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E-mail addresses: mpcampoy@uloyola.es, macardenete@uloyola.es, mcdelgado@uloyola.es
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Medieninhaber (Verleger), Hersteller: Österreichisches Institut für Wirtschaftsforschung • 1030 Wien, Arsenal, Objekt 20 • Tel. (43 1) 798 26 01-0 • Fax (43 1) 798 93 86 • http://www.wifo.ac.at/ • Verlags- und Herstellungsort: Wien

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Analysis of structural changes in Andalusian economy using Social Accounting Matrices

Authors:

Campoy Muñoz, Pilar (mpcampoy@uloyola.es);

Cardenete Flores, Manuel Alejandro (macardenete@uloyola.es)

Delgado López, María del Carmen (mcdelgado@uloyola.es)

Departament: Economía

University: Universidad Loyola Andalucía

Abstract: The goal of this work is to analyze the possible effects of crisis on Andalusian economic structure during the period 2005-2010 using Social Accounting Matrices (SAMs). The SAMs describe the circular flow of income and provide a statistical database for the analysis of the key sectors in the regional economy, the linkages between these sectors and their relevance in terms of employment. Specifically, a linear SAM model is applied to calculate the decomposition of multipliers in their three effects (direct, indirect and induced), as well as the multipliers of the employment for each sector in the regional economy. Finally, the comparative analysis of the different years allows us to draw some conclusions about the changes in the productive structure as consequence of the crisis.

Keywords: Regional Accounts, Input- Output Tables, Social Accounting Matrices, Multisectoral Models, Key Sectors.

JEL Classification: C67; D57; R15.

1. Introduction

Knowledge of the productive structure of an economy, either national or regional level, is of major importance for the design of public policies devoted to improving its macroeconomic performance. In this regard, both the identification of key sectors and the analysis of their evolution over time are critical issues for the regional economic development. Fortunately, these tasks can be addressed by means of several tools developed in the area of economic analysis over the last few decades.

The Input-Output Tables (IOTs) are one of the most commonly used tools in the analysis of the economic structural changes, especially those happened in the short term (Cardenete et al., 2014), with several examples at national level (Ramos and Robles, 2009; Sonis et al., 1995) and also at regional level (Holland and Cooke, 1992; Thakur and Alvayay, 2012). Based on OIT logic, Social Accounting Matrices (SAMs) provide further information than the previous one through the integration of social statistics into the Input-Output Framework. As results, SAMs are powerful databases which could be employed to build more sophisticated economic analysis tools, such as multiplier models or applied general equilibrium models. In the vein of the multiplier models, SAMs have been also employed to analyse the structural change at both national (Cardenete and Delgado, 2011; Reinert and Roland-Holst, 1994; Roberts, 1995) and regional level (Llop, 2007). In the case of Spain and, in particular, the region of Andalusia, there are a number of studies that analyse the economic structure and its evolution from the beginning of the previous decade to the onset of the financial crisis. The study of Lima et al., (2004) focuses on the nineties and outlines the ability of the construction branch and services sector as stimulators of the economic activity in the region, confronted with the inability of the manufacturing industry as developer of the regional growth. The study of Cardenete and Fuentes (2009) extends the analysis to 2005, highlighting the consolidation of agriculture and building sectors as promoters of the regional economy, at the same time food industry and services sectors are set up as key sectors. Finally, the study of Cardenete et al. (2014), covering the period from 2000 to 2005, points out again the key role of the building sector and the relevance of the primary and tertiary sectors on the regional economy, as well as the emerging importance of some industrial sectors such as the manufacture of coke and refined petroleum products or the metallurgy.

Over the 2005-2010 period, the development of the main regional macroeconomic variables suggests the possibility of structural changes in the Andalusian productive structure as a result of the economic and financial crisis suffered by the world economy. Thus, in the year 2005 the regional economy showed an overall positive balance, with reference indicators performing slightly higher than the Spanish and European average, largely as a consequence of the dynamism of the services sector and the booming building sector. However, this balance became negative in 2010, with some of the above mentioned sectors bearing the brunt, especially the building sector and some service activities, which made a negative contribution to the regional GDP growth and to the employment.

In this context, the goal of this work is to identify those productive sectors which no longer stimulate the regional economy or, on the contrary, those which have gained in importance on the regional development over the reference period. To do so, the SAMs for Andalusia in the years 2005 and 2010 are used to identify key sectors in the corresponding years and to make a comparison on the basis of the first one. In addition, the intersectoral relationships in the regional economy are analysed by means of the "structural path analysis" methodology. Furthermore, the multiplier decomposition allows us to analyse the linkages between the remuneration paid to the primary factors of production and the various institutions shaping the regional final demand, while the effect on regional employment of changes in regional final demand are estimated by the employment multipliers.

The rest of the work is structured as follows. Section 2 briefly describes the SAMs framework. In Section 3, the SAMs for Andalusian economy in the years 2005 and 2010 are presented. Section 4 is devoted to the empirical application. The work ends with the main conclusions.

2. Social Accounting Matrices

SAMs are matrix presentations of the whole set of economic flows amongs agents in a given time period, typically one year. SAMs enlarge the information provided by OITs, showing the intersectoral relationships in the economic system and also the relationship among the productive structure and the transactions of distribution, accumulation and use

of income of the different institutions. In fact, SAMs are based on OITs suplemented by information drawn from National Income and Product Accounts, budget surveys and a host of tax, socioeconomic and demographic data, thus showing the circular flow of income.

In their basic structure, SAMs can be understood in the light of such economic model. The firms in the productive system obtain their income from the sale of their products (either as intermediate goods to other firms or as final goods to final demand), which is used to remunerate primary factors provided by the households. The household income, which makes up the added-value, is intended to the consumption, the saving and also the payment of taxes. In addition, the economic exchanges with the foreign sector generate inflows or outflows in the economic system under study. Thus, the use of income increases the requirement of production,fuelling a new cycle.

Since SAMs are the depiction of the full set of transactions in the economy, the economic flows embodied in SAMs should satisfy the standard aggregate identities, for example the aggregate total spending carried out by the different agents in the system which should be equal to the total income, thus the sum of each column necessary equals the sum of the corresponding row of the matrix structure. Furthermore, this structure can be easily adapted to provide finer detail in any of its accounts. Figure 1 shows a simplified structure for SAM, highlighting its main components. The three matrices which sum up the economic transactions among agents are in light grey: the intermediate consumption matrix, the added value matrix and the final demand matrix, so that the total output is equal to the total demand.

