**Evaluating the FLQ and AFLQ Formulae for Estimating Regional Input Coefficients: Empirical Evidence for 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 and AFLQ formulae for estimating regional input coefficients. Particular attention is paid to the problem of choosing a value for the unknown parameter δ in these formulae. Two alternative approaches suggested in the literature are evaluated. A statistical test is also performed of differences between the regional and national use of intermediate inputs, and Round’s ‘fabrication’ formula is applied in an effort to make suitable adjustments for such differences. However, the FLQ and AFLQ, without any fabrication adjustments, are found to give the best overall results of the non-survey methods considered in the paper. These two formulae produce very similar results, which is in line with the findings of previous studies.

*Keywords:* Regional input−output tables; Argentina; Location quotients; FLQ; AFLQ; Fabrication effects

1 **INTRODUCTION**

Regional input−output tables are an invaluable aid to regional planning, yet building a survey-based regional table can be complex, expensive and time consuming. 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 largely 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 doing so, we restrict our attention to methods based on location quotients (LQs).**1**

 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 understate regional trade. This understatement is largely due to the fact that these conventional LQs either rule out (as with the SLQ) or greatly underestimate (as with the CILQ) the extent of *cross-hauling* (the simultaneous importing and exporting of a given commodity).**2**

 In an effort to capture the full extent of regional imports from other regions, 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 variant, the AFLQ formula, which takes regional specialization into account, was proposed by Flegg and Webber (2000).

 The FLQ’s focus is on the output and employment generated within a particular region. It should only be applied to national input−output tables where the inter-industry transactions 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 transactions table (Kronenberg, 2009, 2012).

 A sizable body of empirical evidence now demonstrates that the FLQ can produce more accurate 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, 2014) and Germany (Kowalewski, 2015). 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. The study by Lindberg et al. (2012) is an interesting recent application of the FLQ approach.

 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 as 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 outlines how the survey-based input−output table for Córdoba was reconciled with that for Argentina. The data are then used to compare and contrast the regional and national economic structures. Section 3 considers why inconsistencies between the regional and national tables might arise, along with the possible implications. Section 4 then examines how alternative estimates of regional input coefficients were derived by adjusting the national coefficients. In the subsequent two sections, we present our analysis of sectoral input coefficients and output multipliers. Section 7 considers how well the competing methods are able to estimate Córdoba’s imports from other Argentinian regions. This section is followed by an exploration of alternative ways of determining a value for the unknown parameter δ in the FLQ and AFLQ formulae. In the penultimate section, the deviations between national and regional use of intermediate inputs are explored. Here we attempt to correct for such disparities 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.**3** 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, measured in terms of shares of output, 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). Extensive surveys of key sectors and big companies were used to determine sources of inputs and to measure gross output. The sampling frame was based on the 1994 census. Weights derived from that census were applied to scale the survey data to encompass those companies and industries not covered in the surveys.**4**

 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 forsupply 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, survey data on imports of goods and services from the rest of the country and from the rest of the world were added. The questionnaires specifically asked firms about the regional origin of their inputs and the destination of their sales. 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.**5** To circumvent this problem, the transactions for Córdoba were aggregated to correspond with the national sectoral classification. 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 is reviewed in Section 3.

**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:**6**

 *SLQi* (1)

where  is regional output in sector *i* and  is the corresponding national figure.  and  are the respective regional and national totals.

 Table 1 reveals that Córdoba has a high degree of specialization in sectors 1 and 17. Other sectors exhibiting significant specialization include 4, 13 and 16. It is also worth noting that the key sectors 1, 4 and 17 account for 41% of Córdoba’s output. On the other hand, relatively low values of *SLQi* occur in sectors such as 11 and 25. These differences are important since the SLQ approach to regionalization presupposes 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. Conversely, the region is more likely to be self-sufficient in those sectors in which it is specialized. For example, following the SLQ approach, we might expect the propensity to import from other regions to be relatively high in sector 8 but relatively low in sector 17.

 Table 1 also shows that sectors 2 and 10 play a minuscule role in Córdoba’s economy, so we decided to amalgamate sector 2 with 1 and 10 with 3.**7** This decision to base the statistical analysis on twenty-eight rather than thirty sectors has the merit of simplifying the discussion, while ensuring that these two sectors do not have an undue impact on the results.

