USE OF ENTERPRISES DATA IN ECONOMIC PLANNING

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ABSTRACT
The process of economic planning is classically dealt with Leontief's input-output analysis. In this work we indicate some problems that arose in the building and use of this method. We propose an alternative method that uses a productive enterprises' database and a microsimulation procedure to determine the propagation of economic changes to the whole set of enterprises, to see the impact of the changes and to guide the procedures to implement them.

KEY WORDS
Microsimulation, economic planning, databases, input-output analysis.

1. Introduction

Many economic problems require certain degree of economic planning. Production of new goods or services, installation of big enterprises, exploitation of new resources, changes in technology, changes in the productions due to international agreements, and many similar processes pose complex problems. The complexity arises from the fact that some alteration in a sector of the economy entails modifications in other sectors: new imports, search for new markets, new types of employment, capitals, and other resources. Besides, the implementation of the changes alters social, ecological, and regional equilibrium.

2. The Input/Output matrix methods: Utility and problems

A well known classical method to cope with some of these complexities is the use of Input-Output matrices, originated from Leontief' seminal works [1,2]. The practical implementation and use of the matrix may be found in many books as Miller and Blair [3]. The building of these matrices was recommended by the United Nations [4] [5]. In these and related works [6], methods to build the IO matrix from enterprises data, the use of the matrix to get an overview of a national economy, to compare economies of different countries, and the use for economic planning are discussed. Although the problems of building and using an IO matrix in planning are generally known [7] we will refer briefly to them to justify the method that we propose.

2.1 The data to build an IO matrix.

The data to build the matrix are based in surveys or censuses about the production (outputs) and spending (inputs) of enterprises. The imported inputs are usually distinguished from the nationally produced, and capital inputs may be distinguished from the other inputs. If an enterprise produces only one product, the technical coefficients (quantity of each resource used in the production of a unit of the product) result immediately for that enterprise. If there are many enterprises producing only this product the data can be aggregated, assuming, which may be erroneous, that equal technology is used, and mean technical coefficients may be computed.

The problem arises for the enterprises that produce many products and give the data of the inputs for the whole production. Besides, in many cases, there are products that are not produced as the unique product of some enterprises. Different methods are proposed to estimate the technical coefficients for such products using the information given for multiproducers. They are based in the dubious assumption that all the enterprises use the same technology and the same inputs to produce the same products.

The cited works of the United Nations recommend to divide the enterprise in "establishments" that produce only one product and use the so computed technical coefficients to discount the resources in producers that have this and other products as outputs, assuming the same technology in all the producers. The division in monoproducer establishments is not possible in many cases and it is recommended to get at least, a "principal" product and methods are recommended to deal with "secondary products". All methods are exposed to serious criticisms, so that the estimation of technical coefficients compatible with the whole information may be affected by an error difficult to be determined.

In the data of a large survey of 1982 establishments of the BCV (Venezuelan Central Bank) we find, in the private manufacture sector, 551 monoproducers and 50% of the products were never found as unique product. The method of "discounts" for the inputs of multiproducers, using technical coefficients found in monoproducers, leads sometimes to negative residual inputs, probably because of different technologies in the producers and different forms of aggregation in inputs designed with the same name.

When using these methods, the IO matrix at a certain aggregation level of the sectors is computed.

2.2 Aggregation

Aggregation of the enterprises in a few (say 15 or 30) economic sectors (usually using the Uniform International classification of Economic Activities after the UN) is adequate to get a quick global vision of the economic system, to appreciate the relative strength of interrelation of the sectors and to compare with other national economies for which similar matrices are available. But less aggregated matrices (several hundreds of sectors) are required for planning. It is, for instance, not enough to know that an increment of the construction sector implies certain increment of forestry, it is necessary to know what types of timber production are requested, which are different of those used by furniture or wood pulp. It is also necessary in many cases to discriminate, into different sectors, similar products produced by different technologies that use different input resources and have different impacts. Sometimes, an increment in a sector that is judged as quantitatively unimportant may be impossible to accomplish by lack of a key resource or technology and the deficit may be a bottleneck in the desired production processes. The aggregation may hinder the existence of bottlenecks whose knowledge is essential for the planners.

