AN INTERTEMPORAL LINEAR PRICE MODEL WITH EXTRACTIONS

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Abstract

The problem of competitiveness has becoming one of the main concerns of European governments. This is reflected trough out the Europe 2020 Strategy that includes as key priority the promotion of efficient and productive use of inputs. Differently to other "well-behaved" European "neighbours", in Spain, productivity growth closely connected to competitiveness improvements has been remarkably slow during the last decade. Then, this paper is a first attempt to shed some light about the main determinants of national prices, taking into account the role played by inter-sectoral linkages. In these lines, the contribution of the present analysis is two-fold. Firstly, differently to what is common practice in the Input-Output literature, we have evaluating endogenous price impacts using the HEM for yearly Spanish Input-Output data that relates to the periods 2000 and 2007. In our view, this novel approach helps to identify which production units might be considered as "first best candidates" for those policies that pursue to improve overall efficiency levels and thus, competitiveness. Secondly, we have introduced a longitudinal dimension to the aforementioned evaluated "price linkage indicator". In doing so, we have used a simple version of the well-known structural decomposition analysis, breaking down the variation of the sectoral "price linkage measure" between the two periods here considered into the contribution of both, changes in intermediate-demand technology and value-added technology .

Keywords: input-output analysis, key sectors analysis, production efficiency.

JEL Classification: C67, C63, D24, D57.

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1. INTRODUCTION

The theoretical structure of price models for linear input-output economies is well known from the contribution of Atsumi (1985). In an empirical vein, and rather surprisingly, the price model has been used less often than its sibling quantity model, despite the fact that they share the same theoretical basis and their viability is guaranteed by the very same Hawkins-Simon (1949) condition or Perron-Frobenius eigenvalue condition. Some applications of the price model include McElroy *et al* (1982) who study general price formation for the US; Catsambas (1982), in turn, uses a price model to evaluate the incidence of an excise gasoline tax on income distribution also in the US. In a related study, Hugues (1986) explores in a price model the distributive role of a fuel tax using data for Thailand. Derrick and Scott (1993) examine the role of the sales tax in prices whereas Roland-Holst and Sancho (1995) generalize the price model to the SAM framework and study and decompose its cost multipliers. More recently and for the Spanish case, Cardenete and Sancho (2002) develop a model of regional prices with taxes and Cardenete *et al* (2007) exploit the structure of a regional model to assess the impact of a fuel tax. Llop and Pié (2008), in turn, use in quite an innovative way a Leontief price model (Leontief, 1941; 1986) to study environmental issues in Catalonia, whereas Sancho (2010) proposes a methodological way to separate visible and non-visible price effects induced by the different indirect taxation instruments. All these applications seek to elicit and understand the empirical workings of the price formation mechanism using the linear paradigm as the basis of analysis. Clearly, the advantage of the linear approach, both in the quantity and the price versions, results from its operational simplicity and its ability to combine theory with structural, disaggregated data.

The quantity input-output model has been extensively used for the determination of so-called key or strategic sectors. When a sector receives an exogenous stimulus, the productive response to that stimulus involves the receiving sector as well as the remaining economic sectors that must adjust their production to fulfil, in a first stage, the needs of the receiving sector and they do so by supplying input deliveries to the triggering sector. Any such change activates, in second and posterior stages, new productive adjustments, which cease when the original stimulus has been fully absorbed by all sectors in the economy and an overall new balance is achieved. Any sectoral stimulus can therefore be globally evaluated by the increased economic output that ensures it. A sector is termed as a key sector, therefore, if facing the same stimulus (usually unitary to facilitate comparisons) is capable of pulling production in all sectors above some economic average. In this case, and because of its pulling capacity, such a sector is denominated as a key backward sector.

Forward key sectors have also been introduced to measure the pushing capacity of a sector but either because their interpretation is rather awkward (i.e. requires simultaneous identical increases in all sectors) or because they are based in the alternative input-output Ghosh model (i.e. often criticized in terms of its alleged implausibility (Oosthehaven, 1988; 1989, Guerra and Sancho, 2012), key forward sectors are not as commonly used in the empirical literature (Miller and Blair, 2009).

A competing approach to determine key sectors is based upon the hypothetical extraction method (HEM). Instead of measuring the pulling output capacity of a sector following an exogenous injection, the HEM investigates the role of a sector by way of simulating its absence in the economy. The absence is modelled setting relevant input-output coefficients to zero. The thus modified technology matrix is used to calculate the hypothetical new equilibrium in quantities. Since technical coefficients are now hypothetically lower, the new quantity equilibrium will also be lower. This can easily be seen to be a consequence of the series expansion of the Leontief inverse .The fall in output that would follow the extraction of a sector, even if hypothetical, indicates the hidden productive role of that sector in the interconnected economy. And the larger the output fall, the more relevant the sector would be in terms of its "key" contribution to the overall output of the economy. Check Miller and Lahr (2001) for an excellent and very complete discussion of the HEM in input-output economics.

The widespread use of the HEM to elicit key "productive" sectors has been restricted, to the best of our knowledge, to the quantity model of Leontief. The price model, however, could also be used to study key "cost" sectors in a fully dual manner to the formal procedures used for the quantity model. The detection and quantification of cost linkages would be informationally relevant for the design of tax policies or the implementation of primary factors policy stimulus. Sectors with high cost linkages would be prone, for instance, to exert larger inflationary pressures in response to exogenous increases in prices, as for example, an increase in social contributions paid by employers or in wages. An evaluation of how these exogenous shocks travel and propagate through the economy would provide authorities with significant information for price containment policies.

In this paper we therefore propose to implement the HEM in the Leontief price model to evaluate "hidden" cost linkages that stem from sectoral direct and indirect interdependencies. Furthermore, we also explore the inter-temporal dimension of these cost linkages by using SDA (structural decomposition analysis) to Spanish input-output data for the years 2000 and 2007. In Section 2 we provide the required technical procedural details of the analysis. In Section 3 data is presented and some empirical results for the Spanish economy are discussed. Finally, Section 4 concludes with a summary of the main findings and the description of future lines of research.

