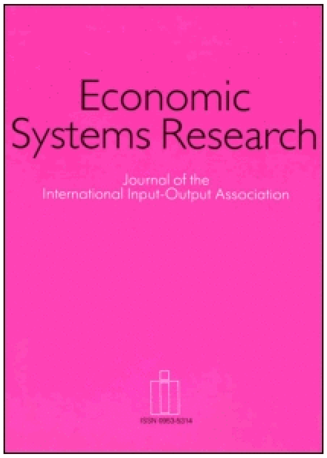

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Missing Links in Key Sector Analysis

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ABSTRACT *In general terms, key sectors analysis aims at identifying and quantifying the economic impact of a sector in a given economy. For a sector, we mean here either an industry or a region, or even a cluster of them. Quite a few measures and methodologies of varied complexity have been proposed in the literature, from multiplier sums to extraction methods, but not without debate about their properties and information content. All of them, to our knowledge, focus exclusively on the interdependence effects that result from an input–output structure of the economy. By so doing the approach misses critical links beyond the interindustry ones. A productive sector's role is that of producing but also that of generating and distributing income among primary factors and households as a result of production. Thus, when measuring a sector's role, the income generating process should not be omitted if we want to elucidate the sector's true economic impact. A simple way to make the missing income links explicit is to use the SAM (Social Accounting Matrix) facility. Extending an extraction methodology to the SAM we compare lost output with and without the missing links. We observe that substantial differences in sectoral lost gross output arise but, even more important, we capture the implied shifting in the rank ordering of sectors.*

KEY WORDS: Key sectors, extraction methods, economic linkages, SAM analysis

1. Introduction

What is the importance of an economic sector? To this very simple question economists have provided many answers, from straightforward backward and forward linkage indicators based on multiplier matrices to differential output measures based on hypothetical extraction methods or other related procedures. Still there is no fully accepted consensus on which measure is most appropriate. Each measure has its own share of pros and cons depending upon what specifics they try to capture and quantify. Backward (BW) linkages, for instance, are constructed from the Leontief inverse whereas forward linkages (FW) use the inverse matrix from the Ghosh model. While the Leontief model has a clear technological interpretation well rooted in production theory, the Ghosh model lacked a

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corresponding embedding in standard micro theory until Dietzenbacher (1997) suggested interpreting the model as a price model. For a long time therefore, more conceptual credit has been given to BW linkages than to FW linkages since only the former were believed to trace the ripple effects implicit in the underlying technology. The notions of backward and forward linkages started with Chenery and Watanabe (1958), Rasmussen (1956), and were further developed by many authors. Schultz (1977), Sonis *et al*. (1995, 1997) and Dietzenbacher (2002) are good surveys of this literature and its developments. Recently, the hypothetical extraction method (HEM) has received ample attention again as an alternative to simple linkage measures. The basic idea behind HEM is that to elicit the economic role of a sector, or a cluster of sectors, we somehow need to simulate the impact of its elimination from the economy. Should a given sector cease to interact with the rest of sectors, what would the opportunity cost be measured in terms of lost gross output? A comprehensive recapitulation of HEM can be found in Miller and Lahr (2001) and recent applications include Sánchez-Chóliz and Duarte (2003) and Cai and Leung (2004).

These two approaches, different as they are, have followed closely and exclusively the interindustry framework. This has the advantage of simplicity but two possible problems. Firstly, substantial links from the income and expenditure circuits may be unnecessarily omitted. Secondly, the extraction of a sector, let us name it sector i, is modelled replacing the initial input–output matrix $\mathbf{A}$ with a new matrix $\mathbf{A}_{(i)}$ where the coefficients describing bilateral interactions between i and the rest of sectors j (with $j \neq i$) are reset to zero. This amounts, even if it is merely hypothetically, to an input-reducing change of techniques, hence cost reducing too given the input–output fixed prices implicit assumption. If the economy is able to operate with the new matrix, one wonders why it operated first with higher costs. An explanation is sometimes offered based on the presence of foreign trade (Dietzenbacher and van der Linden, 1997; Miller and Lahr, 2001). Thus, another implicit assumption is that after the extraction, the remaining sectors can shift their previous (but now domestically unavailable) input purchases to the foreign partners at no cost (that is to say, perfect substitutability and small country assumptions at the very least). Two comments are in order here. Firstly, the interactions are never made explicit in the subsequent modelling and, secondly, the shifting makes sense only if the omitted sector produces a tradable good. These conceptual difficulties might conceivably be dealt with using a fully specified CGE model.