**3 SOME CAVEATS**

Before considering any results, we should note some reasons why inconsistencies between the regional and national input−output tables might arise. One concern is that these tables refer to different years and that technological and structural changes in the period 1997−2003 might have altered the national input coefficients significantly. Whilst it is true that there was much macroeconomic instability in Argentina during this period, there is scant 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.**8**

Another possible concern is that the regional table made more use of non-survey data. However, it was built entirely using national accounting methods and indirect methods were not employed to estimate regional transactions. Moreover, identical sectoral definitions were used in constructing the regional and national tables, based on the ISIC (revision 3). Even so, any differences between Argentina and Córdoba in terms of the mix of commodities in each sector or in the technology employed would still cause problems.

A final caveat concerns possible aggregation bias. Typically, the analyst faces a situation where the national table has many more sectors than the regional table. For example, Flegg and Tohmo (2014) had to aggregate transactions for fifty-eight Finnish national sectors in order to create a table consistent with the data available for twenty-six regional sectors. In such cases, Sawyer and Miller (1983), Lahr and Stevens (2002) and other authors emphasize that, in order to minimize aggregation bias, regionalization of a national table via the use of LQs should precede aggregation.**9** It is also recommended that regional weights should be used when aggregating.

 However, our study is unusual as it was the regional rather than the national table that had to be aggregated. Hence the debate about whether regionalization should precede aggregation or vice versa is irrelevant. Furthermore, since the aggregation was performed on disaggregated regional transactions, the aggregated regional sectors should reflect the regional economic structure.

 Nevertheless, the loss of information entailed by aggregation must be acknowledged; clearly, it would have been preferable if we had been able to start with a disaggregated national table containing 124 sectors. Aggregation bias arises because the detailed sectors comprising each aggregated regional sector are apt to differ in terms of their input requirements and propensity to import from other regions. However, this bias should be less acute in a diversified regional economy such as Córdoba’s (see Table 1).**10**

**4 REGIONALIZATION**

At the outset, the 28 × 28 national and regional transactions matrices were transformed into matrices of input coefficients. The national coefficient matrix was then ‘regionalized’ via the following formula:

 *rij* = *βij* × *aij* (2)

where *rij* is the regional input coefficient, *βij* is an adjustment coefficient and *aij* is the national input coefficient. *rij* 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. *aij* likewise excludes any supplies of *i* obtained from abroad. The role of *βij* is to take account of a region’s purchases of input *i* from other regions.

If we replace *βij* in equation (2) with an LQ, we can obtain estimates of the *rij*. Thus, for instance:

 = *SLQi* × *aij* (3)

Another possibility is to replace *βij* with CILQ*ij*, which is defined as follows:

 *CILQij* (4)

where the subscripts *i* and *j* refer to the supplying and purchasing sectors, respectively. No adjustment is made to the national coefficient where *CILQij* ≥ 1 and likewise for *SLQi*. The CILQ has the merit that a different scaling can be applied to different cells in a given row of the national coefficient matrix. Unlike the SLQ, the CILQ does not presuppose that a purchasing sector is either an exporter or an importer of a given commodity but never both.

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

 *FLQij ≡ CILQij × λ\** for *i* ≠ *j* (5)

 *FLQij ≡ SLQi × λ\** for *i* = *j* (6)

where:

 *λ\* ≡* [log2(1 +)]δ (7)

It is assumed that 0 ≤ *δ* < 1; as *δ* increases, so too does the allowance for interregional imports. *δ* = 0 represents a special case where *FLQij* = *CILQij*. 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.

 In our empirical analysis, we also consider the *augmented* FLQ (AFLQ) formula formulated by Flegg and Webber (2000), which aims to capture the impact of regional specialization on the size of regional input coefficients. This effect is measured via *SLQj*. The AFLQ is one of the formulae examined in a Monte Carlo study by Bonfiglio and Chelli (2008), who found that it gave marginally better results on average than the FLQ.**11** It is defined as follows:

 *AFLQij ≡ FLQij ×* log2(1 + *SLQj*) (8)

However, the specialization term, log2(1 + *SLQj*), is only applicable where *SLQj* > 1. The AFLQ has the novel property that it can encompass situations where *rij* > *aij* in equation (2). Like the FLQ, it is constrained to unity.

