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Empirical Evidence on the Use of the FLQ Formula for Regionalizing National Input-Output Tables: The Case of the Province of Córdoba, Argentina

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This paper uses survey-based data for the Argentinian province of Córdoba to carry out an empirical test of the performance of the FLQ formula for regionalizing national input–output tables. Particular attention is paid to the problem of choosing a value for the unknown parameter δ in this formula. Two alternative approaches suggested in the literature are evaluated. A statistical test is also performed of differences between regional and national technology, and Round's 'fabrication' formula is applied in an effort to make suitable adjustments for such differences. However, the FLQ formula, without any fabrication adjustments, is found to give the best overall results of the non-survey methods considered in the paper.

Keywords: Regional input–output tables; Argentina; Location quotients; FLQ; Fabrication effects

1 INTRODUCTION

Regional input–output tables are a very useful tool for regional planning, yet constructing a survey-based regional table can be a complex, expensive and lengthy task. As a result, regional tables based primarily on survey data are rare. An exception is the province of Córdoba in Argentina, which is fortunate in having a detailed survey-based table for the year 2003 with 124 sectors. Our primary aim is to make full use of this rich data set to assess the relative performance of alternative non-survey methods for constructing regional tables.

In the common situation where the construction of a survey-based regional table is not feasible, analysts have to resort to indirect methods of estimation. Typically, they endeavour to 'regionalize' the national input–output table, so that it mirrors as far as possible the industrial structure of the region under consideration. Of especial importance is the need to make sufficient allowance for interregional trade.

Location quotients (LQs) offer a straightforward and inexpensive way of regionalizing a national input–output table. In the past, analysts have often used the *simple* LQ (SLQ) or the *cross-industry* LQ (CILQ), yet these conventional LQs are known to yield overstated regional sectoral multipliers. This upward bias occurs because these LQs tend to understate imports from other regions. In an effort to overcome this problem, Flegg et al. (1995) proposed a new variant of the existing LQs, the FLQ formula, which took explicit account of the relative size of a region. They postulated an inverse relationship between a region's relative size and its propensity to import from other regions. Flegg and Webber (1997) subsequently refined this FLQ formula. Another refinement was put forward by Flegg and Webber (2000); this *augmented* FLQ (AFLQ) formula sought to capture the impact of regional specialization on the size of regional input coefficients. However, as the AFLQ is more complex than the FLQ and has not proved to be more accurate, it will not be employed here.

The FLQ's focus is on regional output and employment. It should only be applied to national input–output tables that exclude imports (type B tables), such as the one that is examined here (Flegg and Tohmo, 2013b). However, where the focus is on the overall supply of goods, Kronenberg's Cross-Hauling Adjusted Regionalization Method (CHARM) can be used for purposes of regionalization. This new method is suitable for examining environmental impacts. CHARM can only be used in conjunction with type A tables, those where imports have been incorporated into the national table (Kronenberg, 2009, 2012).

A sizable body of empirical evidence now demonstrates that the FLQ can produce much better results than the SLQ and CILQ. This evidence includes, for instance, case studies of Scotland (Flegg and Webber, 2000), Finland (Tohmo, 2004; Flegg and Tohmo, 2013a,c) and Germany (Kowalewski, 2013). Furthermore, Bonfiglio and Chelli (2008) carried out a Monte Carlo simulation of 400,000 output multipliers. Here the FLQ clearly outperformed its predecessors in terms of generating the best estimates of these multipliers.

Even so, the FLQ formula contains an unknown parameter δ and there is considerable uncertainty regarding its appropriate value (Bonfiglio, 2009). This issue is important since the value of δ and regional size jointly determine the size of the adjustment for interregional trade in the FLQ. By exploring this issue, we aim to offer some guidance on what value of δ would be the best to use in particular circumstances.

The rest of the paper is structured as follows. The next section explains how the survey-based input–output table for Córdoba was reconciled with that for Argentina. The data are then used to highlight any salient differences or similarities in the regional and national economic structures. The third section examines how alternative estimates of the regional table were derived by 'regionalizing' the national table. In the subsequent two sections, we present our analysis of sectoral input coefficients and output multipliers. This is followed by a consideration of alternative ways of determining a value for the unknown parameter δ in the

FLQ formula. In the penultimate section, the differences between national and regional technology are explored. Here we attempt to correct for such differences by applying Round's 'fabrication' adjustment. The final section contains our conclusions.

2 INPUT–OUTPUT TABLES FOR CÓRDOBA AND ARGENTINA

The province of Córdoba is located just north of the geographical centre of Argentina. It produces about 8.3% of the gross output of Argentina and employs about 7.9% of its labour force.[1] The provincial capital, Córdoba, which is situated some 700 km north-west of Buenos Aires, is Argentina's second-largest city. The province has a diversified economy and its key sectors include agriculture, livestock, motor vehicles and food processing. It also has a vigorous services sector and a growing tourism industry. Agriculture is focused upon soy beans, wheat, maize and other cereals. The production of beef and dairy products is very important, and the province also produces products such as fertilizers, agrochemicals, tractors and agricultural machinery. Hydroelectricity and nuclear power are the main source of energy for the province's industries. In addition, many different materials are mined, along with construction materials such as marble and lime.