The intermediate consumption matrix shows the transactions in goods and services among productive sectors, as well as among the public sector. The purchases of intermediate goods and services in each sector are displayed in columns, as results columns totals indicate the intermediate consumption in each sector; while row totals display the sales made by each sector in the economic system. On the other hand, the added-value matrix shows the primary factors (labour and capital) employed in each productive sector, emcompassing accounting items such as Gross Wages and Salaries, Fixed Capital Consumption, Net Operating Surplus, Mixed Revenues and Employer Social Security Contributions. Finally, final demand matrix shows the final consumption spending, that is,

the private consumption spending, the government spending, the investment and the exports to the foreign sector.

Figure 1. Social accounting matrix: simplified structure.

	Productive sectors	**Primary factors**	**Institutions**	**Investment**	**Foreign sector**
Productive sectors	Intermediate consumption		Consumption of public sector and households	GFCF	Exports
Primary factors	AV payments to factors				
Institutions	Taxes on activities, goods and services	Income distribution	Current transfers among institutions	Taxes on capital assests	Transfers from the foreign sector
Investment			Internal saving		Foreign saving
Foreign sector	Imports		Transfers to the foreign sector		

Source: Cardenete and Moniche (2001).

The SAM structure is completed with the "closure matrix" of the circular flow of income in the multisectoral economic structure represented. This matrix, placed on the lower right-side and unshaded area of the Figure 1, displays the relationships between added-value and final spending. Thus, the rows show the total resources available to the households and the public sector to pay their consumption and investment spending, while the columns exhibit their different uses in consumption, savings or taxes.

3. Statistical information

The databases employed in this work are the empirical SAMs of the Andalusian economy, which were built from the Input-Output Framework for 2005 and 2008 published by Statistics and Cartography Institute of Andalusia (IECA). The SAM for 2005[1] was elaborated from supply and use tables by means of the input-output technology. By contrast, the SAM for 2010[2] was obtained by means of an updating technique called Cross Entropy Method (Cardenete and Sancho, 2006) on the SAM for 2008[3].

[1] Cardenete et al. (2010a).
[2] Campoy et al. (2014)
[3] Cardenete et al. (2014).

The structures of both SAMs have been adapted for comparison reasons. Table 1 presents the corresponding structure, called SAMAND. A two-digit number is added at the end to identify the SAM for the corresponding year involved in the analysis, that is, SAMAND05 and SAMAND10. In their basic structure, SAMAND encompasses 34 accounts in both rows and columns, with 26 accounts for productive sectors, and 8 accounts for institutions, including the foreign sector account. The data for each account are expressed in thousand of euros and valued at purchaser's prices.

Table 1. Social Accounting Matrix for Andalusia.

1	Agriculture	18	Building materials
2	Stockbreeding	19	Other transportation equipment
3	Fishing	20	Various manufacturing industries
4	Energy products extraction	21	Building industry
5	Extraction of minerals other than energy products	22	Commerce
6	Petroleum refine and nuclear fuel processing	23	Transport, warehousing and communications
7	Electric power production and distribution	24	Other services
8	Gas and hot water production and distribution	25	Commercial services
9	Water collection, treatment and supply	26	Non-commercial services
10	Food, beverage and tobacco industry	27	Labour
11	Textile, clothing, leather and footwear industry	28	Capital
12	Timber, cork and paper industry	29	Consumers
13	Chemical, rubber processing and plastic materials industry	30	Savings / Investment
14	Non-metallic mineral products and metallurgy industry	31	Direct taxes
15	Metallic products manufacture	32	Indirect taxes
16	Machinery industry	33	Government
17	Automobile	34	Foreign sector

Source: Own elaboration based on Cardenete et al. (2010b).

4. Empirical application

4.1. Key sectors: structural analysis indicators

The information provided by SAMs allows a detailed analysis of the productive structure of an economic system by applying several techniques. Among them, we employ Linear SAM Models, based on the inverse matrix of Leontirf's model (1941) and Ghosh's model (1958) and the combination of two kinds of intersectoral linkages, the *Backward Linkages*

(diffusion effect) and the *Forward Linkages* (absorption effect) calculated from these inverse matrices. Before giving a detailed description of these linkages, the Linear SAM Models are briefly introduced.

Following Cardenete et al. (2010b), SAM is a square matrix of order *n* in which each row and column represents one of the accounts (productive sectors or institutions), which satisfies the corresponding budget constraint (total income is equal to total spending). Each component Y_{ij} of the matrix represents a bilateral income flow between account *i* and account *j*. By agreement, the rows (*i*) give the monetary income in the corresponding accounts (receipts or monetary supplies), while the columns (*j*) give the spending (payments or monetary uses). The average spending coefficients, noted as $a_{ij} = Y_{ij} / Y_j$, *i*, *j* = 1, 2, …, *n*, indicates the payments to account *i* per unit of income in account *j*. Based on the above, the SAM can be expressed as follows:

$$Y_i = \sum_{j=1}^{n} \left(Y_{ij} \Big/ Y_j \right) \cdot Y_j = \sum_{j=1}^{m} \left(a_{ij} Y_j \right) + \sum_{j=m+1}^{m+k} \left(a_{ij} Y_j \right); n = m + k \qquad (1)$$

The distinction between endogenous and exogenous accounts is noted through the subindex *m* and *k* respectively[4]. This allows the distinction between the total income of endogenous (Y_m) and exogenous (Y_m) accounts, as well as four submatrices within the average spending coefficients: A_{mm}, A_{mk}, A_{km}, and A_{kk}. Thus, the total income of endogenous accounts can be expressed as $Y_m = A_{mm} Y_m + A_{mk} Y_k$, and then, following the same procedure as applied to Leontief's equation, the accounting multipliers matrix *M* of the SAM is obtained:

$$Y_m = MZ \qquad (2)$$

being $M = \left(I - A_{mm} \right)^{-1}$ and *Z* the vector of exogenous columns $\left(A_{mk} Y_k \right)$. *M* represents the input requirement in response to unit income or spending increase in a given account; while *Z* shows the distribution of the income flows of exogenous accounts among the endogenous accounts. Calling *dZ* the changes in the exogenous account vector, the changes in the income of endogenous accounts is given as (Polo, Roland-Host and Sancho, 1990):

