THE MISSING LINK IN KEY SECTORS ANALYSIS[1]

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Abstract

In general terms key sectors analysis aims at identifying the impact that a productive sector has in the economy. 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 the 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' economic role. A simple way to make the missing income link explicit is to use the SAM (Social Accounting Matrix) facility. Using a standard extraction methodology we compare lost output with and without the missing link and observe the substantial differences in sectoral lost gross output associated as well as the implied shifting in the rank ordering within a sector.

Keywords: Key sectors, Extraction methods, Multisectoral models, Input-output analysis, SAM analysis.

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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 Gosh model. While the Leontief model has a clear technological interpretation well rooted in production theory, the Gosh model lacks a corresponding embedding in standard micro-theory. One therefore is tempted to give more conceptual credit to BW linkages than to FW linkages since the former trace the ripple effects implicit in the underlying technology. These notions started with Chenery & Watanabe (1958), Rasmussen (1956), and were further developed by many authors. Shultz (1977) and Sonis et al. (1995) are good surveys of these literature. As for hypothetical extraction methods (HEM), as well as their properties and their economic interpretation, a good and complete recapitulation can be found in Miller & Lahr (2001). The basic idea in this area is to elicit the role of a sector, or cluster of sectors, by way of simulating its elimination from the economy. Should a given sector cease to somehow interact with the rest of sectors, what would the opportunity cost be measured in lost gross output?

These two approaches, different as they are, have followed closely and exclusively the input-output 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, say sector i, is modelled replacing the initial input-output matrix A_0 with a new matrix $A_{(i)}$ where the coefficients describing bilateral interactions between i and $j \neq i$ are reset to zero. This amounts to, even if it is merely hypothetically, to an input reducing change of techniques, hence cost reducing too given the input-output fix-price implicit assumption. If the economy is able to operate with the new matrix, one but wonders why it operated first with higher costs. An explanation is sometimes offered based on the presence of foreign trade (Dietzenbacher & Van der Linden, 1997, Miller & 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 difficulties might conceivably be dealt with in a fully specified CGE model.

The proposal in this note rests in a simpler approach that seeks to extend the input-output approach to account for all the linkages between sectors, factors and demand. These interactions can be made explicit if we make use of the detailed bilateral exchanges given by a SAM and its implemented 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 critical links. A simple way out is to enlarge the set of interdependencies to effectively include the missing link between production, income and expenditure. 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 Section 2 we comment on the SAM methodology. Section 3 present some results and Section 4 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, respectively, by Y_e and Y_x, and we partition the normalized SAM into corresponding submatrices we obtain:

$$\begin{bmatrix} Y_e \\ Y_x \end{bmatrix} = \begin{bmatrix} A_{ee} & A_{ex} \\ A_{xe} & A_{xx} \end{bmatrix} \cdot \begin{bmatrix} Y_e \\ Y_x \end{bmatrix} \qquad (1)$$

We can now use (1) to express endogenous income Y_e as a function of exogenous income Y_x

$$Y_e = A_{ee} \cdot Y_e + A_{ex} \cdot Y_x = (I - A_{ee})^{-1} \cdot A_{ex} \cdot Y_x = (I - A_{ee})^{-1} \cdot Z \qquad (2)$$

Expression (2) yields the Leontief model as a special case when $e = n$. Under this assumption on endogenous accounts, the matrix A_{ee} coincides with the n-dimensional Leontief coefficients matrix A_0, the n-vector Y_e is the vector of gross sectoral output, and the vector $Z = A_{ex} \cdot Y_x$ 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 (2) incorporating the newly added sector. We would now have $e=n+1$ endogenous accounts in the model, and correspondingly endogenous income Y_e would be a $n+1$ vector whereas exogenous income $Z = A_{ex} \cdot Y_x$ would now be a n-1 vector. We can then compare industrial sectoral output in the standard Leontief and the extended SAM models by comparing the first n coordinates of the endogenous vectors Y_e that solve (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.

The extraction of a given productive sector ℓ, adapting Dietzenbacher, Van der Linden & Steenge (1993) amounts to resetting all inter-industry technical coefficients $a_{i\ell}$ and $a_{\ell i}$ for $i \neq \ell$ to zero. 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 $i, j \neq \ell$ 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 A_0 (or A_{ee} with $e=n$) and the hypothetical matrix A_{ee}^{ℓ} (with $e=n+h+k$) where sector ℓ is extracted, and using (2) two corresponding income vectors Y_0

and Y_{ee}^{ℓ}. By comparing these two vectors first n coordinates, 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 the larger endogeneity incorporated in the enlarged matrix 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 for the most recent SAM database of the Spanish economy (Cardenete & 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 10 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, labor, 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 billions of euros under the standard Leontief setup. The output loss rises substantially to 69.57 billions, however, when added general equilibrium effects are taken into account since lost industrial output also entails lost income and henceforth lost consumption–aspects both 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 show and Table 2 depicts. In this Table 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 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.

[Table 1 around here]

[Table 2 around here]

4.- ***Concluding remarks***

We have explored in this note 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.

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Appendix: Sectoral correspondence

1. Agriculture	6. Machinery and transportation equipment
2. Mining	7. Other manufactures
3. Energy	8. Construction
4. Foodstuffs	9. Private services
5. Chemical products	10. Public sector services

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

	EXTRACTED SECTORS									
	GROSS OUTPUT EFFECT: SAM MODEL (in millions of euros)									
SECTORS	1	2	3	4	5	6	7	8	9	10
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

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