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RESEARCH ARTICLE

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Double concentration explaining the outstanding increase in Spanish crop production

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Abstract

Aim of study: To evaluate the changes in Spanish agricultural production since 1950s in a context of intense transformations in terms of the regional and crop composition.

Area of study: Spanish provinces during the second half of the twentieth century.

Material and methods: We use index decomposition analysis to evaluate the changes in the value and volume of crop production, as well as the role of product composition and the regional distribution of production.

Main results: Spanish agriculture have focused on certain regions in the south or in the east of Spain. Some products like vegetables or fruits have a positive prices and composition effects, encouraging the production in these provinces.

Research highlights: We found a 'double concentration': Spanish agriculture has increasingly tended to produce high value-added products, such as vegetables, fruit and olive oil. On the other hand, crop production is concentrated in the southern and eastern provinces of Spain.

Additional key words: Spain; agricultural sector; agricultural development; index decomposition; regional analysis

Abbreviations used: CAP (Common Agricultural Policy); CE (Composition Effect); EEC (European Economic Community); IDA (Index Decomposition Analysis); LMDI (Logarithmic Mean Divisia Index); NRA (Nominal Rate of Assistant); PE (Price Effect); QE (Quantity Effect); RE (Share Effect); SE (Scale Effect)

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Introduction

Agricultural production and productivity in Europe and their drivers have been among the main themes of agricultural economics (Hayami & Ruttan, 1985; Grigg, 1992; O'Brien & Prados, 1992; Federico, 2005; Lains & Pinilla, 2009; Alston & Pardey, 2014; Gollin *et al.*, 2014). They developed strongly during the second globalization (the second half of the twentieth century), owing to major transformations in the sector. These included technical innovations that increased dependence on the non-agricultural sectors of the economy, growing market integration of agricultural products and a reduction in the share of the labour and land factors of production (while capital increased its share).

The case of Spain is striking for, among other reasons, its steady increase in agricultural production and productivity, especially during the second half of the twentieth century (Clar *et al.*, 2016). Such continuous growth was not seen in other European countries, and since the 1980s agricultural production has stagnated (Martín-Retortillo & Pinilla, 2015). This growth was not spread evenly across the Spanish regions, and it also varied by product group.

On a massive scale, Spain introduced technical innovations from the non-agricultural sectors of the economy, such as agricultural machinery, chemical fertilizers and hybridization and selection of seeds (Grigg, 1992; Abad & Naredo, 1997; Hassine & Kandil, 2009). Moreover, the development of irrigation boosted agricultural production thanks to the great advances in water infrastructure.

Spain's agricultural mechanization was faster than that of other European countries, despite administrative obstacles to the widespread introduction of tractors in the 1950s (Clar, 2009).[1] Thus, Spain converged with the European level of mechanization (Martín & Pinilla, 2015).

Second, chemical products such as fertilizers and pesticides were another important non-agricultural input. While the introduction of these chemicals was significant throughout Europe during the twentieth century (and especially after the Second World War), in Spain it was done on a huge scale, so that once again the country converged on European levels.

Third, as mentioned above, biological innovations did much to bring about an improvement in agricultural production and productivity. These advances, which began in the final decades of the nineteenth century (Olmstead & Rhode, 2008), intensified in the 1940s and 1950s, focusing on the hybridization and genetic selection of seeds. The most developed countries all benefited from these innovations, but because of their particular climate conditions, the yield increase was lower in the Mediterranean countries than in Western Europe (Pujol, 2011; Harwood, 2018).

Finally, the expansion of irrigation was also relevant in a European Mediterranean country like Spain. On the one hand, the technical innovations related to irrigation infrastructure allowed water to be supplied to arid regions: while the area of land irrigated more than doubled on the European continent generally, in Spain it almost tripled in the second half of the twentieth century. This expansion was especially intensive during the 1950s, 1960s and 1970s, when the Franco dictatorship promoted the construction of dams as a pillar of its agrarian policy. Irrigated production as a share of total agricultural production increased from 42.3% to 65.5% between 1955 and 2006 (Pinilla, 2008; Cazcarro *et al.*, 2015a; Martín-Retortillo & Pinilla, 2015). On the other hand, the use of plastic greenhouses, sprinkler and drip irrigation and sandy soils were among the most important technical innovations that allowed an improvement in water productivity (López and Losada, 1999; Cazcarro *et al.*, 2019).