[4] It should be noted that the selection of the number of endogenous accounts (*m*) depends on the analysis to be developed and then the number of exogenous accounts (*k*) is determined. These latter explain the changes on the income of the endogenous accounts.

$$dY_m = MdZ = Md\left(A_{mk}Y_k\right) = MA_{mk}dY_k \qquad (3)$$

The *i-th* column of *M* shows the total income generated in each endogenous account *i* when one unit income flows from exogenous institutions to the corresponding endogenous. This interpretation, besides normalization[5], allows the calculation of the *Backward Linkages* ($BL_{.j}$):

$$BL_{.j} = \frac{M_{.j}}{\frac{1}{n}\sum_{j=1}^{n} M_{.j}} \qquad (4)$$

The $BL_{.j}$ enables to determine the difussion effect or the effect on the economy of an increase of demand of the sector represented by the account *j*, in other words, where the inputs required to increase the output of the sector *j* come from. Those sectors whose $BL_{.j}$ >1 exhibit power of dispersion, in such a way that a change in the output of the sector *j* influences the economic system above the average.

The second kind of intersectoral linkage, the *Forward Linkages* ($FL_{i.}$), is calculated from the Ghosh's Price model (Augustinovics, 1970; Dietzenbacher, 1997). The $FL_{i.}$ quantifies the change in the output of sector *i* as a consequence of one exogenous unit increase of the primary inputs in sector *j* (or in their prices). Following Dietzenbacher (1997), each component of Goshian inverse matrix, the distribution coeeficients noted as δ_{ij}, indicates how much to increase the output value of sector *j* to generate one unit increase in the added-value of sector *i*. The $FL_{i.}$ are calculated from these coefficients as follows:

$$FL_{i..} = \frac{\sum_{j=1}^{n} \delta_{ij}}{\frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{n} \delta_{ij}} \qquad (5)$$

The $FL_{i.}$ enables to analyze the absorption effects or the consequences of a change in the valuation of the output of sector *j* on the system. Those sectors with $FL_{.j}$>1 demonstrate cost dispersion capacity, in such a way that the changes in their added-value affect the system above the average.

[5] The normalization is accomplished through the division of the effect of each sector by the average effect of sectors. In turn, this latter is calculated as the sum of the effects of all the sectors divided by the number of sectors considered.

The combination of both linkages allows us to categorize productive sectors according to the sectoral classification presented in Table 2:

Table 2. Sectoral classification from $BL_{.j}$ and $FL_{i.}$.

	FL<Average (FL)	FL> Average (FL)
BL> Average (BL)	Promoter sector	Key sector
BL< Average (BL)	Independent sector	Base sector

Source: Rasmussen (1956).

Key sectors demand and supply a large amount of intermediate inputs to and from the rest of productive sectors, so that any shock on these sectors has an effect greater than the average in the economic system. Exactly the opposite of what occurs with independent sectors, whose influence on the economy falls below the average. Promoter sectors are in an intermediate position, these sectors are large demanders of intermediate inputs, which enables them to lead other activities and to foster the economic grothw. Finally, base sectors, whose output are largely demanded by other sectors and thus variations in their prices or quantities have major effects on the rest of the productive sectors.

By calculating the $BL_{.j}$ and $FL_{i.}$, we obtain the following classification of the productive sectors of the Andalusian economy for the two years involved in our analysis. As shown in Table 3, there are four key sectors in 2005, Petroleum refining and nuclear fuel processing (6), Food, beverage and tobacco industry (10), Non-metallic mineral products and metallurgy industry (14), and Building industry (21). Besides, there are six base sector corresponding to the branches of Energy products extraction (4), Chemical, rubber processing and plastic materials industry (13), Machinery industry (16), Commerce (22), Transport, warehousing and communications (23) and Other services (24). The sectors classified as promoters are the most numerous with a total of ten sectors, the three ones falling within the primary sector (1, 2 and 3), and the other seven sectors belonging the secondary sector, concretely Electric power production and distribution (7), Gas and hot water production and distribution (8), Textile, clothing, leather and footwear industry (11), Metallic products manufacture (15), Building materials (18), Other transportation equipment (19) and Various manufacturing industries (20). Finally, the remaining six sectors are classified as independent; Extraction of minerals other than energy products

(5), Water collection, treatment and supply (9), Timber and cork industry (12), Automobile (17), Commercial services (25) and Non-Commercial services (26).

Table 3. Classification of productive sectors of Andalusian economy in 2005.

# Account	Productive sector	FL	BL	Classification
6	Petroleum refine and nuclear fuel processing	1.35	1.10	Key
21	Building industry	1.29	1.35	Key
10	Food, beverage and tobacco industry	1.23	1.18	Key
14	Non-metallic mineral products and metallurgy industry	1.12	1.10	Key
24	Other services	1.69	0.88	Base
23	Transport, warehousing and communications	1.56	0.91	Base
4	Energy products extraction	1.53	0.61	Base
22	Commerce	1.33	0.74	Base
16	Machinery industry	1.12	0.81	Base
13	Chemical, rubber processing and plastic materials industry	1.06	0.92	Base
20	Various manufacturing industries	0.91	1.11	Promoter
18	Building materials	0.87	1.09	Promoter
15	Metallic products manufacture	0.85	1.22	Promoter
7	Electric power production and distribution	0.85	1.03	Promoter
1	Agriculture	0.83	1.00	Promoter
8	Gas and hot water production and distribution	0.78	1.24	Promoter
19	Other transportation equipment	0.77	1.24	Promoter
2	Stockbreeding	0.72	1.09	Promoter
11	Textile, clothing, leather and footwear industry	0.70	1.01	Promoter
3	Fishing	0.62	1.01	Promoter
25	Commercial services	0.99	0.84	Independent
5	Extraction of minerals other than energy products	0.92	0.91	Independent
12	Timber ,cork and paper industry	0.90	0.98	Independent
17	Automobile	0.70	0.77	Independent
9	Water collection, treatment and supply	0.68	0.95	Independent
26	Non-Commercial services	0.62	0.90	Independent

Source: Own elaboration.