2.3 Additional information that do not enter in the matrix

Other important issue is that in the aggregation some information useful for planning is lost. That information is sometimes collected in the survey, as location of the establishments. Other might have been easily collected, such as limits in the production and semi-quantitative data about the dependence of the input increments on each increment production of each product. Considerations over the supply markets, quality of management, strategic importance of the product, social relevance of the establishment, educational and training impacts, and pollution problems are generally lost when an IO matrix is used. Some of them as environmental and employment issues may be of course added without difficulty to the matrix [5] although the responsibilities for the impacts are not seen in the matrix model and must be searched back in the original basic data. Know-how data in the establishment, sometimes appreciated during the survey are frequently not registered because there are not methods to embody them in the matrix building.

2.4 Linear and independence assumptions in the use of the matrix

When the productions are computed by solving the Leontief equations for a given consumption, the assumption of a linear proportionality between resources and the production and the assumption of independent additive contributions of each input on the production are introduced to make the solution feasible. These assumptions are not strictly true That the proportionality between input and production does frequently not hold is a known technical fact in cost accounting methods [8].

Although some of the errors are mitigated with increasing aggregation this, as we have said, decreases the planning usefulness of the IO matrix method.

A most realistic non linear and interactive function production is a Cobb-Douglas type relation for labor and capital, which we can generalize to all the inputs. A simple deduction leads to an equation that expressed the relative increases of productions as a linear combination of the relative changes in the inputs used in the production. This can be obtained if the producer knows the relative weights of the production factors (inputs) on the relative increments of the productions (outputs) of each product. Some enterprises have an estimation of their own IO matrix. This may be useful to the estimation of the aggregate matrix but it would be difficult to use because the different technology among enterprises with similar productions. Another important information that enterprises have but not used in the usual implementation of the matrix is the classification between proportional increase in certain inputs and non proportional or discontinuous change in other inputs when the outputs change. Besides, some enterprises develop their own input-output matrix for certain products, which are a partial representations of their technologies. All this important information is difficult to use in aggregate input-output matrix compilation, but may be easily embodied in the method that we propose.

3. The method of enterprises data (EDM)

We propose a method that solves many of these shortcomings of the IO in planning, and allows to use many important information easy to collect but difficult to use in that classical method.

The method do not pretend to plan the whole national economy and less to optimize the plan as may be seen for instance in [9]. The object is to predict economic, environmental, regional and social effects of planned changes in production, new enterprises and technologic changes, based in country or region real economy. In the sequel we use the word enterprise or establishment indistinctly.

3.1 The database's establishments

The method we propose consists in the direct use of the data from the enterprises or establishments given as a database, and in the developing algorithmic microsimulation techniques to use that database in the planning processess. Many of these data are now collected by the governments for the required National Accounts yearly published as a national compromise with the UN or the recommended building of IO matrices.

As described above, for each establishment we have a list of the productions (outputs) of the different products and a complete list of inputs both expressed at constant prices for a fixed production time (in our example one year). The imported inputs and exported outputs must be specified. We add all the information qualitative or quantitative that we could got about an enterprise: the employment of diverse categories, technology, location, social and environmental impacts, taxes, and strategic characteristics cited in 2.3.

Obtained data about relationships between increments of production and inputs must be added to the database. Of course the upkeep of that database may also be useful in other applications, for example to search establishments that have prescribed interesting characteristics or to obtain information about the establishments, using logical conditions and statistical procedures (included Data Mining) embodied in many database packages.

3.2 Use of enterprise's database in planning

To use this databases in planning problems we developed some algorithms. An example is described in Figure 1.

We note that many different algorithms are possible depending of the object of the planning process.

3.2.1 The production plan

This consists of the required amount of some products. This plan may be based in estimated new national consumption or export needs, but may also included estimated productions of intermediate goods. It may also include reductions in the production of goods dictated by ecological, strategic or international agreements reasons. For simplicity in exposition let us consider only desired increases in productions and for brevity we will called them deficits.

3.2.2 Search of establishments that may reduced the deficit

To minimize the impact of the plan on the enterprises we may start looking in the database the enterprise whose production structure (outputs of its different products) is most correlated with the deficit. Correlation coefficient was used in our example. We computed the increase of the production in that enterprise to satisfy the plan without introducing spurious (not in the deficit) productions with the increment. We may restrict this increase to a quantity that may be registered in the database as the maximum output for each product in this enterprise. The selection of the enterprises may be conditioned to other criteria in the database: geographic, belonging to industrial clusters, type of enterprise, size, imports required, as it was mentioned above. Usually it is not possible to cover the deficits increasing with only one enterprise. This allow to reduce the deficit and possibly to cover the deficit of only one product. The consideration of other enterprises may further reduce the deficit of the plan. The process of reduction is stopped by some automatic or user decided criterion.