A 124 × 124 input–output table for the province of Córdoba in 2003 was developed by the Centro de Estudios Bonaerenses (CEB). This table was constructed on the basis of exhaustive surveys of key sectors and big companies, which sought to reveal productive structures and to measure levels of gross output. Expansion weights from national output surveys were applied to expand the survey data to encompass the less important sectors.[2]

To reconcile the data for individual sectors, sectoral supply and demand were estimated. Many imbalances were evident, which were addressed by replacing the less dependable data with data of superior quality. Figures for supply were provided by the Dirección General de Estadísticas y Censos and the Ministerio de Economía de Córdoba. Demand was estimated via surveys of companies, via the household expenditure survey of the Instituto Nacional de Estadísticas y Censos (INDEC), and by data on exports, also from INDEC. Figures for governmental consumption and household transfers were based on information gathered by the government, by health programmes, by the Administración Nacional de Seguridad Social and by non-profit organizations related to households.

To complete the regional input–output table, the survey data on imports of goods and services from the rest of the country and from the rest of the world were added. Finally, taxes net of subsidies, and trade and freight margins, were incorporated. These latter figures were obtained from the national and provincial tax bodies and from the trade margins survey.

The first problem encountered when trying to reconcile the input–output tables for Córdoba and Argentina was that the most recent national table had thirty sectors, whereas the provincial table contained 124 sectors.[3] To circumvent this problem, the transactions for Córdoba were aggregated to correspond with the national sectoral classification. A new set of intraregional input coefficients, based on thirty sectors, was then computed. Another obstacle was that Córdoba's data were in basic prices, whereas the national data were in producers' prices. Therefore, the national output data were adjusted to basic prices by deducting taxes on production and adding subsidies, using data from Chisari et al. (2009). A final issue was that the national table was for 1997, whereas the provincial table was for 2003. Here it was assumed that the national input coefficients had remained stable between 1997 and 2003. This assumption can be justified by the fact that, although there was a great deal of macroeconomic instability in Argentina during this period, there is little evidence of major structural change. For instance, there is a very strong correlation (r = 0. 972) between the shares of GDP in 1997 and 2003 of thirteen broadly defined national sectors.[4]

Table 1 near here

There are some noticeable differences in the extent to which Córdoba and Argentina specialize in particular industries. These differences are captured in the simple LQs (SLQs) displayed in Table 1, which were computed using the following formula:[5]

$$SLQ_i \equiv \frac{Q_i^r/\Sigma_i Q_i^r}{Q_i^n/\Sigma_i Q_i^n} \equiv \frac{Q_i^r}{Q_i^n} \times \frac{\Sigma_i Q_i^n}{\Sigma_i Q_i^r} \qquad (1)$$

where Q_i^r is regional output in sector i and Q_i^n is the corresponding national figure. $\Sigma_i Q_i^r$ and $\Sigma_i Q_i^n$ are the respective regional and national totals.

Table 1 reveals that Córdoba has a high degree of specialization in sectors 1 (agriculture, cattle raising, hunting and forestry) and 17 (manufacture of vehicles). Other sectors exhibiting significant regional specialization include 4 (production of food, beverages and tobacco products), 13 (non-metallic mineral products) and 16 (machinery and equipment, electrical apparatus, technical instruments, and equipment for radio, television and telecommunications). On the other hand, relatively low values of SLQ_i occur in sectors such as 11 (manufacture of substances and chemical products) and 25 (financial intermediation). These differences are important because LQ-based approaches presuppose that sectors in which the region is *not* specialized will be unable to fulfil all of the requirements for the commodity in question from within the region and so will need to 'import' some of these items from other regions. On the other hand, the region is more likely to be self-sufficient in those sectors in which it is specialized. For example, we might expect the propensity to import from other regions to be relatively high in sector 8 (production of paper and paper products) but relatively low in sector 17 (manufacture of vehicles).

3 REGIONALIZATION

At the outset, the 30 × 30 national and regional transactions matrices were transformed into matrices of input coefficients. The national coefficient matrix was then 'regionalized' via the following formula:

$$r_{ij} = \beta_{ij} \times a_{ij} \qquad (2)$$

where r_{ij} is the regional input coefficient, β_{ij} is an adjustment coefficient and a_{ij} is the national input coefficient. r_{ij} measures the amount of regional input i needed to produce one unit of regional gross output j; it thus excludes any supplies of i 'imported' from other regions or obtained from abroad. a_{ij} likewise excludes any supplies of i obtained from abroad. The role of β_{ij} is to take account of a region's purchases of input i from other regions.

