A Comment on Tobias Kronenberg's "Construction of regional input–output tables using nonsurvey methods: the role of cross-hauling"[1]

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This paper examines the effectiveness of a new non-survey regionalization method: Kronenberg's Cross-Hauling Adjusted Regionalization Method (CHARM). This aims to take into account the fact that regions typically both import and export most commodities. Data for Uusimaa, Finland's largest region, are employed to carry out a detailed empirical test of CHARM. This test gives very encouraging results. CHARM is suitable for studying environmental questions but it can only be applied in situations where foreign imports have been included in the national input-output table. Where the focus is on regional output and employment, location quotients (LQs) can be used for purposes of regionalization. On both theoretical and empirical grounds, the FLQ appears to be the most suitable LQ currently available. It should be applied to conventional national input-output tables, which exclude foreign imports. Both types of table are available at the national level for all European Union members, as well as for some other countries.

Keywords: *regional input-output tables; cross-hauling; location quotients; CHARM; FLQ*

Introduction

Regional scientists have tried for several decades to develop a satisfactory way of "regionalizing" national input–output tables, so that adequate regional tables can be produced at an acceptable cost, but the phenomenon of cross-hauling has bedevilled their efforts. *Cross-hauling* occurs when a sector simultaneously imports and exports the same commodity. This is a chronic problem in small regions that do not represent a functional economic area (Robison and Miller, 1988) but it is also problematic in larger regions (Kronenberg, 2009). It is apt to be more serious in densely populated and highly urbanized countries, especially those where commuting across regional boundaries is important (Boomsma and Oosterhaven, 1992, pp. 272–273). Kronenberg highlights the *heterogeneity* of products as the main cause of cross-hauling; he illustrates this point by referring to the fact that interregional trade in automobiles occurs in Germany, with BMWs being transported from Bavaria to Lower Saxony and Volkswagens being sent in the opposite direction, despite the fact that, in principle, each region could be self-sufficient in its own marque (Kronenberg, 2009, p. 49). Cross-hauling is important because it results in an underestimation of interregional trade and hence an overstatement of regional multipliers. Kronenberg proposes a new way of dealing with this problem, which he calls the Cross-Hauling Adjusted Regionalization Method (CHARM). Before examining his proposal, however, some pertinent issues need to be considered concerning the nature of published national input–output tables and the different ways in which they can be adapted to correspond to the structure of regional economies.

Format of input–output tables

Published input–output tables can take several alternative forms, ranging from type A to type E.[2] This nomenclature follows Kronenberg (2011) and the United Nations (1973). At the outset, let us examine the traditional *type B* table. An illustration is given by the survey-based tables for 1995 constructed by Statistics Finland (2000) for the whole country, as well as for each of its 20 regions. These tables are based on an identical set of 37 sectors, which is very convenient since it avoids awkward problems that arise when aggregation of national sectors is required.

Table 1 near here

Table 1 shows extracts from the tables for Finland and Etelä-Pohjanmaa (E-P), a region that generated 2.9% of Finnish output in 1995.[3] For simplicity, only five supplying sectors and one purchasing sector are shown. The table reveals that intermediate inputs sourced from within the E-P region accounted for 35.5% of the gross output of meat and fish, whereas other Finnish regions accounted for 51.4%. However, taken together, intermediate inputs emanating from within Finland accounted for 86.9% of the gross output of meat and fish in this region, which does not differ greatly from the figure of 83.7% for the national industry. It may be noted, finally, that the proportion of intermediate inputs obtained from abroad is very similar for the national and regional industries, as is the pattern of primary inputs.

The interpretation of the coefficients now needs to be considered. The regional input coefficients, the r_{ij}, measure the number of units of regional input *i* needed to produce one unit of gross output of regional industry *j*, e.g. $r_{1,6} = 0.2404$. These coefficients encompass intermediate inputs produced in the region under consideration but exclude inputs from other Finnish regions or from abroad. By contrast, the national input coefficients, the a_{ij}, measure the number of units of national input *i* needed to produce one unit of gross output of national industry *j*, e.g. $a_{6,6} = 0.2998$. These coefficients encompass intermediate inputs originating from within Finland but exclude inputs from other countries. It should be noted that the a_{ij} are sometimes erroneously referred to as national *technical* coefficients, a problem highlighted by Hewings and Jensen (1986).

Type A tables differ from type B tables in terms of the way in which imports are treated and this has important implications for the meaning of the input coefficients. In a type A national table, foreign imports are allocated *indirectly* to the commodities that use these imports as intermediate inputs. For example, foreign steel used by the automobile industry would be included as an intermediate input for this industry; it would thus appear in the relevant row for steel and column for automobiles in the interindustry matrix.

In a type A table, the input coefficients, the a_{ij}^*, measure the number of units of input *i* needed to produce one unit of gross output of national industry *j*. These coefficients encompass intermediate inputs originating not just from within Finland but also from other countries. The a_{ij}* are true national *technical* coefficients because they reflect the underlying technology and are not affected by the pattern of trade. It is not possible to derive estimates of the a_{ij}* from Table 1 because foreign imports are not disaggregated by sector.

In addition to tables of types A and B, members of the European Union (EU) also produce symmetric national tables that are a variant of type A; these are referred to here as *type E* tables (the E stands for Eurostat, the statistical office in the EU). This is the tabular format discussed in Kronenberg (2009). The German tables he discusses, which he refers to as ESA 95 tables, are compiled in accordance with the rules of the European System of Accounts (ESA). ESA 95 is the standard for all EU countries. However, since the ESA 95 rules also apply to the other types of table, the tables Kronenberg (2009) discusses will be referred to here as type E tables rather than as ESA 95 tables. Type E tables can easily be derived from those of type A; all that is required is to transpose the column vector of total imports by commodity to produce a row vector of total imports (from other regions and from abroad) by industry. Furthermore, by summing output and imports, one can estimate total supply by industry and hence compute *supply* multipliers. These should not be confused with the type I *output* multipliers that are associated with type B tables.