2. AN INTERTEMPORAL PRICE MODEL WITH EXTRACTIONS

We consider an economy composed by *n* productive sectors. For each sector, denoted by *j*=1,…*n*, production takes place using a Leontief production function that models technology as a fixed combination of primary inputs, $v_j = [V]_j$ and *n* non-primary or intermediate inputs, $z_{ij} = [Z]_{ij}$:

$$X_j = \min\left[\frac{z_{1j}}{a_{1j}},\ldots,\frac{z_{nj}}{a_{nj}};\frac{v_j}{l_j}\right] \qquad \forall j,i=1,.....n \tag{1}$$

where $a_{ij} = [A]_{ij}$ refers to the well-known structural direct input-output technical coefficients while $l_j = [L]_j$ are the direct requirements of primary inputs per unit of gross output $x_j = [X]_j$. We therefore posit a standard fixed coefficient production process with constant returns to scale. This technology can be defined as a set of matrices, i.e. (*A*, *L*), with each column of them specifying the combined amount of direct inputs per unit of output.

Because of the inherent budget constraint for each productive sector, the total value of all outlays for primary and non-primary inputs in the *j* sector must be equal to the value of the total gross output generated in this sector of the economy:

$$p_j x_j = \sum_{i=1}^{n} p_i z_{ij} + v_j \qquad \forall j=1,\ldots,n \tag{2}$$

with $p_j=[P]_j$ being the equilibrium price per unit of output in sector *j*=1,2,..,*n*.

Consequently, equilibrium prices can be defined as a function of the technology in intermediate demand and value-added components (*A*, *L*):

$$p_j = \sum_{i=1}^{n} p_i a_{ji} + l_j \qquad \forall j=1,\ldots,n \tag{3}$$

or in matrix notation:

$$P' = P'A + L \qquad (4)$$

It is well known that if the non-negative matrix A has a dominant eigenvalue $\lambda \in (0,1)$, i.e. in economic terms, matrix A is productive. Then, the system of equations in (4) can be solved in the following way:

$$P' = L(I - A)^{-1} \qquad (5)$$

We can transpose the model solution in (5) and express it in terms of column vectors rather than row vectors; then expression (5) would become:

$$P = (I - A')^{-1} L' \qquad (6)$$

For the purposes of this analysis, the n production units in the economy are split in two groups of sectors or block of industries, namely block 1 that contains h sectors and block 2 that is formed by the remaining n-h sectors. Taking into account this subdivision of the n production units, we can express (6) accordingly in partitioned form as:

$$\begin{bmatrix} P_1 \\ P_2 \end{bmatrix} = \begin{bmatrix} I - A'_{11} & A'_{21} \\ A'_{12} & I - A'_{22} \end{bmatrix}^{-1} \begin{bmatrix} L'_1 \\ L'_2 \end{bmatrix} \qquad (7)$$

where:

$$\begin{bmatrix} I - A'_{11} & A'_{21} \\ A'_{12} & I - A'_{22} \end{bmatrix}^{-1} = \begin{bmatrix} \Lambda' & \Lambda' A'_{21}(I - A_{22})^{-1} \\ (I - A'_{22})^{-1} A'_{12}\Lambda' & (I + (I - A'_{22})^{-1} A'_{12}\Lambda' A'_{21})(I - A'_{22})^{-1} \end{bmatrix} \qquad (8)$$

with $\Lambda' = (I - A'_{11} - A'_{21}(I - A'_{22})^{-1} A'_{12})$

This partitioned representation of the well-known Leontief price model makes possible to evaluate and quantified sectoral "hypothetical extraction" linkage measures (Miller and Lahr, 2001) not in terms of its economy-wide effects over gross output but rather in terms of its impact on sectors' costs structure or final price composition, what we have called "the price linkage measure". A question might arise now and it is how we proceed to model the extraction of an industry or groups of industries in order to obtain a comprehensive indicator that provides useful and quantifiable information about this proposed "price linkage measure".

Several types of extractions have been suggested in the literature to quantify the average direct and indirect stimuli generated by one sector in the economy (Miller and Lahr, 2001; Miller and Blair, 2010) and each of them has been designed accordingly to the tasks of the analysis in question. For our analysis' purposes, we have modelled the extraction of a sector by way of nullifying all the direct coefficients where that sector has an influence (either as a supplier to or as a demander of inputs), including self-supply deliveries. If the "hypothetically extracted" group of sectors refer to those that pertain to block 1 then the "new" technical coefficient matrix $\overline{A}$ would become:

$$\alpha^{(-1)} a_{ij} = \overline{a}_{ij} = \left[\overline{A}\right]_{ij} \tag{9}$$

where $\alpha^{(-1)}$ is an auxiliary binary scalar that equals 1 if i=1 or j=1 and equals zero otherwise[1]. Consequently, after applying the "full" extraction of block 1 and assuming that both primary inputs prices and technology remained unchanged, the "new" (in hypothetical terms) price equilibrium in the economy would be determined by:

$$\begin{bmatrix} \overline{P}_1 \\ \overline{P}_2 \end{bmatrix} = \begin{bmatrix} I & 0 \\ 0 & (I - A'_{22})^{-1} \end{bmatrix} \begin{bmatrix} L'_1 \\ L'_2 \end{bmatrix} \tag{10}$$

If we now calculate the difference between the pre-extraction equilibrium reflected in expression (7) and the post-extraction equilibrium shown in (10):

$$\begin{bmatrix} \Delta P_{1(-1)} \\ \Delta P_{2(-1)} \end{bmatrix} = \begin{bmatrix} P_1 - \overline{P}_1 \\ P_2 - \overline{P}_2 \end{bmatrix} = \begin{bmatrix} I - \Lambda' & \Lambda' A'_{21}(I - A_{22})^{-1} \\ (I - A'_{22})^{-1} A'_{12}\Lambda' & (I - A'_{22})^{-1} A'_{12}\Lambda' A'_{21}(I - A'_{22})^{-1} \end{bmatrix} \begin{bmatrix} L'_1 \\ L'_2 \end{bmatrix} \tag{11a}$$