Table 4 displays the sectoral classification in 2010. At first glance, the number of productive sectors in each group has not changed substantially over time, the number of key and promoter sectors remains stable, while the number of base sectors increases to seven and the number of independent sectors drops to five compared to 2005. However, significant variations have occurred in the composition of each group, excluding the key sector group. Thus, sectors classified as independents in 2005 become base sectors in 2010, as in the case of Commercial services (25), or promoters, as occurs with Extraction of minerals other than energy products (5) and Water collection, treatment and supply (9). On the other hand, Fishing (3) and Electric power production and distribution (7), move from promoter to independent group in 2010.

Table 4. Classification of productive sectors of Andalusian economy in 2010.

# Account	Productive sector	FL	BL	Classification
6	Petroleum refine and nuclear fuel processing	1.21	1.02	Key
21	Building industry	1.15	1.34	Key
14	Non-metallic mineral products and metallurgy industry	1.07	1.11	Key
10	Food, beverage and tobacco industry	1.03	1.02	Key
22	Commerce	2.12	0.98	Base
23	Transport, warehousing and communications	1.71	0.97	Base
24	Other services	1.45	0.87	Base
4	Energy products extraction	1.31	0.65	Base
16	Machinery industry	1.18	0.76	Base
13	Chemical, rubber processing and plastic materials industry	1.05	0.90	Base
25	Commercial services	1.01	0.85	Base
19	Other transportation equipment	0.89	1.23	Promoter
5	Extraction of minerals other than energy products	0.86	1.02	Promoter
18	Building materials	0.86	1.10	Promoter
20	Various manufacturing industries	0.84	1.09	Promoter
1	Agriculture	0.83	1.02	Promoter
15	Metallic products manufacture	0.78	1.16	Promoter
9	Water collection, treatment and supply	0.76	1.05	Promoter
11	Textile, clothing, leather and footwear industry	0.71	1.10	Promoter
2	Stockbreeding	0.70	1.07	Promoter
8	Gas and hot water production and distribution	0.66	1.16	Promoter
7	Electric power production and distribution	0.93	0.99	Independent
12	Timber, cork and paper industry	0.92	0.96	Independent
17	Automobile	0.71	0.81	Independent
3	Fishing	0.63	1.00	Independent
26	Non-Commercial services	0.62	0.80	Independent

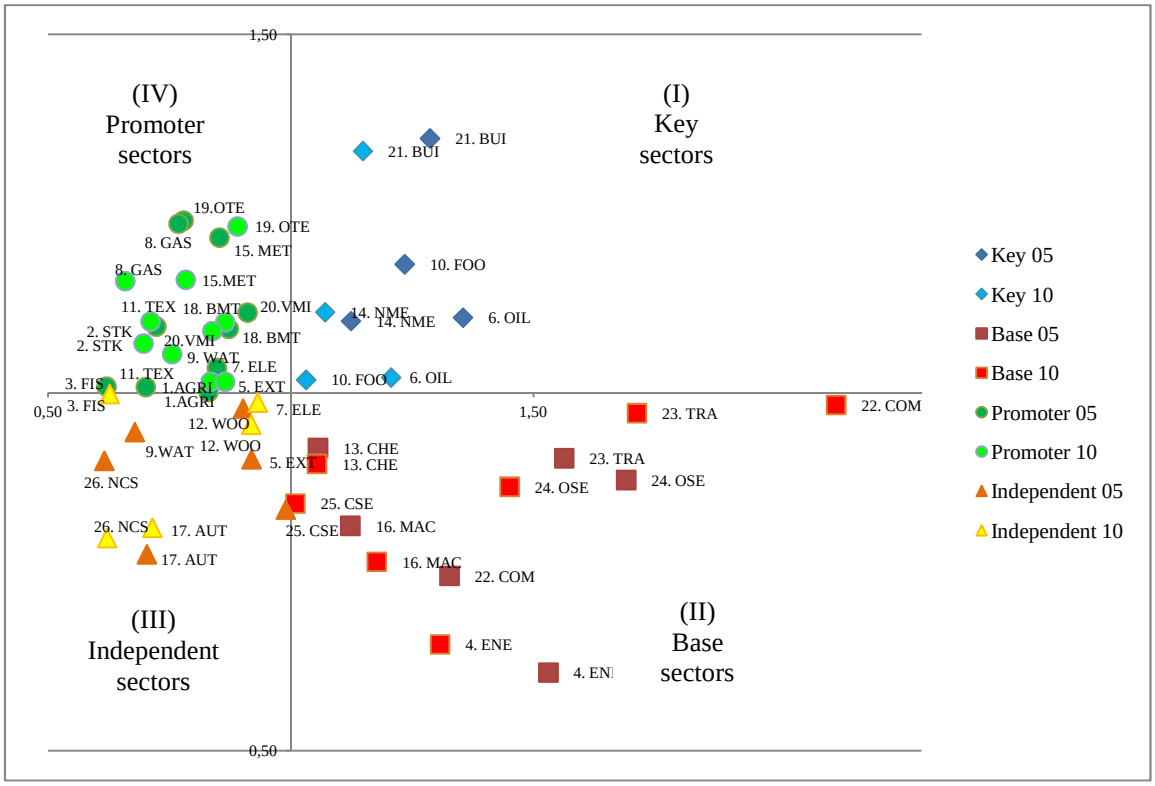
Source: Own elaboration.

The results obtained confirm the evolution of the structure of the Andalusian economy over the reference period. Thus, Building industry (21) has reduced its participation in the regional Gross Added Value (GAV) and employment, altough it remains high, about 11.2% and 8.4% respectively. On the other hand, Petroleum refining and nuclear fuel processing (6), whose firms represent about 20% of the total firms in the Spanish sector , and Food, beverage and tobacco industry (10), which counts for around 6% of regional exports, have slightly reduced their share in the GAV. Only Non-metallic mineral products and metallurgy industry (14), retains its share in both regional GAV and employment, and its production counts for around 30% of regional exports.

In Figure 2, the productive sectors have been represented taking into account the values corresponding to the $BL_{.j}$ (ordinate axis) and $FL_{i.}$ (abcissa axis) for both years, 2005 and 2010. The key sectors are represented in region I, base sectors in region II, independent

sectors in region III and, finally, promoters sectors in region IV. In addition to the changes already mentioned, this figure allows an easy comparision of the sectoral classification in both years.

Figure 2. Comparison of sectoral classification of the Andalusian economy between 2005 and 2010.



Source: Own elaboration.