If we replace β_{ij} in equation (2) with an LQ, we can obtain estimates of the r_{ij}. Thus, for instance:

$$\hat{r}_{ij} = SLQ_i \times a_{ij} \qquad (3)$$

Another possibility is to replace β_{ij} with CILQ_{ij}, which is defined as follows:

$$CILQ_{ij} \equiv \frac{SLQ_i}{SLQ_j} \equiv \frac{Q_i^r / Q_i^n}{Q_j^r / Q_j^n} \qquad (4)$$

where the subscripts i and j refer to the supplying and purchasing sectors, respectively. *Note:* No adjustment is made to the national coefficient where $CILQ_{ij} \geq 1$ and likewise for SLQ_i.

However, for reasons alluded to earlier, the authors would recommend the use of the FLQ, which is defined as follows:

$$FLQ_{ij} \equiv CILQ_{ij} \times \lambda^* \quad \text{for } i \neq j \tag{5}$$

$$FLQ_{ij} \equiv SLQ_i \times \lambda^* \quad \text{for } i = j \tag{6}$$

where:

$$\lambda^* \equiv [\log_2(1 + \Sigma_i Q_i^r / \Sigma_i Q_i^n)]^\delta \tag{7}$$

It is assumed that $0 \leq \delta < 1$; as δ increases, so too does the allowance for interregional imports. $\delta = 0$ represents a special case where $FLQ_{ij} = CILQ_{ij}$. As with other LQ-based formulae, the FLQ is constrained to unity.

Two facets of the FLQ formula are worth stressing: its cross-industry foundations and the explicit role given to regional size. Thus, with the FLQ, the relative size of the regional purchasing and supplying sectors is considered when making an adjustment for interregional trade, as is the relative size of the region. By taking explicit account of a region's relative size, the FLQ should help to address the problem of cross-hauling, which is likely to be more serious in smaller regions than in larger ones (see, for example, Robison and Miller 1988, table 2). Smaller regions are liable to be more open to interregional trade.

4 INPUT COEFFICIENTS

Even though most analysts are apt to be more concerned with the outcomes for regional sectoral multipliers, it is often fruitful to examine the estimates of the regional input coefficients as well. In line with previous research (Flegg and Tohmo, 2013a,c), the following statistics will be employed in this assessment:

$$\text{STPE} = 100\, \Sigma_{ij} | \hat{r}_{ij} - r_{ij} | / \Sigma_{ij} r_{ij} \tag{8}$$

$$\text{WMAE} = (1/n) \Sigma_j w_j \Sigma_i | \hat{r}_{ij} - r_{ij} | \tag{9}$$

$$\tilde{\text{U}}^{\text{S}} = \{\text{sd}(\hat{r}_{ij}) - \text{sd}(r_{ij})\}^2 \tag{10}$$

$$\tilde{\text{U}}^{\text{M}} = \{\text{m}(\hat{r}_{ij}) - \text{m}(r_{ij})\}^2 \tag{11}$$

$$\text{U} = 100 \sqrt{\frac{\Sigma_{ij} (\hat{r}_{ij} - r_{ij})^2}{\Sigma_{ij} r_{ij}^{\,2}}} \tag{12}$$

where $\hat{r}_{ij}$ is the estimated regional input coefficient, r_{ij} is the corresponding benchmark value (derived from the survey-based coefficient matrix for Córdoba in 2003) and n is the number of sectors. STPE and WMAE denote the standardized total percentage error and the weighted mean absolute error, respectively. w_j is the proportion of total regional output produced in sector j. $\tilde{\text{U}}^{\text{M}}$ and $\tilde{\text{U}}^{\text{S}}$, where m( ) is the mean and sd( ) is the standard deviation, are components of the mean squared error (MSE); they are included to assess how far each method of estimation is able to: (i) avoid bias and (ii) replicate the dispersion of the benchmark distribution of coefficients.[6] Finally, U is Theil's well-known inequality coefficient, which has the merit that it encompasses both bias and variance (Theil et al., 1966, pp. 15–43). A selection of results is presented in Table 2.

Table 2 near here

The results in Table 2 are ambiguous in terms of identifying the best method of estimation: whereas the STPE and U suggest that the SLQ should be preferred to the FLQ, the WMAE indicates the converse. This ambiguity is out of line with the findings of other studies (see, for example, Flegg and Tohmo, 2013a,c; Kowalewski, 2013). However, a scrutiny of the data for individual sectors revealed that this inconsistency was largely due to the inclusion of two atypical sectors in the analysis, which had a disproportionate impact on the results for the FLQ, especially those for the STPE and U. This effect is illustrated in Figure 1. It was assumed that $\delta = 0.123$ (the optimal value reported in Table 2 for the STPE).

Figure 1 near here

Table 1 shows that sectors 2 and 10 play a minuscule role in Córdoba's economy, each accounting for less than 0.1% of output, yet Figure 1 reveals that their inclusion in the analysis clearly distorts the outcomes. In the case of the FLQ, sector 2 accounts for 8.6% and 6.3%, respectively, of the values of the STPE and U^2. The outcome for sector 10 is more dramatic: it accounts for 14.3% and 60.8% of the respective values of these statistics. Therefore, to obtain a set of results less affected by outliers, the calculations were redone after excluding these two sectors. The outcomes are displayed in Table 3.