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[1] Similar and symmetrical considerations would apply to the extraction of the block of sectors 2. We omit the details here for simplicity.

or in simpler matrix notation:

$$\begin{bmatrix} \Delta P_{1(-1)} \\ \Delta P_{2(-1)} \end{bmatrix} = \begin{bmatrix} P_1 - \bar{P}_1 \\ P_2 - \bar{P}_2 \end{bmatrix} = \begin{bmatrix} H & C \\ G & U \end{bmatrix} \begin{bmatrix} L_1' \\ L_2' \end{bmatrix} \tag{11b}$$

Expressions (11) show the decline in all prices in both blocks after the simulated extraction of the cost linkages associated to block 1. This method of extraction was first proposed by Paelinck *et al* (1965) and then used by Strassert (1968), Schultz (1977) and has been widely used later on by Heimler (1991), Dietzenbacher and Van der Linden (1997), and Temurshoev (2010), among others. The endogenous decline in unitary prices evaluated through expressions (11) above, i.e. $\Delta P_{1(-1)}$ and after simulating the removal of overall intermediate deliveries of block 1 is, in our view, an appropriate approximate indicator to the role played by the direct and indirect sectoral cost interdependencies originated by block 1 in determining the final price structure and thus competitiveness levels in the economy.

We now move to show how the inter-temporal dimension is incorporated in our approach. The idea here is to identify not only which sector is "key" in determining the unitary cost structure for a specific period but also how and why the "price linkage indicator" has varied within periods in an economy. In doing so, we adopt and implement the structural decomposition technique first proposed by Carter (1970) for the input-output methodology. In fact, the analysis of changes in technical coefficients across periods can provide useful information about actual and potential sources of efficiency (Gowdy and Miller, 1987; Rose and Chen, 1991; Casler and Hadlock, 1997; Oosterhaven and Van der Linden, 1997). This constitutes indeed our main interest since the endogenous impact we aim to evaluate relates to unitary prices, which capture the underlying technologically efficient use of intermediate inputs and value-added. We would like to stress, however, that we leave aside dynamic considerations in our input-output price model, such as those used in previous research (Leontief, 1970; Liew, C.K, 1977; Liew, C.J., 2000; Leontief and Duchin, 1986; Los, 2001).

If the objective is then to decompose the total inter-temporal change of our proposed price linkage indicator defined through expression (11) from period *t* to period *t+s*, if we make use of the simpler version in (11b), as it is common practise in the SDA analysis and for the simplest case of two determinants, we can take the arithmetic mean of the two polar decompositions that leads to an exact solution which yields[2]:

$$\Delta P^{s}_{1(-1)} = \left[\Delta H^{s}\left((L_1^{t+s}+L_1^{t})/2\right)'+\Delta C^{s}\left((L_2^{t+s}+L_2^{t})/2\right)'\right]+\left[\left((H^{t+s}+H^{t})/2\right)\Delta L_1'^{s}+\left((C^{t+s}+C^{t})/2\right)\Delta L_2'^{s}\right]$$
$$\Delta P^{s}_{2(-1)} = \left[\Delta G^{s}\left((L_1^{t+s}+L_1^{t})/2\right)'+\Delta U^{s}\left((L_2^{t+s}+L_2^{t})/2\right)'\right]+\left[\left((G^{t+s}+G^{t})/2\right)\Delta L_1'^{s}+\left((U^{t+s}+U^{t})/2\right)\Delta L_2'^{s}\right] \quad (12)$$

Using expression (12) we see that the inter-temporal variation of the price linkage indicator ensuing the extraction of block 1, $\Delta P^{s}_{1(-1)}$ and $\Delta P^{s}_{2(-1)}$ can be grouped in two components: firstly, the variation that relates to changes in the weight of direct and indirect sectoral interdependencies, i.e. $(\Delta H^{s}, \Delta C^{s}, \Delta G^{s}, \Delta U^{s})$; secondly, the variation due to the changes in the direct primary input requirements or value added technology, i.e. $(\Delta L_1'^{s}, \Delta L_2'^{s})$.

3. DATA SOURCES AND SOME EMPIRICAL RESULTS FOR SPAIN

We use data contained in the input-output tables for the Spanish economy for the years 2000 and 2007. These tables have been taken from the data compiled by the Spanish National Statistics Institute (INE). The Symmetric Input-Output Table for the first period or "reference" year (SIOT 2000) was directly provided from the aforementioned statistical sources, while the Symmetric Input-Output Table for 2007 (SIOT2007) has been constructed by the authors from the information included in the make and use tables. In merging the economic flows coming from these two sources, we have used the industry-technology assumption as indicated in the European System of Accounts (1995). Formal details for the application of this assumption can be found in Ten Raa (1995). The Spanish input-output tables follow the SEC-95, now the SEC-2008 methodology, to comply with European Union data harmonization.

In our analysis the sectoral break-down consists in 46 production units. The sectoral disaggregation applied to the SIOT2000 and the SIOT2007 along with name abbreviations and the corresponding code according to the Classification of Products by Activity for 2008(CPA-2008) are included in AnnexA.

[2] This technique consists in mixing the Laspeyres and Paasche Index that for the two factor case meets the factor reversal property. There is a strong connection between the SDA and the Index Number theory .See, for instance, Dietzenbacher and Los (1998), Sun (1998), Ang and Zhang, 2000 and Hoekstra and Van der Bergh, 2003 and Boer, 2008, 2009.

Additionally, since one of the purposes of the present analysis relies on comparing changes in our proposed price linkage indicator over time, it is necessary for an appropriate understanding of these variations to transform input-output flows in constant prices. Therefore, to 'neutralize' the nominal effect that conditions inter-temporal changes in our evaluated price linkage indicator defined in section 2 we have used as base-prices those that relate to the period 2007.

