An integrated MRIO - CGE model for studying water and production reallocations in Spain

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Abstract: Over the last years, two tools have sparked a growing interest with regard to their potential usefulness in solving environmental and economic problems. This paper proposes to combine multiregional input-output (MRIO) and Computable General Equilibrium (CGE) tools in order to take advantage of the opportunities offered by both models for analyzing reallocation criteria in the Spanish economy. The main objective is to assess the economic and environmental impacts of alternative production distributions following different reallocation criteria. We specifically focus on agricultural and agri-food sectors through their full supply chains for the Spanish economy, which shows important asymmetries within different regions as a consequence of important resources imbalances.

For this purpose, we first design a CGE model from the information of a MRIO for Spain, considering all 17 Spanish regions, plus the European Union and the rest of the world for the year 2005. Additionally, water flows are computed. We then address the design of possible geographical production reallocation effects focused on stimulating production of water intensive products in regions with greater water resources availability through the development of short supply food chains (SSFCs) between agriculture and agri-food industry. Income and water variations are evaluated to provide guidelines for decision-makers hand-in-hand with economic and environmental impacts.

KEY WORDS: MRIO, CGE models, reallocation criteria, short supply food chain.

JEL classification: C68, D57, L66, P16, Q10, Q25.

1. Introduction

The Spanish economy is characterized by imbalances between natural water availability and water demand across Spanish regions showing important asymmetries within different regions as a consequence of these resources imbalances (see Cazcarro et al., 2013). These imbalances have important effects on trade, transport costs, demand and water savings. In spite of the influence of another factor such as sunlight, regions such as Andalusia, Extremadura, or Murcia (South, Central and Mediterranean regions) with relative low availability have water intense productions. In addition, differences are observed among Spanish regions in the supply food chains. Some regions in Spain, mainly small regions in the North of Spain such as Galicia, Cantabria and Basque Country, Canarias island and Castile-La Mancha and Castile-Leon (Central regions) present a high share of purchases of agricultural and agri-food industry inputs in the own regions, while other regions like Murcia, Madrid and Extremadura tend to buy these inputs to other regions. The study of alternative food chains with alternative measures of proximity relations between agricultural and agri-food industry sectors shows thus a great interest. Numerous previous studies have analyzed the influence of alternative food chains through short supply food chains, e.g. Sonnino and Marsden (2006) in Europe, Renting et al. (2013) for seven European Union members, and Aubry and Kebir (2013) for the Paris region.

In this study, we try to assess economic and environmental impacts of changes on production reallocation criteria focused on stimulating production of water intensive products in regions with greater water resources availability. With this aim we develop the first Computable General Equilibrium (CGE) model based on the information of the multiregional input-output (MRIO) model for Spain where the model is even extended to compute water flows. It allows us to consider the differences between Spanish regions of resources imbalances, and consumption and production patterns.

An additional aim of this work is to combine both tools to take advantage of the opportunities offered by both of them. On the one hand, MRIO analysis offers a high

disaggregation level and additional, policy-relevant insights into clearly identified areas. Specifically, this analysis includes an evaluation of the contribution of supply chains to overall environmental pressures and impacts (Wiedmann and Barrett, 2013). In this regard, MRIO analyses have been increasingly used to measure and allocate responsibility for environmental impacts (see the review in (Wiedmann, 2009)). On the other hand, CGE models incorporate a more flexible analytical framework for scenario analyses because they can model both supply and demand side behaviour, prices and quantities simultaneously and endogenously (Turner et al., 2009). CGE modelling is now firmly established in the academic literature as the dominant approach for analysing global, national and regional environmental issues (see, e.g. (Turner et al., 2011) and (Duarte et al., 2014).

Our analysis aims also to evaluate the effects of the development of short food supply chains between agriculture and agri-food industry and how these changes may affect the environment depending on the conditions of the different regions. In this regard, once differences among regions are evaluated, we work on designing possible measures based on alternative production reallocation criteria in the line of sustainability.

The remainder of the article is organized as follows. In Section 2, we discuss the review of the literature on multi-regional CGE models. Section 3 presents the outline of the model, its calibration and the data incorporated. Section 4 describes the scenarios, and the results obtained for them are presented in Section 5, also highlighting some policy insights. Finally, Section 6 closes the work with conclusions and discussion.

