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Estimating Interregional Trade Using National Data

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Abstract. This paper combines a gravity-type approach and a non-survey technique to estimate regional exports (imports) when there is limited data. First, regional Input-Output (I-O) tables are estimated from a national I-O table by utilizing an iterative method. Second, a gravity-type model is used to transform regional I-O tables into an interregional I-O table. Finally, trade coefficients are determined from a simultaneous linear equations system under a set of constraints.

Introduction

The objective of this paper is to propose a method to estimate interregional trade when there is no available data and/or the amount of primary data to be obtained is restricted by cost considerations. As such, the proposed method falls into a group of methods referred to as nonsurvey or minimum survey methods. However, this study goes further. It combines a gravity-type model [1, pp. 119-149] and a biproportional matrix method [2].

The next section briefly surveys the relevant literature and introduces the estimation procedure used in this study. In parts III and IV, the techniques for estimating regional and interregional trade are described. The final part presents the concluding remarks.

A Survey of Nonsurvey Methods

Research on the estimation of trade coefficients has been extensive, despite the mixed results such research has generated. The reason for the search is the high cost of constructing regional input-output tables based on a full-survey data.

In the beginning, the regional input-output tables were based on national technical coefficients. [3; 4, pp. 113-119]. In other words, the regional Input-Output coefficients were taken to be equal to the national Input-Output coefficients. The next step was that of using national Input-Output coefficients with some adjustments based on such things as the region's share in domestic value added, and/or population. During the 60's, the so-called "RAS" method was developed [5]. In the regional applications of the method, a matrix of regional coefficients is derived from either a national matrix or a regional matrix constructed for an earlier date.

The RAS method of constructing regional Input-Output tables from national data has been tested extensively. The results range from being marginally acceptable [6-8] to unsatisfactory [9, 10].

More recent studies focused on comparing nonsurvey regional Input-Output models with survey-based models for the purpose of testing the accuracy of nonsurvey models [11-13]. Such comparisons however, have not been conclusive. In fact, it was argued that survey-based models may not be the best standards for comparison due in part to their high level of aggregation. Nevertheless, there is agreement that if more and more of exogenous information were utilized in the estimation process, the realiability of the estimated would be greatly enhanced. [9, 10, 13]

The novelty of the present paper lies in its emphasis on constructing an interregional Input-Output table within a general equilibrium framework consisting of a set of regional interindustrial Input-Output relaitonships, and on incorporating exogenous infomation in the estimation process. In addition to being operational, such an approach gives a more realistic simulation of interregional trade with two way flows between regions [14].

The estimation procedure used can be summarized as follows: First, given a national Input-Output table at time t, (Xij)t, and vectors of total gross Output and total gross outlay for region i (i=1,....,m), regional Input-Output table for that region is constructed using an iterative technique [2, 14]. Second, a gravity-type method [1, pp. 119-149] is used to transform regional Input-Output tables into an interregional Input-Output table. Finally, trade coefficients are determined from a simultaneous linear equation system under the restrictions that the sum of deliveries from each regional sector to other regions is equal to the total known deliveries from the regional sector to other regions, and that the sum of deliveries into a region for each type of good is equal to total use in that region [15].

Estimating Regional Input-Output Tables

The method used here is due to McMenamin and Haring; it is similar to the RAS procedure [2]. It is applicable to the problem of estimating a regional table at one data based on a similar national table. It is a cost effective method since it requires little input data. The only required data are an I-O table for the national and total gross output and total gross outlay vectors for the regions for which the new table is constructed. It should be noted that in its original applicaiton, the method was used to estimate a regional input-output table at one data based on a similar table from an earlier point in time [2]. Therefore, not only is the application different in this study, but also the data requirements are not as limiting.

The procedure is as follows. Let:

x_{ij} be a national I-O table,
y_i be a vector of total gross output for a region,
z_j be a vector of total gross outlay for the same region,
$x_{t,ij}$ be the regional I-O table after iterations,
i=1,...,m be the number of rows, including the payment sector, and
j=1,...,n be the number of columns, including the final demand sector.

