0.02)	(0.00)	(-0.37)
Latvia	80.7501	80.0128	78.8718	82.1313	75.3378*	78.4316	77.7534	76.6472	80.6395	76.3587*
		(0.04)	(0.09)	(0.00)	(-0.30)		(0.04)	(0.10)	(0.00)	(0.30)
Slovakia	66.1548	65.9480	62.6401	64.7949	62.5941*	65.3514	65.3514	62.6928*	64.1736	63.6991
		(0.02)	(0.06)	(0.00)	(-0.03)		(0.00)	(0.05)	(0.00)	(0.09)
Slovenia	67.5126	67.5126	67.9622	68.0666	67.2894*	68.2789	68.2789	68.8636	68.9218	67.6108*
		(0.00)	(0.01)	(0.00)	(-0.30)		(0.00)	(0.02)	(0.00)	(0.76)
Spain	50.8017	50.8017	50.0621*	50.1163	50.1483	54.8679	54.8679	54.1206	54.6517	53.9439*
		(0.00)	(0.01)	(0.00)	(0.29)		(0.00)	(0.06)	(0.00)	(0.16)

Note: Parameter values are reported in parentheses.
* The optimal values.

TABLE 2. EVALUATION THROUGH MAD OF THE IO TABLE PROJECTIONS FOR EA-19 COUNTRIES (2010 AND 2015)

	MAD									
	2010					2015				
Countries	CILQ	FLQ	AFLQ	AFLQ (	ACILQ	CILQ	FLQ	AFLQ	AFLQ (	ACILQ
Austria	0.0052	0.0052	0.0051 *	0.0052	0.0052	0.0052	0.0052	0.0051 *	0.0051	0.0051
		(0.00)	(0.03)	(0.00)	(0.92)		(0.00)	(0.03)	(0.00)	(0.88)
Belgium	0.0060	0.0060	0.0059*	0.0060	0.0059	0.0060	0.0060	0.0059	0.0059	0.0059*
		(0.01)	(0.06)	(0.00)	(0.10)		(0.00)	(0.03)	(0.00)	(-0.14)
Estonia	0.0061	0.0061	0.0062	0.0064	0.0061 *	0.0061 *	0.0061	0.0062	0.0064	0.0061
		(0.00)	(0.05)	(0.00)	(0.66)		(0.00)	(0.04)	(0.00)	(1.00)
France	0.0040	0.0040	0.0039*	0.0040	0.0040	0.0042	0.0042	0.0041 *	0.0042	0.0041
		(0.00)	(0.05)	(0.00)	(0.68)		(0.00)	(0.10)	(0.00)	(0.63)
Germany	0.0042	0.0042	0.0041 *	0.0041	0.0041	0.0042	0.0042	0.0042	0.0042	0.0041 *
		(0.00)	(0.01)	(0.00)	(0.40)		(0.00)	(0.00)	(0.00)	(0.21)
Italy	0.0042	0.0042	0.0041	0.0041	0.0040*	0.0043	0.0043	0.0043	0.0043	0.0041 *
		(0.00)	(0.00)	(0.00)	(-0.20)		(0.00)	(0.02)	(0.00)	(-0.37)
Latvia	0.0070	0.0070	0.0069	0.0071	0.0065*	0.0066	0.0066	0.0065	0.0068	0.0065*
		(0.04)	(0.09)	(0.00)	(-0.30)		(0.04)	(0.10)	(0.00)	(0.30)
Slovakia	0.0057	0.0056	0.0054	0.0055	0.0053*	0.0058	0.0058	0.0056*	0.0057	0.0057
		(0.02)	(0.06)	(0.00)	(-0.03)		(0.00)	(0.05)	(0.00)	(0.09)
Slovenia	0.0058	0.0058	0.0059	0.0059	0.0058*	0.0060	0.0060	0.0061	0.0061	0.0060*
		(0.00)	(0.01)	(0.00)	(-0.30)		(0.00)	(0.02)	(0.00)	(0.76)
Spain	0.0044	0.0044	0.0043*	0.0044	0.0044	0.0047	0.0047	0.0046	0.0047	0.0046*
		(0.00)	(0.01)	(0.00)	(0.29)		(0.00)	(0.06)	(0.00)	(0.16)

Note: Parameter values are reported in parentheses.
* The optimal values.

