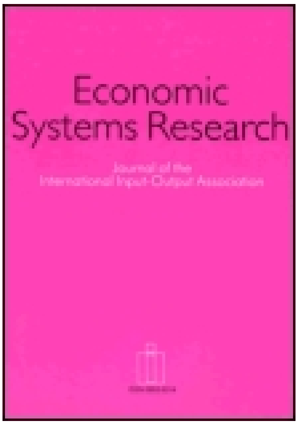

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THE ROLE OF SUPPLY CONSTRAINTS IN MULTIPLIER ANALYSIS

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THE ROLE OF SUPPLY CONSTRAINTS IN MULTIPLIER ANALYSIS

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Multiplier analysis based upon the information contained in Leontief's inverse is undoubtedly part of the core of the input–output methodology and numerous applications and extensions have been developed that exploit its informational content, both at the national and regional levels. Nonetheless there are some implicit theoretical assumptions whose policy implications need to be assessed. This is the case for the 'excess capacity' assumption, which implies that resources are available as needed to adjust production to new equilibrium states. In an actual economy, however, new resources are often scarce and always costly. When supply constraints intervene, the assessment of the effects of government demand policies may be substantially different from that of the standard Leontief multiplier matrix. Using a closed general equilibrium model that incorporates supply constraints, we perform some simple numerical exercises and proceed to derive two 'constrained' multiplier matrices, based upon the implicit Jacobian matrix, that can be compared with the standard 'unconstrained' Leontief matrix.

Keywords: Multipliers; Key sectors; Economic linkages; Policy evaluation; General equilibrium

1. INTRODUCTION

There is some widely accepted conventional wisdom concerning the effectiveness of discretionary government expenditure policies. The story goes somewhat like this: since economic sectors differ in terms of their 'push' and 'pull' effects, the sector where new demand injections are applied becomes a relevant issue for policy makers who wish to maximise the impact of government policies (Devarajan et al., 1993). The literature has therefore provided the 'key sector' concept as a guiding principle to authorities with regard to policy design. The standard 'key sector' concept and measurement, however, depends on a series of assumptions that have not been usually questioned or its implications tested. In very simple terms, a sector is deemed to be 'key' when an exogenous expenditure inflow falling on it is 'multiplied' over and above some reference average level. The key word here is 'multiplied' and this explains why multiplier matrices play such a significant role in the 'key sector' literature.

In a national or regional economy with many goods and services, a multiplier matrix is a numerical description of how an exogenous inflow into one sector ends up affecting the rest of the sectors in the economy, once the set of structural (demand and supply)

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interconnections is fully taken into account. The best known multiplier matrix is the classic Leontief inverse built from the matrix of direct technical coefficients in the inter-industry model (Leontief, 1941). Beyond direct interdependencies, Leontief's inverse is able to pick up in a clear and systematic way indirect ones 'down the line' in the production process. Refinements of the multiplier matrix have incorporated additional layers of interdependencies, especially related to the feedback between output, factors' incomes and consumption demand. These are the so-called induced effects. The fact that the standard inter-industry model neglected the induced effects linked to final demand was correctly pointed out by Diamond (1974, 1976) in his work dealing with development issues. When final demand is left unexplained, 'key sector' measurements are bound to be downward biased. Diamond tackles this issue incorporating a fixed coefficient demand subsystem into the input–output model. Another formulation, perhaps a bit more elegant and compact in formal terms, is the SAM (Social Accounting Matrix). A SAM captures the whole circular flow of income in a unified but disaggregated configuration and allows selecting the level of endogeneity of accounts in quite a simple way (Pyatt and Round, 1979; Pyatt, 1985). In fact, Diamond's approach is a particular case of the SAM approach for a particular class of endogenous accounts. More recently, the meaning and interpretation of the multiplier concept itself has been debated regarding the need to distinguish between gross and net multipliers (Oosterhaven and Stelder, 2002; de Mesnard, 2002; Dietzenbacher, 2005).