The figure highlights that the difussion effect has decreased for three of the four key sectors (with the exception of the Non-metallic mineral products and metallurgy industry (14)), while this effect has increased for the most of the base sectors (except for Chemical, rubber processing and plastic materials industry (13), Machinery industry (16) and Other services (24)). With respect to the absortion effect, it has disminished for all the key sectors and also for most of the base sectors (except in the cases of Commerce (22), Transport, warehousing and communications (23) and, to a lesser extent, Machinery industry (16)). Moreover, the independent sectors have increased thier difussion effects, except Non-Commercial services (26). Finally, within the promoter sectors, Gas and hot water production and distribution (8), Metallic products manufacture (15) and Various manufacturing industries (20) have had both lower difussion and absorption effects, while

Textile, clothing, leather and footwear industry (11) and Other transportation equipment (19) have had respectively higher diffusion and absorption effects.

4.2. Landscape for the Andalusian economy

The previous analysis is extended by means of the *structural path analysis methodology* methodology (Sonis et al., 1997) applied to the regional economy. This methodology allow us to study the sectoral relationships through the calculation of the Multiplier Product Matrix (*MPM*). That matrix is obtained from the components multiplier matrix *M* of the SAM:

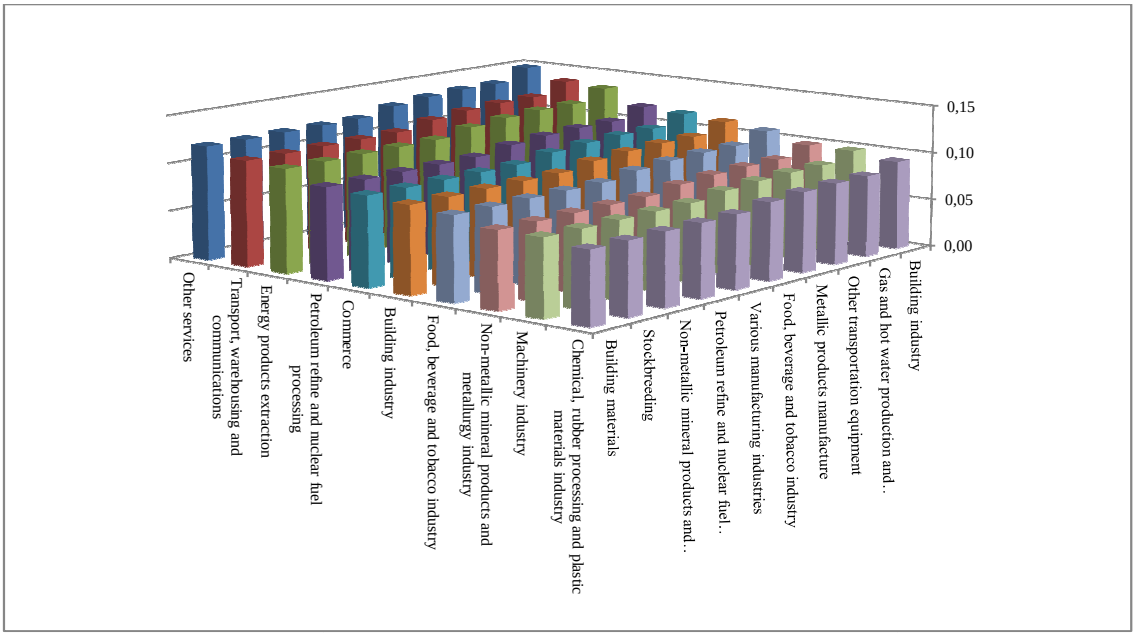
$$MPM_{ij} = \frac{M_{i.} M_{.j}}{\sum_{i=1}^{n}\sum_{j=1}^{n} m_{ij}} \qquad (6)$$

Where $M_{i.}$, $M_{.j}$ are multiplier vectors whose elements are obtained as the sum of the corresponding row or column of the matrix *M*. The product of these vectors is corrected by a factor called "global intensity" that corresponds with the sum of all the components of the associate matrix *M* (Lima et al., 2004).

Based on the *MPM* a landscape can be built, allowing visualization of the interaction among sectors, as well as which sectors have power of dispersion and which other sectors have sensitivity of dispersion. The former have a greater than average impact on the economy due to changes on themselves, while the latter are largely influenced by changes in the rest of the system. Figures 3 and 4 show the landscape for the Andalusian economy in 2005 and 2010 respectively. In addition, the Figure 5 displays the results obtained for 2010 reordered according to the ranking of sectors in 2005.

The Figure 3 exhibits the ten accounts with larger intersectoral linkages in 2005. As can be seen, Other services (24) has the highest economic impact, regardless of the sectors with which it interacts, although the interaction with Building industry (21) stands out. On the contrary, Chemical, rubber processing and plastic materials industry (13) has the lowest impact, especially in its relation with Building materials (18). In general, the tertiary sector (22, 23 and 24), along with Building industry (21), Energy products extraction (4) and Petroleum refine and nuclear fuel processing (6), show an important diffusion effect on the Andalusian economy in 2005.

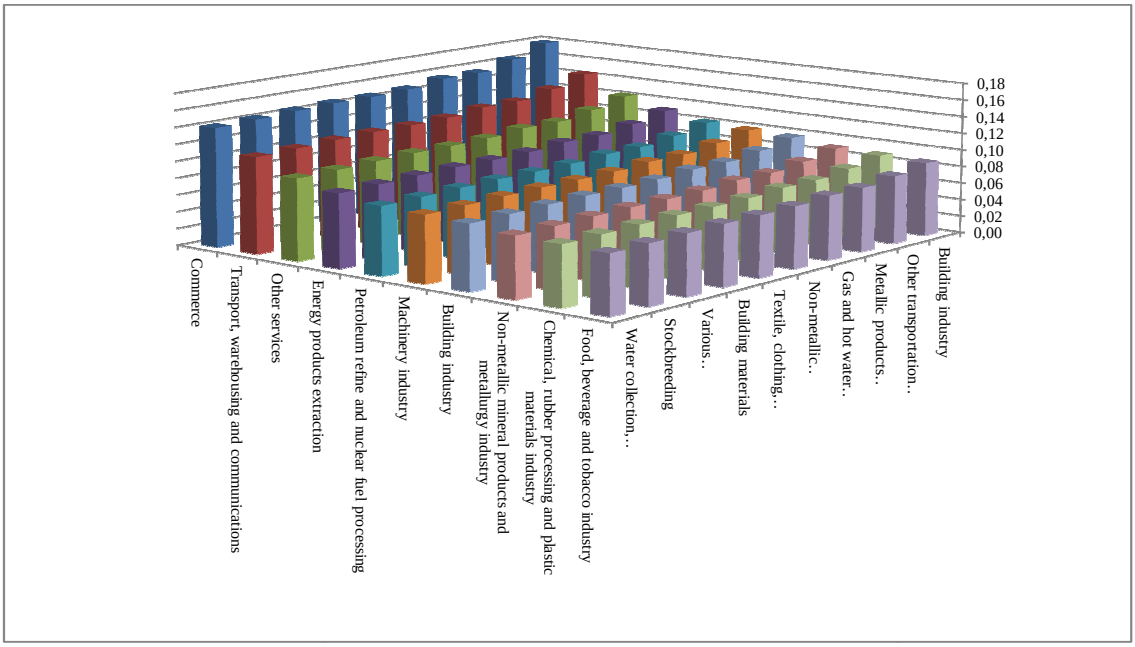
Figure 3. Landscape for the Andalusian economy in 2005.



