DETECTION OF KEY SECTORS BY USING SOCIAL ACCOUNTING MATRICES: AN ALTERNATIVE APPROACH[1]

by

M. Alejandro Cardenete[2], Gaspar J. Llanes[3]

M. Carmen Lima[4], Carmen R. Morilla[5]

Abstract

This paper provides a new methodology for the detection of productive key sectors within a national (or regional) economy. In contrast with other methods applied so far, this one presents two innovations. Firstly, the so-called *traditional models*, which are based on building normalised backward and forward linkage indicators, are combined with more modern *extraction models*. Secondly, Social Accounting Matrices (SAM) are the databases used instead of Input-Output Tables (IOT), in order to determine those indicators. This paper attempts to show the advantages of this system by empirically applying it to the SAM for Spain in the year 2000, in order to detect the key sectors in Spanish economy.

Keywords: Input-Output Tables, Social Accounting Matrix, national accounting, key sectors.

1 INTRODUCTION

The systems to determine productive key sectors are usually classified into two methodological categories: the so-called *traditional models*, and the *hypothetical extraction*

Contact author: M. Carmen Lima: Department of Economics, Universidad Pablo de Olavide Ctra. Utrera, km.1. 41013 Seville, SPAIN. mlimdia@upo.es

[1] Acknowledgements

The first author would like to thank the funding provided by the Centre for Andalusian Studies Foundation and is also very grateful to the SEC2003-05112/ECO research project from the Spanish Ministry of Science and Technology. The first and second authors would like to thank the General Secretariat for Economic Affairs of the Andalusian Regional Government. The first and third authors are grateful to the "Excellence Research Project" SEJ-01252 and to the SEJ-246 research project, both from the Andalusian Regional Government, as well as to the XT0039-2004 research project, from the Catalonian Regional Government. The fourth author would like to thank the National Institute for Statistics. The authors take responsibility for any error in this paper.

[2] Department of Economics, Universidad Pablo de Olavide.

[3] General Secretariat for Economic Affairs, Andalusian Regional Government.

[4] Department of Economics, Universidad Pablo de Olavide.

[5] Department of Applied Economics II, Universidad de Sevilla.

models. Briefly, both traditional and hypothetical models are based on the combination of two indicators: *a backward linkage* (*BL*) indicator and a *forward linkage* (*FL*) indicator, which are traditionally obtained from a symmetrical input-output table (SIOT).

The backward linkage indicator (*BL*) analyses the effect of a change in the final demand of a specific sector on the economy total production, whereas the forward linkage indicator (*FL*) values the effect that a global change in the final demand of all sectors has on the production of a specific sector.

Through these indicators it is possible to determine the key activity sectors in an economy. Those sectors, supported by their generating a high multiplier and fostering effect on production, can be used to design strategies for development as part of the economic policy.

In this paper, following Cardenete and Sancho (2006), we suggest the use of a Social Accounting Matrix (SAM), which is a more complex database than the traditional SIOT, to detect the key sectors. It is well known that Social Accounting Matrices bring about an enlargement of the traditional input-output frame, since they reflect the complete circular flow of income. From this perspective, the measurement of the economic transactions incorporated in a SAM allows the extraction of more precise information about the different economic agents, such as producers, consumers, public administration and the foreign sector, as well as about the behaviour of the productive factors[6].

The methodological proposal in this paper rests on a simple approach that seeks to extend the input-output approach to account for all the backward and forward linkages between sectors, factors and demand. This method combines the so-called *traditional models*, based on building normalised backward and forward linkage indicators, with more modern *extraction models* and it uses Social Accounting Matrices (SAM) as databases instead of Input-Output Tables (IOT). This is a simple way to enlarge the set of interdependencies to effectively include the missing links between production and the income and expenditure side. Lost output will also translate now into lost factor income and reduced expenditure, hence furthering the economic impact of the extracted sector.

The present paper is divided into several sections. First of all, we will briefly go over the main models used to detect key sectors, paying particular attention to those that will be useful for our empirical application. In the next section we will present the results of the simulations already done and we will then finish with a summary of the main conclusions.

2 MODELS FOR THE DETECTION OF KEY SECTORS.

The analysis of the so-called linkages, which are used to examine the interdependence between productive structures, has had a long history since the pioneering works of Chenery and Watanabe (1958), Rasmussen (1956) or Hirschman (1958).