The computation of multiplier matrices within the linear inter-industry paradigm, however, does not question a pivotal assumption in the model, namely, that there is a perfectly elastic supply of primary factors whose prices are exogenously fixed. This means that these non-produced inputs can be commanded as needed while prices for goods and services are unaffected by this resource pull.[1] At the same time, intermediate inputs can be produced as they are needed provided primary factors are unrestricted in supply. In other words, there are no binding supply constraints. But economics is the science of scarce resources and constraints are pervasive and do work in limiting what can be achieved. Guerra and Sancho (2011), for instance, examine how the restrictions imposed by the public sector's budget constraint affect the value of government multipliers. With a fixed expenditure level, any reshuffling in the basket of goods purchased by the government gives rise to both output and substitution effects that work in opposite directions. Thus, and in sharp contrast with the usual intuition, government multiplier values can in fact be seen to be negative.

In broader terms, when supply constraints are at work, extra resources for producing more of a good can only be found if they are shifted from elsewhere. If factors of production are not available beyond a set amount, this entails an economy-wide general reallocation where output and price effects will be simultaneously at play. Under this wider, more comprehensive scenario a suitable tool of analysis is that of Computable General Equilibrium models (CGE). The advantage of the CGE approach is that it integrates price and quantity adjustments of demand and supply following the tenets of well established and well understood economic theory. Comparisons of the economic estimates arising from linear and CGE models are relevant from a policy perspective both at the national and regional levels although the regional perspective has been clearly dominant.

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[1] See Miller and Blair (2009, Chapter 2, Table 2.15).

McGregor et al. (1996) use the AMOS model of the Scottish economy to analyse the convergence of CGE model results towards those obtained by means of the demand-driven Leontief multipliers. In fact, under an adaptive inter-temporal model and Samuelson's (1966) non-substitution conditions, the inter-industry estimates can be seen to be the limiting estimates of a CGE implementation. Rickman (1992) explores the effects of alternative closure rules (Keynesian and neoclassical) for CGE model solutions in assessing regional assistance programs, while Gillespie et al. (2001) refine the analysis to incorporate possible displacement effects of regional assistance programs and show that in the presence of bargaining in regional labour markets, aggregate macro impacts obtained from input–output analysis and CGE models can be substantially different, with input–output techniques overestimating likely impacts. Partridge and Rickman (1998, 2010) also note the usual overestimation of input–output estimates and provide a good, comprehensive survey on the advances in CGE modelling at the regional level that allow us to overcome some of the limitations of input–output analysis.

These comparisons of input–output and CGE modelling are based on comparing aggregate macro or micro magnitudes in response to non-marginal policy changes. What we propose in this paper, in contrast, is to look directly at the rich and exhaustive information contained in medium-to-large size multiplier matrices resulting from small, marginal changes in policy parameters. The justification for this complementary approach is that multiplier matrices are quickly computed or easily estimated, are straightforwardly interpreted, and provide a very detailed snapshot of the underlying direct and indirect set of structural interdependencies. To this effect, we use a SAM database of the Spanish economy as the common statistical background for both the linear and the CGE computations. We first obtain the standard multiplier matrix representing a situation with excess supply and we refer to this matrix as the 'unconstrained' Leontief inverse. Secondly, we implement a CGE model of the Spanish economy and proceed to estimate multiplier matrices under a set of factor limitations. These 'constrained' matrices are in fact numerical approximations of the Jacobian of the CGE model in reduced form. A comparison of results for the 'unconstrained' and 'constrained' multiplier matrices shows that supply constraints are relevant, and perhaps even critical, in ascertaining the effects of government expenditure policies. The availability of alternative multiplier matrices may provide useful information to policy authorities in the assessment of expenditure programmes once the multiplier data are properly contextualised to the proper economic environment. Actual empirical results will likely be different in booming times, with the economy reaching full employment of resources, than in times of recession – when idle resources are common – and the modelling techniques should be properly used and attuned to the relevant scenarios.

The paper is organized as follows. Section 2 succinctly describes the basic CGE model and database. Section 3 exposes the underlying methodology for the computation of multiplier matrices. In Section 4 we recap and discuss the empirical results. Section 5 concludes and summarizes.