TABLE 3. EVALUATION THROUGH MAPE OF THE IO TABLE PROJECTIONS FOR EA-19 COUNTRIES (2010 AND 2015)

	MAPE									
	2010					2015				
Countries	CILQ	FLQ	AFLQ	AFLQ (	ACILQ	CILQ	FLQ	AFLQ	AFLQ (	ACILQ
Austria	0.0156	0.0156	0.0155*	0.0156	0.0156	0.0156	0.0156	0.0154*	0.0154	0.0156
		(0.00)	(0.03)	(0.00)	(0.92)		(0.00)	(0.03)	(0.00)	(0.88)
Belgium	0.0165	0.0165	0.0164*	0.0166	0.0164	0.0163	0.0163	0.0162	0.0162	0.0162*
		(0.01)	(0.06)	(0.00)	(0.10)		(0.00)	(0.03)	(0.00)	(-0.14)
Estonia	0.0177	0.0177	0.0181	0.0186	0.0177*	0.0175*	0.0175	0.0180	0.0183	0.0175
		(0.00)	(0.05)	(0.00)	(0.66)		(0.00)	(0.04)	(0.00)	(1.00)
France	0.0123	0.0123	0.0120*	0.0121	0.0121	0.0130	0.0130	0.0126*	0.0128	0.0126
		(0.00)	(0.05)	(0.00)	(0.68)		(0.00)	(0.10)	(0.00)	(0.63)
Germany	0.0130	0.0130	0.0128*	0.0128	0.0129	0.0134	0.0134	0.0132	0.0132	0.0130*
		(0.00)	(0.01)	(0.00)	(0.40)		(0.00)	(0.00)	(0.00)	(0.21)
Italy	0.0123	0.0123	0.0120	0.0120	0.0116*	0.0126	0.0126	0.0124	0.0124	0.0118*
		(0.00)	(0.00)	(0.00)	(-0.20)		(0.00)	(0.02)	(0.00)	(-0.37)
Latvia	0.0210	0.0208	0.0205	0.0214	0.0196*	0.0204	0.0202	0.0199	0.0210	0.0199*
		(0.04)	(0.09)	(0.00)	(-0.30)		(0.04)	(0.10)	(0.00)	(0.30)
Slovakia	0.0172	0.0172	0.0163	0.0163	0.0163*	0.0170	0.0170	0.0163*	0.0167	0.0166
		(0.02)	(0.06)	(0.00)	(-0.03)		(0.00)	(0.05)	(0.00)	(0.09)
Slovenia	0.0176	0.0176	0.0177	0.0177	0.0175*	0.0178	0.0178	0.0179	0.0179	0.0176*
		(0.00)	(0.01)	(0.00)	(-0.30)		(0.00)	(0.02)	(0.00)	(0.76)
Spain	0.0132	0.0132	0.0130*	0.0130	0.0130	0.0143	0.0143	0.0141	0.0142	0.0140*
		(0.00)	(0.01)	(0.00)	(0.29)		(0.00)	(0.06)	(0.00)	(0.16)

Note: Parameter values are reported in parentheses.
* The optimal values.

Table 4. Evaluation through SD-MAD of the IO table projections for EA-19 countries (2010 and 2015)