Table 3 near here

The new results are in accord with those of previous studies: the FLQ now outperforms the SLQ in terms of all criteria. While the exclusion of the two atypical sectors enhances the performance of both methods in terms of the STPE and U, the impact on the FLQ is much more pronounced.[7] Table 3 also confirms that the CILQ is the worst of the three methods (even though it does perform fairly well in terms of the WMAE). Flegg and Tohmo (2013c) also found the CILQ to be the worst of the four methods they examined using Finnish data.

Table 3 shows that the optimal δ for U is noticeably higher than that for the STPE. This divergence can be explained by the different properties built into each formula: by squaring the term $(\hat{r}_{ij} - r_{ij})$ rather than taking the absolute value, U puts more emphasis on avoiding large errors. To achieve this, a somewhat larger δ is needed, namely 0.145 rather than 0.123. Another noteworthy finding is that $\tilde{U}^M$ is minimized when $\delta = 0.075$, whereas U (which takes both bias and dispersion into account) requires $\delta = 0.145$. Thus a strategy of minimizing bias would necessitate using a relatively low value of δ.

It is worth noting, finally, that the optimal value of δ for the WMAE is close to zero. However, this outcome is largely due to the impact on the WMAE of sector 4 (production of food, beverages and tobacco products). This sector accounts for 18.4% of output in Córdoba and it has a disproportionate effect on the WMAE. For example, when the value of δ is cut from, say, 0.15 to 0.012, the WMAE falls from 0.4574 to 0.4371. 36.2% of this change is attributable to sector 4.

5 OUTPUT MULTIPLIERS

Following previous research (Flegg and Tohmo, 2013a,c), the following statistics will be employed to assess the accuracy of the estimated multipliers:

$$\text{MPE} = (100/28)\,\Sigma_j\,(\hat{m}_j - m_j)\,/\,m_j \tag{13}$$

$$\text{STPE} = 100\,\Sigma_j\,|\hat{m}_j - m_j|\,/\,\Sigma_j\,m_j \tag{14}$$

$$\text{WMAE} = \Sigma_j\,w_j\,|\hat{m}_j - m_j| \tag{15}$$

$$\tilde{\text{U}}^{\text{M}} = \{\text{m}(\hat{m}_j) - \text{m}(m_j)\}^2 \tag{16}$$

$$\tilde{\text{U}}^{\text{S}} = \{\text{sd}(\hat{m}_j) - \text{sd}(m_j)\}^2 \tag{17}$$

$$\text{U} = 100\sqrt{\frac{\sum_j (\hat{m}_j - m_j)^2}{\sum_j m_j^{\;2}}} \tag{18}$$

where $\hat{m}_j$ is the estimated type I output multiplier for regional sector j (column sum of the LQ-based Leontief inverse matrix), whereas m_j is the corresponding benchmark value (derived from the survey-based coefficient matrix for Córdoba in 2003). MPE denotes the mean percentage error. This statistic has been added to the set of criteria because it offers a covenient way of measuring the amount of bias in a relative sense.[8] It has also been used in many previous studies. A selection of results is presented in Table 4.

Table 4 near here

We should note at the outset that the errors in the multipliers are much smaller than those in the coefficients. This is an unsurprising outcome: much offsetting of errors occurs when computing multipliers from the Leontief inverse matrix.[9] It may still be possible, therefore, to obtain good estimates of multipliers even if the coefficients are subject to considerable error. Here the choice of an appropriate method of estimation is crucial.

The MPE shows that, on average across the 28 sectors, the FLQ with δ = 0.065 would eliminate any bias in the estimated multipliers. By contrast, the SLQ and CILQ would overstate the average multiplier by 3.8% and 6.8%, respectively. A potential demerit of the MPE is that large positive and negative errors could offset each other, thereby giving a spurious impression of accuracy. The STPE, WMAE and U cannot be distorted in this way and, in fact, confirm the finding from the MPE that the FLQ is the most accurate method. Even so, although all four statistics show that the FLQ is demonstrably superior to the CILQ, it is only modestly better than the SLQ. The results confirm that the SLQ's major weakness is its tendency to overstate coefficients and hence multipliers.

The results for $\tilde{\text{U}}^{\text{M}}$ and $\tilde{\text{U}}^{\text{S}}$ display an interesting pattern: as the value of δ rises above 0.072, the FLQ exhibits more bias but a closer correspondence between the standard deviations of $\hat{m}_j$ and m_j. δ = 0.072 is optimal for $\tilde{\text{U}}^{\text{M}}$, whereas $\tilde{\text{U}}^{\text{S}}$ requires δ = 0.195. U strikes a compromise between these two extremes, indicating a value of 0.123.

A notable similarity between the results for coefficients and multipliers is that, in both cases, minimum bias for the FLQ is attained by using a relatively low value of δ. However, with the WMAE, there is a sharp contrast between the outcomes shown in Tables 3 and 4: whereas δ = 0.012 minimizes the WMAE for coefficients, δ = 0.193 is required for multipliers. As before, sector 4 can explain some of this difference in outcomes: this sector requires a relatively low value of δ to minimize $\Sigma_i\,|\hat{r}_{i4} - r_{i4}|$ but a relatively high value in the case of multipliers.