Apart from these technical developments, the new institutional framework was also key to the expansion of Spanish agricultural production. Spanish agriculture took a step toward reintegration with the Stabilization and Liberalization Plan of 1959, but it was the country's 1986 entry to the European Economic Community (EEC henceforth) that provided the main stimulus. In the period from 1960 to 1986, Spanish agri-food exports grew at an annual rate of 5.8%, while imports rose by 4.7%. This export growth coincides with a slight increase in the openness ratio during the 1970s, and with a strong increase from 1985 to the first years of the twenty-first century (Clar *et al.*, 2015).

Spain's entry into the EEC not only eased commercial exchanges, but also modified the level of agricultural protectionism. Intervention in the agricultural sector was relatively low until Spain became a member of the EEC. In fact, the Nominal Rate of Assistance (NRA) was very low during the 1950s, 1960s and early 1970s, compared with other Western European countries.[2] Basically, the common agricultural policy (CAP henceforth) guaranteed high prices (generally higher than international prices), which encouraged agricultural protection from the early days of the EEC right up until the MacSharry reform of 1992. Spain's low level of agricultural protection increased from 1986, when the country joined the EEC. Thus, the NRA grew from approximately 10%, as a percentage of the undistorted price in the first half of the 1980s, to a maximum of 70% by the end of that decade (Anderson & Valenzuela, 2008).[3]

In sum, the lack of agricultural support and the dictatorial context until the later 1970s both generated an agricultural system based on the productivist model. This model focused on increases in agricultural production, the expansion of irrigation, the large-scale adoption of non-agricultural technical innovations, and modification of the regional and crop patterns of agricultural production. All this, combined with a high number of hours of sunshine and better availability of water resources increased the sector's potential in the following decades. Since the 1980s, with accession to the EEC and implementation of the CAP, this increase in production has been linked to international markets – especially in the case of those export products

[1] Despite the higher increase in agricultural mechanization in Spain, the level of mechanization was lower than the Western European countries in the decades of the 1940 and 1950 (Martín-Retortillo & Pinilla, 2015).

[2] The Nominal Rate of Assistance (NRA) tries to approximate to the percentage by which government policies have raised gross returns to farmers above what they would have been without the government's intervention (or reduced them, if NRA < 0). In the empirical work, the NRA is expressed as a percentage of the undistorted price (Anderson & Valenzuela, 2008).

[3] The second period of analysis includes the entrance of Spain in the ECC, with the CAP in place. This involved policies of support in prices (subsidies) to some products such as cereals until around 1991. From 1992 there was a reorientation towards direct aids to maintain farmer's agrarian income (coupled with production until 2003 and then decoupled). This implies some heterogeneities in the processes of prices creation, in the same fashion that different drivers (institutional, changes in openness's and demands from foreign markets, livestock demand, etc.) have played a role in prices formation. The deflation used in this article takes into account the general inflation of all the crop products in the sample, and hence it is more a reference which allows to distinguish a differential evolution of relative prices among crops, than a method to capture and disentangle these drivers.

in greatest demand (Clar *et al.*, 2018), such as vegetables, olive oil and wine.

With all of that, the objective of this paper is to analyse the changes in Spanish crop production during the second half of the twentieth century and investigate how, where and why it experienced such a sustained and significant growth.

Material and methods

Data

In this section, we go into the main data sources to analyse Spanish agricultural production since the 1950s. First, we collected the physical agricultural production (Q_{ijt} expressed in tonnes) from Spain's Agrarian Statistics Yearbooks for 1955, 1980, 2005 and 2010 (MAPAMA, 1955, 1980, 2005, 2010). We worked with 48 Spanish provinces (see Table S1 [suppl.] for the names of the provinces and the relation to wider administrative regions) and 132 agricultural products. Then we obtained information on the current prices (P^c_{it} expressed in *pesetas/tonne*) received by farmers for each crop (MAPAMA, 1955, 1980, 2005, 2010). Note that in order to separate the inflation impact and to account for the change in real production and in the value of crops, the data have been deflated, using 1980 as a base year. We calculated price indices for the periods 1955-1980 and 1980-2005/2010 using the 132 crops included in the sample and taking 1980 as a base year. These indices inform on the average change experienced by the prices of the crops during both time-spans. Thus, they can be considered as a reference that allows evaluating the changes in crop prices over time. The calculated agricultural price indices were around 7.4 and 2.8 for 1955 to 1980 and 1980 to 2005/2010, respectively.[4] The prices indices are used to obtain 1955 and 2005/2010[5] deflated prices (P_{it} expressed in constant 1980 pesetas), introduced below in Eq. (1) to estimate monetary agricultural production.