2. Review of the literature

Several CGE applications to regional environmental issues have been applied, e.g. (Despotakis and Fisher, 1988), (Hanley et al., 2009), (Li and Rose, 1995), see (Bergman, 2005) for a general review. Also a limited number of studies have tried to strengthen not only some of the IO data as its base, but also the power of IO modelling or at least the different technologies and economic regional structures to combine with CGE modelling. (Turner et al., 2011) point out the flexiblility of analytical frameworks such as CGE, especially to modelling changes in conditions, while maintaining consistency with the IO accounting framework. In particular they modeled post-shock IO tables and calculate the pollution content of interregional trade flows in each year after the demand shock (an increase in export demand in one region). (Robson, 2009) identifies three aspects that characterize the approach taken in developing a multi-regional CGE model: 1. The method of regional disaggregation, 2. The theoretical structure (those two aspects essentially based on a choice between a “top-down” disaggregation of economy-wide simulation results, and a “bottom-up” method that treats each region as if it is an economy in its own right) and 3. The method of implementation (linearized model or a levels model). Those “bottom-up” types are feasible when separate IOTs are available for each region, as it is the case in our study, and we find also in this line regional CGE models adopting ORANI, as "bottom-up" type of multi-regional CGE models, where national results were driven by (i.e. are additions) of regional results. Some examples of this type of regional model are the Monash Multiregional Forecasting model (MMRE, (Adams et al., 2002)) or The Enormous Regional Model (TERM, (Horridge et al., 2003)).

In the area of labour markets, other multi-regional CGE models (such as (Tsigas, 1997b) and (Carrico and Tsigas, 2014)) and modify hypothesis about the role of the federal government; factor mobility between regions or allowing for lower-skilled jobs to substitute more easily with other primary factors than higher-skilled jobs.

We also encounter in the literature (e.g. (Li et al., 2009)) dynamic multiregional CGE models reflecting the sizes of economies and differences in industrial structures across regions and interregional linkages, with commodities made in different regions have different elasticities of substitution.

Climate change impact research has employed as well multi-regional CGE models with findings about consequences on growth and global income distribution dynamics. (e.g., (Eboli et al., 2010); (Bussolo et al., 2008)).

In this work we follow that thread of literature, looking for the first time at the Spanish regions with a multi-regional CGE, in order to study environmental (mainly water) and economic impacts of changes in consumption patterns provoked by economic crisis, high unemployment rates and the exodus of population in recent years in Spain.

3. The model

In this paper, we develop a multi-region, multi-sector, static Computable General Equilibrium (CGE) model for Spain. The core database is a multiregional input-output (MRIO) model for Spain obtained from (Cazcarro et al., 2013) which considers all 17 Spanish regions, plus the transactions carried out with the European Union (EU) and the rest of the world (ROW) for the year 2005. This model thus covers all intra-regional, interregional and international transactions in the economy. In this section, we set out an overview of the model.