2. THE MODEL

The CGE model we use is a numerical representation of the Spanish economy and follows the basic principles of the Walrasian equilibrium concept. For this class of general equilibrium models Dervis et al. (1982) is a classic reference, with Ginsburgh and Keyzer (2002), Kehoe et al. (2005), Hosoe et al. (2010) and Burfisher (2011) being very good up-to-date reviews of the state of the art. Seung and Waters (2010), in turn, show the versatility and wide range of applicability of this type of modelling. Our model includes 26 productive sectors and is enlarged by including both public and foreign activities. The production technology is given by a nested production function. The domestic output of a sector is obtained by combining, through a Leontief technology, inputs from the rest of sectors and value-added. In turn, this value-added is generated from primary factors (labour and capital) using a simple Cobb-Douglas aggregator. The overall output of a sector is also obtained from a Cobb-Douglas combination of domestic output and imports, according to the Armington hypothesis.[2] On the demand side, there is one representative consumer whose demand for current consumption and savings comes from maximizing a Cobb-Douglas utility aggregator subject to a disposable income constraint. Disposable income includes primary factors income (labour and capital) netted out with social transfers and income taxes.

We consider the Spanish economy as a small economy within the world context. The demand level of the foreign sector is assumed to be exogenously given, in the sense that the total amount of exports is not influenced by the domestic variables.[3] Imports, on the other hand, are imperfect substitutes for domestic production, following the Armington hypothesis. Import levels are endogenously determined. Thus, the foreign sector may incur a deficit, which is endogenously determined.

Relative prices and activity levels of the productive sectors are endogenous variables. All agents, consumers and firms, behave rationally as utility and profit maximisers. Firms are organised in productive sectors and they strive to maximise profits. Because constant returns-to-scale are assumed, this entails in practice that firms are cost minimisers. Final and intermediate demand for goods and services and supply of goods and services by firms is coordinated through the price mechanism. In its simplest possible expression, an equilibrium for this economy is a pair of vectors of prices (for goods and factors) and activities (for goods and factors) so that demand equals supply in all markets. An exception to this rule is contemplated in the labour market where idle resources can be modelled as a proxy for unemployment. This is performed introducing a feedback between the real wage and the unemployment rate that relates to the power of unions, or any other socio-economic factors inducing frictions and rigidities in the labour market (see Kehoe et al., 1995). This feedback is controlled with an elasticity ε that allows for two polar representations of the labour market. On the one hand, unemployment can be kept fixed if wages are flexible enough ($\varepsilon \to 0$); on the other hand, when wages are rigid enough unemployment fluctuates ($\varepsilon \to \infty$). We introduce this feature using a wage curve (Blanchflower and Oswald, 1990, 1994) that captures the relationship between the real wage (ω/cpi) and the

[2] Ballard et al. (1985) report that Cobb-Douglas unitary elasticity for value-added generation is more realistic than for the Armington function. We use Cobb-Douglas throughout as an approximation to illustrate how competing multiplier matrices can be derived. Also, Cobb-Douglas and Leontief models are related in the sense that they share the same calibrated share coefficients. See El-Hodiri and Nourzad (1988).

[3] We adopt here the simple activity analysis approach first proposed by Kehoe and Serra-Puche (1983).

unemployment rate u. The specific model implementation follows Kehoe et al. (1995):

$$\frac{\omega}{cpi} = \left(\frac{1-u}{1-\bar{u}}\right)^{\frac{1}{\varepsilon}} \tag{1}$$

where ω is the nominal wage rate, cpi a consumers' price index, and $\bar{u}$ the benchmark unemployment rate.

The government raises taxes to obtain public revenues, which are returned to the private sectors in the form of social transfers and subsidies and in the form of public demand for goods and services. The government may also incur a deficit if the accrued tax collections are not enough to cover for all of the public outlays. Transfers are endogenously determined within the model, whereas government demand for goods and services is an exogenous parameter resulting from policy decisions. Tax rates are fixed at benchmark effective rates. This makes the public deficit to become an endogenous variable in the model.

Regarding investment and savings, this is a savings driven model. The closure rule is defined in such a way that aggregate investment is determined by total savings (private, public and foreign). Public and foreign savings are related to the endogenous deficit (or surplus) of the government and the rest of the world. Private savings are also endogenous and are the result of the utility maximisation problem of the representative consumer discussed above.