Location quotients

Location quotients (LQs) are a popular way of regionalizing national input–output tables, especially in the initial stages. For this purpose, the following alternative LQs are often used:

$$SLQ_i \equiv \frac{RE_i/TRE}{NE_i/TNE} \equiv \frac{RE_i}{NE_i} \times \frac{TNE}{TRE} \qquad (1)$$

$$CILQ_{ij} \equiv \frac{SLQ_i}{SLQ_j} \equiv \frac{RE_i/NE_i}{RE_j/NE_j} \qquad (2)$$

where SLQ_i is the *simple* LQ, $CILQ_{ij}$ is the *cross-industry* LQ, RE_i is regional employment (or output) in supplying sector *i* and NE_i is the corresponding national figure. RE_j and NE_j are defined analogously for purchasing sector *j*. TRE and TNE are the respective regional and national totals.

So long as no aggregation of national sectors is required, the following simple formula can be used to convert national into regional input coefficients:

$$r_{ij} = \beta_{ij} \times a_{ij} \tag{3}$$

where r_{ij} is the regional input coefficient, β_{ij} is an *adjustment coefficient* and a_{ij} is the national input coefficient, derived from a type B table. 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 3 with SLQ_i or $CILQ_{ij}$, we can obtain estimates of the r_{ij}. Thus, for instance:

$$\hat{r}_{ij} = SLQ_i \times a_{ij} \tag{4}$$

Note: no adjustment is made to the national coefficient where $SLQ_i \geq 1$ or $CILQ_{ij} \geq 1$. We now need to consider how these conventional LQs deal with cross-hauling. In fact, the SLQ rules out the possibility of cross-hauling *a priori*. It presupposes that a region will import from other regions, yet not export to them, if $SLQ_i < 1$ but do the opposite if $SLQ_i \geq 1$. The CILQ does not preclude cross-hauling, as some cells in a given row of the adjustment matrix can have $CILQ_{ij} < 1$, while others can have $CILQ_{ij} \geq 1$. Hence imports and exports of commodity *i* can occur simultaneously. The problem is that the CILQ does not make adequate allowance for cross-hauling, so that it still tends to underestimate imports from other regions and hence to overstate regional multipliers.

Flegg *et al.* (1995) attempted to overcome this underestimation of interregional trade via their FLQ formula. In its refined form (Flegg and Webber, 1997), the FLQ is defined as:

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

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

where:

$$\lambda^* = [\log_2(1 + TRE/TNE)]^{\delta} \tag{7}$$

$0 \leq \delta < 1$; 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.

By taking explicit account of the relative size of a region, the FLQ should help to address the problem of cross-hauling, which is more likely to be prevalent in smaller regions than in larger ones. Smaller regions are apt to be more open to interregional trade.

Use of Location Quotients

Kronenberg argues (p. 48) that "LQ methods should not be applied to ESA 95 tables". We presume that he is referring here to tables of types A and E; if so, we are in full agreement. Nevertheless, his rationale is worth examining. Kronenberg cites the use of an equation like 4, where SLQ_i is employed to scale the a_{ij} rather than the a_{ij}^*. The SLQ would not, therefore, capture any differences between regional and national trading patterns with respect to foreign imports. This criticism echoes one by Hewings and Jensen (1986), who are quoted by Kronenberg (p. 47) thus: "The only manner in which the logic of the CB and quotient techniques can be validated is to apply the techniques to the [national technical coefficients], and this would require further adjustment of the national input-output table" (p. 310). *Note:* CB denotes Commodity Balance, a concept to be discussed later.

Our understanding of Hewings and Jensen's argument is that, if LQs are used, they should be applied to national input coefficients that incorporate inputs from abroad, i.e. to the a_{ij}^* rather than to the a_{ij}. Indeed, in the well-known GRIT (Generation of Regional Input–Output Tables) procedure, Phase I involves adding foreign inputs to domestic inputs to produce an estimated national technical coefficients matrix. This phase is followed by a second one, in which LQs are employed to adjust for regional imports (West, 1990, pp. 107–108). Hewings and Jensen's argument appears to suggest, therefore, that LQ methods *should* be applied to tables with indirectly allocated imports (types A and E), whereas Kronenberg contends that they should not. Let us now explore this argument.

At the outset, some definitions are required. Let:

$$a_{ij} = t_{ij}^n \times a_{ij}^* \qquad (8)$$

Likewise, for a region,

$$r_{ij} = t_{ij}^r \times r_{ij}^* \qquad (9)$$

where t_{ij}^n and t_{ij}^r are the respective national and regional *trading* coefficients, $0 \leq t_{ij}^n, t_{ij}^r \leq 1$, while a_{ij}^* and r_{ij}^* are the corresponding *technical* coefficients. In particular, r_{ij}^* measures the number of units of input *i*, regardless of source, needed to produce one unit of regional gross output *j*. If we assume that $r_{ij}^* = a_{ij}^*$, then

$$r_{ij} = t_{ij}^r \times a_{ij}^* \qquad (10)$$

Furthermore,

$$r_{ij} = (t_{ij}^r / t_{ij}^n) \times a_{ij} \qquad (11)$$

Expressions 10 and 11 offer alternative routes to estimating the r_{ij}, so which one should the analyst pursue? In earlier times, the paucity of relevant data meant that using formula 10 would have involved the awkward task of reallocating intermediate imports to individual cells of the transactions matrix. Nowadays, however, in the case of the EU and some other countries (e.g. Australia, Japan and Mexico), the necessary data are readily available, so the regional analyst faces a genuine choice.