Hence, the paper focuses on three key moments for the Spanish agricultural sector. First, we look at the mid-twentieth century (1955), just before the 1959 Stabilization and Liberalization Plan mentioned above, which brought an end to Spanish autarky and heralded openness to international markets. This period also preceded the rapid development of hydraulic infrastructures during the middle years of Franco's dictatorship. Second, as a mid-point we focus on 1980, when a large number of water infrastructures had already been developed. This moment in time also witnessed the beginning of democracy in Spain and preparations for the country to join the EEC, which triggered a great commercial expansion and important changes for agriculture. Finally, we looked at the beginning of the twenty-first century by averaging a dry (2005) and a humid (2010) year, following Cazcarro *et al.* (2015b).[6] This final period paints a picture of a democratic, globally integrated and more environmentally aware country.

Methodology

After describing the data sources and characteristics, we explain the methods used for the empirical analysis. To start, we estimated monetary agricultural production ($Prod_{ijt}$ expressed in pesetas) for each crop *i*, province *j* and year *t*. We used information on the physical production (Q_{ijt}) and prices (P_{it}) introduced in the previous section, which yields:

$$Prod_{ijt} = Q_{ijt}P_{it} \tag{1}$$

From Eq. (1) we can also obtain, for each period, the total production by region ($Prod_{jt} = \sum_i Q_{ijt}P_{it}$), the total production by crop ($Prod_{it} = \sum_j Q_{ijt}P_{it}$) and the total national production ($Prod_t = \sum_i \sum_j Q_{ijt}P_{it}$).

Then, we proceeded to quantify the main forces behind the historical changes in this variable. This allowed us to identify the most significant structural patterns driving trends in the value of agricultural production. With this objective, we used decomposition analysis, which links the change to an aggregate variable (*i.e.* monetary production in our case) with a set of determinants. Note that the effects derived from decomposition analysis display the changes that would have happened *if all the other factors had remained constant*. A previous study on agricultural patterns using decomposition analysis for different explanatory factors and different regional and sectoral detail can be found in Cazcarro *et al.* (2015b). Of the existing decomposition techniques, we utilized IDA (Ang & Zhang, 2000); and more specifically, we concentrated on the Logarithmic Mean Divisia Index (LMDI henceforth). We followed Ang (2015), who suggests using the LMDI-I additive decomposition presented in Ang *et al.* (2010) when working with a quantity indicator.[7]

[4] These indices are very similar to the ones calculated from the agriculture's value added deflator provided by Prados de la Escosura (2017) that reach 7.6 and 2.5 for 1955 to 1980 and 1980 to 2005/2010, respectively. For the whole economy, the price increase was larger as the indices obtained from the GDP deflator in Prados (2017) are 11.4 and 4.6 for 1955 to 1980 and 1980 to 2005/2010, respectively.

[5] We take these years to examine changes up to the present, since there was relatively high variation in precipitations in these years, with 2005 a relatively dry year and 2010 a relatively humid year (1955 and 1980 were both average years).

[6] Checking the representativeness of our years, agricultural production of 1955 represents 1.02 on 5 years average focused on that year; the case of 1980 represents 1.04 on 5 years average focused on that year; 2005 represents 0.94 on 5 years average focused on that year; and 2010 represents 1.02 on 5 years average focused on that year.

[7] For observations with zero values, we apply the analytical limit strategy when doing the decomposition analysis (Ang & Liu, 2007).

Note that the whole set of effects presented in this section was calculated for the two sub-periods of analysis (1955 to 1980 and 1980 to 2005/2010). In order to obtain these impacts for the entire period (1955 to 2005/2010), we followed Ang *et al.* (2010), who stated that the chaining procedure is preferable when more than two years' worth of data are available, since it takes better account of the ups and downs of the period.[8] Thus, we got two sets of decompositions (1950 to 1980 and 1980 to 2005/2010) that are chained, yielding a result for the whole period (1955 to 2005/2010) (Ang, 1994; Ang & Liu, 2007; Ang *et al.*, 2010).