The economic data used in the study come from a Social Accounting Matrix of the Spanish economy for 2000 assembled by Cardenete and Fuentes (2009). This 2000-SAM for Spain includes a total of 38 accounts, including 26 productive sectors, two primary factors (labour and capital), a capital (savings/investment) account, a government account that collects three broad categories of taxes (an income tax, a payroll tax, and four distinct indirect taxes), a private consumption and a foreign sector. Because all agents and accounts satisfy a budget constraint, the matrix structure is such that column sums and row sums coincide for each account. A simplified representation of the 2000-SAM is given by Figure 1.

The values for the technological coefficients, the tax rates and the coefficients of the utility function are calibrated to reproduce the 2000-SAM as an initial or benchmark equilibrium for the economy. In the simulations, the wage rate is taken as numéraire and the rest of the prices vary as required to meet equilibrium conditions. Calibration entails

2000-SAM	Production	Factors	Households	Government	Capital	Foreign
Production	Intermediate demand		Private demand	Public demand	Investment demand	Exports
Factors	Value added					
Households		Factorial income		Net transfers		Net transfers
Government	Indirect taxes	Payroll taxes	Income taxes			
Capital			Savings	Savings		Savings
Foreign	Imports					

FIGURE 1. Schematic representation of the Spanish SAM for 2000.

selecting numerical values for coefficients and parameters so that when used in the model they reproduce the observed empirical data in the 2000-SAM as an equilibrium. The GAMS software module computes the benchmark equilibrium and uses it as a internal basis for subsequent simulation runs. This guarantees very fast compilation and execution time and in practice yields convergence in all studied cases.

3. THE MULTIPLIER MATRICES

We consider a disaggregated economy with n goods ($n = 26$) described by a technology of intermediate consumptions $\mathbf{A}$ – an $n \times n$ matrix with fixed coefficients – and price responsive, variable labour and capital coefficients obtained using Shephard's lemma (see Sancho, 2009). The equilibrium outputs in this economy are represented by the n vector $\mathbf{x} = (x_1, x_2, \ldots, x_n)$' whereas market clearing prices for goods is given by the n vector $\mathbf{p} = (p_1, p_2, \ldots, p_n)$'. The government formulates public demand for these n goods that appears in an n-vector $\mathbf{g} = (g_1, g_2, \ldots, g_n)$' and constitutes part of the economy's final demand (along with private consumption, investment and foreign demand). Under the standard assumptions of the linear inter-industry model, matrix $\mathbf{A}$ is all that is needed to obtain the direct and indirect repercussions that yield the multiplier matrix $\mathbf{L}$ ($\mathbf{L}$ for Leontief); this matrix $\mathbf{L}$ provides detailed bilateral information on the effects of increasing in one unit the level of government demand. If $\mathbf{A}$ is a productive matrix (see Nikaido, 1972), then matrix $\mathbf{L}$ can be approximated using the matrix series expansion or directly calculated through matrix inversion:

$$\mathbf{L} = \mathbf{I} + \mathbf{A} + \mathbf{A}^2 + \mathbf{A}^3 + \cdots + \mathbf{A}^k + \cdots = \sum_{k=0}^{\infty} \mathbf{A}^k = (\mathbf{I} - \mathbf{A})^{-1} \tag{2}$$

The generic element ℓ_{ij} of $\mathbf{L}$ is known to have the following differential or 'ratio' meaning:

$$\ell_{ij} = \frac{\Delta x_i}{\Delta g_j} = 1 + a_{ij} + a_{ij}^{(2)} + a_{ij}^{(3)} + \cdots + a_{ij}^{(k)} + \cdots \tag{3}$$

where

$$\begin{aligned} a_{ij}^{(2)} &= \sum_{k=1}^{n} a_{ik} \cdot a_{kj} \\ a_{ij}^{(3)} &= \sum_{k=1}^{n} a_{ik} \cdot a_{kj}^{(2)} \\ &\cdots \\ a_{ij}^{(k)} &= \sum_{k=1}^{n} a_{ik} \cdot a_{kj}^{(k-1)} \end{aligned} \tag{4}$$

and $a_{ij}^{(k)}$ represents the amount of good i needed in stage k to have available the input of good j needed in the production stage $k-1$. The unit 1 in Equation 3 represents the initial injection and the remainder of terms represents the additional output required in each production stage for that unit to be effectively put out.