**5 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, 2014), the following statistics will be employed in this assessment:

 STPE = 100Σ*ij*||/Σ*ij**rij* (9)

 WMAE = (1/*n*)Σ*j**wj*Σ*i* || (10)

 ŨS =  (11)

 ŨM =  (12)

 U = 100 (13)

where  is the estimated regional input coefficient, *rij* is the corresponding benchmark value (derived from the survey-based coefficient matrix for Córdoba in 2003) and *n* = 28 is the number of sectors. STPE and WMAE denote the standardized total percentage error and the weighted mean absolute error, respectively. *wj* is the proportion of total regional output produced in sector *j*. ŨM and ŨS, 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 is able to (i) avoid bias and (ii) replicate the dispersion of the benchmark distribution of coefficients.**12** Finally, U is Theil’s well-known index of inequality, which has the merit that it encompasses both bias and variance (Theil et al., 1966, pp. 15−43).

**Table 2 near here**

 A selection of results is presented in Table 2, where the outcomes from the SLQ, CILQ and FLQ will be examined first. The table reveals that the FLQ outperforms the SLQ in terms of all criteria, which is in accord with the findings of Flegg and Tohmo (2013a, 2014) and Kowalewski (2015).**13** The CILQ is the least accurate of the three methods, although it does perform relatively well in terms of the WMAE. Flegg and Tohmo (2014) also found the CILQ to be the worst of the four methods they examined using Finnish data.

 Table 2 records a somewhat higher optimal *δ* for U than for the STPE. This divergence can be explained by the different properties built into each formula: by squaring the term rather than taking an absolute value, U puts more emphasis on avoiding large errors. To achieve this, a larger *δ* is needed, namely 0.139 rather than 0.118. Another noteworthy finding is that ŨM is minimized when *δ* = 0.087, whereas U (which takes both bias and dispersion into account) requires *δ* = 0.139. Thus a strategy of minimizing bias would necessitate using a relatively low value of *δ*.

 The optimal *δ* for the WMAE is close to zero but this outcome is largely due to the impact on the WMAE of sector 4. This sector accounts for 18.4% of Córdoba’s output, which has a large effect on the WMAE.

 Comparing the performance of the FLQ and AFLQ is complicated by the fact that the AFLQ exhibits a higher optimal *δ* across all criteria. This is no coincidence, as it reflects the different properties of the two formulae.**14** Looking at the results as a whole, it seems reasonable to select *δ* = 0.1 as a typical value for the FLQ and *δ* = 0.15 for the AFLQ. On this basis, one can see that the STPE, WMAE and U judge the AFLQ to be slightly more accurate than the FLQ and that ŨM and ŨS give conflicting outcomes.

**6 OUTPUT MULTIPLIERS**

Following previous research (Flegg and Tohmo, 2013a, 2014), the following statistics will be employed to assess the accuracy of the estimated multipliers:

 MPE = (100/28)Σ*j*/*kj* (14)

 STPE = 100Σ*j*||/Σ*j**kj* (15)

 WMAE = Σ*j**wj*|| (16)

 ŨM =  (17)

 ŨS =  (18)

 U = 100 (19)

where is the estimated type I output multiplier for regional sector *j* (column sum of the LQ-based Leontief inverse matrix), whereas *kj* 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.**15** It has also been used in many previous studies. A selection of results is presented in Table 3. As before, the outcomes for the SLQ, CILQ and FLQ will be examined first.

**Table 3 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.**16** 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* = 0.081 would eliminate any bias in the estimated multipliers, whereas the SLQ and CILQ would overstate the average multiplier by 4.0% and 9.2%, 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. Indeed, the results for ŨM and ŨS show that the FLQ is far more successful than the CILQ in minimizing both bias and dispersion. Relative to the SLQ, the FLQ’s superiority is overwhelming as regards dispersion but is less pronounced in terms of bias.

 The results for ŨM and ŨS in Table 3 display an interesting pattern: as the value of *δ* rises above 0.05, the FLQ exhibits more bias but a closer correspondence between the standard deviations of  and  *δ* = 0.073 is optimal for ŨM, whereas ŨS requires *δ* = 0.321. U strikes a compromise between these two extremes, indicating a value of 0.104. This value is, however, noticeably higher than the *δ* = 0.042 shown by the STPE.