Before going into the formulation of the decomposition effects, we need to define the logarithmic mean of monetary production. Using 1 for the final period and 0 for the initial period, we get:

$$L(Prod_{ij1}, Prod_{ij0}) = \frac{Prod_{ij1} - Prod_{ij0}}{\ln(Prod_{ij1}) - \ln(Prod_{ij0})} \quad (2)$$

After that, following Ang *et al.* (1998) we proceeded with the decomposition of monetary agricultural production. We first developed the 'value decomposition' and then the 'reallocation decomposition'. In both, their multi-dimensional (crop and province dimensions) and multi-level (different levels of aggregation) character allows an in-depth examination of the long-term agricultural changes and patterns, highlighting their main structural heterogeneities.[9]

Thus, Eq. (3) represents the change in monetary agricultural production between periods 0 and 1.

$$\Delta Prod = Prod_1 - Prod_0 = \sum_i \sum_j Q_{ij1} P_{i1} - \sum_i \sum_j Q_{ij0} P_{i0} = QE + PE \quad (3)$$

This change can also be expressed as the sum of the quantity and price effects obtained using the LMDI-I additive decomposition introduced by Ang *et al.* (1998). This yields Eqs. (4) and (5) for the quantity (QE) and price (PE) effects, respectively:

$$QE = \sum_i \sum_j L(Prod_{ij1}, Prod_{ij0}) \ln\left(\frac{Q_{ij1}}{Q_{ij0}}\right) \quad (4)$$

$$PE = \sum_i \sum_j L(Prod_{ij1}, Prod_{ij0}) \ln\left(\frac{P_{i1}}{P_{i0}}\right) \quad (5)$$

This first decomposition, the 'value decomposition', tries to capture the extent to which long-term changes in monetary agricultural production are driven by changes in the volume of production (QE) and by changes in the value (price) of the different crops (PE). Note that although monetary agricultural production has been deflated for the whole crop production, the price effect exists as a result of the price differences among different products and might be especially informative when working with regional and crop detail. This perspective extends to the role of agricultural expansion and to the specific crops and regions responsible for the increase in the value of Spanish production that has resulted from the growing production of high-value products.

Similarly, in our second decomposition, the change in monetary agricultural production between years 1 and 0 can be expressed as the sum of the change in the product shares within provinces (composition effect, CE), the change in provincial composition of production (share effect, RE) and the change in total monetary production (scale effect, SE).

$$\Delta Prod = Prod_1 - Prod_0 = \sum_i \sum_j \left(\frac{Prod_{ij1}}{Prod_{j1}} * \frac{Prod_{j1}}{Prod_1} * Prod_1\right) - \sum_i \sum_j \left(\frac{Prod_{ij0}}{Prod_{j0}} * \frac{Prod_{j0}}{Prod_0} * Prod_0\right) = \sum_i \sum_j c_{ij1} * r_{j1} * s_1 - \sum_i \sum_j c_{ij0} * r_{j0} * s_0 = CE + RE + SE \quad (6)$$

Again, following Ang *et al.* (1998), we estimated the CE, RE and SE in the following equations:

$$CE = \sum_i \sum_j L(Prod_{ij1}, Prod_{ij0}) \ln\left(\frac{c_{ij1}}{c_{ij0}}\right) \quad (7)$$

$$RE = \sum_i \sum_j L(Prod_{ij1}, Prod_{ij0}) \ln\left(\frac{r_{j1}}{r_{j0}}\right) \quad (8)$$

$$SE = \sum_i \sum_j L(Prod_{ij1}, Prod_{ij0}) \ln\left(\frac{s_1}{s_0}\right) \quad (9)$$

Accordingly, we can explain the changes in monetary production as a result of variations in: 1) the crop composition of production (CE) that allows us to evaluate the productive change toward higher- or lower-value products within regions; 2) the regional redistribution of production (RE) that provides information on the geographical displacement of monetary production between regions; and 3) the scale of monetary production (SE). Hence, the 'reallocation decomposition' sheds light on the contribution of structural changes, *i.e.* on the changes in crop and regional specialization patterns.

Results

The Spanish agricultural production: a view based on regions and products

Table 1 shows the level of production in monetary units and its annual growth rates. We can observe continuous growth in Spanish agricultural production of almost 2%

[8] They literally acknowledge that 'chaining analysis is preferred because it gives results which are more representative of the true situation, it makes full use of the data available, and it is more flexible in terms of application'.