In estimating the SIOT2000 in real terms, we have followed a technique based on the double deflation method[3] . The first step of this technique consists in deflecting sectoral intermediate flows and the final demand flows, row by row, using respectively the Industrial Production Price Index (IPRI), when available, and the consumer price index[4] (CPI). Secondly, the value added component have been adjusted as a way of a "residual" making compatible the use-resource accounting identity once considering sectoral imports flows in constant prices. Details about the corresponding statistical sources when deflecting intermediate demand flows for each production unit are summarized in AnnexB.

[3] Alternative methods to transform Input-Output Tables in constant prices are those presented by De Boer and Broesterhuizen (1991), Durand (1994,1996) and Dietzenbacher and Hoen (1998).

[4] It is well-known that inter-temporal trends of producer prices remarkably differed from consumer prices. A combined use of the Industrial Production Index and the Consumer Price Index makes possible to control for this distinction when deflacting both, intermediate and final demand flows for those industrial production sectors. Unfortunately, it was not possible for the case of the service sectors, not at least for the years we considered in our approach. The Regulation (1158/2005) approved by the European Council tries to fill this gap in macroeconomic statistics.

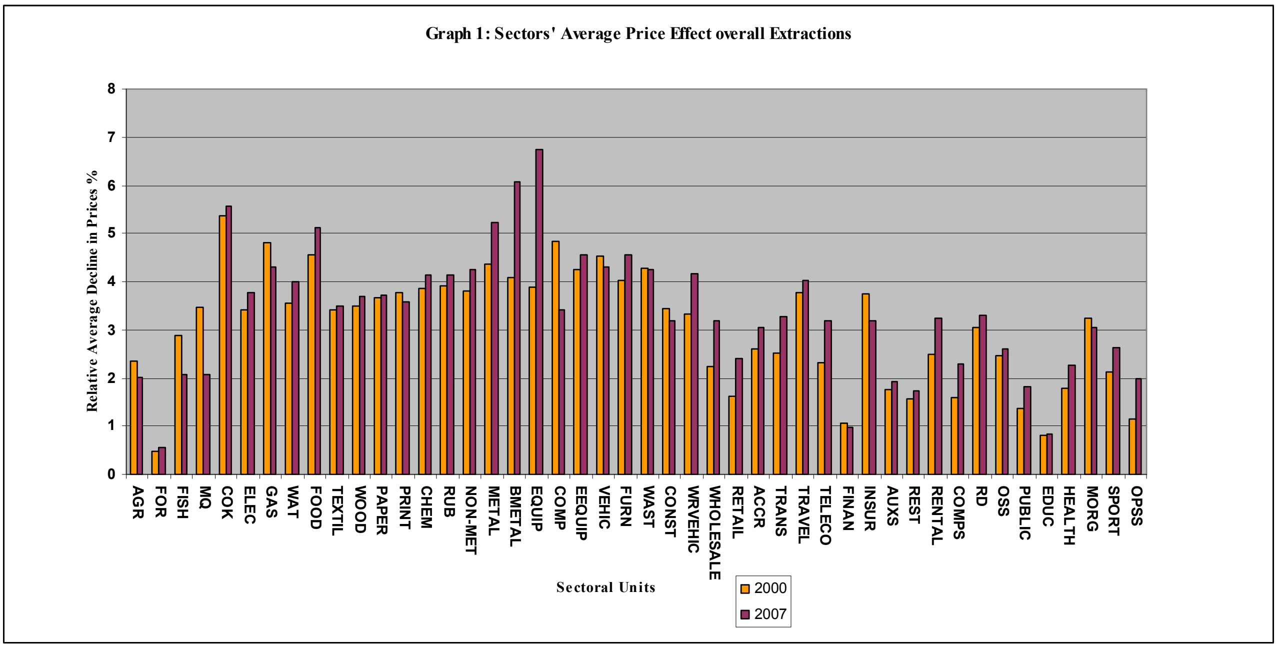
Table 1: Evaluated Decline in Prices after Extraction: "Price Linkage Indicator 2000". Average and Dispersion Measures. Spanish SIOT2000				
Extracted Sector	**Price Average Impact (%)**	**Variance**	**Maximum**	**Minimum**
AGR	2,48	0,0064	40,99	0,12
FOR	0,92	0,0005	12,40	0,07
FISH	0,98	0,0040	43,00	0,00
MQ	**8,17***	**0,0243**	**69,15**	**0,60**
COK	**5,23**	**0,0151**	**84,24**	**0,46**
ELEC	**4,02**	**0,0053**	**51,03**	**0,25**
GAS	2,39	0,0115	73,24	0,05
WAT	1,54	0,0062	53,64	0,04
FOOD	3,15	0,0138	77,67	0,08
TEXTIL	2,00	0,0063	54,44	0,08
WOOD	2,52	0,0076	58,24	0,10
PAPER	**3,59**	**0,0086**	**59,36**	**0,12**
PRINT	**3,28**	**0,0073**	**59,01**	**0,19**
CHEM	**6,50**	**0,0083**	**59,49**	**0,62**
RUB	**3,47**	**0,0078**	**60,34**	**0,23**
NON-MET	2,54	0,0077	59,24	0,13
METAL	**6,36**	**0,0131**	**67,32**	**0,40**
BMETAL	**5,64**	**0,0090**	**61,53**	**0,50**
EQUIP	**4,65**	**0,0074**	**58,91**	**0,39**
COMP	2,07	0,0118	74,09	0,04
EEQUIP	**3,47**	**0,0090**	**63,46**	**0,15**
VEHIC	3,02	0,0104	67,23	0,13
FURN	1,95	0,0080	61,20	0,05
WAST	2,69	0,0091	64,11	0,09
CONST	**3,31**	**0,0057**	**52,20**	**0,31**
WRVEHIC	2,57	0,0053	50,36	0,25
WHOLESALE	**4,60**	**0,0030**	**37,34**	**0,51**
RETAIL	1,22	0,0016	27,61	0,08
ACCR	2,46	0,0052	39,53	0,11
TRANS	**7,80**	**0,0040**	**38,42**	**0,83**
TRAVEL	1,65	0,0083	61,95	0,03
TELECO	**3,59**	**0,0027**	**37,07**	**0,33**
FINAN	**3,16**	**0,0009**	**18,17**	**0,71**
INSUR	1,83	0,0100	68,28	0,07
AUXS	1,96	0,0052	40,45	0,11
REST	**3,45**	0,0014	25,94	0,39
RENTAL	1,97	0,0034	40,59	0,15
COMPS	1,18	0,0014	26,00	0,06
RD	1,66	0,0048	47,29	0,10
OSS	**10,64**	**0,0035**	**40,90**	**1,34**
PUBLIC	0,47	0,0010	21,66	0,00
EDUC	0,64	0,0003	12,48	0,11
HEALTH	0,98	0,0017	28,07	0,13
MORG	1,23	0,0059	52,35	0,02
SPORT	1,63	0,0024	33,78	0,08
OPSS	0,48	0,0007	18,48	0,01
Overall Sectors' Average measures	**3,07**	**0,0065**		