There is, in fact, a compelling reason why it is inadvisable to apply LQs to the national technical coefficients. To illustrate this point, consider the case of the manufacture of basic metals and fabricated metal products (sector 11 in the regional tables discussed later). A region that did not produce such items would have $SLQ_{11} = CILQ_{11,j} = 0$. Using formula 10, we would set all input coefficients in row 11 of the type A regional table equal to zero, which would be tantamount to saying that industries in that region made no use whatsoever of such inputs. Formula 11, on the other hand, would yield much more sensible results. As before, we would set all input coefficients in row 11 of the type B regional table equal to zero but the required imports would be included under foreign and domestic imports.

Furthermore, Flegg and Webber (1997, p. 801) argue that the a_{ij}* "reflect commodities produced by both domestic and foreign workers and they thus provide a questionable theoretical basis for the application of LQs derived from domestic employment". They go on to suggest (*ibid.*) that LQs should be regarded not as trading coefficients but instead as adjustment formulae that:

> attempt to capture differences in the regional and national ability to fulfil the needs of purchasing sectors. Such differences are likely to be reflected in the ratio RE_i / NE_i and hence in the SLQ and CILQ. This ratio is also likely to reflect differences in regional and national propensities to import foreign goods; $m_{ij}^r > m_{ij}^n$ would produce a lower RE_i / NE_i and vice versa. On this interpretation, greater import penetration – whether from abroad or from other regions – would be reflected in lower regional employment and hence in smaller LQs.

In view of the above arguments, we would say that Kronenberg is right to contend that LQ methods should *not* be applied to tables with indirectly allocated imports (types A and E).

We now need to consider exactly what is involved in using LQs to estimate the value of the ratio (t_{ij}^r / t_{ij}^n) in equation 11. First, let us decompose t_{ij}^r, which represents the proportion of regional output supplied by regional producers, as follows:

$$t_{ij}^r = (1 - rpia) - rpior \qquad (12)$$

where *rpia* and *rpior* are the regional propensities to import from abroad and from other regions, respectively. These propensities are assumed, for simplicity, to be invariant across sectors. Dividing through by t_{ij}^n yields the expression:

$$\frac{t_{ij}^r}{t_{ij}^n} = \left[\frac{1-rpia}{1-npia} - \frac{rpior}{1-npia}\right] \qquad (13)$$

So that, from equation 11, we obtain:

$$r_{ij} = \left[\frac{1-rpia}{1-npia} - \frac{rpior}{1-npia}\right] \times a_{ij} \qquad (14)$$

Furthermore, if we assume that *rpia* = *npia*, we get:

$$r_{ij} = \left[1 - \frac{rpior}{1-npia}\right] \times a_{ij} \qquad (15)$$

The bracketed terms in equations 14 and 15 measure the tendency for a region to source its inputs from within its borders and it is this tendency that LQs attempt to proxy. The FLQ should be well placed to accomplish this task, since it takes into account the relative size of the supplying and purchasing sectors, along with the relative size of the region.

To clarify the meaning of equation 14, we can make use of the data in Table 1. The values of the variables can be derived as follows:

Foreign import propensity for Finland: 0.0576/0.8941 = 0.0644, so $1 - npia = 0.9356$

Foreign import propensity for E-P: 0.0536/0.9222 = 0.0581, so $1 - rpia = 0.9419$

E-P's propensity to import from other regions: 0.5139/0.9222 = 0.5573

Hence $\left[\frac{0.9419}{0.9356} - \frac{0.5573}{0.9356}\right] = 1.0067 - 0.5957 = 0.411$, so that $\hat{r}_{ij} = 0.411 \times a_{ij}$.

The scalar 0.411 gives us a rough estimate of what is needed for a 'typical' supplying sector. If we assume that *rpia* = *npia*, formula 15 yields a scalar of 0.404, which shows that the divergence between the national and regional propensities to import from abroad has a negligible impact in this instance.

It is worth noting that the ratio (t_{ij}^r / t_{ij}^n) in equation 11 can exceed unity, which means that it can encompass cases where $r_{ij} > a_{ij}$. Such cases are catered for by the *augmented* FLQ (AFLQ), which includes a regional specialization term. However, the empirical evidence suggests that this more complex adjustment formula does not yield significantly better results (Flegg and Webber, 2000; Bonfiglio and Chelli, 2008; Flegg and Tohmo, 2011).

Performance of the FLQ

Kronenberg remarks that the FLQ approach "has met with mixed success" (p. 49). However, we would say that this evaluation fails to give due weight to the considerable body of published evidence that demonstrates the clear superiority of the FLQ over the conventional LQs, although it is true that some of this evidence was not available at the time Kronenberg was writing. This evidence includes studies using survey-based data for Peterborough (Flegg *et al.*, 1995), Scotland (Flegg and Webber, 2000), one Finnish region (Tohmo, 2004), all Finnish regions (Flegg and Tohmo, 2011), along with the Monte Carlo study by Bonfiglio and Chelli (2008), who examined 400,000 sectoral output multipliers. On the other hand, Riddington *et al.* (2006) found the FLQ to be unhelpful, albeit on the basis of findings pertaining to a single sector in one Scottish region (Flegg and Tohmo, 2011).