 In the case of ŨM, the findings for coefficients and multipliers are fairly similar in terms of the optimal *δ*. There is, however, a sharp contrast between the outcomes for the WMAE in Tables 2 and 3: whereas *δ* = 0.008 minimizes the WMAE for coefficients, *δ* = 0.088 is required for multipliers. As before, sector 4 can explain some of this difference in outcomes. Another noticeable contrast between the two tables is that the optimal *δ* for the STPE is 0.118 for coefficients, yet only 0.042 for multipliers.

 Turning now to an assessment of the relative performance of the FLQ and AFLQ, it again seems appropriate to select 0.1 and 0.15 as the respective typical values of *δ* for the FLQ and AFLQ. On this basis, one can see that the STPE and U judge the AFLQ to be a little more accurate than the FLQ, whereas the WMAE suggests the opposite. ŨM and ŨS again give conflicting outcomes.

7 **ESTIMATING IMPORTS**

A key objective of any LQ-based formula is to estimate a region’s imports from other regions and the following statistics will be employed to assess the accuracy of these estimates:

 MAE = (1/28)Σ*j*|| (20)

 WMAE = Σ*j**wj*|| (21)

 TPE = 100 (22)

where is the estimated propensity to import from other regions for sector *j* in Córdoba (expressed as a proportion of the gross output of that sector), whereas *mj* is the corresponding benchmark value. MAE and WMAE are the unweighted and weighted mean absolute errors. TPE (total percentage error) measures the error in estimating *M*, the sum of Córdoba’s imports from other regions. A selection of results is presented in Table 4.

**Table 4 near here**

 The results for imports are very similar to those for coefficients (Table 2) and multipliers (Table 3) and confirm the previous conclusions. As before, the FLQ and AFLQ clearly outperform the SLQ and CILQ. Here it is striking that the SLQ overestimates the sum of Córdoba’s imports from other regions by 291.8%, while the CILQ overestimates this sum by 22.3%. By contrast, the FLQ (with *δ* = 0.1) understates total imports by 9.6%, while the AFLQ (with *δ* = 0.15) does so by 4.75%. The outcomes for the MAE and WMAE are also noticeably better for the FLQ and AFLQ than for the SLQ and CILQ. Looking at the results as a whole, it is evident that the AFLQ’s performance is a little better than that of the FLQ.

**8 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 for the FLQ. The first method was put forward by Bonfiglio (2009), who derived the following regression equation using simulated data from a Monte Carlo study:

 = 0.994*PROP* − 2.819*RSRP* (23)

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). The principal advantage of a Monte Carlo approach is that the findings should be generally applicable. By contrast, the results derived from a single region may reflect the peculiarities of that region and thus not be valid in general. On the other hand, the simplifying assumptions underlying a Monte Carlo simulation mean that it cannot replicate the detailed economic structure and sectoral interrelationships of regional economies.**17**

 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 (2015, table 1), were used to derive the following estimate of *δ* for the state of Baden-Wuerttemberg in 1993:

 = 0.994 × 0.205 − 2.819 × 0.134 = −0.174 (24)

Here the state’s share of total German employment (*ibid.*, p. 244) 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:

 = 0.994 × 0.3016 − 2.819 × 0.2925 = −0.525 (25)

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  as required.

 These examples serve to highlight a problem with Bonfiglio’s approach: the theoretical constraint *δ* ≥ 0 is not imposed on equation (23), so it can yield for regions that are relatively large or exhibit below-average propensities to import from other regions or have both characteristics. Cases in point are Uusimaa and Baden-Wuerttemberg. Of course, one could circumvent this problem of negative values by arbitrarily setting *δ* = 0 but that solution would lack any theoretical basis. Furthermore, for Uusimaa in 1995, setting *δ* = 0 yields an MPE for the type I output multipliers of 15.0%, whereas using *δ* = 0.383 yields MPE ≈ 0.**18**

 A practical obstacle to the use of Bonfiglio’s formula is that data for *PROP* and *RSRP* would not usually be available to analysts, so proxies or assumed values would need to be used. However, this is not really a problem as to *RSRP* since regional size (measured in terms of employment or output) should be a suitable proxy.**19** A more serious issue in any application is apt to be a lack of data for *PROP*.

 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*δ* = −1.8379 + 0.33195ln*R* + 1.5834ln*P* − 2.8812ln*I* + e (26)

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. Observations on ln*δ* were derived by finding the value of *δ* that minimized the MPE for each Finnish region.