The iteration starts by constraining the row sums of the gross flows (sales) in x_{ij} to the corresponding total gross Output values:

$$X_{1,1j} = (Y_1 / \sum_{k=1}^{n} X_{1k})(X_{1j})$$

Then we find the column sums of these gross flows (purchases) and constrain them to the total gross outlay values:

$$X_{2,1j} = (Z_j / \sum_{k=1}^{n} X_1, K_j)(X_{1,1j})$$

The row sums of these column-constrained gross flows (sales) can again be constrained to the gross output values:

$$X_{t-1,ij} = (y_i / \sum_{k=1}^{n} X_{t-2,ik})(X_{t-2,ij})$$

$$X_{t,ij} = (Z_j / \sum_{k=1}^{n} X_{t-1,kj})(X_{t-1,ij})$$

The iterative process continues until the vectors of row and column totals for the estimated I-O matrix have converged to within ε of the total gross output and total gross outlay vectors:

$$Y_i - \sum_{j=i}^{n} X_{t,ij} < \varepsilon \qquad (i = 1,\ldots,m)$$

$$Z_j - \sum_{j=1}^{n} X_{t,ij} < \varepsilon \qquad (j = 1,\ldots,n)$$

The matrix obtained, $X_{t,ij}$, is the estimated regional I-O table for the i^{th} region.

The above method was applied to the two regions of Turkey for the purpose of estimating regional I-O tables [15]. Briefly, an existing national I-O table was transformed into two regional I-O tables. Total gross outlay and total gross output vectors were calculated using provincial value added. The results were considered satisfactory both in terms of the discrepancies and the speed of convergence. The I-O tables for the regions could be added to obtain the national I-O table. Moreover, convergence was very rapid. The vectors of row and column totals had converged to within ε of the total gross output and total gross outlay vectors in seven iterations.

Estimating Interregional Input-Output Tables

A thorough description of regional economy requires more than an understanding of local technical coefficients. It is expected that a region would be more dependent upon trade with other regions within the nation, than the nation as a whole.

While a regional I-O table gives us a good idea of the regional Input requirements, it does not provide information concerning the source of these Inputs. Therefore, an interregional I-O approach is called for which describes the economic system not only in terms of interdependent industries, but also in terms of interrelated regions. In estimating interregional trade, the method suggested by Leontief and Strout is utilized [1, pp. 119-149].

This method can be summarized as follows. Let:
$X_{i,ok}$ be the total internal Input of good i in region k,
$X_{j,ko}$ be the Output of good j in region k,
$FD_{i,k}$ be the internal final demand of good i in region k,

and

$r_{ij,k}$ be the technical coefficients describing the amount of good i required to produce one unit of good j in region k.

Then:

$$X_{i,ok} = \sum_{j=i}^{n} (r_{ij,k} X_{j,ko}) + FD_{i,k}$$

The interdependence between the Outputs and Inputs of the different regions is described as:

$$X_{i,ko} = \sum_{p=1}^{n} X_{i,kp} \qquad (i = 1,\ldots,n)$$

$$X_{i,op} = \sum_{k=1}^{n} X_{i,kp} \qquad (k,p = 1,\ldots,m)$$

where $X_{i,kp}$ is the total shipment of good i from region k to region p. Summing the last two equations we obtain:

$$\sum_{k=1}^{n} \sum_{p=1}^{n} X_{i,kp} = \sum_{k=1}^{n} X_{i,ko} = \sum_{p=1}^{n} X_{i,op} = X_{i,oo}$$

where $X_{i,oo}$ is the aggregate demand for good i.

In what follows, a two-region system will be assumed for the ease of exposition. They are regions A and B. In applying the above gravity-type model to the present study, it is necessary to calculate regional internal final demand. Regional internal final demand, if not given, may be calculated on the basis of the region's shares in total value added and/or population. After the weighted averages are found on the basis of the total value added and/or population, they can be applied to total internal final demand to find regional internal final demands (IFD_A and IFD_B). These are then subtracted from regional final demands (FD-National Exports) obtained from the regional I-O tables, *i.e.*

$$FD_A - IFD_A, \text{ and}$$
$$FD_B - IFD_B$$

The result is the net regional exports (imports), *i.e.*

$$(X_{AB} - X_{BA}), \text{ or}$$
$$(X_{BA} - X_{AB})$$

where

X_{AB} is exports of Region A to B (imports of B), and
X_{BA} is exports of Region B to A (imports of A).