Given the great variety of different outcomes displayed in Table 4, which value of δ should analysts choose? A key issue is the relative emphasis placed on avoiding bias, as opposed to minimizing variance. If bias is the greatest concern, then a $\delta \approx 0.075$ would be sensible. However, if each aspect is equally important, then the δ = 0.123 generated by U would be a reasonable choice. This figure is also fairly close to the δ = 0.134 for the STPE.

6 CHOOSING A VALUE FOR δ

The earlier discussion has shown how important it is to select a suitable value for δ, so it is opportune to examine two proposed methods for obtaining such a value. The first method was put forward by Bonfiglio (2009), who derived the following regression equation using simulated data from a Monte Carlo study:

$$\hat{\delta} = 0.994\,PROP - 2.819\,RSRP \tag{19}$$

where *PROP* is the propensity to interregional trade (the proportion of a region's total intermediate inputs that is purchased from other regions) and *RSRP* is the relative size of regional purchases (the ratio of total regional to total national intermediate inputs).

To evaluate Bonfiglio's method, two tests were carried out using data for Germany and Finland. In the first application, survey-based data from Kowalewski (2013, table 1), were used to derive the following estimate of δ for the state of Baden-Wuerttemberg in 1993:

$$\hat{\delta} = 0.994 \times 0.205 - 2.819 \times 0.134 = -0.174 \tag{20}$$

Here the state's share of total German employment (*ibid.*, p. 5) was used as a proxy for *RSRP*. In the second application, using data from Statistics Finland (2000), an even more negative result was obtained for the Finnish province of Uusimaa in 1995:

$$\hat{\delta} = 0.994 \times 0.3016 - 2.819 \times 0.2925 = -0.525 \tag{21}$$

In this instance, the outcome reflects the fact that Uusimaa is by far the largest Finnish province. It also has the lowest value of *PROP*. For the other nineteen provinces, Bonfiglio's method generated $0 \le \hat{\delta} < 1$, as required.

These examples serve to highlight a problem with Bonfiglio's approach: the theoretical constraint $\delta \ge 0$ is not imposed on equation (19), so it can yield negative values of δ for regions that are relatively large or exhibit below-average propensities to import from other regions or both. Cases in point are Uusimaa and Baden-Wuerttemberg. The approach is, therefore, of limited applicability.

An alternative method is suggested by Flegg and Tohmo (2013a), who estimated the following regression equation using survey-based data for twenty Finnish regions in 1995:

$$\ln \delta = -1.8379 + 0.33195 \ln R + 1.5834 \ln P - 2.8812 \ln I + \mathrm{e} \tag{22}$$

where R is regional size measured in terms of output and expressed as a percentage; P is a survey-based estimate of each region's propensity to import from other regions, divided by the mean value of this propensity for all regions; I is a survey-based estimate of each region's average use of intermediate inputs (including inputs imported from other regions), divided by the corresponding national proportion of intermediate inputs; e is a residual. This equation has the merit that $\delta \geq 0$. Moreover, unlike equation (19), it takes explicit account of any differences between the regional and national ratios of intermediate use.

Equation (22) can, in fact, be rewritten in the following alternative forms, which may be more convenient in some cases (Flegg and Tohmo, 2013c):

$$\ln \delta = 0.8169 + 0.33195 \ln R + 1.5834 \ln p - 2.8812 \ln I + e \qquad (23)$$

$$\ln \delta = -1.8296 + 0.33195 \ln R + 1.5834 \ln p - 2.8812 \ln i + e \qquad (24)$$

where p is an estimate of each region's propensity to import from other regions, measured as a proportion of gross output, and i is an estimate of each region's average use of intermediate inputs (including inputs imported from other regions).

Using equation (23), along with data from Kowalewski (2013, table 1 and p. 10), the following estimate of δ was derived for Baden-Wuerttemberg in 1993:

$$\hat{\delta} = \exp(0.8169 + 0.33195 \ln 14.38 + 1.5834 \ln 0.1019 - 2.8812 \ln 0.9925) = 0.151$$

Kowalewski (2013, table 3) found that the optimal value of δ varied from 0.11 to 0.17, depending on which statistical criterion was used to evaluate the estimated multipliers. It is reassuring that 0.151 falls within this range.

To provide a further test of Flegg and Tohmo's regression model, it was applied to data for Córdoba and Argentina. The following estimate of δ was derived using equation (24):

$$\hat{\delta} = \exp(-1.8296 + 0.33195 \ln 8.27 + 1.5834 \ln 0.115 - 2.8812 \ln 0.422) = 0.127$$

Table 4 shows that this figure is very close to the optimal values of δ obtained from the STPE and U (0.134 and 0.123, respectively) but it noticeably exceeds the 0.065 from the MPE. Thus Flegg and Tohmo's approach works very well indeed in this instance, so long as our concern is not simply with avoiding bias.