** Price Average impacts in bold refer to sectors with above sectors' average price effects.*

In the very first step of our empirical analysis, the price model with extractions defined in equations 6-11(b) has been applied to the data set previously described. Accordingly, in Table 1 we have summarized the results for the Spanish economy for the first period here considered, 2000. The results shown down the first column in this table refer to the average decline in prices in overall sectors once each production unit is sequentially extracted from the economic national system. This measure constitutes the sectors' price linkage indicator as defined in Section 2. In addition to average effects, we have computed some related dispersion measures of the calculated hypothetical fall in overall sectors' costs, namely, the maximum, the minimum and its variance too (second, third and fourth columns in Table 1). Some "behavioural" information about how the decline in prices propagate within the inter-industrial grid might be relevant because, in our view, it provides useful information about to the degree of "heterogeneity" of the overall sector's price sensitiveness to the sector that is hypothetically extracted. From the results of the evaluated price linkage indicator it can be asserted that, for the first period considered in this analysis, sectors that appear to be 'key' in determining overall sectors price structures are those production units included and/or closely connected to the energy production block (*The Mining and Quarrying Sector* **(MQ)***, Coke and refined petroleum products* **(COK)** and *The Electricity Sector* **(ELEC)**), to the manufacturing industry (*The Chemical Sector* **(CHEM)***, Fabricated Metal Products* **(METAL)***, Machinery and Equipment* **(EQUIP)** and *Basic Metals Sector* **(BMETAL)**) and to the *Transport Service Sector* **(TRANS).** These results are not surprising since the aforementioned sectors constitute relevant if not essential, intermediate inputs in any production process. In these lines, once mimicking the same methodological exercise, similar conclusions might be drawn in terms of 'key price or cost sectors' for the other period analysed in this study 2007 (See Table 2). Perhaps, the most noticeable exception within the energy production block is the *Gas Sector* **(GAS)** that during the time-frame considered and in line with our findings, turned out to get "importance" in influencing average national prices.

As mentioned above, for a more complete evaluation of the role played by each production unit in delimiting costs structures in the Spanish economy, we have also analysed the average distributive 'power' of the price linkage indicator using the variance of this effect. According to this dispersion measure, The *Transport Sector* **(TRANS)** followed by the *Electricity Sector* **(ELEC)**, presented the lowest sectoral 'concentration' in influencing the average decrease in prices. These findings indicate that, not only are these two identified key sectors important for influencing overall sectors cost structures but also they might be also 'best price policy candidates' in terms of its potential distributive effects.