The 'multiplier' concept is clear given the recursive structure in Equations 3 and 4. When the government increases its demand for good j by one unit, equilibrium output in sector i needs to adjust by ℓ_{ij} units. In the calculation of matrix **L**, however, and because of the excess supply assumption of the Leontief model, additional primary factors are always available as needed. We refer to this standard matrix as the 'unconstrained' multiplier matrix. In an economy with supply constraints, in contrast, resources are not always available, and this set-up is the proper operational terrain of a CGE model. If more of good j is demanded (say, by the government) a general reallocation in prices and quantities will be required in order to fulfil the extra demand for j. The appraisal of the effect of the additional public demand can be obtained from a numerical approximation of the Jacobian matrix of the CGE equilibrium equations. Let us denote this matrix by **M**. Its generic term is given by the derivative:

$$m_{ij} = \frac{\partial x_i(g/u)}{\partial g_j} = \lim_{\Delta G_j \to 0} \frac{\Delta x_i}{\Delta g_j} \tag{5}$$

In Equation 5, $x_i(g/u)$ symbolizes the dependence of equilibrium quantities **x** on policy decisions on public demand levels **g**, conditional to the labour market scenario as indicated by the unemployment rate u as proxy. The numerical 'multiplier' matrix derivative **M** is computed comparing the benchmark equilibrium values with the counterfactual equilibrium values that ensue from a 'small' change Δg_j in public demand for good j. The CGE model absorbs the 'small' change Δg_j and re-computes the equilibrium for $n = 26$ sequential runs where $j = 1, 2,\ldots, n$. Equation 4 measures the difference Δx_i in output between the two equilibria, benchmark and counterfactual, and provides an approximation to the implicit Jacobian matrix. The software we use, algebraic GAMS (see Brooke et al., 1992), does not offer a direct estimate of the multiplier matrix, thus we need to evaluate it numerically by way of simulation. To guarantee that results indeed converge to a stable value, we have used different 'small' values for Δg_j and taken differences both from above and below benchmark public demand values. Numerical results are seen to be locally robust around the reported values m_{ij}. At the end, the n simulation runs yield an $n \times n$ matrix of multipliers under the supply constraints that the CGE model explicitly incorporates. For simplicity of exposition, we produce two such matrices. The first one is obtained under the assumption that all primary resources are kept fixed at the benchmark levels, hence unemployment is fixed too. It closely corresponds to the basic standard Walrasian model. In the second one the condition is partially relaxed and we allow labour use to vary from the benchmark level in response to allocation changes, hence unemployment is now variable.

4. DISCUSSION

In this section, we illustrate the rich possibilities of the analysis calculating three multiplier matrices. The first one corresponds to the standard 'unconstrained' Leontief inverse **L**. We then proceed to calculate two 'constrained' multiplier matrices, which correspond to the two different labour market scenarios outlined above, in this case both under the CGE modelling facility. In the first one, total primary factors (labour and capital) are kept at the initial levels. Any reshuffling in production, in response to a change in public demand policies by the government, necessarily takes place under these aggregate resource constraints. Factors are mobile among sectors though. With a fixed level of labour, equilibrium adjustments in the labour market occur via prices. In the CGE model this is controlled by the elasticity ε between the wage rate and the unemployment rate with a 0 value. We call the derived matrix in this *rigid* unemployment scenario as $\mathbf{M}_{\mathrm{CGE1}}$. The second labour market scenario relaxes, as explained before, the restriction in the use of labour. Now more labour can be commanded if needed, or less labour is actually used if not needed. This characterization of the labour market is relevant from the viewpoint of the Spanish economy where high levels of labour are unused and cannot be employed under normal circumstances. An elasticity ε with a value of ∞ takes care of this *flexible* unemployment scenario in the CGE model, where adjustments now take place in labour quantities for a fixed wage rate. The corresponding matrix will be referred to as $\mathbf{M}_{\mathrm{CGE2}}$.