3. 1. Outline of the model

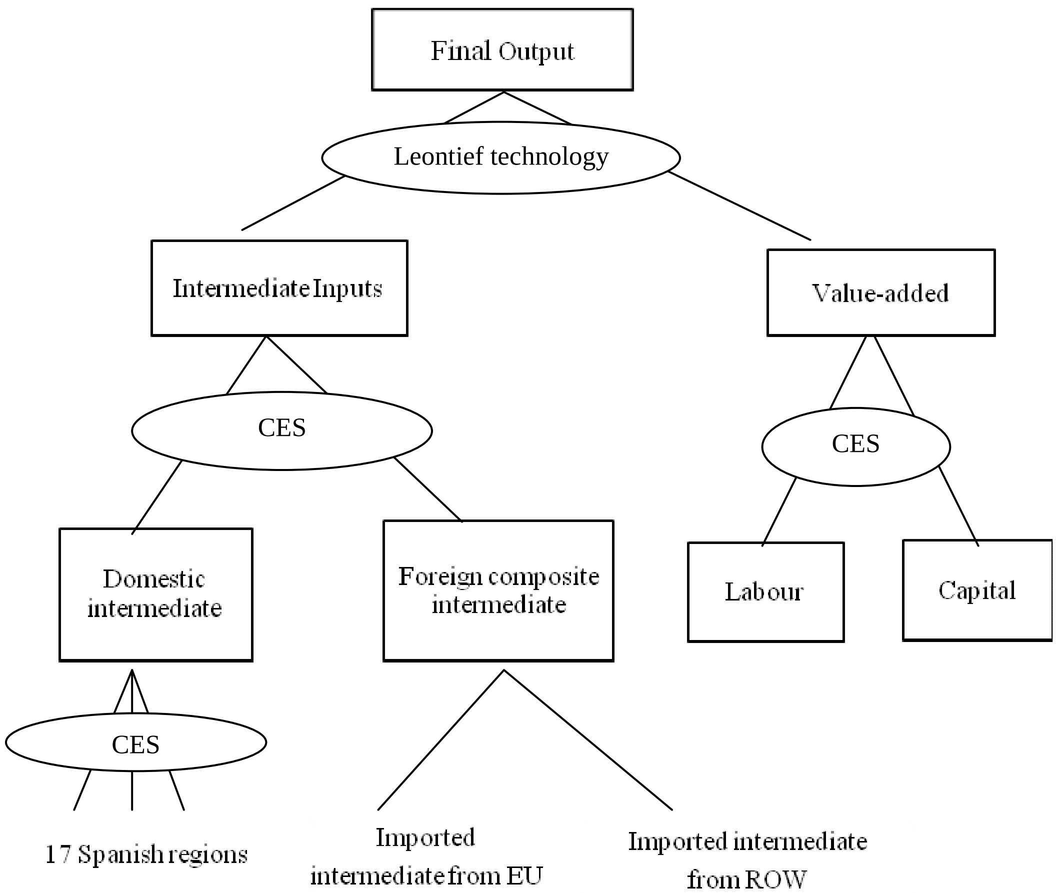
The model breaks down the economy in 40 sectors. In line with the objective of this study, we take a special interest in agriculture sector and agri-food industry, being the latter sector disaggregated into four sectors: meat industry, dairies, other food industries and beverages and tobacco. This model has a nested production and utility structure using flexible functional forms. The representation of the nested production technology in the model for the Spanish economy is illustrated in Figure 1[1].

On the top level of the production structure, producers minimize their costs assuming a Leontief fixed proportion technology of intermediate inputs and value-added as in the bulk of the literature. Aggregate value-added is a Constant Elasticity of Substitution (CES) function of factors of production (labour and capital). The value of this elasticity of substitution for labour and capital is slightly lower in agricultural sectors due to the relative importance of farm land in agricultural production in which

[1] In the case of the foreign regions (the rest of the European Union and the rest of the world), we do not include the nested production function for the intermediate inputs.

substitution possibilities for these factors have been largely exhausted (see (Seung et al., 1998); (De Melo and Tarr, 1992); and (Jomini et al., 1991)). CES functions are widely used in CGE modeling to represent both production and utility. This selection allows the advantage of being well behaved, with a decent degree of flexibility and consistent with assumptions used in CGE models (linear homogeneity/homothecity), and reflects alternative options of adjustment in the demand of factors of production, from changes in their relative prices (Gómez et al., 2004). Moreover, this model structure enables us to overcome some of the technical limitation of an input-ouput model, in particular the restrictions associated with an entirely passive supply side in the economy and the assumption of universal Leontief technology (Gilmartin et al., 2008).