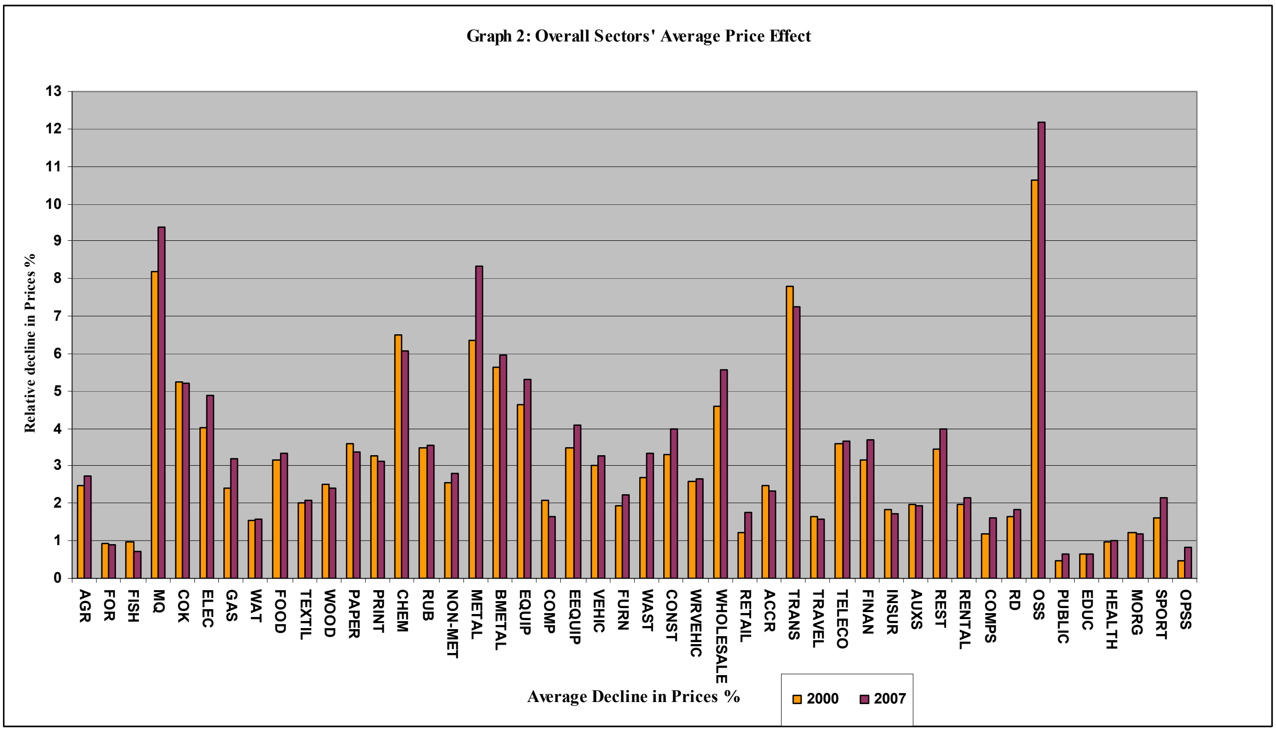
Table 2: Evaluated Decline in Prices after Extraction: Price Linkage Indicator 2007. Average and Dispersion Measures. Spanish SIOT2007 Base 2000=100.				
Extracted Sector	**Price Average Impact (%)**	**Variance**	**Maximum**	**Minimum**
AGR	2,72	0,0092	41,45	0,16
FOR	0,90	0,0127	11,84	0,07
FISH	0,72	0,0138	29,59	0,00
MQ	**9,38**	**0,0159**	**85,76**	**0,70**
COK	**5,22**	**0,0112**	**96,76**	**0,40**
ELEC	**4,88**	**0,0102**	**56,50**	**0,44**
GAS	**3,21**	**0,0100**	**74,10**	**0,13**
WAT	1,58	0,0089	55,26	0,05
FOOD	3,35	0,0091	84,88	0,11
TEXTIL	2,10	0,0066	53,10	0,11
WOOD	2,42	0,0075	58,03	0,14
PAPER	**3,37**	**0,0075**	**57,13**	**0,16**
PRINT	3,13	0,0078	53,95	0,26
CHEM	**6,07**	**0,0116**	**61,62**	**0,53**
RUB	**3,55**	**0,0134**	**61,10**	**0,25**
NON-MET	2,81	0,0159	62,79	0,33
METAL	**8,32**	**0,0153**	**77,84**	**0,59**
BMETAL	**5,97**	**0,0122**	**84,78**	**0,42**
EQUIP	**5,30**	**0,0103**	**93,67**	**0,37**
COMP	1,64	0,0079	49,20	0,06
EEQUIP	**4,10**	**0,0085**	**62,36**	**0,36**
VEHIC	3,28	0,0074	59,53	0,19
FURN	2,21	0,0072	65,65	0,10
WAST	3,35	0,0063	57,48	0,18
CONST	**3,98**	**0,0053**	**45,49**	**0,93**
WRVEHIC	2,66	0,0057	61,54	0,21
WHOLESALE	**5,56**	**0,0054**	**49,71**	**0,54**
RETAIL	1,75	0,0062	39,61	0,13
ACCR	2,33	0,0065	44,66	0,11
TRANS	**7,27**	**0,0052**	**48,77**	**0,81**
TRAVEL	1,59	0,0052	62,70	0,03
TELECO	**3,68**	**0,0041**	**48,84**	**0,40**
FINAN	**3,69**	**0,0034**	**15,91**	**0,97**
INSUR	1,74	0,0045	56,58	0,11
AUXS	1,94	0,0035	32,11	0,16
REST	**4,00**	**0,0037**	**27,78**	**0,48**
RENTAL	2,14	0,0061	49,99	0,18
COMPS	1,60	0,0055	36,46	0,10
RD	1,83	0,0050	48,83	0,11
OSS	**12,17**	**0,0044**	**41,34**	**1,89**
PUBLIC	0,63	0,0023	28,23	0,00
EDUC	0,64	0,0028	12,89	0,08
HEALTH	1,02	0,0032	32,96	0,12
MORG	1,18	0,0035	48,02	0,02
SPORT	2,14	0,0028	40,97	0,15
OPSS	0,84	0,0020	30,53	0,01
Overall Sectors' Average measures	**3,35**	**0,0075**		



Graph 1: Sectors' Average Price Effect overall Extractions

Once we have single out those productive units that following our propose methodology, came out to be the most potentially relevant in terms of overall sectors' price sensitiveness, another interesting question might be addressed: which sectors are the most cost sensitive in the economy?. In answering this question, we have opted for using and interpreting the results of the evaluated extractions in an alternative way, namely, for each sectoral unit, we have computed its corresponding average price decline across all evaluated extractions.

The outcomes of this previously described procedure for 2000 and 2007 are shown in Graph 1 above. One of the conclusions that we can extract from these results that sectors with the highest price sensitiveness once again refer to those that were detected to be 'key sectors' in terms of prices, the energy related sectors and sectors included in the manufacturing industry. Nevertheless, when comparing the results of the price linkage indicator and the price sensitiveness measures of these two groups of industries remarkably vary as it is, for instance, the case of the Electricity Sector **(ELEC)** and the Gas Sector **(GAS)**. According to our price linkage index, the Electricity Sector **(ELEC)** appear to be a key sector in determining overall national prices for the two years, 2000 and 2007. However, the Gas Sector **(GAS)** though still a "key price sector" at least for the last period, presents stronger average cost sensitiveness.



As already mentioned in the introduction, another objective of our approach consisted in carrying out an inter-temporal analysis to the evaluated price extractions applied to the two periods, 2000 and 2007. Although, in terms of sectors' price "keyness" conclusions do barely differ between these years, on one hand, overall sectors' price sensitiveness have increased during this time-frame, from 3,07 percent to 3,35 percent average decline in sectors' prices and on the other hand, the average dispersion of the transmission in price effects has decreased (See along the last rows in Table 1 and Table 2 respectively).

Therefore, in order to shed some light about which have been the main determinants of the detected rise in sectors' price sensitiveness evaluated through our proposed sectors' price linkage measures we have applied the simple decomposition analysis technique described in Section 2, expression (12). Following to this expression the variation in sectors' price linkage measures from 2000 to 2007, has been split in two determinants: the contribution explained by the changes in the strength of sectoral interdependencies or the Leontief inverse matrix $(\Delta H^s, \Delta C^s, \Delta G^s, \Delta U^s)$ and the contribution of those changes that occur within the sectoral value-added requirements $(\Delta L_1'^s, \Delta L_2'^s)$.