Because of the large amount of numerical data, we only present a summary of the overall results in this section. The complete numerical results of the analysis can be obtained from the authors upon request. Table 1 shows the aggregate multiplier values for each of the 26 goods and for the three multiplier matrices. These aggregate values reflect the column summation of all the pull effects that a unitary injection in sector j would induce in all sectors i, once all general equilibrium adjustments in production levels have taken place.[4] Table 2 presents the ‘own’ multiplier value for each good whereas Table 3 presents the ‘net’ value indicating pull effects as they spread in the rest of the sectors.

From the data in Table 1 we can see that there is a huge difference in total multiplier effects when supply constraints are taken into account (50.603 in matrix **L** versus 3.075 and −5.611 from ‘**M** rigid’ and ‘**M** flexible’, respectively). Notice that the usual and expected positive multiplier effects no longer hold true. In the ‘flexible’ scenario, in fact, the total aggregate effect is negative. Even though more labour can in principle be commanded in this ‘flexible’ scenario, the general reallocation in prices and quantities produces ‘crowding out’, a familiar possibility that is extensively discussed in standard macroeconomics (see Barro, 2009) and replicated here by the CGE microeconomic model. More government demand for goods and services gives rise to a contraction in the rest of final demand entries, even larger in magnitude than in the *rigid* case, and thus less labour is employed. A possible explanation for this effect can be traced to the reduction in public savings that is induced by the increased level of public demand. With less aggregate savings, investment falls, which in turn translates into a detrimental and countervailing effect upon final demand.

When we look at the results in Tables 2 and 3, we observe that the ‘own’ multiplier values are least affected by the general reallocation. Their values are smaller, as expected, in the ‘constrained’ scenarios but not substantially. The main drag that curbs the potential ‘unconstrained’ multiplier values is found in the reduction in activity levels in the rest of sectors. Sectoral changes in other sectors’ output are now negative and individually small,

[4] Summation is possible because of the standard normalization of data in the model implementation: each unit is defined as having a worth of one euro.

TABLE 1. Multiplier values (column sums of multiplier matrices)

Sectors	**L**	$\mathbf{M}_{CGE1}$	$\mathbf{M}_{CGE2}$
1. Agriculture, cattle and forestry	1.939	−0.675	−2.524
2. Fishing	2.012	−0.111	−0.437
3. Coal	2.075	−0.059	0.113
4. Oil and Gas	1.016	0.982	0.967
5. Rest of extractives	2.121	0.381	−0.038
6. Refine	1.694	1.114	0.852
7. Electricity	1.983	−0.094	−1.400
8. Water	1.747	0.874	0.102
9. Distribution of water	2.011	−0.266	−0.502
10. Food	2.332	0.299	−0.312
11. Manufacturing of textiles and leather	2.151	0.378	0.230
12. Manufacturing of wood	2.172	0.384	0.035
13. Chemicals	1.994	0.553	0.296
14. Mining	2.223	0.023	−0.329
15. Manufacturing of metal products	2.009	0.446	0.059
16. Machinery	2.142	0.192	0.129
17. Manufacturing of textiles and leather	1.798	0.527	0.472
18. Manufacturing of construction material	2.000	0.853	0.760
19. Transport	1.917	0.502	0.687
20. Other manufactures	2.161	0.244	0.127
21. Construction	2.287	−0.084	−0.016
22. Vehicles	1.982	−0.278	−0.353
23. Commerce	1.800	−0.857	−1.331
24. Transport and Communications	1.851	−0.431	−1.209
25. Commercial Services	1.614	−0.643	−0.634
26. Non-commercial services	1.571	−1.181	−1.359
Total	50.603	3.075	−5.611

Source: Own elaboration.

L: Leontief multipliers

$\mathbf{M}_{CGE1}$: general equilibrium multipliers with rigidity in labour market

$\mathbf{M}_{CGE2}$: general equilibrium multipliers with flexibility in labour market

but their aggregation may counteract the induced ‘own’ effect. They could even reverse its sign, as we have seen in Table 1 above for the *flexible* scenario. These summary results can be further scrutinised consulting the full multiplier matrices where very specific sectoral detail is provided.