Now let us consider some key findings of Flegg and Tohmo (2011), who examined data for all 20 Finnish regions in 1995, using survey-based type B tables containing 37 sectors. They used the following criteria to assess the relative performance of the FLQ and the conventional LQs in estimating type I sectoral output multipliers:

$$\mu_1 = (100/n)\,\Sigma_j\,(\hat{m}_j - m_j)/m_j \quad (16)$$

$$\mu_2^* = 100\,(\overline{\hat{m}} - \overline{m})/(\overline{m} - 1) \quad (17)$$

$$\mu_3 = 100\,\Sigma_j\,q_j\,(\hat{m}_j - m_j)/m_j \quad (18)$$

$$\mu_4 = 100\sqrt{\frac{\sum_j(\hat{m}_j - m_j)^2}{\sum_j m_j^2}} \quad (19)$$

$$\mu_5 = (1/n)\,\Sigma_j\,|\hat{m}_j - m_j|/m_j \quad (20)$$

$$sd = [(1/n)\,\Sigma_j\,\{(|\hat{m}_j - m_j|/m_j) - \mu_5\}^2]^{0.5} \quad (21)$$

where $\hat{m}_j$ is the estimated type I output multiplier for sector *j* (column sum of the LQ-based Leontief inverse matrix) in a given region, m_j is the corresponding survey-based multiplier, q_j is the proportion of regional output produced in sector *j* and n = 37 is the number of sectors.

Table 2

Table 2 reveals that the FLQ – irrespective of which statistic is used – yields far more accurate results than the SLQ and CILQ. The most likely explanation of this outcome is that the SLQ and CILQ make inadequate downward adjustments to the national input coefficients, to allow for imports from other regions, and hence greatly understate regional propensities to import. The strong upward bias in input coefficients and hence multipliers is also manifested by the similarity in the mean values of μ_1 and μ_5 for the SLQ and likewise for the CILQ.

Kronenberg's approach

Kronenberg eschews the use of LQs in favour of an approach based upon the resurrection and refinement of the classical *commodity balance* (CB) approach. A key issue for him is the way in which imports from abroad are allocated in national input–output tables. Here his use of type E tables as the basis for the application of his new approach is entirely appropriate since his aim is to capture the underlying technology of production. Let us now consider the salient differences between CHARM and the CB approach.

First note that the *commodity balance* for commodity i, b_i, is identical to *net* exports:

$$b_i \equiv e_i - m_i \qquad (22)$$

where e and m denote exports and imports, respectively. The value of b_i is estimated by subtracting the estimated sum of intermediate and domestic final use of commodity i from an estimate of its output (Kronenberg, 2009, p. 46). The CB method and CHARM yield exactly the same values of b_i but different values, in general, for the volume of trade, $e_i + m_i$. This is because CHARM takes cross-hauling into account. The amount of cross-hauling, q_i, is measured via the equation (*ibid.*, p. 47):

$$q_i = (e_i + m_i) - |(e_i - m_i)| \qquad (23)$$

where $(e_i + m_i)$ is the *volume* and $(e_i - m_i)$ is the *balance* of trade, respectively. In the CB approach, $q_i = 0$ because $e_i > 0$ and $m_i > 0$ cannot, by assumption, occur simultaneously. By contrast, under Kronenberg's approach, $q_i > 0$ is possible and, indeed, likely. He posits that q_i is proportional to the sum of the intermediate and domestic final use of commodity i, with the factor of proportionality being equal to the degree of product heterogeneity (*ibid.*, p. 51).

Using data for the German state of North Rhine–Westphalia (NRW), Kronenberg computes supply multipliers for 16 sectors. *Note:* He refers to these as "output" multipliers but, to avoid confusion, we use the term "supply" multipliers. As expected, the CB method yields unrealistically low figures for regional exports and imports, whereas CHARM generates more sensible figures for both (*ibid.*, Table 3). However, even though the regional supply multipliers from CHARM are generally smaller than those for Germany, their average value is only marginally lower (1.553 versus 1.590) (*ibid.*, Table 4). This suggests that CHARM may still be overestimating these multipliers, although it is true that NRW is a relatively large region (with around 21.7 % of national employment).

Case Study of Uusimaa

A limitation of Kronenberg's case study is that he did not have the required survey-based regional data to assess the accuracy of his CHARM-based estimates of imports, exports and multipliers. Fortunately, in the case of Finland, the necessary figures can be derived for all its regions in 2002. Here we examine data for Uusimaa, the largest region, which produced 34.6% of national output in 2002 and accounted for 31.4% of aggregate employment. Uusimaa's diversified industrial structure is illustrated in Table 3.

Table 3

It should be noted that we have pursued a more disaggregated approach than Kronenberg did, so as to maximize the amount of available information and minimize aggregation bias. Even so, a lack of regional data meant that the 59 national sectors had to be reduced to the 26 regional sectors displayed in Table 3.[4]

Table 4

As expected, Table 4 shows that the CB method substantially underestimates Uusimaa's total exports and imports and, consequently, its volume of trade. CHARM performs markedly better, although it too understates the overall amount of trade. This superior relative performance is primarily due to the fact that CHARM takes cross-hauling into account, whereas the CB method rules out the possibility of a sector's being both an exporter and an importer of a given commodity.

Table 5

From Table 5, we can see that CHARM almost invariably produces the best estimates of the volume of trade in individual sectors. This pattern is especially noticeable with respect to manufacturing (sectors 5 to 15), where it can be explained by the heterogeneity of many manufactured products and the concomitant cross-hauling. Sector 13 is a good example: whereas CHARM captures 83.2% of the volume of trade, the CB method accounts for only

30.2%. Furthermore, the more detailed results in Table 4 reveal that CHARM captures almost all of the exports in sector 13 and two-thirds of the imports; by contrast, the CB method accounts for half of the exports but none of the imports.

The differences between CHARM and the CB method are generally less striking for the non-manufacturing sectors. We should not expect cross-hauling to be an issue for many service industries, so CHARM is unlikely to outperform the CB method. Indeed, both methods perform very poorly indeed in the sectors Hotels and restaurants (19) and Education (24), even though the amount of trade involved is modest. Furthermore, there are three sectors (2, 17 and 25) where both methods dramatically overstate the volume of trade and by comparable amounts. This problem can, in turn, be attributed to errors in estimating the *balance* of trade, b_i, which equals net exports. Table 4 gives estimated values for b_i of –353.4, –1,175.5 and –538.3 (× €1 million) for sectors 2, 17 and 25, respectively, which are not at all like the corresponding survey-based figures of –122, 163 and 63. In the case of Construction (sector 17), the error is due to the fact that the intermediate and final demands for construction were overestimated by 6.5% and 7.8%, respectively, while output was underestimated by 14.0%. For Health and Social Care (sector 25), the error can be attributed a 10.4% overstatement of final demand and a 4.9% understatement of output. Finally, for Forestry and Logging (sector 2), output was overstated by 24.8% but this error was dwarfed by the fact that the intermediate and final demands for this sector's output were overestimated by 97.9% and 120.6%, respectively.