The process of increasing productions may be terminated because deficits of all products become negligible or no admissible enterprise is found to reduce the deficit, or the deficit of certain products cannot be further reduced.

Up to this point the result is the production's increment propositions in some enterprises and perhaps an irreducible deficit. Then it is necessary to consider, for each enterprise, the increments of the inputs in goods and services to satisfy the computed increments of outputs. This requires and inversion of the production function of the affected enterprises. One simple way is to assume that the increases of the inputs are proportional to the increments of the outputs. This is the usual hypothesis in the Leontiev method. In our method more realistic estimates are possible (see below).

The increments of the imported inputs are accounted and for the moment it is assumed that the corresponding imports may be done. In a more sophisticated approach it is easy to introduce import restrictions.

The necessary input increments of nationally produced goods and services are then added to the deficit and, if the new deficit is not admissible, the described process of reduction is repeated. This iteration expresses one form (not the only one) in which the original production plan propagates to the rest of the economy. The process is proved to be convergent towards negligible increments of the productions perhaps except some irreducible productions of commodities that may be provided by imports or may be produced nationally by new enterprises. In this last case the process may be repeated.

The output is a list of the enterprises whose production must be modified and, for each one, the required increases in outputs, inputs (including employment), and total imported goods and services for each enterprise. The output included irreducible deficits.

The increments of productions may be made in the indicated enterprises or by creation of new similar enterprises.

3.2.3 The inversion of the production functions

In the second step of the described iteration method the problem arises of computing the increments of the inputs given increments of the outputs. As the last are usually more than the former the problem is indeterminate. When there is only one product or many products with the same proportion of increase the usual hypothesis is to assume for each input an increase proportional to the increment of the output. As we discussed in 2.4 this is not a reliable assumption. If there are many output products increased in different proportions a weighted estimate of these increment may be applied to the inputs but this is even not realistic. We try the following methods.

1) Assumption of an input-output matrix for the enterprise. Some enterprises have developed IO matrices. They are normally different for different enterprises even for those which produce the same items because they differ in technology. It is then possible to compute for this particular enterprise the coefficients c_{ij} that give the quantities of input j required to produce a unit of product i. For each of the n increments of productions ΔP_i of the enterprise we compute the increments of the inputs:

$\Delta I_j = \sum_{i=1}^{n} c_{ij} \Delta P_i$ for the ΔI_j j=1… m inputs

2) Use of a non linear input function. A possible non linear function is a Cobb Douglas type: $P_i = k_i \prod_{j=1}^{m} I_j^{a_{ij}}$ were k_i and a_{ij} are coefficients that depend on technology. Its meaning may be seen applying logarithms and taken differences:

$$\frac{\Delta P_i}{P_i} = \sum_{j=1}^{m} a_{ij} \frac{\Delta I_j}{I_j} \quad i = 1 \ldots n \qquad (1)$$

So, a_{ij} is the proportion in which the fractional increment of the input j contributes to the fractional increment of the output i. This may be estimated in some enterprises. The problem is that usually $m>n$ so, the number of unknowns is greater than the number of equations. A solution is to assume that the entrepreneur minimizes the total cost of the inputs. It is possible to look for the minimum of the function:

$$\text{Minimum of}: \quad F = \sum_{j=1}^{m} \Delta I_j \qquad (2)$$

subject to the restrictions:

$$\Delta P_i = \sum_{j=1}^{m} h_{ij} \Delta I_j \quad i = 1,2 \ldots n \qquad (3)$$

where $h_{ij} = a_{ij} \frac{P_i}{I_j}$

It is necessary to impose restrictions to the substitutions between the inputs (given by the classical iso-product curves). An approximate solution is to estimate some minimum r_j for each input and add the restrictions, i.e.:

$\Delta I_j \geq r_j$

The solution can be done by linear programming.

The minimization of (2) and (3) by Lagrange multipliers leads to a singular matrix, while minimization of sum of squares is workable but has not a sound economic meaning.

3) Separation of direct and indirect inputs. This separation is made in cost accounting techniques, see, for instance, [7]. Direct costs are proportional to the productions and may be used to estimated the c_{ij} of the first method. Indirect costs in the input j may be constant for ample variations of production but may change suddenly for certain increases of the productions at the successive points.