7 DIFFERENCES IN TECHNOLOGY

All LQ-based methods assume identical regional and national technology, i.e. that national and regional firms use the same proportions of different inputs to produce a given commodity. Unfortunately, this assumption cannot be tested directly with the data available here because each sector's imports from other regions are not disaggregated by type of input. Instead, we shall test the assumption that Córdoba and Argentina use the same mix of intermediate and primary inputs. Primary inputs include value added and imports from abroad. Value added refers to the income of capital and labour.

The following regression model was formulated to test the hypothesis that Córdoba and Argentina used the same mix of intermediate and primary inputs in 2003:

$$I_{jr} = \alpha + \beta I_{jn} + \varepsilon_{jr} \qquad (25)$$

where I_{jr} is a survey-based estimate of the proportion of intermediate inputs (including inputs imported from other Argentinian regions) used by sector j in Córdoba, I_{jn} is the corresponding proportion of intermediate inputs for Argentina, and ε_{jr} is a random error term. The following result was obtained (n = 28):

$$\hat{I}_{jr} = 0.1204 + 0.7346 I_{jn} \tag{26}$$

Standard errors: 0.0508 ($\hat{\alpha}$), 0.1188 ($\hat{\beta}$). $R^2 = 0.595$.

This regression gives some grounds for rejecting the null hypotheses $\alpha = 0$ and $\beta = 1$; in particular, $\hat{\alpha}$ is significantly greater than zero and $\hat{\beta}$ is significantly less than one, both at the 2.5% level. The regression crosses the 45° line at $I_{jn} = 0.4535$, which reflects the fact that some Córdoban sectors use a higher proportion of intermediate inputs than Argentina, while others use a lower proportion. On average, Córdoba has a slightly higher proportion of intermediate inputs than Argentina (0.4187 versus 0.4061).

So long as the required data are available or can be approximated, a convenient way of adjusting for differences between regional and national intermediation ratios is to apply Round's 'fabrication' factor (Round, 1972, p. 6). This approach involves using the following formula to adjust the national technical coefficients prior to applying LQs:

$$a_{ij}^{r} = \frac{1-(w_j^r/x_j^r)}{1-(w_j^n/x_j^n)} a_{ij}^{n} \tag{27}$$

where w denotes value added, x denotes gross output, r and n refer to the region and the nation, respectively, a_{ij}^{n} is the national technical coefficient and a_{ij}^{r} is the adjusted value of this coefficient (cf. Miller and Blair, 2009, pp. 356–357). The outcomes of this procedure are presented in Table 5. It should be noted that this application does not adhere to Round's formula exactly, inasmuch as we do not include foreign imports in the sums of intermediate inputs. We are assuming identical regional and national propensities to import foreign goods.

Table 5 near here

A comparison of Tables 4 and 5 reveals a surprising outcome: the use of Round's fabrication adjustment prior to the application of LQs yields substantially worse results. For instance, for the SLQ, the MPE changes from an overstatement of 3.8% to an understatement of 5.9%. In addition, the STPE rises from 7.7% to 9.6%, while U rises from 10.0% to 12.2%. It is evident that the FLQ, with no fabrication adjustment, gives the best overall results.

A possible explanation of these unexpected findings is that Round's formula applies the same scaling to every element in a given column of the coefficient matrix; this is bound to introduce errors, even though the overall effect will be correct. It is also possible that the scaling of national coefficients implemented via the FLQ makes adequate adjustments for both interregional trade and differences in technology. Whatever the explanation, it is evident that, for this data set at least, the use of Round's formula is unhelpful in terms of enhancing the performance of the FLQ.

7 CONCLUSION

This paper has used detailed survey-based data for the Argentinian province of Córdoba to assess the relative performance of the FLQ formula for regionalizing national input–output tables. The empirical work employed a range of statistical criteria with contrasting properties, and examined both input coefficients and sectoral output multipliers. In line with the findings of earlier studies, the FLQ produced the most accurate results of the three alternative methods considered, namely the FLQ, SLQ and CILQ. The CILQ generated the least accurate results.

The FLQ formula contains a key unknown parameter δ and two possible ways of determining its value were examined, using survey-based data for Argentina, Finland and Germany. On the basis of this evidence, along with theoretical considerations, it was suggested that the regression approach of Flegg and Tohmo (2013a) offered a promising way forward.

The available data made it possible to explore any divergence between regional and national technology. Although significant differences in the use of intermediate inputs were identified, Round's 'fabrication' formula was found to be unhelpful in making suitable adjustments for these differences. Indeed, the FLQ formula, without any fabrication adjustments, gave the best overall results of the methods considered here. This is an unexpected and important finding.