It should be noted that we followed Kronenberg in making certain assumptions in our calculations of sectoral output and demand. In particular, we used employment data as a proxy for output. This is likely to be problematic in cases where there is a significant divergence between regional and national labour productivity. We also assumed identical national and regional technology. Finally, in calculating the regional final use of each commodity, we simply used the ratio of total regional to total national employment to scale down the national figures (cf. Kronenberg, 1999, p. 46).

Figure 1

Figure 1 highlights the fact that, almost invariably, the CB method substantially underestimates the volume of Uusimaa's imports. CHARM generally performs much better, although it does still often understate the volume of imports. This understatement is especially noticeable for sectors 5, 8, 13, 20 and 22. On the other hand, both methods substantially overstate imports for sectors 17 and 25.

Turning now to the estimates of supply multipliers in Table 5, we can see that both methods typically overstate the size of these multipliers, although CHARM comes much closer to the survey-based results on average. CHARM is invariably the better method for manufacturing (sectors 5 to 15) but the pattern is less clear cut for the non-manufacturing sectors. For instance, the CB method generates the closest estimates for Construction (17) and Health and Social Work (25). Nevertheless, in terms of the mean proportional error, μ_1, as defined in equation 16, it is clear that CHARM is by far the more accurate of the two methods: it yields an average error of 4.0% versus 12.4% for the CB method.

Conclusion

Kronenberg has produced an innovative, rigorous and usable refinement of the classical commodity balance (CB) method. Moreover, his proposed new method (CHARM) is firmly grounded in economic theory. Kronenberg did not, however, possess the survey-based data required to validate CHARM, so the principal aim of this comment has been to subject it to a detailed empirical test. Our case study employed survey-based data for Uusimaa, Finland's largest region. We were able to assess the accuracy of the estimates of exports, imports, volume of trade, balance of trade and supply multipliers generated by CHARM and the CB method for 26 regional sectors in 2002. We found that CHARM outperformed the CB method in all important respects. The results were particularly encouraging for manufacturing sectors, which typically produce heterogeneous commodities and where cross-hauling is rife.

Our findings in terms of supply multipliers are especially worth noting. A tendency towards overstatement of regional multipliers is a well-known characteristic of non-survey techniques, yet CHARM performed well in this respect: on average across the 26 sectors, the unweighted mean supply multiplier from CHARM was 1.542, which is not far above the survey-based figure of 1.482. By comparison, the CB method generated a mean of 1.670. What is more, the mean proportional error from CHARM was 4.0%, which compares very favourably with the 12.4% from the CB method.

CHARM is based on a relatively new type of national input–output table, in which imports from abroad are incorporated into the interindustry transactions matrix, so that the input coefficients derived from this matrix are genuine technical coefficients. We refer to tables of this kind as *type A* tables. Such tables are produced by all members of the EU (and by some other countries too). However, Kronenberg fails to mention that EU countries also produce a more traditional type of national table, from which imports from abroad are excluded. We refer to tables of that kind as *type B* tables. In our comment, we attempt to clarify the differences between these two types of table and then explore the implications. We aver that Kronenberg is right to employ type A tables in the context of CHARM. However, where location quotients (LQs) are being used to regionalize a national table, we argue that there are compelling reasons for applying the LQs to type B tables. Furthermore, of the possible LQs that might be used, we maintain that there are strong theoretical and empirical grounds for using the FLQ.[5]

Kronenberg does not consider possible regional applications for which CHARM, as opposed to LQs, would be suitable. To clarify this issue, suppose that an analyst is interested in the impact of the expansion of a coal-fired power station in a particular region. If he is interested specifically in the environmental effects of burning more coal, then the source of the coal inputs would be irrelevant. In this instance, we would recommend using CHARM to regionalize the type A national table. The resulting regional table could then be employed to estimate supply multipliers. If, on the other hand, the analyst's focus is on regional output and employment, then we would suggest using the FLQ to regionalize the type B national table. The resulting regional table could then be used to compute output and employment multipliers.

The results obtained here for Uusimaa are certainly encouraging in terms of the effectiveness of CHARM as a regionalization method in situations where type A regional tables are most appropriate. However, one should always be cautious in generalizing from the findings of a case study of a single region. It would be interesting to see whether CHARM works as well for other Finnish regions, especially those where manufacturing is less important. It is also worth noting that CHARM typically did still yield overestimates of supply multipliers, so it would be interesting to explore whether this overestimation also occurs in other regions or, if not, whether it can be explained in terms of some characteristic of the method itself.

Notes

1. We would like to thank Tobias Kronenberg for clarifying several points regarding the application of CHARM. Helpful comments were received from Andrew Mearman, Anthony Plumridge, Don Webber and Chris Webber.
2. The discussion in this section draws heavily on Kronenberg (2011).
3. Etelä-Pohjanmaa is also known as South Ostrobothnia.
4. In fact, we could have followed Kronenberg in including a separate sector for "private households with employed persons". However, because this sector has no intermediate inputs, we opted

instead to subsume it into our sector 26. The source for our national data was http://epp.eurostat.ec.europa.eu/portal/page/portal/esa95_supply_use_input_tables/data/workbooks (accessed 23 May 2011). The regional data for Uusimaa were obtained from www.stat.fi.