Figure 1. Production function structure



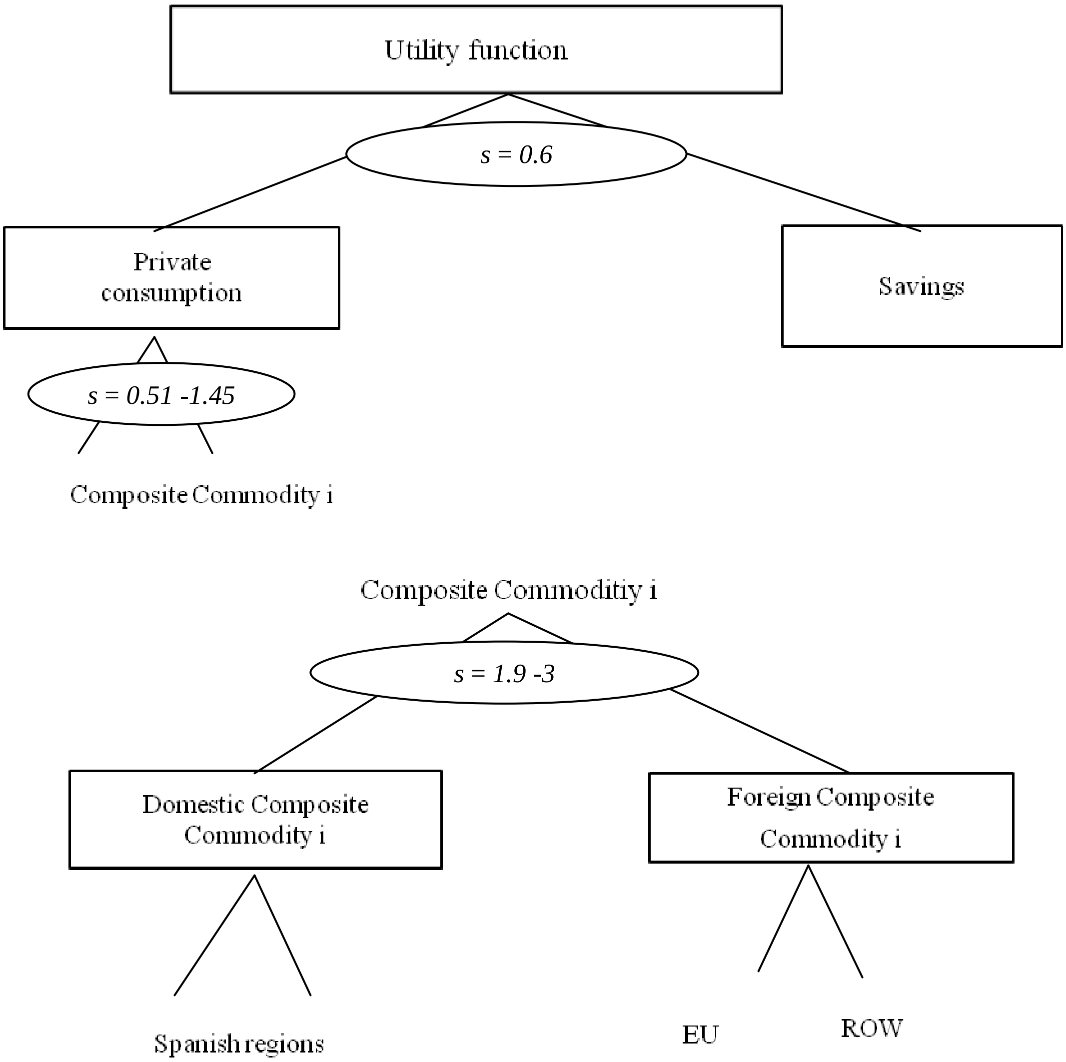
Source: Own work.

On the bottom left side of the second level of the nested production structure, each intermediate input is produced assuming a CES function using both domestic and foreign goods distinguished by region of origin. In particular, we distinguish domestic inputs from the 17 Spanish regions and foreign inputs from the rest of the European Union and the rest of the world. Thus, each region uses domestically sourced inputs, inputs from the rest of the Spanish regions and foreign inputs from the EU and ROW. This assumption follows Armington (1969), as goods are distinguished by region of origin, there are different degrees of substitution between imported and domestic varieties of commodities for relative price divergences across regions. In other words, there is an imperfect substitution between domestic and imported intermediate materials of the same commodity. The final stage determines the degree of substitution which occurs across Spanish regions (i.e., interregional). The degree of substitution across Spanish regions has a large degree of substitution following previous studies such as (Tsigas, 1997a).

On the demand side, there are four main components of final demand: private consumption, government, investment and exports. Figure 2 reflects the nested demand specification structure. At the top level, a representative decision-maker maximizes a utility function subject to the budgetary constraint (total expense cannot be upper than income). The allocation of demand is defined by a three-stage nested CES utility function. In the first stage, the decision-maker faces a consumption-savings decision. The second stage allocates private household expenditure across commodities sourced both domestically and from abroad. The third stage determines the degree of substitution which occurs between the domestic composite variety and its foreign counterpart. Level three thus implements the Armington assumption at the household level. Meanwhile, total public expenditure is modelled through a fixed coefficients structure. The lump sum transfers between the government and the consumer are endogenously adjusted to ensure the same budget balance for the government as in the baseline.

On the other hand, output in each sector can be earmarked to domestic or foreign demand through a Constant Elasticity of Transformation (CET) function. Interestingly, our model also distinguishes the destination of intermediate inputs to domestic demand or foreign exports.

Figure 2. Nested structure for allocation of demand



Source: Own work.