 Equation (26) has the merit that *δ* → 0 as *R* → 0. Moreover, unlike equation (23), it takes explicit account of any differences between the regional and national ratios of intermediate use. It can, in fact, be rewritten in the following alternative forms, which may be more convenient in some cases (Flegg and Tohmo, 2014):

 ln*δ* = 0.8169 + 0.33195ln*R* + 1.5834ln*p* − 2.8812ln*I* + *e* (27)

 ln*δ* = −1.8296 + 0.33195ln*R* + 1.5834ln*p* − 2.8812ln*i* + *e* (28)

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 (27), along with data from Kowalewski (2015, table 1 and p. 249), the following estimate of *δ* was derived for Baden-Wuerttemberg in 1993:

= exp(0.8169 + 0.33195ln14.38 + 1.5834ln0.1019 − 2.8812ln0.9925) = 0.151

 By contrast, Kowalewski (2015, table 3) found an optimal value of *δ* = 0.17 when using the MPE to evaluate the estimated multipliers.

 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 (28):

 = exp(−1.8296 + 0.33195ln8.27 + 1.5834ln0.115 − 2.8812ln0.422) = 0.127

Table 3 shows that this figure exceeds the optimal value of *δ* = 0.081 for the MPE, so caution must be exercised when using this approach to derive an initial value of *δ*.

 Two important issues still need to be explored regarding Flegg and Tohmo’s approach. The first issue concerns the theoretical foundations of their regression model, while the second pertains to its practical application. As to the first issue, the purpose of the model was to offer a way of refining the choice of a value for *δ*. The variable *P* was included to allow for cases where regions had either above-average or below-average propensities to import from other regions, whereas *I* was included to encompass situations where a region’s use of intermediate inputs was either above or below average. ln*P* and ln*I* should have positive and negative estimated coefficients, respectively, as they do in equation (26).

 The role of *R* is less straightforward, owing to the fact that regional size is an integral part of the FLQ formula, whereby there is a monotonically increasing non-linear relationship between the scalar *λ\** and regional size, as shown in equation (7). *R* was included in the regression to refine this in-built relationship and to reflect the authors’ observation that the optimal value of *δ* tended to rise along with regional size in a sample of twenty Finnish regions (Flegg and Tohmo, 2013a, table 3). Although more research clearly needs to be undertaken to establish whether this same pattern would occur elsewhere, the evidence discussed above for Baden-Wuerttemberg and Córdoba is consistent with the existence of a positive elasticity of *δ* with respect to *R*.**20**

 As regards the application of Flegg and Tohmo’s approach, the way equation (26) is formulated should make it easier for analysts to derive an estimate of *δ*. In particular, instead of having to come up with a figure for a region’s propensity to import from other regions, the analyst would only need to make an informed assumption about how far this propensity diverged from the average for all regions in that country, which should be an easier task. In the same way, an adjustment could be made to allow for any assumed divergence between the regional and national ratios of intermediate use. Furthermore, it would be straightforward (and indeed desirable) to use equation (26) to perform a sensitivity analysis. If the analyst wished to use the AFLQ rather than the FLQ, then a slightly higher value of *δ* would need to be chosen at the outset.

 It is evident that both approaches reviewed here have merits and demerits, which should be borne in mind when deciding which one to pursue. One should also be aware that, with Bonfiglio’s method, the estimated *δ* declines with regional size, whereas Flegg and Tohmo’s method exhibits a positive relationship between *δ* and regional size.

**9 USE OF INTERMEDIATE INPUTS**

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:

 *Ijr = α + βIjn + εjr* (29)

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

  (30)

Standard errors: 0.0508  0.1188  *R2* = 0.595.

 This regression gives some grounds for rejecting the null hypotheses *α* = 0 and *β* = 1; in particular,  is significantly greater than zero and  is significantly less than one, both at the 2.5% level. The regression crosses the 45° line at *Ijn* = 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:

  (31)

where *w* denotes value added, *x* denotes gross output, *r* and *n* refer to the region and the nation, respectively,  is the national technical coefficient and  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 3 and 5 reveals a surprising outcome: when evaluated in terms of the STPE, WMAE and U criteria, Round’s adjustment invariably yields less accurate results. For instance, for the SLQ, the STPE rises from 12.0% to 24.1%, the WMAE from 0.190 to 0.460, and U from 14.1% to 35.4%.**21** Likewise, the results for the FLQ and AFLQ are much less accurate. The decline in the CILQ’s performance is not so dramatic, yet it is still true that Round’s adjustment makes matters worse.