It is worth emphasizing that, as with other pure non-survey methods, the FLQ can only be relied upon to produce a satisfactory *initial* set of regional input coefficients. Such coefficients should always be appraised by the analyst on the basis of informed judgement, any available superior data, surveys of key sectors and so on. Indeed, the FLQ formula is, in the authors' opinion, very well suited to building the non-survey foundations of a hybrid model.[10]

Notes

1. Source: Instituto Nacional de Estadísticas y Censos and Ministerio de Economía de la Nación Argentina.
2. The CEB worked with the World Bank and the Ministerio de Economia de Córdoba to construct the survey-based input–output matrix for Córdoba. For a discussion of methodology, see http://estadistica.cba.gov.ar/LinkClick.aspx?fileticket=xEa_WsSZLHo%3D&tabid=413&language=es-AR.
3. Source: Instituto Nacional de Estadísticas y Censos and Ministerio de Economía de la Nación Argentina. Tablas Insumo-Producto para Argentina 1997.
4. GDP was measured in constant prices of 1993. Source: INDEC.
5. Note that all of the LQs used in this paper are based on output rather than on the more usual employment. Sectoral output data are not normally available, so that employment has to be used as a proxy.
6. The $\text{MSE} \equiv \{\text{m}(\hat{m}_j) - \text{m}(m_j)\}^2 + \{\text{sd}(\hat{m}_j) - \text{sd}(m_j)\}^2 + 2(1-r) \times \text{sd}(\hat{m}_j) \times \text{sd}(m_j)$, where r is the correlation coefficient between $\hat{m}_j$ and m_j. Cf. Theil et al., 1966, pp. 29–30.
7. This outcome can be explained by the fact that, for purchasing sectors 2 and 10, the FLQ makes insufficient allowance for imports from other regions. This occurs for sector 2 because the unconstrained FLQ exceeds unity for 29 of the 30 supplying sectors, so there is only one sector where an adjustment is made for imports from other regions. Similarly, for sector 10, the unconstrained FLQ exceeds unity for 28 supplying sectors. By contrast, the unconstrained SLQ exceeds unity for only 11 of the 30 supplying sectors, so there are 19 sectors where an allowance is made for imports from other regions.
8. A demerit of the MPE, in the context of coefficients, is that it is inflated in cases where r_{ij} is close to zero. Hence results for this measure are not displayed in Tables 2 and 3.

9. See Miller and Blair (2009, pp. 324–327) for a numerical example. The detailed results of Sawyer and Miller (1983) provide a very clear illustration of the point that errors in coefficients are likely to be far greater than those in multipliers.
10. For more discussion of the hybrid approach, see Jackson (1998) and Lahr (1993, 2001).

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TABLE 1. Sectoral shares of gross output at basic prices in 2003: province of Córdoba and Argentina

Sector	Description	Share for Córdoba	Share for Argentina	SLQ_i
1	Agriculture, cattle raising, hunting and forestry	0.184	0.078	2.364
2	Fishing and related services	0.000	0.003	0.007
3	Mining and quarrying	0.005	0.043	0.112
4	Production of food, beverages and tobacco products	0.184	0.122	1.509
5	Manufacture of textile products	0.003	0.013	0.221
6	Tanning, production of leather and leather goods	0.007	0.010	0.760
7	Production of wood and manufacture of wood products	0.003	0.007	0.464
8	Production of paper and paper products	0.006	0.013	0.498
9	Publishing and printing, reproduction of recordings	0.005	0.009	0.522
10	Oil refining	0.001	0.045	0.020
11	Manufacture of substances and chemical products	0.014	0.056	0.248
12	Manufacture of rubber and plastic products	0.014	0.016	0.836
13	Manufacture of non-metallic mineral products	0.010	0.007	1.536
14	Manufacture of common metals	0.008	0.025	0.327
15	Manufacture of metallic products, except for machinery and equipment	0.010	0.010	0.997
16	Manufacture of machinery and equipment, electrical apparatus, technical instruments, and equipment for radio, television and telecommunications	0.031	0.020	1.565
17	Manufacture of vehicles	0.042	0.018	2.321
18	Manufacture of office equipment	0.006	0.004	1.377
19	Electricity, gas and water	0.021	0.021	1.001
20	Construction	0.052	0.040	1.304
21	Wholesale and retail trade	0.078	0.085	0.915
22	Hotels and restaurants	0.021	0.025	0.869
23	Transport, storage and communication services	0.053	0.067	0.797
24	Post and telecommunications	0.022	0.022	0.988
25	Financial intermediation	0.016	0.031	0.527
26	Real estate, business and renting services	0.079	0.077	1.018
27	Public administration and defence	0.030	0.042	0.700
28	Education	0.030	0.025	1.221
29	Health	0.030	0.028	1.052
30	Community, social and personal services	0.036	0.040	0.909

Source: Authors' calculations using data from the Ministerio de Economía de Córdoba.