Labour and capital are assumed to be perfectly mobile across industries, and capital even regions. This assumption implies that all sectors in any region face the same market price for capital. Labour can be mobile across regions but move imperfectly across Spanish regions, so there are wage differences between Spanish regions. Specifically, we model labour supply through a CET function following (Gaasland, 2008) and (Boeters and Savard, 2012). We adopt a nested CET function of labour supply which allocates labour in two tiers, comprising the optimal allocation between the Spanish regions and the foreign regions in the first stage, and across Spanish regions, in the second stage. Transformability of labour is imperfect and the choice between regions is driven by unemployment rates (i.e. a higher unemployment rate involves a higher elasticity value and a greater mobility across regions).For this reason, our model includes a wage curve specification as an organizing framework, following (Blanchflower and Oswald, 1990), which allows us to consider imperfect competition mechanisms within the labour market when analyzing unemployment. The value of the elasticity of real wages with respect to unemployment is -0.07, in line with other recent Spanish results (García-Mainar and Montuenga-Gómez, 2012) and the evidence on the existence of a wage curve in Spain (see in detail (De Schoutheete, 2012); (Sanromá and Ramos, 1999); (Villaverde, 1999)). This wage curve corresponds to the empirical evidence for Spain on the inverse relationship between the level of real wages and the unemployment rate. For this purpose, we introduce the wage curve in the model, following (Küster et al., 2007), that requires including an additional equation in the model to substitute flexible wages by a wage equation, in which the wage rate is linked to the level of unemployment.

In the model, we consider two foreign regions: the rest of the European Union, and the rest of the world. The exchange rate between Spain and the European Union is fixed and is used as the *numeraire* while trade balance adjusts, as they trade mainly in euros. On the other hand, the trade balance between these two regions and other countries is kept constant and exchange rate adjusts.

Finally, total investment equals total saving, where savings are composed of savings from all institutions. The market equilibrium conditions are satisfied by the

adjustment of relative prices. Zero degree homogeneity is assumed for all supply and demand functions in the model. In line with the general equilibrium framework, only relative prices are relevant for the specification of the quantities of goods supplied and demanded.

3.2. Calibration and Data

A base scenario is a prerequisite for the application of any CGE model. As explained above, we use the 2005 MRIO for Spain, which was obtained from (Cazcarro et al., 2013) as our base scenario. The structural data embedded in the MRIO are used to ascribe actual values to some of the model's parameters (for example the relative size and import intensity of sectors). Other parameter values are determined exogenously (for example wage setting functions obtained from (INE, 2005) and elasticities values of demand and substitution). These are informed by a combination of literature review of CGE models based on similar peculiarities and the modeller's judgement, and can all be subjected to sensitivity analysis (Table 1). A final set of parameter values is determined through calibration of the model to reproduce the base year dataset.

Table 1. Elasticity parameters used in the model

Substitution elasticity between:	
Intermediate inputs and value-added	$\sigma^{Y} = 0$
Labour and capital [a]	$\sigma^{KL} = 0.7$ (Farm sectors) $\sigma^{KL} = 0.8$ (All other sectors)
Domestic and import goods [b]	$\sigma^{A1} = 1.9 – 3$
Domestic commodities (Spanish regions) [c]	$\sigma^{A2} = 3.8 –6$
Demand elasticity coefficients [d]	$\sigma^{C} = 0.51\text{-}1.45$
Utility function [e]	$\sigma^{U} = 0.6$
Transformation elasicity between:	
Exports and domestic goods [f]	$\sigma^{T} = 0.7 - 3.9$
Labour supply [g]	$\sigma^{T} = 0. 564 - 1.385$

[a] (Seung et al., 1998); (De Melo and Tarr, 1992); and (Jomini et al., 1991)
[b] (Hertel, 1997)
[c] (Tsigas, 1997a).
[d] All sector demand elasticity coefficients are taken from (Mainar, 2010).
[e] (De Schoutheete, 2012).
[f] (De Melo and Tarr, 1992).
[g] Own elaboration based on (INE, 2005).

The model is programmed as a mixed complementarity problem (MCP) using

GAMS/MPSGE (Rutherford, 1999), and is solved with the PATH algorithm, which is documented in (Dirkse and Ferris, 1995).