[6] For furtner advantages in the use of multipliers based on SAM instead of on IOT, see Roland-Holst, D.W. (1990).

In this paper we suggest the use of the methodology developed by Rasmussen (1956) to obtain the *BL*, and that of Augustinovics (1970) designed to obtain the *FL*, both of them considered as traditional models. Concerning the *BL*, we particularly propose the database to be a SAM and not a SIOT. This SAM should have a high degree of endogenisation in the institutional sectors, which would allow an adequate close of the circular flow of income. At the least, not only productive factors' (labour and capital) rent should be endogenised, but also that of households. In this way, if we analyse the *BL* we find out that the change in the final demand of a certain sector will not only reflect how the rest of the sectors may change in order to 'supply' that alteration in the final demand, but also, since the productive activity will increase, the factors' remuneration and the consumers' expenditure will increase as well, thus influencing the productive sectors again in a "second round".

Starting with the model proposed by Rasmussen (1956), we calculate the associated inverse matrix $B_t = (I - A_t)^{-1}$, being I an identity matrix of size n and A_t the average tendency matrix of expenditure between the different endogenous accounts in the SAM.

Furthermore, we derive a vector $B_{.j}$ in which each element corresponds with the sum of a column in the matrix (we can develop an analogous analysis for rows). The elements of the associated inverse matrix B_t are denoted by b_{ij}.

$$B_{.j} = \sum_{i=1}^{n} b_{ij} \qquad j = 1 \ldots n \tag{1}$$

The next step is to obtain the expression of the *BL*. Following Rasmussen (1956) and Hirschman (1958) we can normalise the previous equation as:

$$BL_j = \frac{B_{.j}}{\frac{1}{n}V} \qquad j = 1 \ldots n \tag{2}$$

where V is:

$$V = \sum_{i=1}^{n} \sum_{j=1}^{n} b_{ij} \qquad i, j = 1 \ldots n \tag{3}$$

Once this indicator is normalised, if the backward linkage is above one, a one unit change in the final demand of sector j will generate a growth above the average on the global activity of the economy.

In 1976, Jones stated that the detection of *FL* as defined by Rasmussen (summation of rows in Leontief inverse matrix) did not have the property of being a symmetrical measurement as far as *BL* (summation of rows in Leontief inverse matrix) are concerned. From a similar perspective, Augustinovics (1970) had already brought up the detection of *FL* by means of the rows summation of the Ghoshian inverse matrix, in which the distribution coefficients (δ_{ij}) – obtained from the SIOT by dividing each cell by the row total and not by the column total – replace the technical coefficients. Ghosh model calculates changes in gross sectoral outputs for exogenously specified changes in the sectoral inputs of primary factors. Ghosh's 'supply-driven' input-output model is a well-known alternative to Leontief's traditional 'demand-driven' input-output model, as Dietzenbacher (1997) observed.

This way, *FL* is calculated as $O_{i.}$:

$$O_{i.} = \sum_{j=1}^{n} \delta_{ij} \qquad i = 1 \dots n \tag{4}$$

From where we may obtain a valuation of the global effect that altering the supply of primary inputs in a particular sector has on all sectors. As it is shown in equation (2), the normalisation process of O_i is as follows:

$$FL_j = \frac{B_{i.}}{\frac{1}{n}V} \qquad i = 1 \dots n \tag{5}$$

Again, after its normalization, if the indicator is above one, a one unit change in all sectors will generate a growth above the average in sector i. In this case, we will use the SIOT for the simple reason that, if primary inputs, which are the thread of the circular flow of income, are kept as exogenous, the economic interpretation lying in FL will lose its meaning once the institutional sectors are endogenized through the use of the SAM.

Those sectors in which both forward linkages and backward linkages values are above one will be considered to be key sectors.

As opposed to the already commented traditional models, *hypothetical extraction models* value the importance of a sector by analysing the consequences derived from its elimination. Depending on whether a sector is included or not, the output may present differences, which will measure the importance of such sector. The first approach to applying this methodology was that of Paelinck et al. (1965), which was further developed and refined by Strassert (1968), Schultz (1977), Cella (1984), Clements (1990) and Heimler (1991). In this paper we follow Dietzenbacher et al. (1993) approach, which is a reviewed version of previous extraction models.[7]