The methodological proposal in this note rests in a simpler approach that seeks to extend the input–output approach to account for all the BW linkages between sectors, factors and demand. These interactions can be made explicit if we make use of the detailed bilateral exchanges given by a Social Accounting Matrix (SAM) and its underlying linear model. Notice that the input–output model is embedded as a subset of the SAM model but one that misses some of the aforementioned income-expenditure critical links. A simple way out is 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 eliminated sector. We do not distinguish here between tradable and non-tradable goods since we focus on the methodology rather than on the classification of goods – an empirical matter, after all. In the next section we present our extension of the extraction methodology to the SAM framework. The section after illustrates some results obtained using a recent numerical SAM of the Spanish economy. The final section concludes.

2. The SAM Model and the Hypothetical Extraction

A SAM is a square database detailing all direct bilateral exchanges among agents and sectors. Because all income is accounted for, row sums coincide with column sums for each and all agents and sectors. This consistency requirement correctly identifies all budget constraints. A typical SAM includes n production sectors, k primary factors, h consumers, a capital account describing the savings/investment flows, as well as accounts for the government and the external sectors. In this simple presentation, all in all, we would have a total of $m = n + k + h + 3$ accounts. These m accounts are commonly separated into e endogenous and x exogenous accounts with $m = e + x$. If we denote total endogenous and exogenous income vectors, respectively, by $\mathbf{y}_e$ and $\mathbf{y}_x$, and we partition the normalized SAM into corresponding submatrices we obtain:

$$\begin{pmatrix} \mathbf{y}_e \\ \mathbf{y}_x \end{pmatrix} = \begin{bmatrix} \mathbf{A}_{ee} & \mathbf{A}_{ex} \\ \mathbf{A}_{xe} & \mathbf{A}_{xx} \end{bmatrix} \begin{pmatrix} \mathbf{y}_e \\ \mathbf{y}_x \end{pmatrix} \tag{1}$$

We can now use equation (1) to express endogenous income $\mathbf{y}_e$ as a function of exogenous income $\mathbf{y}_x$

$$\mathbf{y}_e = \mathbf{A}_{ee}\mathbf{y}_e + \mathbf{A}_{ex}\mathbf{y}_x = (\mathbf{I} - \mathbf{A}_{ee})^{-1}\mathbf{A}_{ex}\mathbf{y}_x = (\mathbf{I} - \mathbf{A}_{ee})^{-1}\mathbf{z} \tag{2}$$

Expression (2) yields the Leontief model as a special case when $e = n$. Under this assumption on endogenous accounts, the matrix $\mathbf{A}_{ee}$ coincides with the n-dimensional Leontief coefficients matrix $\mathbf{A}$, the n-vector $\mathbf{y}_e$ is the vector of gross sectoral outputs, and the vector $\mathbf{z} = \mathbf{A}_{ex}\mathbf{y}_x$ is the n-vector of final demands. Assume now that we want to capture the linkages between the n industrial sectors and a previously exogenous sector. We can proceed in this direction by enlarging the set of interdependencies in equation (2) incorporating the newly added sector. We would now have $e = n + 1$ endogenous accounts in the model, and correspondingly endogenous income $\mathbf{y}_e$ would be a $n + 1$ vector whereas exogenous income $\mathbf{z} = \mathbf{A}_{ex}\mathbf{y}_x$ would now be an $n - 1$ vector. We can then compare industrial sectoral outputs in the standard Leontief and the extended SAM models by comparing the first n coordinates of the endogenous vectors $\mathbf{y}_e$ that solve equation (2) in both cases. This enlargement can of course include more than one newly added endogenous sector. Thus, it is traditional in SAM analysis to include consumers (h) and factors (k) as the new endogenous sectors.[1]