TABLE 2. Assessment of accuracy using different criteria: sectoral input coefficients for Córdoba in 2003 (n = 30)

Method	Criterion				
	STPE	WMAE × 10^2	$\tilde{U}^M \times 10^4$	$\tilde{U}^S \times 10^6$	U
SLQ	68.09	0.5699	0.1702	1.317	64.28
CILQ	82.50	0.4253	5.8755	100.771	105.10
FLQ (δ = 0.05)	72.70	0.4128	0.9594	35.586	92.23
FLQ (δ = 0.1)	72.16	0.4191	0.2559	28.919	91.78
FLQ (δ = 0.15)	72.08	0.4292	0.0011	23.513	91.65
FLQ (δ = 0.2)	72.54	0.4404	0.1707	19.349	91.79
Optimal δ	0.123	0.012	0.154	0.440	0.145

TABLE 3. Assessment of accuracy using different criteria: sectoral input coefficients for Córdoba in 2003 (n = 28)

Method	Criterion				
	STPE	WMAE × 10^2	$\tilde{U}^M \times 10^4$	$\tilde{U}^S \times 10^6$	U
SLQ	66.07	0.6104	0.8719	3.378	61.24
CILQ	70.13	0.4533	3.0144	36.640	76.65
FLQ (δ = 0.05)	59.63	0.4399	0.0616	0.896	55.26
FLQ (δ = 0.1)	59.06	0.4467	0.0622	0.029	54.46
FLQ (δ = 0.15)	58.97	0.4574	0.5552	0.288	54.21
FLQ (δ = 0.2)	59.47	0.4695	1.4755	1.320	54.47
Optimal δ	0.123	0.012	0.075	0.112	0.145

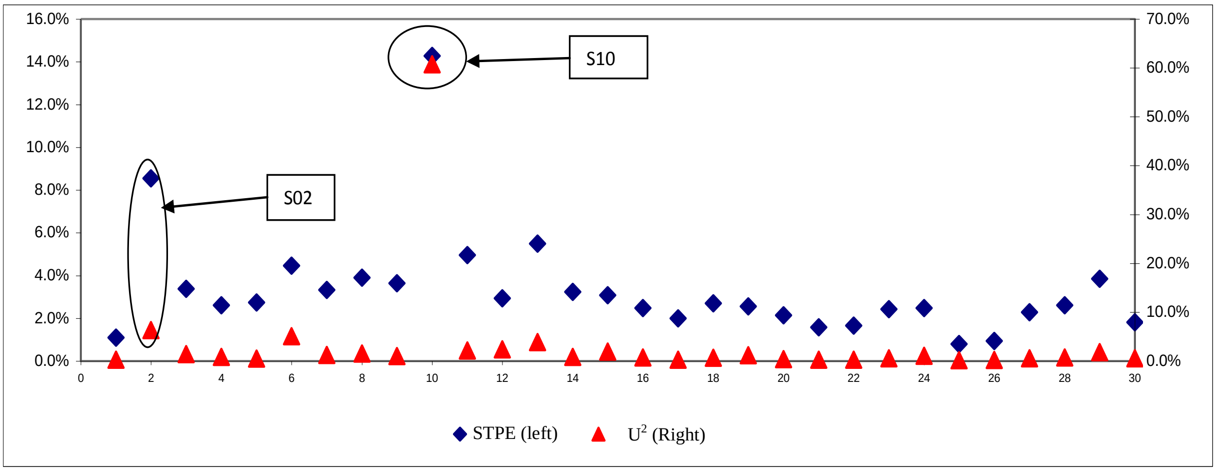
TABLE 4. Assessment of accuracy using different criteria: sectoral type I output multipliers for Córdoba in 2003 (n = 28)

Method	Criterion					
	MPE	STPE	WMAE	$\tilde{U}^M \times 10^3$	$\tilde{U}^S \times 10^3$	U
SLQ	3.800	7.706	0.0874	2.391	0.070	9.966
CILQ	6.760	9.757	0.1563	10.886	8.236	13.584
FLQ (δ = 0.05)	0.527	6.513	0.1049	0.163	3.996	8.959
FLQ (δ = 0.1)	–1.194	6.323	0.0907	0.244	1.569	8.041
FLQ (δ = 0.15)	–2.825	6.324	0.0787	1.816	0.303	8.072
FLQ (δ = 0.2)	–4.303	6.842	0.0795	4.503	0.004	8.860
Optimal δ	0.065	0.134	0.193	0.072	0.195	0.123

TABLE 5. Assessment of accuracy using different criteria: sectoral type I output multipliers for Córdoba in 2003 incorporating Round's fabrication adjustment (n = 28)

Method	Criterion					
	MPE	STPE	WMAE	$\tilde{U}^M \times 10^3$	$\tilde{U}^S \times 10^3$	U
SLQ	–5.868	9.559	0.2372	11.394	10.833	12.194
CILQ	–5.480	8.308	0.1840	9.013	4.169	10.448
FLQ (δ = 0.05)	–8.179	10.355	0.2093	18.231	5.568	12.632
FLQ (δ = 0.1)	–9.177	11.454	0.2271	23.023	8.185	13.834
FLQ (δ = 0.15)	–10.144	12.550	0.2454	28.202	11.152	15.101
FLQ (δ = 0.2)	–11.036	13.563	0.2630	33.443	14.219	16.339
Optimal δ	0.000	0.000	0.000	0.000	0.000	0.000

FIGURE 1. The effect of including the atypical sectors 2 and 10 in the analysis



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