5. Boomsma and Oosterhaven (1992, p. 273) express the view that "any expert who knows his region reasonably well may come up with better (i.e., at least not systematically biased) export or import coefficients as compared with the results of LQ and other coefficients." However, we would argue that the FLQ does, to a large extent, overcome the problem of bias, although other sources of error obviously remain.

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Table 1

Input Coefficients in Finland in 1995

	Etelä-Pohjanmaa	**Finland**
Industry	**Meat and fish**	**Meat and fish**
01 Agriculture	0.2404	0.3594
06 Meat and fish	0.0350	0.2998
26 Hotels and restaurants	0.0007	0.0018
27 Transport	0.0315	0.0324
33 Renting and business activities	0.0115	0.0300
Total use of domestic products at basic prices	**0.3547**	**0.8365**
Total use of imported products	0.5139	0.0000
Foreign imports	0.0536	0.0576
Value-added tax plus other taxes on products	0.0017	0.0025
Subsidies on products	–0.1372	–0.1250
Total intermediate consumption at purchasers' prices	**0.7866**	**0.7716**
Compensation of employees	0.1385	0.1485
Other taxes on production	0.0001	0.0007
Subsidies on production	–0.0014	–0.0043
Other value added	0.0761	0.0835
Value added at basic prices	**0.2134**	**0.2284**
Output at basic prices	**1.0000**	**1.0000**

Table 2

Assessment of Accuracy using Different Criteria: Sectoral Type I Output Multipliers for 20 Finnish Regions in 1995 (unweighted)

Method	Criterion					
	μ_1	μ_2*	μ_3	μ_4	$\mu_5 \times 100$	sd
SLQ	14.7	59.8	14.2	20.4	15.7	0.1167
CILQ	15.0	63.3	12.3	19.9	16.4	0.1061
FLQ (δ = 0.15)	5.7	26.4	3.4	13.1	9.9	0.0763
FLQ (δ = 0.2)	2.6	10.6	0.5*	11.9*	8.5	0.0682
FLQ (δ = 0.25)	0.4*	–0.7*	–1.7	11.9	8.2	0.0673*
FLQ (δ = 0.3)	–1.9	–12.2	–3.7	12.3	8.1*	0.0680

Source: Flegg and Tohmo (2011, Table 4). * denotes a minimum.

Table 3
Employees in Uusimaa and Finland by Regional Sector

Sector	Description	Uusimaa: Employees RE_i	Finland: Employees NE_i	Regional share (%)	National share (%)	LQ_i
1	Agriculture and hunting (1)	3,409	104,000	0.5	4.4	0.104
2	Forestry and logging (2)	1,105	20,000	0.1	0.9	0.176
3	Fishing (3)	37	2,000	0.0	0.1	0.059
4	Mining and extraction (4–8)	635	6,000	0.1	0.3	0.336
5	Manufacture of food products, beverages and tobacco products (9–10)	9,462	41,000	1.3	1.7	0.733
6	Manufacture of textiles and clothes; dressing and dyeing of fur; tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear (11–13)	1,754	19,000	0.2	0.8	0.293
7	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials (14)	1,576	31,000	0.2	1.3	0.162
8	Manufacture of pulp, paper and paper products; publishing, printing and reproduction of recorded media (15–16)	18,009	72,000	2.4	3.1	0.795
9	Manufacture of coke, refined petroleum products, nuclear fuels, chemicals and chemical products, rubber and plastic products (17–19)	9,127	40,000	1.2	1.7	0.725
10	Manufacture of other non-metallic mineral products (20)	2,964	16,000	0.4	0.7	0.589
11	Manufacture of basic metals and fabricated metal products, other than machinery and equipment (21–22)	8,191	62,000	1.1	2.6	0.420
12	Manufacture of machinery and equipment not classified elsewhere (23)	10,460	63,000	1.4	2.7	0.527
13	Manufacture of office machinery and computers; electrical machinery and apparatus; radio, television and communication equipment and apparatus; medical, precision and optical instruments, watches and clocks (24–27)	26,823	66,000	3.6	2.8	1.291
14	Manufacture of motor vehicles, trailers, semi-trailers and other transport equipment (28–29)	5,986	25,000	0.8	1.1	0.761
15	Manufacture of furniture; manufacturing not classified elsewhere; recycling (30–31)	2,924	19,000	0.4	0.8	0.489
16	Electricity, gas, steam and hot water supply; collection, purification and distribution of water (32–33)	4,915	16,000	0.7	0.7	0.976
17	Construction (34)	42,555	155,000	5.8	6.6	0.872
18	Sale, maintenance and repair of motor vehicles and motorcycles; retail of automotive fuel; wholesale, retail and commission trade, excluding motor vehicles and motorcycles; repair of personal and household goods (35–37)	122,176	300,000	16.5	12.8	1.294
19	Hotels and restaurants (38)	27,228	77,000	3.7	3.3	1.123
20	Land, water and air transport; travel agencies; post and telecommunications (39–43)	66,325	174,000	9.0	7.4	1.211

21	Financial intermediation; insurance and pension funding, except for compulsory social security (44–46)	20,733	41,000	2.8	1.7	1.606
22	Real estate and other business activities; rental of machinery and equipment and of personal and household goods; research and development (47–51)	114,585	236,000	15.5	10.0	1.542
23	Public administration and defence; compulsory social security (52)	52,838	173,000	7.1	7.4	0.970
24	Education (53)	50,405	157,000	6.8	6.7	1.020
25	Health and social work (54)	88,539	321,000	12.0	13.7	0.876
26	Sewage and refuse disposal, sanitation and similar activities; recreational, cultural, sporting and other service activities; private households with employed persons (55–59)	46,665	113,000	6.3	4.8	1.312
Sum		**739,426**	**2,349,000**	**100.0**	**100.0**	

Note: The corresponding 59 national sectors are shown in brackets.