The extraction of a given productive sector, say l, adapting Dietzenbacher *et al*. (1993) amounts to resetting all inter-industry technical coefficients a_{il} and a_{li} to zero for $i \neq l$. Sector l ceases to relate to the remaining sectors by not purchasing inputs from them and not selling its output to them. Sector l still operates providing inputs to itself, purchasing inputs from abroad, and supplying goods to exogenous final demand. Sectors $i, j \neq l$ continue to relate to each other, to purchase imported inputs and to sell to final demand. We therefore have two matrices, the initially given Leontief matrix $\mathbf{A}$ (or $\mathbf{A}_{ee}$ with $e = n$) and the hypothetical matrix $\mathbf{A}_{ee}^{(l)}$ (with $e = n + h + k$) where sector l is extracted, and using equation (2) two corresponding income vectors $\mathbf{y}$ and $\mathbf{y}_e^{(l)}$. By comparing the first n coordinates of these two vectors, we have an estimate of the role played by the extracted sector in terms of output (since these n coordinates indicate gross sectoral outputs) that would be hypothetically lost should sector l be extracted. Notice that incorporating more endogeneity in the enlarged matrix $\mathbf{A}_{ee}^{(l)}$ should give rise to a larger output loss in comparison to the standard extraction applied to the Leontief matrix.

3. Numerical Results

Tables 1 and 2 summarize the results obtained applying the standard Leontief extraction and the proposed extended SAM extraction to a recent SAM database assembled for the Spanish economy (Cardenete and Sancho, 2004). Table 1 shows the effects of sector extraction measured by gross lost output under the standard Leontief assumption and extended SAM endogeneity. In the first case, only the ten productive sectors are considered; in the second one, primary factors and consumption are taken as endogenous to incorporate factors' income generation and distribution. Thus, there are 13 endogenous accounts (10 productive sectors, labour, capital, and consumption) but output losses are compared under the first 10 production coordinates. As an example, the hypothetical extraction of sector 1 (Agriculture) results in a total lost output of €40.98 billion under the standard Leontief set-up. The output loss rises substantially to €69.57 billion, however, when added general equilibrium effects are taken into account since lost industrial output also entails lost income and henceforth lost consumption – aspects that are not included under the Leontief computations. Similar results at the aggregate level are observed for the rest of sectors; sectoral variation can be, however, more pronounced as individual figures shown and Table 2 depict. In Table 2, we illustrate how the hierarchy of key sectors changes depending on the modelling option – and its corresponding numerical database. In short, sectoral importance depends on the included links and, as a general rule, there is substantial shifting in the ordering. Agriculture turns out to be a rather stable sector as far as key sector detection is concerned since the ranking remains quite similar under both modelling options. In the rest of the sectors, however, the ordering changes dramatically. The one sector that keeps its position in the ordering is sector 10 (public sector) indicating its very feeble backward linkages to the rest of sectors.

4. Concluding Remarks

The contribution of this note consists of extending the HEM 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 omission of the general equilibrium links relating output to factorial income and final consumption may be of critical relevance both in aggregate terms (lost gross output) and in the rank ordering of sectors (hierarchy shifting). The problem rests in the simple view of the economy implicit in the Leontief model. In contrast, the SAM model does not lose as much structural information since it encompasses a more structurally detailed view of the workings of the economy. Since the use of a SAM modelling option for key sectors detection is analytically straightforward, our numerical results yield support for its use whenever a SAM database is available. If nothing else a clear categorization of sectoral importance, in differential level as well as in rank ordering, can be revealed when comparing results under the standard approach and the extended SAM alternative. 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.