The importance of a sector is presented in terms of backward and forward linkages within a system with and without the extracted element. Following this last approach, we will briefly explain the first of those linkages[8], BL, as it is presented in the following equation. In this case, the importance of a key sector is calculated as the difference in the total output of the complete economic system once that sector has been extracted:

$$\begin{pmatrix} x^i - \bar{x}^i \\ x^r - \bar{x}^r \end{pmatrix} = \left\{ \begin{bmatrix} L_n^{ii} & L_n^{ir} \\ L_n^{ri} & L_n^{rr} \end{bmatrix} - \begin{bmatrix} (I - A_n^{ii})^{-1} & 0 \\ 0 & (I - A_n^{rr})^{-1} \end{bmatrix} \right\} \begin{pmatrix} f^i \\ f^r \end{pmatrix} \tag{6}$$

Where x is the total output in a complete economic system, $\bar{x}$ is the total output once the sector has been taken out, L is Leontief inverse matrix, A is the technical coefficients matrix, f is the final demand vector, and the superscripts i and r represent the extracted sector and the rest of the system respectively. If we work with an IO table, the n order of the matrices will coincide with that of productive sectors. However, if we work with a SAM, it will turn out to be a higher number equivalent to the number of sectors considered as endogenous. According to Dietzenbacher et al. (1993), total effects of the left part of the equation reflect the backward linkages of sector i on

[7] A review of the *extraction models* can be found in Miller and Lahr (2001).

[8] For details on the obtaining of BL and FL, see Dietzenbacher (1993).

the rest of the economy and those of the rest of the economy on sector i. In our empirical application we calculate vector $x-\bar{x}$ by taking out one sector at a time; so that it will be done n times.

Any element (i, j) in this matrix will represent that case in which sector j has been extracted. This (j, j) diagonal matrix will measure the rest of the sectors' backward linkage on sector j. This is what we call *intrasectorial backward feedback effect*.

Therefore, those elements that do not belong to the matrix's main diagonal will actually represent the *backward linkages*. If we add up the elements of each column in the extraction matrix, we will obtain the total effects (or *total linkages*).

In terms of the forward linkage, the difference is as follows:

$$\left[(x^{i}-\bar{x}^{i}),(x^{r}-\bar{x}^{r})' \right] = (v^{1'} v^{r''}) \left\{ \begin{bmatrix} G_n^{ii} & G_n^{ir} \\ G_n^{ri} & G_n^{rr} \end{bmatrix} - \begin{bmatrix} (I-B_n^{ii})^{-1} & 0 \\ 0 & (I-B_n^{rr})^{-1} \end{bmatrix} \right\} \tag{7}$$

Where v denotes the primary input vector, G is the Ghosian inverse, B is the output allocation matrix and the rest of the elements have already been described above. See Dietzenbacher et al. (1993) for a further development of the extraction model.

In this second methodology, we can see the same arguments repeated when interpreting the outcomes if we use the SAM and the SIOT. Consequently, we will use the SAM to calculate BL, and the SIOT to calculate FL.

3 DATABASE AND EMPIRICAL APPLICATION

This work has been developed by taking a domestic Social Accounting Matrix for Spain, which was elaborated by Morilla and Llanes (2004). This matrix was created according to SEC95[9]'s criteria and was disaggregated in 30 activity sectors. For its updating the "Cross Entropy Method" (CEM), which was developed by Robinson et al. (2001), has been applied.

We have proceeded to calculate the BL and FL that correspond to each activity sector, which can be consulted upon in the appendix in detail.

In order to simplify, we will now present the detected productive key sectors, which are shown in Table 1. The first simulation presents the key sectors that have been exclusively detected from the SIOT by following a combination of Rasmussen's BL and Augustinovics' FL *traditional models*. In the other two columns, key sectors detected through the use of a *traditional model* again and through a *hypothetical extraction model* are shown respectively. However, in this case, a SAM has been used for the BL, whereas the FL have resulted from using an IO table.

When a SAM is used to calculate the backward linkage, one may see that we can detect a number of key sectors (11) higher than the number resulting from using an IO table (7) exclusively. The new detected sectors are services such as Trade and Repair (21), Transport and Communications (23), Real Estate and Business Services (25). This is due to the fact that multiplier effects of the Services activity are minimised if only

[9] See Carrasco (1999).

Table 1: Comparison of key sectors by using different methodologies and databases.