A word of caution is necessary since the variability in these data strongly suggest that the evaluation of government policies should be contextualized with macro data on the state of the economy. When resources are idle and price effects are negligible, multiplier results from the Leontief inverse **L** can be seen as empirically reasonable. In the presence of actual supply bottlenecks or whenever price effects are deemed to influence both demand and supply adjustments, however, the Leontief inverse loses its appeal and a different information set is required. In this situation, multiplier data of the type contained in matrices **M** may provide a better appraisal of the effectiveness of expenditure policies. A literal reading of multiplier data can be therefore misleading if results are not properly contextualised.

TABLE 2. Values on principal diagonal of multiplier matrices

Sectors	**L**	$\mathbf{M}_{CGE1}$	$\mathbf{M}_{CGE2}$
1. Agriculture. cattle and forestry	1.107	1.080	1.051
2. Fishing	1.002	1.001	1.001
3. Coal	1.005	1.002	1.003
4. Oil and Gas	1.001	1.002	1.002
5. Rest of extractives	1.008	0.993	0.990
6. Refine	1.088	1.084	1.079
7. Electricity	1.173	1.154	1.141
8. Water	1.000	0.999	0.997
9. Distribution of water	1.002	1.001	1.000
10. Food	1.228	1.208	1.186
11. Manufacturing of textiles and leather	1.246	1.240	1.238
12. Manufacturing of wood	1.324	1.294	1.288
13. Chemicals	1.205	1.178	1.172
14. Mining	1.093	0.997	0.986
15. Manufacturing of metal products	1.101	1.058	1.050
16. Machinery	1.088	1.005	1.003
17. Manufacturing of textiles and leather	1.141	0.983	0.977
18. Manufacturing of construction material	1.298	1.240	1.236
19. Transport	1.144	1.126	1.128
20. Other manufactures	1.102	1.038	1.034
21. Construction	1.287	0.524	0.539
22. Vehicles	1.058	1.043	1.043
23. Commerce	1.050	0.897	0.853
24. Transport and Communications	1.204	1.127	1.095
25. Commercial Services	1.199	0.968	0.969
26. Non-commercial services	1.054	0.914	0.900
Total	29.209	27.157	26.959

Source: Own elaboration.

L: Leontief multipliers

$\mathbf{M}_{CGE1}$: general equilibrium multipliers with rigidity in labour market

$\mathbf{M}_{CGE2}$: general equilibrium multipliers with flexibility in labour market

Within the structure of a disaggregated general equilibrium model, supply constraints are indispensable and they seem to matter substantially as far as results are concerned. It would therefore be advisable to incorporate this view too when evaluating public demand policy strategies using multiplier estimates. The fact that supply constraints may play a relevant role has also to do with the discipline imposed by market behaviour. When resources are limited and subject to alternative uses, markets work out adjustments that take place via fine-tuning of prices and quantities so as to uphold aggregate and individual feasibility. This adaptability, in fact, is what allows supply constraints to be effective and condition the allocation of goods and services throughout the system. The evidence that general equilibrium multipliers may depart from the usual, generalised positive values of Leontief multipliers also puts the use of extended multipliers (Pyatt and Round, 1979; Pyatt, 1985) into question. Under the same excess supply condition, extended multipliers incorporate more complex interactions between income and output and the increased level of endogeneity produces multiplier values than are higher than the simple Leontief ones. It is likely, however, than when

TABLE 3. Column sums of multiplier matrices, net of values on principal diagonals.

Sectors	**L**	$\mathbf{M}_{CGE1}$	$\mathbf{M}_{CGE2}$
1. Agriculture. cattle and forestry	0.833	−1.755	−3.575
2. Fishing	1.010	−1.112	−1.437
3. Coal	1.070	−1.061	−0.890
4. Oil and Gas	0.015	−0.020	−0.034
5. Rest of extractives	1.113	−0.612	−1.028
6. Refine	0.606	0.030	−0.227
7. Electricity	0.810	−1.248	−2.540
8. Water	0.747	−0.124	−0.895
9. Distribution of water	1.009	−1.266	−1.502
10. Food	1.104	−0.908	−1.497
11. Manufacturing of textiles and leather	0.905	−0.862	−1.008
12. Manufacturing of wood	0.848	−0.909	−1.252
13. Chemicals	0.789	−0.625	−0.876
14. Mining	1.130	−0.974	−1.315
15. Manufacturing of metal products	0.908	−0.613	−0.991
16. Machinery	1.055	−0.813	−0.874
17. Manufacturing of textiles and leather	0.657	−0.456	−0.505
18. Manufacturing of construction material	0.702	−0.387	−0.475
19. Transport	0.773	−0.624	−0.441
20. Other manufactures	1.059	−0.794	−0.907
21. Construction	1.000	−0.607	−0.555
22. Vehicles	0.924	−1.321	−1.396
23. Commerce	0.750	−1.754	−2.184
24. Transport and Communications	0.647	−1.558	−2.303
25. Commercial Services	0.415	−1.611	−1.603
26. Non-commercial services	0.517	−2.096	−2.259
Total	21.394	−24.082	−32.570