Table 1. Comparison of backward linkages from Leontief and SAM models

	Extracted sectors									
Sectors	1	2	3	4	5	6	7	8	9	10
	Gross output effect: SAM model (in millions of euros)									
1	22427	402	875	19359	1026	2047	5364	2981	10181	1353
2	2195	18192	5208	3136	2783	2711	7362	4209	9734	2191
3	1837	865	13904	2975	1472	2631	5925	2721	7838	2340
4	9461	989	2113	28586	2445	4480	9286	6099	27568	3202
5	2566	520	731	3477	17300	3864	8630	3836	6311	2728
6	2185	785	1635	3201	1939	20898	8561	7139	12011	3815
7	6016	1640	3297	11869	5427	24606	71116	30409	26324	6229
8	967	333	655	1516	667	1405	2635	12977	10899	2052
9	21693	6467	12157	36648	15406	31073	58111	42929	125689	21287
10	222	55	127	314	114	231	455	310	721	131
Total	69569	30249	40702	111082	48578	93946	177446	113609	237277	45329
	Gross output effect: Leontief model (in millions of euros)									
Sectors	1	2	3	4	5	6	7	8	9	10
1	22078	55	84	18718	318	612	2665	1051	6675	532
2	1136	131	157	25303	694	923	2378	1314	19330	1172
3	967	2300	2663	13892	6910	13888	25187	19749	77144	11396
4	6294	736	1250	7219	3605	21170	66569	25612	17068	4081
5	1848	324	283	2527	17140	3086	7410	2754	4384	2261
6	694	18073	4693	1687	2243	1587	5395	2693	7232	1539
7	2479	643	13637	1812	1018	1712	4297	1464	5746	1804
8	324	408	787	1126	1174	19909	5767	5072	8331	2920
9	5160	171	288	630	334	734	1365	12783	10329	1667
10										
Total	40980	22841	23842	72912	33437	63622	121034	72492	156239	27372

Sectoral classification: (1) Agriculture; (2) Mining; (3) Energy; (4) Foodstuffs; (5) Chemical products; (6) Machinery and transport equipment; (7) Other manufacturing; (8) Construction; (9) Private services; and (10) Public sector services.

Table 2. Shifting of key sectors hierarchy

SECTOR 1		SECTOR 2		SECTOR 3		SECTOR 4		SECTOR 5	
Leontief model	SAM model	Leontief model	SAM model	Leontief model	SAM model	Leontief model	SAM model	Leontief model	SAM model
1	1	6	2	7	3	2	9	5	5
4	9	3	9	6	9	1	4	3	9
9	4	4	7	3	2	3	1	4	7
7	7	7	4	4	7	4	7	6	2
5	5	8	3	8	4	5	5	8	4
2	2	5	6	9	6	7	6	7	6
3	6	9	5	5	1	6	2	2	3
6	3	2	1	2	5	8	3	9	1
8	8	1	8	1	8	9	8	1	8
10	10	10	10	10	10	10	10	10	10

SECTOR 6		SECTOR 7		SECTOR 8		SECTOR 9		SECTOR 10	
Leontief model	SAM model	Leontief model	SAM model	Leontief model	SAM model	Leontief model	SAM model	Leontief model	SAM model
4	9	4	7	4	9	3	9	3	9
8	7	3	9	3	7	2	4	4	7
3	6	5	4	9	8	4	7	8	6
5	4	8	5	8	6	9	6	5	4
7	5	6	6	5	4	8	8	7	5
6	2	7	2	6	2	6	1	9	3
2	3	1	3	7	5	1	2	6	2
9	1	2	1	2	1	7	3	2	8
1	8	9	8	1	3	5	5	1	1
10	10	10	10	10	10	10	10	10	10

Sectoral classification: (1) Agriculture; (2) Mining; (3) Energy; (4) Foodstuffs; (5) Chemical products; (6) Machinery and transport equipment; (7) Other manufacturing; (8) Construction; (9) Private services; and (10) Public sector services.

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Note

[1]This common endogeneity assumption would make the SAM model somewhat similar to a closed input–output model. The SAM model, however, is more transparent and flexible and allows for alternative endogeneity assumptions (Robinson and Roland-Holst, 1988).

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