Source: Own elaboration.

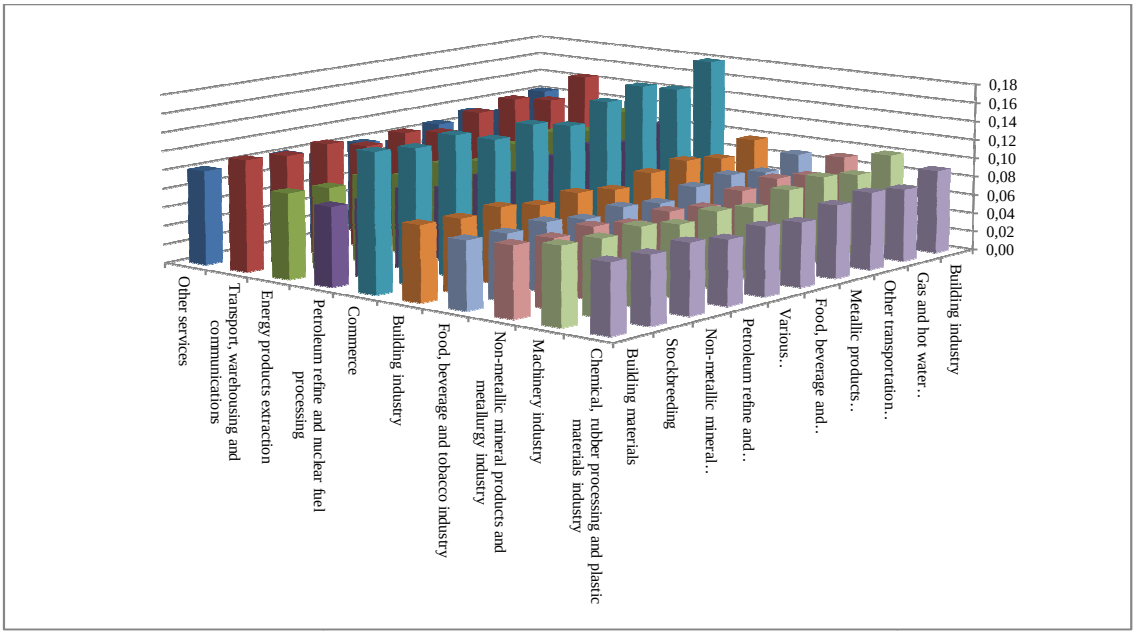
The Figure 4 displays the results obtained in 2010. This time Commerce (22) becomes the sector with the highest economic impact and again when it interacts with Building industry (21). On the other hand, the tertiary sector is increasing in importance.

Figure 4. Landscape for the Andalusian economy in 2010.



Source: Own elaboration.

Figure 5. Landscape for the Andalusian economy in 2010 based on 2005.



Source: Own elaboration.

Finally, Figure 5 allows us to visualize the structural change in the regional economy, showing the results obtained in 2010 but reordered according with the ranking of sector in the base year. As can be seen, the tertiary sector, Petroleum refine and nuclear fuel processing (6) and Energy products extraction (4) continue to have a strong impact in the Andalusian econom. On the other hand, Commerce (22) has achieved a greater impact, especially in its relationships with Building industry (21), Gas and hot water production and distribution (8), Metallic products manufacture (15) and Other transportation equipment (19). Thus these results reinforce the fact that Andalusian economy is switching to a service economy.

4.3. Multiplier decomposition

This section completes the sectoral analysis with the multipliers decomposition methodology, allowing the analysis of other linkages, as well as those studied above, between the income of primary factors and the various institutions that comprise the final demand. Concretely, the accounting multipliers show the total effects of an exogenous unit of rent on each endogenous account of the SAM. To do so, the matrix *M* is broken

down into three matrices by means of the additive expression (Pyatt and Round, 1979). Based on this decomposition, the following effects can be calculated[6]:

- Direct effect = ($I + A$): measures the effect on the activity of a sector of adjusting its output for meeting the new levels of final demand.
- Indirect effect = ($M_l - I - A$): quantifies the adjustment in the output of those sectors that provide inputs to the sector whose demand has originally increased.
- Induced effect = ($M_a - M_l$): determines the impact of increased income (in the demand channel) on the level of activity.
- Total effect = the sum of the previous three effects.

The following tables show the results obtained for the Andalusian economy in 2005 and 2010, taking as endogeous accounts the 26 productive sectors as well as the Labour, Capital and Consumers accounts.

Table 5 ranks the productive sectors in increasing order according to their total effect in 2005. As can be seen, Building industry (21) exhibits the highest total effect with 3.26, while Energy products extraction (4) has the lowest with 1.04. Considering the different kind of effects, the direct effects are always higher than the other two effects. The indirect effects show the lowest values, between 0.01 and 0.62, being the highest values for the industries of the secondary sector (15,19, 21). Only Agriculture (1) and the activities of the service sector (22, 24, 25 and 26) show an induced effect above the unit, which implies that the increased demand of these sectors is translated into an increased demand on all the sectors in the economy.

[6] Being I the identity matrix, A the technical coefficient matrix, M_l Leontief's inverse matrix, and M_a the extended Leontief's inverse matrix, that is, taking Labour, Capital and Consumer as endogenous accounts.