Source: Own elaboration.

L: Leontief multipliers

$\mathbf{M}_{CGE1}$: general equilibrium multipliers with rigidity in labour market

$\mathbf{M}_{CGE2}$: general equilibrium multipliers with flexibility in labour market

pushing production levels upwards in the economy, resource constraints will intervene. This systematic overestimation of multiplier values is the consequence of not considering the disciplining role that supply constraints eventually impose upon resource allocation.

5. CONCLUDING REMARKS

Using a SAM database of the Spanish economy for 2000, we have estimated three possible multiplier matrices and we have illustrated how multiplier values can vary depending on assumptions depicting the economy. We have first calculated the familiar ‘unconstrained’ Leontief inverse under the usual excess supply assumption whereby resources – produced and non-produced – are available as production needs dictate and prices are fixed. We have subsequently proceeded to estimate two multiplier matrices as numerical approximations of the implicit Jacobian matrix using a CGE model with supply constraints. In the first one, labour and capital are fixed in the aggregate and a policy change in terms of expenditures entails a general reshuffling of resources driven by changes in relative prices. In the second CGE multiplier matrix, we contemplate the possibility of using idle labour if needed. In both 'constrained' cases, the multiplier matrices turn out to produce results that are significantly smaller than in the 'unconstrained' Leontief case. A noteworthy observation is that a 'crowding out' situation is potentially possible depending upon the characteristics of the labour market and the closure rule for government activities. When there is idle labour and employment levels can vary, more government demand may not work necessarily in the intended direction. If more government demand is financed with debt, the induced general equilibrium reshuffling in prices and activity levels drives down investment levels and this works to offset the increase in government demand. Results therefore show that the effectiveness of government policies depends significantly on whether or not supply constraints are considered given their role in conditioning the way markets adjust. All this suggests that in the evaluation of actual expenditure policies undertaken by the government, the different modelling outputs should be accordingly contextualised to the proper state of the economy. The systematic use of the Leontief inverse in all scenarios is not always appropriate. The fact that its computation is relatively simple and its interpretation straightforward does not justify its widespread use, unless it corresponds to the proper economic scenario. Similar considerations apply to the output of CGE models, which oftentimes is produced with little regard to its empirical applicability.

There are many aspects influencing the output of a general equilibrium model, but it can be certainly stated that all allocation adjustments can be eventually traced to income and substitution effects. Assuming smooth isoquants and iso-utility curves, substitution in response to changes in prices will of course take place. We may even conceive of a general equilibrium model with perfect complementarity in production and consumption (universal Leontief) and in this case only income effects would be relevant. Under this scenario, results would presumably be less intense since substitution effects would be disregarded. Thus, the cases we explore here, 'unconstrained' and 'constrained', should be seen only as two of the polar cases providing general interval estimates for the possible effects of government discretionary demand policies. Further future research testing the sensitivity of results to the model structure should be conducted. Forcing substitution possibilities upwards and downwards, using for instance constant elasticity of substitution production and utility functions, would provide more accurate information on the role played by substitution effects. The influence of closure rules should also be scrutinised. Finally, there is the methodological issue related to the influence of the level of aggregation on results. The classification used here (26 sectors) is a compromise between the usually higher disaggregation present in interindustry models and the usually smaller one in CGE models. Extending and compressing the classification could also provide insights into how sparse or dense numerical results turn out to be.

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