Table 4
Estimation of Uusimaa trade (millions of euros)

	CHARM				Commodity Balance				Survey				
Sector	Exports	Imports	Trade Balance	Trade Volume	Exports	Imports	Trade Balance	Trade Volume	Exports	Imports	Trade Balance	Trade Volume	Output
1	50.1	889.2	−839.1	939.3	0.0	839.1	−839.1	839.1	146	838	−692	984	182
2	4.9	358.3	−353.4	363.1	0.0	353.4	−353.4	353.4	43	165	−122	208	131
3	0.4	48.7	−48.3	49.1	0.0	48.3	−48.3	48.3	1	47	−46	48	13
4	22.9	979.8	−956.9	1,002.7	0.0	956.9	−956.9	956.9	26	888	−862	914	138
5	279.3	984.9	−705.6	1,264.2	0.0	705.6	−705.6	705.6	1,826	2,131	−305	3,957	2,134
6	173.4	775.5	−602.1	948.9	0.0	602.1	−602.1	602.1	122	730	−608	852	144
7	35.8	458.8	−423.0	494.6	0.0	423.0	−423.0	423.0	148	515	−367	663	208
8	2,190.9	216.4	1,974.5	2,407.4	1,974.5	0.0	1,974.5	1,974.5	2,140	1,682	458	3,822	3,329
9	1,434.4	2,069.4	−635.0	3,503.8	0.0	635.0	−635.0	635.0	1,856	2,371	−515	4,227	2,424
10	95.3	216.5	−121.2	311.8	0.0	121.2	−121.2	121.2	247	417	−170	664	471
11	451.2	889.6	−438.4	1,340.8	0.0	438.4	−438.4	438.4	808	1,411	−603	2,219	1,106
12	749.6	1,132.8	−383.2	1,882.4	0.0	383.2	−383.2	383.2	1,392	1,764	−372	3,156	1,938
13	6,944.5	3,250.1	3,694.4	10,194.6	3,694.4	0.0	3,694.4	3,694.4	7,367	4,883	2,484	12,250	8,979
14	832.5	1,234.3	−401.9	2,066.8	0.0	401.9	−401.9	401.9	941	1,260	−319	2,201	894
15	115.1	424.4	−309.3	539.5	0.0	309.3	−309.3	309.3	234	566	−332	800	305
16	63.7	124.5	−60.8	188.2	0.0	60.8	−60.8	60.8	188	88	100	276	1,593
17	0.0	1,175.5	−1,175.5	1,175.5	0.0	1,175.5	−1,175.5	1,175.5	387	224	163	611	6,311
18	2,562.5	159.1	2,403.4	2,721.6	2,403.4	0.0	2,403.4	2,403.4	4,441	140	4,301	4,581	12,906
19	28.9	61.5	−32.6	90.3	0.0	32.6	−32.6	32.6	170	206	−36	376	1,759
20	2,239.5	602.9	1,636.5	2,842.4	1,636.5	0.0	1,636.5	1,636.5	4,441	2,108	2,333	6,549	10,808
21	1,104.9	50.6	1,054.3	1,155.5	1,054.3	0.0	1,054.3	1,054.3	1,229	177	1,052	1,406	3,845
22	4,838.0	586.8	4,251.2	5,424.8	4,251.2	0.0	4,251.2	4,251.2	4,780	1,601	3,179	6,381	16,476
23	34.9	184.2	−149.3	219.2	0.0	149.3	−149.3	149.3	213	169	44	382	3,889
24	7.0	1.3	5.7	8.3	5.7	0.0	5.7	5.7	32	47	−15	79	2,410
25	0.4	538.7	−538.3	539.1	0.0	538.3	−538.3	538.3	107	44	63	151	4,115
26	662.3	40.1	622.2	702.5	622.2	0.0	622.2	622.2	790	145	645	935	3,843
Sum	**24,922.4**	**17,454.0**	**7,468.4**	**42,376.4**	**15,642.3**	**8,174.0**	**7,468.4**	**23,816.3**	**34,075**	**24,617**	**9,458**	**58,692**	**90,351**

Table 5
Estimates of Supply Multipliers and Trade Volume for CB and CHARM

Sector	Description	Supply Multipliers			Ratio of Estimated to Survey-based Trade Volume	
		Survey	CHARM	CB	CHARM	CB
1	Agriculture and hunting	1.171	1.127	1.143	0.955	0.853
2	Forestry and logging	1.238	1.116	1.123	1.746	1.699
3	Fishing	1.025	1.030	1.032	1.024	1.006
4	Mining and extraction	1.153	1.100	1.110	1.097	1.047
5	Manufacture of food products, beverages and tobacco products	1.536	1.827	1.968	0.319	0.178
6	Manufacture of textiles and clothes; dressing and dyeing of fur; tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	1.139	1.130	1.173	1.114	0.707
7	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	1.262	1.392	1.432	0.746	0.638
8	Manufacture of pulp, paper and paper products; publishing, printing and reproduction of recorded media	1.657	2.045	2.176	0.630	0.517
9	Manufacture of coke, refined petroleum products, nuclear fuels, chemicals and chemical products, rubber and plastic products	1.478	1.575	1.917	0.829	0.150
10	Manufacture of other non-metallic mineral products	1.479	1.632	1.817	0.470	0.182
11	Manufacture of basic metals and fabricated metal products, other than machinery and equipment	1.404	1.691	1.968	0.604	0.198
12	Manufacture of machinery and equipment not classified elsewhere	1.581	1.710	2.115	0.596	0.121
13	Manufacture of office machinery and computers; electrical machinery and apparatus; radio, television and communication equipment and apparatus; medical, precision and optical instruments, watches and clocks	1.634	1.754	2.235	0.832	0.302
14	Manufacture of motor vehicles, trailers, semi-trailers and other transport equipment	1.442	1.531	2.003	0.939	0.183
15	Manufacture of furniture; manufacturing not classified elsewhere; recycling	1.307	1.389	1.509	0.674	0.387
16	Electricity, gas, steam and hot water supply; collection, purification and distribution of water	1.612	1.619	1.692	0.682	0.220
17	Construction	2.001	1.842	1.925	1.924	1.924
18	Sale, maintenance and repair of motor vehicles and motorcycles; retail of automotive fuel; wholesale, retail and commission trade, excluding motor vehicles and motorcycles; repair of personal and household goods	1.735	1.773	1.839	0.594	0.525
19	Hotels and restaurants	1.816	1.850	1.917	0.240	0.087
20	Land, water and air transport; travel agencies; post and telecommunications	1.529	1.774	1.885	0.434	0.250