 If we focus simply on bias, the MPE and ŨM statistics show that Round’s adjustment greatly improves the outcome for the CILQ, as it eliminates most of the previous bias. However, the figures for ŨM and ŨS reveal that this welcome improvement in terms of bias comes at the expense of a big rise in dispersion. For the SLQ, the use of Round’s adjustment has modest effects on bias but substantially increases dispersion.

 It is evident that Round’s adjustment does not produce sensible results for the FLQ and AFLQ: regardless of the value of *δ*, the MPE shows that the multipliers are understated. Moreover, this bias is substantial in most cases. Also, as noted above, the use of this adjustment greatly increases the values of the STPE, WMAE and U.

 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 or AFLQ makes adequate adjustments for both interregional trade and differences in intermediation. 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 any of the LQ-based methods.

**10 CONCLUSION**

This paper has used detailed survey-based data for the Argentinian province of Córdoba to assess the relative performance of the FLQ and AFLQ formulae for estimating regional input coefficients. The empirical work employed a range of statistical criteria with contrasting properties, and examined performance in terms of each method’s ability to estimate input coefficients, as well as sectoral output multipliers and regional imports.

 In line with the findings of earlier studies, the FLQ substantially outperformed the SLQ and CILQ. Even so, the AFLQ gave slightly more accurate results than the FLQ, so it might be preferred on that basis, along with the fact that it takes regional specialization into account and can encompass situations where regional input coefficients are larger than the corresponding national coefficients.

 The FLQ and AFLQ formulae contain 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. However, it should be noted that the AFLQ requires a slightly higher value of *δ* than the FLQ.

 A lack of data made it impossible to explore directly any divergence between regional and national technology, although we did identify significant differences in the use of intermediate inputs. However, Round’s ‘fabrication’ formula was found to be unhelpful in making suitable adjustments for these deviations. Indeed, the FLQ and AFLQ formulae, without any fabrication adjustments, gave the best overall results of the methods considered here. Consequently, we cannot recommend the use of Round’s approach. Instead, we would suggest that any adjustments for disparities in the regional and national use of intermediate inputs should be made by adjusting the value of *δ*.

 It is worth emphasizing that, as with other pure non-survey methods, the FLQ and AFLQ 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, in the authors’ opinion, the FLQ and AFLQ are both very well suited to building the non-survey foundations of a hybrid model.**22**

***Notes***

1. In particular, we do not explore the commodity-balance approach since it tends to give outcomes similar to those from the simple LQ. RAS is not examined because the detailed regional data it requires are not normally available to analysts.

2. See Flegg and Tohmo (2013a, 2014).

3. Source: Instituto Nacional de Estadísticas y Censos and Ministerio de Economía de la Nación Argentina.

4. 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>.

5. Source: Instituto Nacional de Estadísticas y Censos and Ministerio de Economía de la Nación Argentina. Tablas Insumo-Producto para Argentina 1997.

6. 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.

7. The unrounded shares of output for sectors 2 and 10 are 0.0000235 and 0.0009098, respectively.

8. GDP was measured in constant prices of 1993. Source: INDEC.

9. However, owing to a lack of disaggregated regional data, it is often impossible to compute the LQs needed to regionalize prior to aggregation. This was the situation faced by Flegg and Tohmo (2014).

10. For an excellent treatment of the factors causing aggregation bias, see Lahr and Stevens (2002).

11. The minimum mean relative absolute distance was 19.1% for the FLQ (with *δ* = 0.3) but 18.3% for the AFLQ (with *δ* = 0.4). See Bonfiglio and Chelli (2008, table 1).

12.  where  is the sample correlation coefficient between and *rij*. Cf. Theil et al., 1966, pp. 29−30.

13. When sectors 2 and 10 were included as separate sectors, big changes occurred in the outcomes for all statistical criteria except for the WMAE, leading to changes in the ranking of methods. The WMAE still ranked the FLQ as superior to the SLQ, whereas the STPE and U, which do not take the relative size of sectors into account, gave the opposite ranking. To obtain more robust results, we thought it best to exclude these atypical sectors. For multipliers, the same ranking of methods occurred regardless of whether these two sectors were included or not.