4. Scenarios

The integration of multi-regional data and CGE models has numerous possibilities for research on interregional trade and spillover effects across regions. Here our focus is on scenarios of water and production reallocations based on the different resources endowments, technologies, demands and regional and national agricultural and water policies. In this sense one of the hottest question in the policy domain is: How can alternative fiscal measures designed to, e.g. shorten the food supply chain between agriculture and agri-food industry and stimulate production of water intensive products in regions with greater water resources availability, affect the use of resource, e.g. water, and the economic variables?

A 10% tax is applied to production depending on virtual water embodied in households and exports (being the same in all regions) and receipts are earmarked to pay for subsidies to agri-food industry applying two criteria: Share of purchases of both agriculture and agri-food industry inputs in the own region, and size of agriculture and agri-food industry of the total activity in each Spanish region.

Based on those questions, the specific scenarios analyzed are the following:

Scenario 1: Earmarks 100% of subsidies depending on the size of agricultural sector and agri-food industry of the total activity in each Spanish region.

Scenario 2: Earmarks 100% of subsidies depend on the share of purchases of both agricultural and agri-food industry inputs in the own region.

Scenario 3: Earmarks 50% of subsidies depend on the size of agriculture and agri-food industry and 50% depend on the share of purchases of both agricultural and agri-food industry inputs in the own region (mixed scenario).

5. Results

Firstly, let us begin analyzing the destination of subsides by agri-food industry sectors and regions. Table 2 shows that if subsidies depend on the size of agriculture and agri-food industry in Spain (Scenario 1), the amount collected is mainly earmarked for the South and Central agrarian regions such as Andalusia and Castille and Leon and one of the most populated and dynamic region such as Catalonia. If we observe the share of purchases of inputs of agricultural and agri-food industry sectors in the own region, subsidies go mainly to small regions in the North of Spain like Galicia and Cantabria, and other agrarian regions such as Andalusia, Aragon or Barcelona. Finally, in the mixed scenario (Scenario 3) subsidies go mainly to Barcelona, Andalusia and Castille and Leon due to size reasons. Initially, we thus can observe that small regions localized in the North of Spain tend to buy their agricultural and agri-food industry inputs in the own region more than other bigger regions localized in the Central and South of Spain.

Table 2. Destination of subsidies

Scenario\Sector	Meat industry	Dairy farming	Other food industry	Beverages and tobacco
Scenario 1 (Size)	Catalonia (36.41%)	Castille and Leon (15.77%)	Andalusia (32.45%)	Andalusia (25.09%)
	Castille and Leon (15.90%)	Galicia (14.13%)	Catalonia (18.23%)	Catalonia (12.64%)
	Andalusia (10.72%)	Andalusia (11.44%)	Valencian (5.15%)	Castille-La Mancha (11.51%)
Scenario 2 (Share)	Galicia (9.12%)	Catalonia (9.11%)	Andalusia (11.03%)	Aragon (9.25%)
	Castille and Leon (8.14%)	Galicia (9.09%)	Castille and Leon (10.03%)	Canarias (8.55%)
	Cantabria (7.90%)	Castille and Leon (8.43%)	Castille-La Mancha (10.00%)	Castille and Leon (8.06%)
Scenario 3 (Mixed)	Catalonia (21.17%)	Castille and Leon (8.83%)	Andalusia (21.74%)	Andalusia (15.61%)
	Castille and Leon (12.02%)	Galicia (11.61%)	Catalonia (11.38%)	Castille-La Mancha (9.64%)
	Andalusia (9.11%)	Catalonia (9.61%)	Castille and Leon (9.11%)	Catalonia (9.28%)

Source: Own work.

The study of the macroeconomic impacts shows that stimulating the size of the agriculture and agri-food industry (Scenario 1) involves improvements in total production, while stimulating regions with larger share of purchases of agricultural and agri-food industry inputs in the own region (Scenario 2), shows apparently falls in production results in the economy as a whole.

In all scenarios, as private consumption is a function of disposable income, any decrease in the latter (as a result of higher markups taxes in this case) will also depress consumption. On the other hand, the consumer index price increases in all scenarios, and unemployment increases. Finally, the welfare level of the economy gets worse. Therefore, these measures could involve negative economic results for the economy as a whole with the current structure of production.