$P_{i0}, P_{i1}, P_{i2}, \ldots P_{i\max}$

with the values of the required inputs

$F_{ij1}, F_{ij2}, \ldots F_{ij\max}$

at the successive intervals of P_i between the initial production and the maximum one.

The data for this stair shaped (piece-weise constant) function F_{ij} may be estimated in the surveys. For some inputs a fraction is direct and the rest indirect. For example in a large room with many electrical machines that made a product, the electricity consumed by the machines may be proportional to quantity of product. On the other hand the electricity spent for illumination of the room is constant but may leap up if the room is enlarged or another similar room, or a new turn of work is added. The use of this information for the computation of inputs is straightforward. If g_{ij} is the fraction of direct use of the j input in the production of the product i that is variable, the change of the inputs is:

$\Delta I_j = \sum_{i=1}^{n} g_{ij} c_{ij} \Delta P_i + (1 - g_{ij}) F_{ij}$

where:

if P_i and $P_i + \Delta P_i$ lies in the intervals k and k' respectively where $k' \geq k$, then the value of the input is $F_{ij} = F_{ijk'} - F_{ijk}$

(when k = k' the increment of the input is 0)

Many other methods are possible in different enterprises and may be improved as the knowledge of the production methods increases. Different methods for computing the inputs may be used in the same database according to the fidelity of their technology's representation of the particular enterprise, and the available data.

Note that different employment's kinds may be introduced in the same way as the other inputs, using any of the described methods.

4. Experiments with the method

We were not able yet to find a database for a real national economy. Only partial data from a survey of the Venezuelan Central Bank was available. To test the method was decided to estimate data forming a sample of 250 enterprises and 15 products. The assumed data were approximately proportional to the data corresponding to the National Accounts of our country. Methods 1), 2), and 3) to compute the inputs were used obtaining different results because it was difficult to make the methods compatible for a particular real technology, but in a particular method the process was robust to some alterations in the selections of the enterprises.

Although the purpose of this paper is to show the method rather than present realistic results we give an excerpt of the output of a run to give an idea of the possible outputs in the actual algorithm. See Figure 2.

5. Conclusion

The method requires a continuous effort of updating the enterprises' database. This effort may be worthwhile to other purposes. On the other hand the method would be useful in many planning processes: changes in the volume of productions, introduction of new enterprises, changes in technology, regional planning, tax policies, ecological problems, planning in state enterprises, suggestions to private producers, and modifying industry clusters [9] Macroeconomic simulation based in microeconomic data may also be an interesting possibility.

Extensions of the actual implementation may be: introduction of time by recording the necessary times to make the changes in the productions (which may imply another type of bottleneck) separation of capital inputs, introduction of indicators to consider qualitative characteristic in the selection of enterprises, inclusion of social variables, implementation of an algorithm with a friendly environment. Some of them are in progress.

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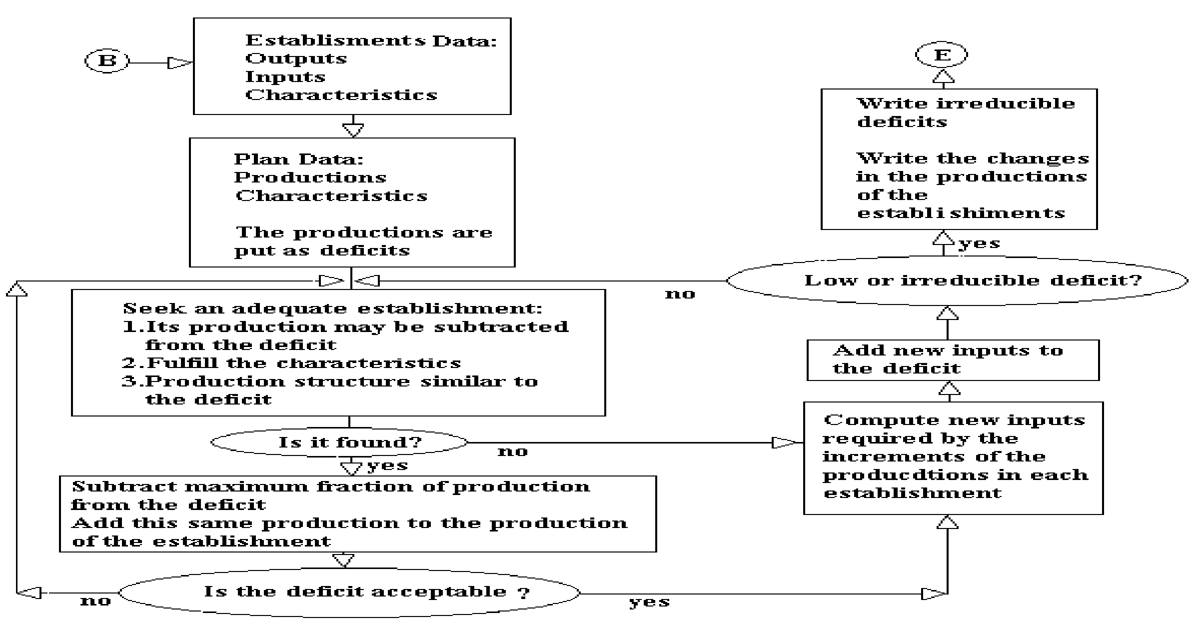