21	Financial intermediation; insurance and pension funding, except for compulsory social security	1.519	1.494	1.532	0.822	0.750
22	Real estate and other business activities; rental of machinery and equipment and of personal and household goods; research and development	1.630	1.591	1.649	0.850	0.666
23	Public administration and defence; compulsory social security	1.631	1.600	1.654	0.574	0.391
24	Education	1.439	1.435	1.460	0.105	0.072
25	Health and social work	1.404	1.374	1.399	3.570	3.565
26	Sewage and refuse disposal, sanitation and similar activities; recreational, cultural, sporting and other service activities; private households with employed persons	1.711	1.699	1.747	0.751	0.665
	Mean	**1.482**	**1.542**	**1.670**	**0.889**	**0.665**
	Mean (excluding sectors 2, 17 and 25)	**1.473**	**1.555**	**1.694**	**0.691**	**0.439**
	μ_1		**3.958**	**12.360**		

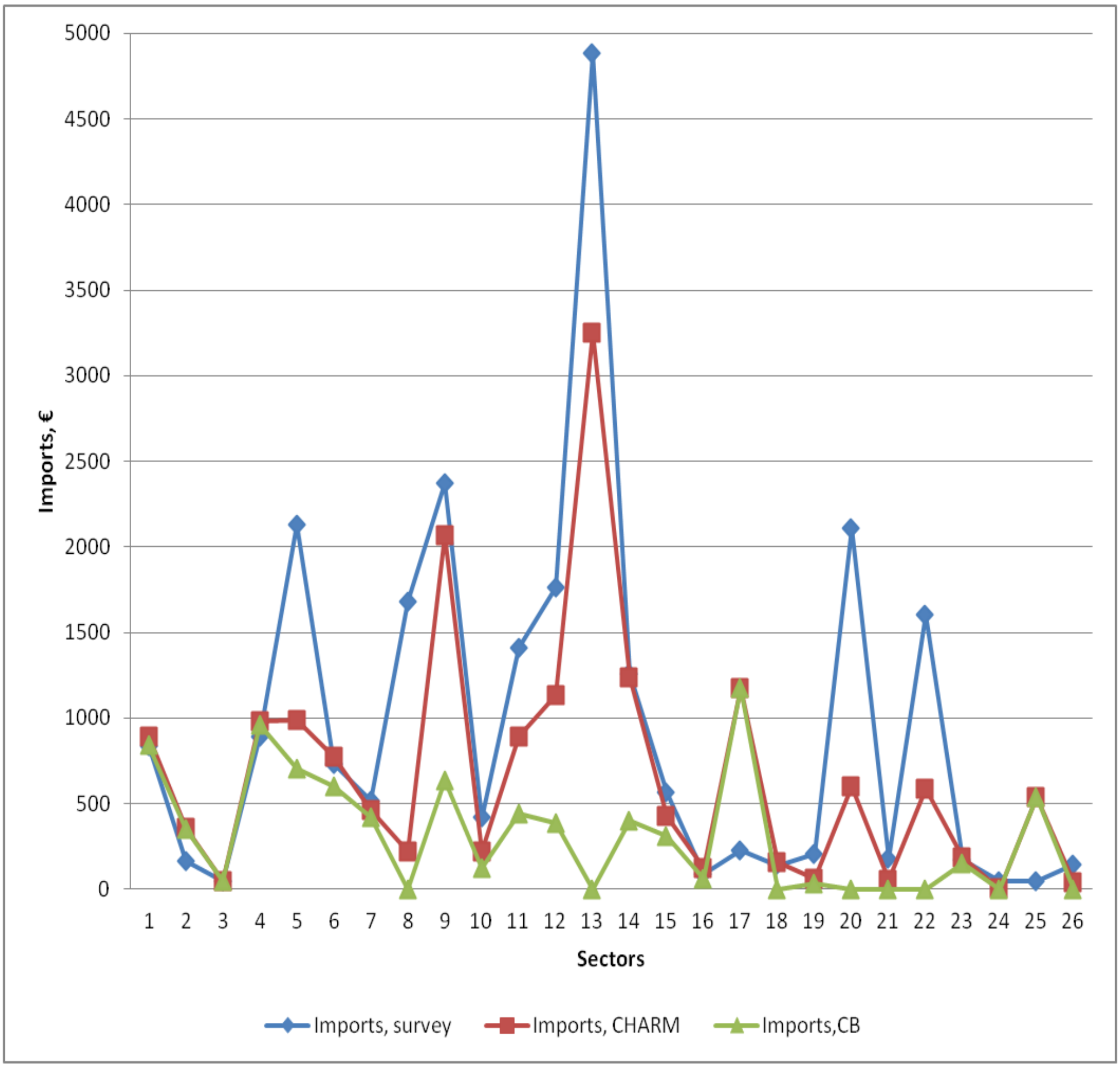

Figure 1. Estimates of the Absolute Trade Volume for CB and CHARM