Table 3. Macroeconomic results (% change with respect to the baseline scenario)

	Scenario 1 (Size)	**Scenario 2 (Share)**	**Scenario 3 (Mixed)**
Total production	0.19	-0.20	0.57
Welfare	-0.54	-0.53	-0.54
Private consumption	-1.08	-1.07	-1.07
Investment	0.52	0.51	0.52
Exports	-1.04	-1.10	-1.07
Imports	0.01	0.01	0.01
CPI	0.47	0.48	0.47
Unemployment	6.93	7.00	6.97

Source: Own work.

Production results by sectors are shown in Table 4. The analysis of these results leads to observe that fiscal measures on water embodied in households and exports provokes falls in agriculture sector and in restaurants as a consequence of these sectors are important consumers of water. Conversely, positive results in the agri-food industry are due to they receive subsidies, except to other food industry which also shows reductions in the production.

More interestingly, the analysis of these results by scenarios leads to observe that Scenario 2 focused on the share of purchases of inputs is more effective than Scenario 1 to improve agri-food industry, which is the objective of these fiscal measures, due to shows larger increases in production in meat industry, dairy farming and beverages and tobacco. As agri-food industry is not the main sector in Spain, stimulating this sector with taxes that affect the rest of the sectors leads to slow down total production, as we observed above.

Table 4. Main production results by sectors (% change with respect to the baseline scenario)

Sectors	Scenario 1 (Size)	Scenario 2 (Share)	Scenario 3 (Mixed)
Agriculture	-6.57	-5.92	-6.25
Meat industry	-2.37	10.05	3.90
Dairy farming	6.58	20.37	13.54
Other food industries	-4.67	-1.51	-3.08
Beverages and tobacco	3.19	10.15	6.71
Restaurants	-4.72	-4.86	-4.79

Source: Own work.

If we adopt a regional approach now, we can observe that the largest increase production is in Cantabria, a small region in the North of Spain, and in Scenario 2 as this region has a great share of purchases of agricultural and agri-food industry inputs in the own region, the same case appears in Canarias island which also buys their inputs in the own region, and another small region in the North of Spain as Navarre.

Again we observe that stimulating agri-food industry production in regions which buy their inputs in the own region (Scenario 2) is a more effective approach to stimulate production than stimulating the size of the agriculture and agri-food industry in Spain. This finding is crucial from a policy perspective. Specifically, these results suggest that

a policy designed to shorten the food supply chain to achieve a more sustainable supply chain may contribute to enhancing production results by stimulating the purchase of agricultural and agri-food industry inputs in the own region.

Table 5. Production results by regions (% change with respect to the baseline scenario)

	Scenario 1 (Size)	**Scenario 2 (Share)**	**Scenario 3 (Mixed)**
Andalusia	0.11	-0.22	-0.06
Aragon	-0.28	0.89	0.31
Castille-La Mancha	-0.11	-0.12	-0.12
Asturias	-0.35	0.57	0.10
Baleares	-0.92	1.15	0.12
Canarias	0.05	1.82	0.95
Cantabria	-0.48	3.61	1.57
Castille and Leon	-0.13	-0.20	-0.17
Catalonia	-0.23	-0.52	-0.37
Galicia	0.05	0.26	0.16
La Rioja	-0.41	1.04	0.34
Madrid	-0.31	-0.88	-0.59
Navarre	-0.16	1.03	0.44
Basque country	-0.60	0.81	0.11
Extremadura	-0.17	0.52	0.17
Murcia. Ceuta and Melilla	0.52	0.02	0.28

Valencian	0.02	-0.02	0.00

Source: Own work.

Table 6 shows the largest variations in production in agri-food industry sectors by regions. The largest reductions in the production of meat industry and other food industry are observed in Murcia, a small region localized in the South of Spain in the Mediterranean cost which is a net importer of water, with falls around 7% comparing to baseline scenario. This recessive effect is also observed in another virtual water importer region like the industrialized region of Madrid, see Cazcarro et al. (2013).

On the other hand, the largest increases in production are observed in small regions in the North of Spain such as Cantabria and Basque Country. Moreover, Cantabria enhances production in all agri-food industries. Therefore, in general in all scenarios, the highest increases are in small regions in the North such as Cantabria and Basque country, in Canarias and Balearic islands, and in Aragon in the case of beverages and tobacco. And the largest recessive effects in production in agri-food industry are in regions in the Mediterranean cost like Murcia, regions in the South like Andalusia, and even Catalonia.