Table 3: Decomposition of the Variations in the Linkage Price Indicator evaluated under the HEM. 2000-2007.			
Extracted Sector	Average Variations in the Decline of prices %	Average Impact of the Technological Effect of Intermediate Demand %	Average Impact of the Technological Effect of Value-Added %
AGR	**0,24**	**0,02**	**0,22**
FOR	-0,02	0,00	-0,02
FISH	-0,26	0,02	-0,28
MQ	**1,21**	**0,32**	**0,89**
COK	-0,01	0,14	-0,15
ELEC	**0,86**	**0,01**	**0,85**
GAS	**0,82**	**0,05**	**0,77**
WAT	0,04	-0,01	0,05
FOOD	0,20	-0,01	0,21
TEXTIL	0,10	0,00	0,10
WOOD	-0,10	0,00	-0,10
PAPER	-0,22	0,00	-0,22
PRINT	-0,15	-0,02	-0,13
CHEM	-0,43	0,01	-0,44
RUB	0,08	-0,01	0,09
NON-MET	0,27	-0,01	0,28
METAL	**1,96**	**-0,16**	**2,12**
BMETAL	0,33	-0,10	0,43
EQUIP	0,65	-0,17	0,82
COMP	-0,43	0,03	-0,46
EEQUIP	0,63	-0,05	0,68
VEHIC	0,26	0,02	0,24
FURN	0,26	-0,02	0,28
WAST	0,66	0,00	0,66
CONST	0,67	-0,01	0,68
WRVEHIC	0,09	0,00	0,09
WHOLESALE	**0,96**	**-0,09**	**1,05**
RETAIL	0,53	-0,03	0,56
ACCR	-0,13	0,00	-0,13
TRANS	**-0,53**	**0,03**	**-0,56**
TRAVEL	-0,06	0,00	-0,06
TELECO	0,09	-0,02	0,11
FINAN	0,53	0,01	0,52
INSUR	-0,09	0,01	-0,10
AUXS	-0,02	0,00	-0,02
REST	0,55	-0,01	0,56
RENTAL	0,17	-0,01	0,18
COMPS	0,42	-0,02	0,44
RD	0,17	0,00	0,17
OSS	1,53	-0,07	1,60
PUBLIC	0,16	-0,01	0,17
EDUC	0,00	0,00	0,00
HEALTH	0,04	-0,01	0,05
MORG	-0,05	0,00	-0,05
SPORT	0,51	-0,03	0,54
OPSS	0,36	-0,02	0,38
Overall Sectors' Average measures	**0,28**	**-0,005**	**0,28**

Table 3 shows the outcome of the SDA for the Spanish economy for the time-frame 2000-2007 that constitutes the second step of our study. From these results several conclusions might be inferred. Firstly, notice that, on average, for most of the cases whereby there has been an above average remarkable increase in sectoral price sensitiveness, close to 1 percent increase (The *Agriculture Sector* **(AGR)**, The *Mining and Quarrying Sector* **(MQ)**, The *Electricity Sector* **(ELEC)**, The *Gas Sector* **(GAS)**, The *Sector of Fabricated Metal Products* **(METAL)**), although the contribution of the two technological effects have been positive, the value-added effect presented a stronger impact than the Leontief inverse effect. Moreover, those sectoral units that turned out to be key sectors in determining overall national prices according to the first step of our study, as it is especially the case of those sectors that relate to the energy and manufacturing block, have raised its average influence in sectors' costs-structures due to the significant growth of primary inputs requirements. The exception is the The *Transport Service Sector* **(TRANS)** presents a different pattern. This sector has lost its weight in determining costs structures by more than 0.5 percent mainly due to a decline in its value-added input requirements.

Secondly, as we might expect in developed economies, the SDA technique indicates that sectors' costs in primary inputs that includes, for instance labour costs, grew and changed faster than sectoral interdependencies. This, of course, does not imply that sectors' linkages on the basis of intermediate demand as the first step of our analysis have revealed are not important. In fact, all methods that allow controlling for these interdependencies help to single out those production units on which policies that in this case pursue increasing overall national competitiveness levels should be redirected.

Lastly, the decomposition of changes in sectors' price linkage measures show that, in general and leaving aside aggregation problems (Temurshoev, 2010 and Su and Ang, 2012), sectors' price dependencies experiment a larger increase in the energy and manufacturing industry together, than the service sector activities during this period. At least in terms of volume (quantities and prices together) the former are more intensive in labour due to the structure of their technology than the latter. In these lines, future research will be devoted to isolate value measures (i.e. wages) from quantity measures (i.e. hours of work or workers) to evaluate their corresponding contribution.

4. CONCLUSIONS.

In this paper we have presented a novel methodology that allows identifying in an innovative manner 'key sectors' in terms of their costs structures. In doing so we have defined a cost linkage measure that consists in applying the HEM to the well-known Leontief price model. The interest of our proposed price linkage indicator for polices orientated to improve efficiency and thus competitiveness levels, relies on providing useful information when singling-out "best-candidates" among the inter-industrial "grid" in terms of both its potential total impact and its potential distributive effect. As empirical scenario where applying this approach, we have chosen the Spanish economy using Input-Output data for two periods, 2000 and 2007. This empirical exercise reveals that for the two years and differently to what it was observed for service activities, with the exception of the Transport Service Sector, those sectors that relate to the Energy and Manufacturing industries turned out to be 'key' in determining overall price-costs structures in the Spanish economy. In our view, this is an interesting result since it indicates that though the service sector in terms of value-added represents the highest contribution, something that it is common among developed economies, the role of this sector in delimiting overall national prices appears not to be very large compared to other production units.