14. For a given *SLQj* > 1, *SLQi*, *δ* and regional size, *AFLQij* > *FLQij*. Therefore, a larger *δ* is required to achieve the same adjustment for regional imports as before.

15. A demerit of the MPE, in the context of coefficients, is that it is inflated in cases where *rij* is close to zero. Hence results for this measure are not displayed in Table 2.

16. 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.

17. For instance, Bonfiglio and Chelli (2008, p. 248) generated their regional input and import coefficients randomly in the interval 0 to 1, yet that range does not represent a realistic representation of a real regional table, where input coefficients tend to be small, except for those along the principal diagonal.

18. See Flegg and Tohmo (2013a, table 4). The FLQ with *δ* = 0 is equivalent to the CILQ with the SLQ along the principal diagonal of the adjustment matrix.

19. For example, Bonfiglio (2009, table 5) shows that the Marche region accounted for 2.7% of total Italian employment and 2.6% of intermediate costs in 1974.

20. Furthermore, in an analysis (as yet unpublished) of survey-based data for six Korean regions, we found that the regression generated sensible results, again consistent with a positive relationship.

21. Sawyer and Miller (1983, p. 1509) report that ‘adjustment of SLQ coefficients to reflect the regional ‘fabrication effect’ provides substantially improved estimates of the survey-based coefficients’. However, unlike the procedure adopted here, their adjustments were applied after regionalization (*ibid.,* p. 1507).

22. 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 | *SLQi* |
|
|
| 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 | Primary oil, gas and coal; 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 | Other industries | 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.

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TABLE 2. Assessment of accuracy using different criteria: sectoral input coefficients for Córdobain 2003 (*n* = 28)

|  |  |
| --- | --- |
| Method | Criterion |
| STPE | WMAE × 102 | ŨM × 104 | ŨS × 106 | U |
| SLQ | 65.618 | 0.602 | 1.161 | 4.299 | 60.648 |
| CILQ | 73.049 | 0.452 | 5.039 | 67.277 | 85.995 |
| FLQ (δ = 0) | 60.101 | 0.431 | 0.727 | 3.505 | 56.561 |
| FLQ (δ = 0.05) | 59.721 | 0.434 | 0.142 | 1.297 | 55.560 |
| FLQ (δ = 0.1) | 59.353 | 0.441 | 0.019 | 0.141 | 54.886 |
| FLQ (δ = 0.15) | 59.445 | 0.451 | 0.431 | 0.103 | 54.736 |
| FLQ (δ = 0.2) | 60.207 | 0.469 | 1.342 | 1.127 | 55.131 |
| AFLQ (δ = 0) | 61.093 | 0.459 | 1.744 | 4.409 | 56.962 |
| AFLQ (δ = 0.05) | 59.897 | 0.446 | 0.655 | 1.738 | 55.668 |
| AFLQ (δ = 0.1) | 58.875 | 0.439 | 0.070 | 0.289 | 54.780 |
| AFLQ (δ = 0.15) | 58.463 | 0.439 | 0.073 | 0.023 | 54.474 |
| AFLQ (δ = 0.2) | 58.733 | 0.446 | 0.632 | 0.605 | 54.642 |
| Optimal δ FLQ | 0.118 | 0.008 | 0.087 | 0.126 | 0.139 |
| Optimal δ AFLQ | 0.149 | 0.120 | 0.125 | 0.138 | 0.151 |

TABLE 3. Assessment of accuracy using different criteria: sectoral type I output multipliers for Córdobain 2003 (*n* = 28)