Table 6. Main variations in production by regions and sectors (% change with respect to the baseline scenario)

Sector	Variation	Scenario 1 (Size)	Scenario 2 (Share)	Scenario 3 (Mixed)
Meat industry	Increase		Canarias (42.92%) Basque country (32.98%)	Basque country (15.14%) Cantabria (15.23%)
	Decrease	Murcia (-6.84%) Extremadura (-6.39%)	Murcia (-7.77%) Catalonia (-6.33%)	Murcia (-7.08%) Catalonia (-3.64%)
Dairy farming	Increase	Galicia (12.55) Andalusia (10.83%)	Cantabria (94.59%) Baleares (91.59%)	Cantabria (49.37%) Baleares (46.81%)
	Decrease		Murcia (-3.82%) Madrid (-1.57%)	
Other food industry	Increase		Cantabria (12.77%) Asturias (7.26%)	Cantabria (4.35%) Canarias (1.80%)
	Decrease	Aragon (-6.43%) Murcia (-3.32%)	Andalusia (-9.05%) Madrid (-7.10%)	Murcia (-7.38%) Andalusia (-6.89%)
Beverages and	Increase	Madrid (6.77%)	Aragon (46.13%)	Aragon (25.79%)

tobacco		Murcia (5.33%)	Cantabria (43.19%)	Cantabria (22.90%)
	Decrease	Asturias (-1.68%)	Murcia (-1.59%) Andalusia (-0.34%)	

Finally, the analysis of environmental results is shown in Tables 7 and 8 by regions and sectors respectively. In the case of environmental results by regions, we can observe water savings in all regions due to falls in consumption. The largest reductions are in regions which have water intense productions like Andalusia, Extremadura or Murcia, which are at the same time regions with low water availability. This result confirms the potential role of fiscal measures to shorten food supply chains through water and production reallocations criteria showing water savings by the larger consumers of water. Moreover, even Cantabria and Navarre, small regions in the North of Spain which increase production, reduce water consumption.

Table 7. Environmental results by regions (% change with respect to the baseline scenario)

Regions	**Variation**	**Regions**	**Variation**
Andalusia	-1.70	Galicia	-1.21
Aragon	-1.51	La Rioja	-1.05
Castille-La Mancha	-1.13	Madrid	-1.13
Asturias	-1.14	Navarre	-1.43
Baleares	-1.22	Basque country	-1.25
Canarias	-0.74	Extremadura	-1.84
Cantabria	-1.33	Murcia	-1.65
Castille and Leon	-1.33	Valencian	-1.08
Catalonia	-1.20	Total	-1.33

Source: Own work.

In the case of environmental results by sectors, the most interesting results is that taking into account that agri-food industry increases production, these sectors save water. Therefore, reallocation criteria could be more efficient for the environment.

Table 8. Environmental results by sectors (% change with respect to the baseline scenario)

Sector	**Variation**
Agriculture	-1.56
Meat industry	-1.70
Dairy farming	-0.68
Other food industry	-1.80
Beverage and tobacco	-0.07
Textile, clothing and leather	-1.19
Hotels	-1.12
Restaurants	-1.14
Real estate activities	-1.21
TOTAL	**-1.33**

Source: Own work.

6. Conclusions and final remarks

The imbalances between natural water availability and water demand across Spanish regions show important asymmetries as a consequence of these resources imbalances. In addition, shortening the food supply chain is one of the main questions in economic policy. Strategies that combine both targets are analyzed in this paper. To achieve these goals, a CGE model has been designed based on the information of a MRIO model for Spain with a high level of disaggregation that allows us to work with a sophisticated tool to consider the differences among Spanish regions of resources imbalances, and evaluate alternative scenario analyses.

The results show that fiscal measures designed to stimulating the purchase of agricultural and agri-food industry inputs in the own region let enhance agri-food industry production. Specifically, small regions localized in the North of Spain show larger increases in production. This expansion even leads to save water in these regions

and sectors. However, as these regions and industry have a small share in the economy as a whole, counterproductive effects are observed in total production as a consequence of such a tax policy. On the other hand, fiscal measures that stimulate the size of agriculture and agri-food industry show positive results in the economy as a whole but a worse effectiveness to enhance agri-food industry production. A mixed scenario which combines both strategies could be efficient to improve agri-food industry without recessive effects in the economy as a whole.

In conclusion, this work demonstrates the efficiency of a support scheme through fiscal measures to stimulating production of water intensive products in regions with greater water resources availability and shortening food supply chain from an environmental point of view.

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