	Traditional Models		Extraction Models
	BL Rasmussen IOT FL Augustinovics IOT	BL Rasmussen SAM FL Augustinovics IOT	BL Dietzenbacher SAM FL Dietzenbacher IOT
Key sectors	7	6	7
	14	7	20
	15	14	21
	17	15	22
	20	17	23
	22	20	25
	24	21	
		22	
		23	
		24	
		25	

Notes: IOT refers to Input Output Table; SAM refers to Social Accounting Matrix; the calculation of FL and BL has already been explained above.
Source: Own elaboration.

intermediate relations of an exclusively productive character are taken into account. Since Services are more intensive in labour force, their effects are therefore potentiated by the circular flow of income.

The simulation corresponding to the *hypothetical extraction model* is still more restrictive as far as the number of detected key sectors is concerned (just 6). This is due to the fact that apart from being influenced by inner productive interrelations, this model also takes into account the actual quantitative importance of a sector in the economy as a whole. In this case, the key sectors are also branches of services, except for Food, Beverage and Tobacco Industries (7) as well as for Building Industry (20).

4 CONCLUSIONS

Although the detection of key sectors has had a long history, it is worth mentioning the contributions of Rasmussen (1956), Augustinovics (1970) and, most recently, Dietzenbacher et al. (1993). These methodologies share their capacity to select those sectors within an economy which are capable of vigorously boosting and transmitting a process of growth in production, employment or GDP in the short term.

The contribution of this paper consists of extending key sector analysis from an Input-Output approach to a SAM framework. This allows us to explore and measure the effects that added endogeneity has for the detection and output evaluation of key sectors. The use of one or other of the models and the choice of a database to which those models are applied can lead to complementary analyses to determine the key sectors within an economy, as proved in this paper. In particular, our method uses the So-

APPENDIX: Table A-1: *BL* and *FL* from SAM-2000 and IOST-2000 for Spain under different simulations.

	Traditional Models			Extraction Models	
	1	2	3	4	5
Sectors	BL Rasmussen IOST	BL Rasmussen SAM	FL Augustinovics IOST	BL Dietzembacher SAM	FL Dietzembacher IOST
1 Agriculture, stockbreeding, hunting and silviculture	1,02	1,18	0,91	0,67	1,55
2 Fishing	0,95	1,16	0,57	0,04	1,63
3 Energy products extraction	0,87	1,20	0,57	0,04	0,22
4 Extraction of minerals other than energy products	1,02	1,14	0,59	0,07	0,34
5 Petroleum refine and nuclear fuel processing	0,70	0,52	0,63	0,17	0,68
6 Electric power, gas and water production and distribution	0,88	1,07	1,15	0,50	1,65
7 Food, beverage and tobacco industry	1,38	1,35	2,01	1,27	3,45
8 Textile and clothing industry	0,98	0,97	0,81	0,26	2,62
9 Leather and footwear industry	1,29	1,08	0,88	0,10	0,49
10 Timber and cork industry	1,06	1,05	0,73	0,15	0,56
11 Paper industry; publishing, graphic arts and reproduction	1,03	0,99	0,86	0,36	1,26
12 Chemical industry	0,97	0,89	0,89	0,45	1,83
13 Rubber processing and plastic materials industry	0,85	0,83	0,68	0,19	1,48
14 Non-metallic mineral products industry	1,09	1,17	1,08	0,44	1,58
15 Metallurgy and metallic products manufacture	1,07	1,03	1,20	0,72	2,85
16 Machinery and mechanical equipment building industry	1,01	1,03	0,77	0,36	2,41
17 Electric, electronic and optical materials and equipment industry	1,21	1,20	1,07	0,45	1,31
18 Transport material manufacture	0,93	0,78	1,04	0,61	1,52
19 Various manufacturing industries	1,09	1,07	0,84	0,26	1,17
20 Building industry	1,14	1,18	2,44	1,94	2,96
21 Motor vehicle trade and repair	0,89	1,17	1,21	2,07	5,23
22 Hotel industry	1,03	1,20	1,44	1,67	3,96
23 Transport, warehousing and communications	0,86	1,12	1,00	1,51	4,40
24 Financial brokerage	2,07	1,54	1,95	0,49	4,13
25 Real estate and renting activities; business services	0,84	1,15	1,21	2,43	4,70
26 Public Administration, defense and social security	0,79	1,16	0,76	0,90	3,93
27 Education	0,70	1,17	0,64	0,75	0,50
28 Health and veterinary activities; social services	0,76	1,17	0,71	0,82	0,53
29 Other social and community service activities	0,90	1,18	0,78	0,56	0,70
30 Households hiring domestic personnel	0,60	1,18	0,55	0,17	0,36

(cont.)