Once net exports are found as shown above, the following relationships can be utilized to compute gross exports (imports):

$$X_A = X_{AA} + X_{AB} + X_{AW}$$
$$X_B = X_{BB} + X_{BA} + X_{BW}$$
$$NX_A = X_{AB} - X_{BA}$$
$$TI = X_{AA} + X_{BB}$$

where

X_A is total output of Region A,

X_B is total output of Region B,

X_{AA} is intraregional transactions in Region A,

X_{BB} is intraregional transactions in Region B,

X_{AB} is exports of Region A to B,

X_{BA} is exports of Region B to A,

NX_A is net exports of Region A,

TI is total intranational transactions,

X_{AW} is exports of Region A to the outside world, and

X_{BW} is exports of Region B to the outside world.

Notice that X_A, X_B, X_{AM}, X_{BW}, $(X_{AA} + X_{BB})$, and NX_A are known. TI is obtained from the regional I-O tables for Regions A and B. X_{AW} and X_{BW} can be obtained from customs data. Therefore, we have a system of four equations in four unknowns. These equations can be solved to obtain X_{AB}, X_{BA}, X_{AA}, and X_{BB}. Finally, total regional exports $(X_{AB} + X_{AM})$ and $(X_{BA} + X_{BW})$ can be computed.

The estimation procedure used can be summarized as follows:

a– Given a national Input-Output table at time $t((X_{ij})t)$, an iterative technique due to McMenamin and Haring [2] is utilized to estimate regional Input-Output table at time t. In the estimation of the regional tables it was assumed that the vectors of total gross Output and total gross outlays for Regions A and B were given.

b– A gravity type method [1, pp. 119-149] is used to transform regional Input-Output table.

c– Finally, trade coefficients are determined from a simultaneous linear equation system under the restrictions that the sum of deliveries from each regional sector to other regions is equal to the total known deliveries from that regional sector to other regions, and that the sum of deliveries into a region for each type of good is equal to total use in that region.

Thus, the construction of an interregional Input-Output table within a general equilibrium framework consisting of a set of regional interindustrial Input-Output relationships is the main tool by which interregional trade is estimated. In addition to being operational, the incorporation of the gravity approach in an I-O model, which simultaneously determines regional Outputs and interregional shipments, reflects actual, empirically observed behavior rather than optimistic principles [14].

Conclusions

It is generally agreed that there is no good substitute for a good survey-based study. However, if the need is to develop methods to handle presently available data, the use of minimum survey methods becomes relevant. Assuming that the regional analyst cannot wait until full survey data are available, there will be room for the efforts to refine methods in order to utilize available data. The present paper should be seen as one such effort.

The main objective of estimating interregional trade within data limitations is carried out by elaborating on a gravity-type model. It became clear, however, that the implementation of such a model required a set of interregional Input-Output tables. The lack of required regional data for constructing interregional Input-Output tables necessitated the use of one of the techniques known as non-survey techniques. The choice of the iterative method of McMenamin and Haring [2], in the first stage of the estimation procedure was made on the basis of its accuracy relative to other non-survey methods. In testing their method, McMenamin and Haring compare the results obtained from two other nonsurvey models, and find that their estimated are very close to the true values.

Two conclusions can be drawn from the preceding discussion. First, in estimating a regional I-O table from its national counterpart, the accuracy obtained will vary with the amount of exogenous information available. The reliability of the estimates will be enhanced if many components of the I-O table are taken as given and not estimated independently. This result was confirmed when the same iterative technique was used once with and once without exogenous information [16]. Second, while it is true that biproportional methods do not require much data and are simple to use, one should be careful not to substitute simplicity for economic logic [10]. Such methods perform better under restrictions imposed on them by economically sound models. It is thought that the gravity-type model used in this study is well-suited for that porpose.

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تقدير التجارة الإقليمية باستعمال البيانات القومية

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ملخص البحث. يمزج هذا البحث بين طريقة الجذب والطرق اللا استبيانية من أجل تقدير الصادرات (الواردات) الإقليمية في حالة عدم توافر بيانات كافية. ففي البداية سوف يتم تقدير وبناء جداول المدخلات/ المخرجات الإقليمية من الجداول القومية باستعمال طريقة تكرارية معينة، وبعد ذلك يجري استخدام نموذج الجذب لتحويل جداول المدخلات/ المخرجات الإقليمية إلى جداول إقليمية متداخلة، وفي النهاية يتم تحديد معاملات التجارة من خلال نظام معادلات خطى آني في ظل مجموعة من القيود.