	SD-MAD									
	2010					2015				
Countries	CILQ	FLQ	AFLQ	AFLQ (	ACILQ	CILQ	FLQ	AFLQ	AFLQ (	ACILQ
Austria	0.0177	0.0177	0.0170	0.0170*	0.0177	0.0173	0.0173	0.0165	0.0165*	0.0173
		(0.00)	(0.00)	(0.00)	(0.99)		(0.00)	(0.00)	(0.00)	(0.91)
Belgium	0.0211	0.0211	0.0204	0.0204*	0.0209	0.0205	0.0205	0.0199	0.0199*	0.0204
		(0.00)	(0.00)	(0.00)	(0.35)		(0.00)	(0.00)	(0.00)	(0.68)
Estonia	0.0200*	0.0200	0.0216	0.0231	0.0200	0.0196*	0.0196	0.0211	0.0228	0.0196
		(0.00)	(0.06)	(0.00)	(1.00)		(0.00)	(0.06)	(0.00)	(1.00)
France	0.0103	0.0103	0.0100	0.0100*	0.0102	0.0109	0.0109	0.0105*	0.0105	0.0105
		(0.00)	(0.00)	(0.00)	(0.77)		(0.00)	(0.00)	(0.00)	(0.66)
Germany	0.0118	0.0118	0.0112	0.0112*	0.0117	0.0121	0.0121	0.0113*	0.0113	0.0118
		(0.00)	(0.00)	(0.00)	(0.79)		(0.00)	(0.00)	(0.00)	(0.49)
Italy	0.0116	0.0116	0.0115	0.0118	0.0106*	0.0116	0.0116	0.0116	0.0123	0.0103*
		(0.00)	(0.08)	(0.00)	(-0.22)		(0.00)	(0.11)	(0.00)	(-0.34)
Latvia	0.0212	0.0212	0.0221	0.0246	0.0198*	0.0228	0.0228	0.0232	0.0241	0.0226*
		(0.00)	(0.08)	(0.00)	(-0.24)		(0.00)	(0.05)	(0.00)	(0.85)
Slovakia	0.0173	0.0173	0.0158	0.0158*	0.0168	0.0186	0.0186	0.0168	0.0168*	0.0185
		(0.00)	(0.00)	(0.00)	(0.40)		(0.00)	(0.00)	(0.00)	(0.91)
Slovenia	0.0206	0.0206	0.0207	0.0207	0.0198*	0.0224	0.0224	0.0223	0.0223	0.0217*
		(0.00)	(0.00)	(0.00)	(-0.25)		(0.00)	(0.00)	(0.00)	(-0.27)
Spain	0.0124	0.0124	0.0122	0.0123	0.0122*	0.0147	0.0147	0.0145	0.0145*	0.0146
		(0.00)	(0.04)	(0.00)	(0.63)		(0.00)	(0.00)	(0.00)	(0.60)

Table 5. Evaluation through THEILS of the IO table projections for EA-19 countries (2010 and 2015)

	Theils									
	2010					2015				
Countries	CILQ	FLQ	AFLQ	AFLQ (	ACILQ	CILQ	FLQ	AFLQ	AFLQ (	ACILQ
Austria	51.7211	51.7211	49.8312	49.8312*	51.7190	51.4612	51.4612	49.2230	49.2230*	51.4060
		(0.00)	(0.00)	(0.00)	(0.98)		(0.00)	(0.00)	(0.00)	(0.91)
Belgium	61.6145	61.6145	59.7255	59.7255*	61.1391	60.3261	60.3261	58.7958	58.7958*	59.9121
		(0.00)	(0.00)	(0.00)	(0.34)		(0.00)	(0.00)	(0.00)	(0.67)
Estonia	63.7640	63.7640	68.4637*	73.0954	63.7640	62.0604*	62.0604	66.6043	71.7731	62.0604
		(0.00)	(0.06)	(0.00)	(1.00)		(0.00)	(0.06)	(0.00)	(1.00)
France	41.5652	41.5652	40.2513	40.2513*	41.1495	44.4197	44.4197	43.1417	43.1417	43.0885*
		(0.00)	(0.00)	(0.00)	(0.76)		(0.00)	(0.00)	(0.00)	(0.65)
Germany	40.9474	40.9474	39.0222	39.0222*	40.7559	42.2390	42.2390	39.7198*	39.7198	41.3043
		(0.00)	(0.00)	(0.00)	(0.77)		(0.00)	(0.00)	(0.00)	(0.46)
Italy	45.3907	45.3907	45.0409	46.0151	41.6174*	46.1871	46.1871	46.1803	48.5414	41.2438*
		(0.00)	(0.08)	(0.00)	(-0.22)		(0.00)	(0.11)	(0.00)	(-0.34)
Latvia	72.9003	72.9003	75.4641	83.5023	68.1747*	70.3506	70.3506	71.6029	74.4515	69.9082*
		(0.00)	(0.08)	(0.00)	(-0.24)		(0.00)	(0.05)	(0.00)	(0.84)
Slovakia	55.8880	55.8880	50.7152*	51.3502	54.3012	55.6174	55.6174	50.5089*	50.7606	55.4594
		(0.00)	(0.02)	(0.00)	(0.40)		(0.00)	(0.01)	(0.00)	(0.90)
Slovenia	66.1206	66.1206	66.3375	66.3375	63.7084*	67.7643	67.7643	67.6086	67.6086	65.8949*
		(0.00)	(0.00)	(0.00)	(-0.25)		(0.00)	(0.00)	(0.00)	(-0.27)
Spain	43.8278	43.8278	43.2448	43.5109	43.2440*	49.0267	49.0267	48.2529	48.2529*	48.4041
		(0.00)	(0.04)	(0.00)	(0.62)		(0.00)	(0.00)	(0.00)	(0.60)

Note: Parameter values are reported in parentheses.
* The optimal values.