While the outcomes in terms of sectors' keyness in affecting economy-wide prices barely change along the 2000-2007 timeframe, both, the average sectoral degree of influence over costs structures and its dispersion power increased. Then, to complete better our study, we have carried out a longitudinal analysis of the price linkage indicator using a simple version of the 'traditional' SDA whereby the variations of this indicator are explained by two effects. These two effects refer to the contribution of the variations in the Leontief inverse and the contribution of the changes in value-added technology. According to the outcomes obtained by this inter-temporal study between the years 2000 and 2007, in most cases, the contribution of the first determinant has presented different signs and a remarkable more modest effect than the contribution of the second determinant. As a attempt to shed some light over these findings and enrich this study, future lines of research will try to sophisticate both, the data set used in this paper and the methodology.

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AnnexA: Sectoral breakdown for the SIOT2000 and SIOT2007

Abbreviation	SECTORS DESCRIPTION	CPA-2008 CODE
AGR	Agriculture, hunting	CPA_A01
FOR	Forestry	CPA_A02
FISH	Fishing and aquaculture	CPA_A03
MQ	Mining and quarrying	CPA_B
COK	Coke and refined petroleum products	CPA_C19
ELEC	Electricity	CPA_D35
GAS	Gas	CPA_D35
WAT	Water Sector	CPA_E36
FOOD	Food products, beverages and tobacco products	CPA_C10-C12
TEXTIL	Textiles, wearing apparel and leather products	CPA_C13-C15
WOOD	Wood and of products of wood and cork, except furniture; articles of straw and plaiting materials	CPA_C16
PAPER	Paper and paper products	CPA_C17
PRINT	Printing and recording services	CPA_C18
CHEM	Chemicals and chemical products	CPA_C20
RUB	Rubber and plastics products	CPA_C22
NON-MET	Non-Metallic Mineral Products	CPA_C23
METAL	Fabricated metal products, except machinery and equipment	CPA_C25
BMETAL	Basic Metals	CPA_C24
EQUIP	Machinery and equipment n.e.c.	CPA_C28
COMP	Computer, electronic and optical products	CPA_C26
EEQUIP	Electrical equipment	CPA_C27
VEHIC	Motor vehicles, trailers and semi-trailers	CPA_C29-C30
FURN	Furniture; other manufactured goods	CPA_C31_C32
WAST	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services	CPA_E37-E39
CONST	Constructions and construction works	CPA_F
WRVEHIC	Wholesale and retail trade and repair services of motor vehicles and motorcycles	CPA_G45
WHOLESALE	Wholesale trade services, except of motor vehicles and motorcycles	CPA_G46
RETAIL	Retail trade services, except of motor vehicles and motorcycles	CPA_G47
ACCR	Accommodation and food services	CPA_I
TRANS	Transport Services	CPA_H49-H56
TRAVEL	Travel agency, tour operator and other reservation services and related services	CPA_N79
TELECO	Telecommunications and Postal services	CPA_J61-J62 & CPA_H53
FINAN	Financial services, except insurance and pension funding	CPA_K64
INSUR	Insurance, reinsurance and pension funding services, except compulsory social security	CPA_K65
AUXS	Services auxiliary to financial services and insurance services	CPA_K66
REST	Real estate services (excl imputed rents)	CPA_L68
RENTAL	Rental and leasing services	CPA_N77
COMPS	Computer programming, consultancy and related services; information services	CPA_J62_J63
RD	Scientific research and development services	CPA_M72
OSS	Other services	CPA_M74_M75
PUBLIC	Public administration and defence services; compulsory social security services	CPA_O84
EDUC	Education	CPA_P85
HEALTH	Health and Social Services	CPA_Q86-Q87
MORG	Services furnished by membership organisations	CPA_S94
SPORT	Sporting services and amusement and recreation services	CPA_R90-R93
OPSS	Other personal services	CPA_S96

AnnexB: Statistical Sources for converting SIOT2007 into SIOT2007 base 2000

Sectoral Unit	Deflactors
AGR	Agriculture Output Price Index (AOPI)
FOR	(AOPI)
FISH	(AOPI)
MQ	Industrial Production Price Index (IPRI)
COK	IPRI
ELEC	IPRI
GAS	IPRI
WAT	Specific Industrial Production Price Index not available. Proxy: Average IPRI
FOOD	IPRI
TEXTIL	IPRI
WOOD	IPRI
PAPER	IPRI
PRINT	IPRI
CHEM	IPRI
RUB	IPRI
NON-MET	IPRI
METAL	IPRI
BMETAL	IPRI
EQUIP	IPRI
COMP	IPRI
EEQUIP	IPRI
VEHIC	IPRI
FURN	IPRI
WAST	Specific IPRI not available. Proxy: Average IPRI
CONST	Specific IPRI not available. Proxy: Average IPRI
WRVEHIC	Specific Service Sector Price Index (SSPI) not available. Proxy: CPI
WHOLESALE	Specific SSPI not available. Proxy: CPI
RETAIL	Specific SSPI not available. Proxy: CPI
ACCR	Specific SSPI not available. Proxy: CPI
TRANS	Specific SSPI not available. Proxy: CPI
TRAVEL	Specific SSPI not available. Proxy: CPI
TELECO	Specific SSPI not available. Proxy: CPI
FINAN	Specific SSPI not available. Proxy: CPI
INSUR	Specific SSPI not available. Proxy: CPI
AUXS	Specific SSPI not available. Proxy: CPI
REST	Specific SSPI not available. Proxy: CPI
RENTAL	Specific SSPI not available. Proxy: CPI
COMPS	Specific SSPI not available. Proxy: CPI
RD	Specific SSPI not available. Proxy: CPI
OSS	Specific SSPI not available. Proxy: CPI
PUBLIC	Specific SSPI not available. Proxy: CPI
EDUC	Specific SSPI not available. Proxy: CPI
HEALTH	Specific SSPI not available. Proxy: CPI
MORG	Specific SSPI not available. Proxy: CPI
SPORT	Specific SSPI not available. Proxy: CPI
OPSS	Specific SSPI not available. Proxy: CPI