Table 5. Decomposition of total effects in direct, indirect and induced effects in 2005.

# Account	Productive sectors	Total effect	Direct effect	Indirect effect	Induced effect
21	Building industry	3.26	1.65	0.62	0.98
26	Non-Commercial services	2.92	1.33	0.19	1.40
1	Agriculture	2.92	1.45	0.24	1.23
19	Other transportation equipment	2.88	1.61	0.47	0.80
2	Stockbreeding	2.83	1.47	0.36	1.00
10	Food, beverage and tobacco industry	2.73	1.61	0.37	0.75
15	Metallic products manufacture	2.73	1.59	0.46	0.68
25	Commercial services	2.58	1.23	0.17	1.17
20	Various manufacturing industries	2.57	1.57	0.29	0.71
7	Electric power production and distribution	2.55	1.44	0.30	0.81
24	Other services	2.54	1.31	0.16	1.07
9	Water collection, treatment and supply	2.53	1.35	0.23	0.94
8	Gas and hot water production and distribution	2.53	1.86	0.23	0.44
18	Building materials	2.46	1.51	0.32	0.63
22	Commerce	2.38	0.93	0.32	1.13
23	Transport, warehousing and communications	2.33	1.33	0.20	0.81
3	Fishing	2.33	1.50	0.19	0.64
11	Textile, clothing, leather and footwear industry	2.28	1.51	0.19	0.59
14	Non-metallic mineral products and metallurgy industry	2.22	1.50	0.34	0.37
6	Petroleum refine and nuclear fuel processing	2.17	1.63	0.22	0.31
12	Timber, cork and paper industry	2.13	1.42	0.23	0.49
5	Extraction of minerals other than energy products	1.95	1.33	0.19	0.42
13	Chemical, rubber processing and plastic materials industry	1.93	1.38	0.17	0.38
16	Machinery industry	1.65	1.25	0.11	0.29
17	Automobile	1.48	1.20	0.10	0.17
4	Energy products extraction	1.04	1.02	0.01	0.02

Source: Own elaboration.

Similarly, Table 6 displays the effect of each productive sector of the regional economy in 2010. Building industry (21) and Energy products extraction (4) remain the sectors with the highest and the lowest total effects respectively. However, as can be seen in Figure 6, changes have happened between these starting and end points; the most outstanding involving Water collection, treatment and supply (9), Commerce (22) and, to a lesser extent, Agriculture (1), Non-metallic mineral products and metallurgy industry (14) and Commercial services (25), which have improved their position regard to 20005 due to an increase in both direct and induced effects. This latter points to some shift in the structure of the Andalusian economy. In the case of Textile, clothing, leather and footwear industry

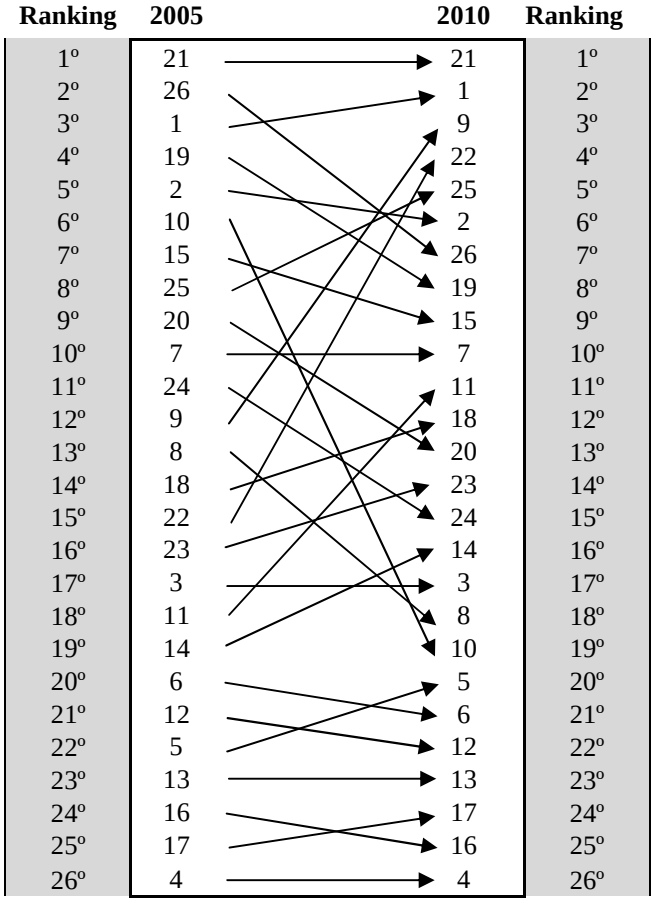
(11), this has also moved up the ranking, but its improvement it is due to the drop of other sectors, such as Gas and hot water production and distribution (8), Food, beverage and tobacco industry (10) or Non-Commercial services (26), rather than the slightly improvement in its effects.

Table 6. Decomposition of total effects in direct, indirect and induced effects in 2010.

# Account	Productive sectors	Total effect	Direct effect	Indirect effect	Induced effect	Positions regard to 2005
21	Building industry	3.24	1.64	0.55	1.05	0
1	Agriculture	3.12	1.41	0.25	1.45	1
9	Water collection, treatment and supply	2.98	1.44	0.29	1.25	9
22	Commerce	2.89	1.39	0.22	1.28	11
25	Commercial services	2.88	1.23	0.16	1.49	3
2	Stockbreeding	2.87	1.45	0.30	1.12	-1
26	Non-Commercial services	2.71	1.20	0.11	1.40	-5
19	Other transportation equipment	2.62	1.57	0.45	0.60	-4
15	Metallic products manufacture	2.59	1.51	0.39	0.69	-2
7	Electric power production and distribution	2.48	1.41	0.21	0.87	0
11	Textile, clothing, leather and footwear industry	2.44	1.49	0.31	0.64	7
18	Building materials	2.43	1.49	0.31	0.63	2
20	Various manufacturing industries	2.42	1.48	0.30	0.65	-4
23	Transport, warehousing and communications	2.41	1.38	0.21	0.82	2
24	Other services	2.40	1.28	0.14	0.98	-4
3	Fishing	2.35	1.39	0.25	0.72	0
14	Non-metallic mineral products and metallurgy industry	2.35	1.51	0.31	0.53	3
8	Gas and hot water production and distribution	2.31	1.78	0.12	0.42	-5
10	Food, beverage and tobacco industry	2.25	1.41	0.26	0.58	-13
5	Extraction of minerals other than energy products	2.16	1.42	0.24	0.50	2
6	Petroleum refine and nuclear fuel processing	2.10	1.48	0.19	0.42	-1
12	Timber, cork and paper industry	2.04	1.35	0.21	0.48	-1
13	Chemical, rubber processing and plastic materials industry	1.87	1.30	0.17	0.39	0
17	Automobile	1.55	1.21	0.12	0.22	1
16	Machinery industry	1.45	1.17	0.09	0.20	-1
4	Energy products extraction	1.13	1.04	0.02	0.07	0

Source: Own elaboration.