|  |  |
| --- | --- |
| Method | Criterion |
| MPE | STPE | WMAE | ŨM × 103 | ŨS × 103 | U |
| SLQ | 3.963 | 12.020 | 0.190 | 3.143 | 13.222 | 14.085 |
| CILQ | 9.182 | 13.089 | 0.084 | 14.680 | 11.489 | 18.635 |
| FLQ (δ = 0) | 3.145 | 8.527 | 0.072 | 1.553 | 2.343 | 11.646 |
| FLQ (δ = 0.05) | 1.236 | 8.349 | 0.068 | 0.165 | 1.827 | 11.105 |
| FLQ (δ = 0.1) | −0.735 | 8.502 | 0.067 | 0.209 | 1.413 | 10.885 |
| FLQ (δ = 0.15) | −2.625 | 8.883 | 0.077 | 1.650 | 1.105 | 11.026 |
| FLQ (δ = 0.2) | −4.385 | 9.600 | 0.094 | 4.237 | 0.779 | 11.461 |
| AFLQ (δ = 0) | 4.922 | 8.658 | 0.101 | 4.226 | 2.805 | 11.770 |
| AFLQ (δ = 0.05) | 2.850 | 8.135 | 0.090 | 1.303 | 2.199 | 10.920 |
| AFLQ (δ = 0.1) | 0.729 | 8.126 | 0.085 | 0.044 | 1.716 | 10.418 |
| AFLQ (δ = 0.15) | −1.278 | 8.388 | 0.084 | 0.451 | 1.343 | 10.333 |
| AFLQ (δ = 0.2) | −3.150 | 8.850 | 0.086 | 2.230 | 1.048 | 10.652 |
| Optimal δ FLQ | 0.081 | 0.042 | 0.088 | 0.073 | 0.321 | 0.104 |
| Optimal δ AFLQ | 0.118 | 0.095 | 0.136 | 0.112 | 0.368 | 0.137 |

TABLE 4. Assessment of accuracy using different criteria: Córdoba’s imports from other regions in 2003 (*n* = 28)

|  |  |
| --- | --- |
| Method | Criterion |
| TPE | MAD | WMAD |
| SLQ | 291.82 | 0.1207 | 0.1051 |
| CILQ | 22.30 | 0.0904 | 0.0549 |
| FLQ (δ = 0) | 12.98 | 0.0601 | 0.0487 |
| FLQ (δ = 0.05) | 1.07 | 0.0578 | 0.0482 |
| FLQ (δ = 0.1) | −9.59 | 0.0571 | 0.0491 |
| FLQ (δ = 0.15) | −18.29 | 0.0579 | 0.0518 |
| FLQ (δ = 0.2) | −26.00 | 0.0623 | 0.0574 |
| AFLQ (δ = 0) | 47.66 | 0.0552 | 0.0432 |
| AFLQ (δ = 0.05) | 25.95 | 0.0518 | 0.0420 |
| AFLQ (δ = 0.1) | 8.41 | 0.0496 | 0.0425 |
| AFLQ (δ = 0.15) | −4.75 | 0.0499 | 0.0449 |
| AFLQ (δ = 0.2) | −15.17 | 0.0543 | 0.0491 |
| Optimal δ FLQ |  |  |  |
| Optimal δ AFLQ |  |  |  |

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

|  |  |
| --- | --- |
| Method | Criterion |
| MPE | STPE | WMAE | ŨM × 103 | ŨS × 103 | U |
| SLQ | 2.374 | 24.066 | 0.460 | 3.528 | 215.258 | 35.430 |
| CILQ | −0.791 | 15.806 | 0.344 | 0.050 | 87.244 | 22.801 |
| FLQ (δ = 0) | −3.071 | 17.136 | 0.347 | 0.589 | 89.593 | 23.190 |
| FLQ (δ = 0.05) | −4.558 | 16.714 | 0.334 | 2.132 | 77.758 | 21.978 |
| FLQ (δ = 0.1) | −6.056 | 16.324 | 0.322 | 4.649 | 66.545 | 20.859 |
| FLQ (δ = 0.15) | −7.497 | 16.152 | 0.311 | 7.976 | 56.422 | 19.899 |
| FLQ (δ = 0.2) | −8.906 | 16.213 | 0.296 | 12.155 | 45.832 | 18.963 |
| AFLQ (δ = 0) | −0.958 | 17.871 | 0.376 | 0.055 | 115.859 | 26.011 |
| AFLQ (δ = 0.05) | −2.635 | 17.292 | 0.359 | 0.301 | 99.935 | 24.365 |
| AFLQ (δ = 0.1) | −4.249 | 16.933 | 0.346 | 1.691 | 86.395 | 23.010 |
| AFLQ (δ = 0.15) | −5.737 | 16.722 | 0.335 | 3.969 | 74.923 | 21.919 |
| AFLQ (δ = 0.2) | −7.246 | 16.578 | 0.322 | 7.274 | 62.468 | 20.716 |
| Optimal δ FLQ | 0.000 | 0.389 | 0.422 | 0.000 | 0.552 | 0.334 |
| Optimal δ AFLQ | 0.435 | 0.000 | 0.513 | 0.015 | 0.625 | 0.397 |