Figure 1. General scheme of the algorithm

Enter the Production Plan — **COMMENTS**

		Min			Ind		Cons				Fin				Type of product
0	0	30	0	0	20	0	140	0	0	0	10	0	0	0	Products 1 to 15 (a construction plan)

Search for Aceptable Establishment covering deficit of plan — Search for similar acceptable establishments
184 MODIFIED IncrFrac 0.30303030 AcumIncrFrac 0.30303030 — Establishmen number 184 is acceptable

Judge Deficit — Deficit is judged not acceptable
12 MODIFIED IncrFrac 0.24096386 AcumIncrFrac 0.24096386 — Establishment number 12 is acceptable

………………………………………………… — Search and Judge repeated many times…
Judge Deficit
Finish Production Adjust . Compute inputs for the new production variations
New inputs added to deficit
Judge deficit. Deficit not acceptable — New total deficit not accepted
10 MODIFIED IncrFrac 0.037 0.0AcumIncrFrac 0.037000 — Search of Establishments re-started…
…………………………………………………………………………… — Many adjustment of productions and inputs follow…
Judge Deficit
Finish Production Adjust Compute inputs for the new production variations
Original and actual deficit including new inputs
0.0 0.0 30.0 0.0 0.0 20.0 0.0 140.0 0.0 0.0 0.0 10.0 0.0 0.0 0.0
0.6 0.5 0.1 0.4 0.6 0.4 0.2 0.9 0.8 0.8 0.3 0.2 0.8 0.2 0.1 — This deficit will be acceptable (<2% of deficit)
Judge Deficit
Deficit plus new inputs accepted. Plan satisfied !!!!!!!! — Adjustment iterations are finished

RESULTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Products
5364	15928	1219	7748	1223	25115	2162	7418	26244	8199	2981	12618	4213	10547	5707	National Output
0.0	0.0	30	0.0	0.0	20	0.0	140	0.0	0.0	0.0	10	0.0	0.0	0.0	Plan
5.103	1.475	32.76	4.144	10.5	48.03	3.35	145.6	11.56	9.84	4.25	22.54	11.46	2.017	1.627	Induced Output
0.00	0.00	0.432	0.00	0.00	1.791	0.00	0.632	0.00	0.00	0.00	1.89	0.00	0.00	0.00	Plan deficit %

Modified Establishments (Total 29 from 250)

#Est%	Var%	Prod	Inputs	Imported	Empl	Aggr.Val	Zone
2	1.388%	170.000	61.114	10.454	56	98.432	Zulia
Var.			2.360*	0.849*	0.145*	1*	1.367*
10	0.037%	3952.000	395.347	232.180	1423	324.473	Oriente
Var.			1.475*	0.148*	0.087*	1*	1.241*
12	24.096%	127.000	64.944	10.877	63	51.179	Guayana
Var.			31.699*	15.004*	4.888*	14*	27.002*
… ………………………							23 more modified establishments follow…
211	0.403%	852.000	271.831	127.083	564	453.086	Centro
Var.			3.431*	1.095*	0.512*	2*	1.825*
213	2.018%	62.000	18.074	8.830	40	35.096	Zulia
Var.			1.251*	0.365*	0.178*	1*	0.708*
217	4.299%	350.000	89.236	30.035	121	230.729	Centro
Var.			15.047*	3.836*	1.291*	5*	9.20 Centro

Figure 2. A run of the actual algorithm. (excerpt of the output)