Figure 6. Evolution of productive sectors in Andalusia: 2005-2010.



Source: Own elaboration.

4.3. Employment multipliers

In this section employment multipliers are calculated on the basis of both SAMs and employment data from Annual Regional Accounts of Andalusia (IECA, 2013). These multipliers indicate the degree of sensitivity to shock of each productive sector in final demand, in terms of employment. Thus, the employment multiplier for a sector *j* in the economy is as follows:

$$E_j = \sum_{i=1}^{n} w_{n+1,i} b_{ij} \qquad (7)$$

Being $w_{n+1,i} = Y^{e_i} / X_i$, where Y^{e_i} and X_i are the employment and the total output of sector *i* respectively; and b_{ij} is the component *ij* of the matrix *M* for the associate SAM.

The Table 7 displays the employment multipliers of each productive sector of the regional economy during the period of study.

Table 7. Employment multipliers for Andalusia in 2005 and 2010.

# Accounts	Productive sectors	Multipliers	
		2005	2010
8	Gas and hot water production and distribution	41.86	33.60
18	Building materials	33.08	29.31
15	Metallic products manufacture	30.81	25.28
5	Extraction of minerals other than energy products	29.59	26.72
7	Electric power production and distribution	28.97	21.17
14	Non-metallic mineral products and metallurgy industry	26.90	20.67
12	Timber, cork and paper industry	26.71	24.27
2	Stockbreeding	25.16	19.01
21	Building industry	25.09	21.44
6	Petroleum refine and nuclear fuel processing	24.43	19.55
4	Energy products extraction	23.92	22.36
9	Water collection, treatment and supply	22.51	19.14
23	Transport, warehousing and communications	20.91	19.28
19	Other transportation equipment	18.22	17.98
20	Various manufacturing industries	18.10	14.62
10	Food, beverage and tobacco industry	17.42	10.85
1	Agriculture	17.35	15.11
13	Chemical, rubber processing and plastic materials industry	17.04	14.00
16	Machinery industry	16.42	13.05
24	Other services	14.29	14.30
3	Fishing	12.56	14.11
25	Commercial services	10.81	8.95
22	Commerce	9.53	15.15
11	Textile, clothing, leather and footwear industry	9.33	10.18
17	Automobile	7.58	7.59
26	Non-Commercial services	6.02	3.00
1-26	All sectors	534.61	460.69

Source: Own elaboration.

In 2005, industries belonging to the secondary sector (5, 7, 8, 15 and 18) exhibit the greatest capacity to create employment, being able to generate between 29 and 42 jobs for every million euros injected in those sectors, coming from an exogenous shock in their own final demand. On the other hand, some activities of the tertiary sector (22 and 26) and also of the secondary sector (11 and 17) don´t even create 10 jobs per million euros. The ranking remains stable in 2010, although a decrease in their capacity can be observed, thus

the same exogenous shock gives a total of 535 jobs on the economy in 2005, while this figure is reduced to 461 jobs in 2010. This decrease is general across all the productive sectors, with two exceptions Fishing (3) and Commerce (22), which can create 1.5 and 5.6 jobs more than in 2005.

5. Concluding remarks

In this work, a structural analysis of the Andalusian economy has been carried out for 2005 and 2010. Between these years there was an economic downturn with severe consequence in terms of regional production and employment. The use of a Linear SAM model through the multiplier decomposition allows us to classify the regional productive sectors according to their capacity to influence and to be influenced by changes in themselves and in the rest of the economic system, considering the acorresponding average values as referece. Thus, the sectors classified as key sectors for both periods are Petroleum refining and nuclear fuel processing (6), Food, beverage and tobacco industry (10), Non-metallic mineral products and metallurgy industry (14) and Building industry (21), although the crisis has reduced their role as promoters of growth and employment in Andalusia. Concretly, Petroleum refining and nuclear fuel processing (6) and Food, beverage and tobacco industry (10) have lesser effects on the economy compared with 2005, to a greater extent than Building industry (21). The primary sector is unchanged compared with 2005, keeping its share in the economic variables and its relative importance in the regional system. Concretely, Agriculture (1) exerts one of the biggest effects on the remaining sectors, in both directly and induced ways. In the secondary sector, besides key sectors, Water collection, treatment and supply (9) begins to gain relevance. Finally, the tertiary sector continues to grow in importance, examples can be found in the evolution of Commerce (22) and Transport, warehousing and communications (23), with high diffusion effect, or Commercial services (25) with a positive variation in its induced effect on the whole economy. In addition, during this period, only both Commerce (22) and Fishing (3) have increased their capacity to generate employment after a positive shock on the final demand of the economy.

This analysis highlights the stability of the Andalusian economic structure regarding the sectors that invigorate the regional economy, and also the dependence of Building

industry (21), which has already been highlighted in previous works. On the other hand, this analysis also shows that some activities, both from industry and service sector, have become more significant on the network of intersectoral relationships and on their relationships with the remuneration paid to the primary factors and the various institutions shaping the final demand in the regional economy. However, these facts do not allow us to state conclusively that a structural change has happened to the regional economy over this period. One possible explanation could be that this work has been carried out by using the SAMAND10, obtained as an actualization of the SAMAND08. In turn, the latter has been elaborated by using statistical data for that year, but also by updating a previous sample, including data from 2005. Therefore, the availability of a new Input-Output Framework will enable us to obtain define conclusions about the possible change in the regional economy over the period considered.

Finally, it should be noted that the Linear SAM model applied is based on premises such as the linear behavior of the agents or the unchanged coefficients. Both limitations can be overcome by using Non-linear General Equilibrium models such as CGE models.

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