Source: Morilla, C.R. and Llanes, G. (2004) and own elaboration. Note: Identification of *key sectors*: Activity sectors with both *BL* and *FL* values above 1.

cial Accounting Matrix since it reflects the effects derived from the circular flow of income. Therefore, it allows reaching more precise conclusions, especially in relation to the strategic importance of certain activities of the Services sector, which could be eclipsed by those key sectors detected exclusively from a SIOT perspective. The differential effects can be important enough to provide valuable information to help policy makers in accomplishing a more insightful design of industrial and development policies that may affect the economy as a whole.

REFERENCES

Augustinovics, M. (1970) "Methods of International and Intertemporal Comparison of Structure", in A. P. Carter and A. Bródy (Ed.) *Contributions to Input-Output Analysis*, pp. 249–269, Amsterdam, North-Holland.

Carrasco, F. (1999) *Fundamentos del Sistema Europeo de Cuentas Nacionales y Regionales* (*SEC 1995*). Ediciones Pirámide. Madrid.

Cardenete, M. A. and Sancho, F. (2006) "Missing Links in Key Sector Analysis", Economic Systems Research, 18 (3), pp. 319–327.

Cella, G. (1984) "The Input-Output Measurement of Interindustry Linkages", *Oxford Bulletin of Economics and Statistics*, 46, pp. 73–84.

Chenery, H. B. and Watanabe, T. (1958) "International Comparisons of the Structure of Production", *Econometrica*, 26, pp. 487–521.

Clements, B. J. (1990) "On the Decomposition and Normalization of Interindustry Linkages", *Economics Letters*, 33, pp. 337–340.

Dietzenbacher, E. (1992) "The Measurement of Interindustry Linkages: Key sectors in The Netherlands", *Economic Modelling*, 9, pp. 419–437.

Dietzenbacher, E.. van der Linden, J. A. and Steenge, A. E. (1993) "The Regional Extraction Method: EC Input-Output Comparisons", *Economic Systems Research*, 5, pp. 180–206.

Dietzenbacher, E, (1997) "In vindication of the Ghosh model a reinterpretation as a price model", *Journal of regional Science*, 37 (4), 1997, pp. 629–651.

Heimler, A. (1991) "Linkages and Vertical Integration in the Chinese Economy", *Review of Economics and Statistics*, 73, pp. 261–267.

Hirschman, A. (1958) *The strategy of economic development*, New Haven: Yale University Press.

Jones, L. P. (1976) "The Measurement of Hirschman Linkages", *Quarterly Journal of Economics*, 90, pp. 323–333.

Miller, R. E. and Lahr, M. L. (2001) "A taxonomy of extractions", in: M. L. Lahr and R. E. Miller (Eds.) *Regional Science Perspectives in Economic Analysis: A Festschrift in Memory of Benjamin H. Stevens*, pp. 407–411 (Amsterdam Elsevier Science).

Morilla, C. R. and Llanes, G. (2004) "Multiplicadores domésticos SAMEA en un modelo multisectorial ecoambiental de la economía española", *mimeo*.

Paelinck, J., Caevel, J de and Degueldre, J. (1965) "Analyse Quantitative de Certains Phénomènes du Développement Régional Polarisé: Essai de Simulation Statique d'Itinéraires de Propagation", In: *Problèmes de Conversion Economique: Analyses Théoriques et Etudes Appliquées* (Ed. Génin M. T.) pp. 341–387, Bibliothèque de l'Institut de Science Economique, Paris.

Rasmussen, P. (1956) *Studies in Inter-Sectorial relations*, Einar Harks, Copenhagen.

Robinson, S., Cattaneo, A. y El-Said, M. (2001) "Updating and Estimating a Social Accounting Matrix Using Cross Entropy Method", *Economic Systems Research*, 13 (1), pp. 47–

64.

Roland-Holst, D. W. (1990) "Interindustry analysis with social accounting methods", *Economic Systems Research*, 2 (2), pp. 125–145.

Schultz, S. (1977) "Approaches to Identifying Key Sectors Empirically by Means of Input-Output Analysis", *Journal of Development Studies*, 14, pp. 77–96.

Strassert, G. (1968) "Zur Bestimmung Strategischer Sektoren mit Hilfe von Input-Output Modelen", *Jahrbücher für Nationalökonomie und Statistik*, 182, pp. 211–215.