[9] For a review of the importance of the multi-level and multi-dimensional character of IDA, see Ma (2014).

Table 1. Monetary production value (prices deflated using the base year 1980) by region (in million pesetas) and annual growth rates

	Region	Level (million pesetas)			Annual growth rates (%)		
		1955	1980	2005/2010	1955 to 1980	1980 to 2005/2010	1955 to 2005/2010
AN	Andalusia	84,854	224,431	363,687	4.0%	1.8%	2.8%
AR	Aragon	22,814	64,116	93,543	4.2%	1.4%	2.8%
AS	Asturias	8,307	9,472	6,541	0.5%	-1.4%	-0.5%
CB	Cantabria	2,141	2,887	1,880	1.2%	-1.6%	-0.2%
CL	Castile and Leon	79,737	132,993	114,888	2.1%	-0.5%	0.7%
CM	Castile-La Mancha	44,508	119,454	107,900	4.0%	-0.4%	1.7%
CT	Catalonia	31,577	87,691	77,362	4.2%	-0.5%	1.7%
EX	Extremadura	22,137	53,936	93,546	3.6%	2.1%	2.8%
GA	Galicia	34,348	56,970	54,056	2.0%	-0.2%	0.9%
IB	Balearic Islands	5,929	13,097	10,791	3.2%	-0.7%	1.2%
MC	Murcia	7,836	32,340	72,200	5.8%	3.0%	4.4%
MD	Madrid	6,592	9,640	5,783	1.5%	-1.9%	-0.3%
NC	Navarra	10,855	22,694	26,713	3.0%	0.6%	1.7%
PV	Basque Country	6,917	8,722	7,163	0.9%	-0.7%	0.1%
RI	La Rioja	6,821	16,143	15,035	3.5%	-0.3%	1.5%
VC	Valencian Comm.	44,785	101,584	89,958	3.3%	-0.4%	1.4%
TOT	Total	420,158	956,170	1,141,047	3.3%	0.7%	1.9%

Sources: Own elaboration from MAPAMA (1955, 1980, 2005, 2010).

annually over more than 50 years. The highest growth was from 1955 to 1980, when the figure increased by 3.3% annually. This growth coincides with the widespread adoption of chemical products and agricultural machinery and the construction of major hydraulic infrastructures during the Franco dictatorship.[10] However, growth was slower from 1980 to 2005/2010 (0.7% annually). Even then, however, Spanish agriculture increased its production, in contrast to other European countries, where production remained stable from the mid-1980s.

Table 1 and Fig. 1 show that crop production was concentrated in the south and east of Spain, especially in Andalusia and Murcia; meanwhile, the northwest lost importance in terms of agricultural production. If at the beginning of the period the region of Andalusia had a share of 20.2% of Spanish crop production, and 23.5% in 1980, by the end of the period this had risen to 31.9%. Other regions –like Aragon, Extremadura and Murcia– substantially increased their own importance in Spanish crop production. This concentration coincides with a period of vast construction of hydraulic infrastructures during the Franco dictatorship, particularly in the Mediterranean area and the Ebro basin. By contrast, the two regions of Castile and Leon and Galicia, both situated in the northwest, lost almost half of their weighting in total crop production.

Looking at Fig. 1, the largest increases in Spanish crop production occurred in the provinces of Almeria, Badajoz, Murcia, Seville, Zaragoza, Huesca, Valencia, Cordoba, Granada and Lerida, being many of them in the east, and several in the south of Spain. The case of Almeria –the most south-easterly province and the most arid – is striking. The role of increased irrigation in this water-scarce region (albeit a region with good soil and plenty of sunshine hours) is a dominant explanatory factor in the agricultural revolution that occurred. Here we find a yearly growth in crop production of 6.3% throughout the period.

The different specialization of each province produced these differential growths. In order to obtain a complete view, it is necessary also to observe the evolution of production in terms of groups of products; this helps us to understand the changing crop patterns of Spanish agriculture. As Table 2 shows, the biggest growth is to be found in vegetables, which moved from making up 10% of the total production value in 1955 to 32% in 2005/2010. Table 2 also shows increases in the share of

[10] There was also some construction of hydraulic infrastructures before the Franco dictatorship, especially from 1911 to 1936. However, the most significant building was in the 1950s, 1960s and 1970s (Herranz, 2004).

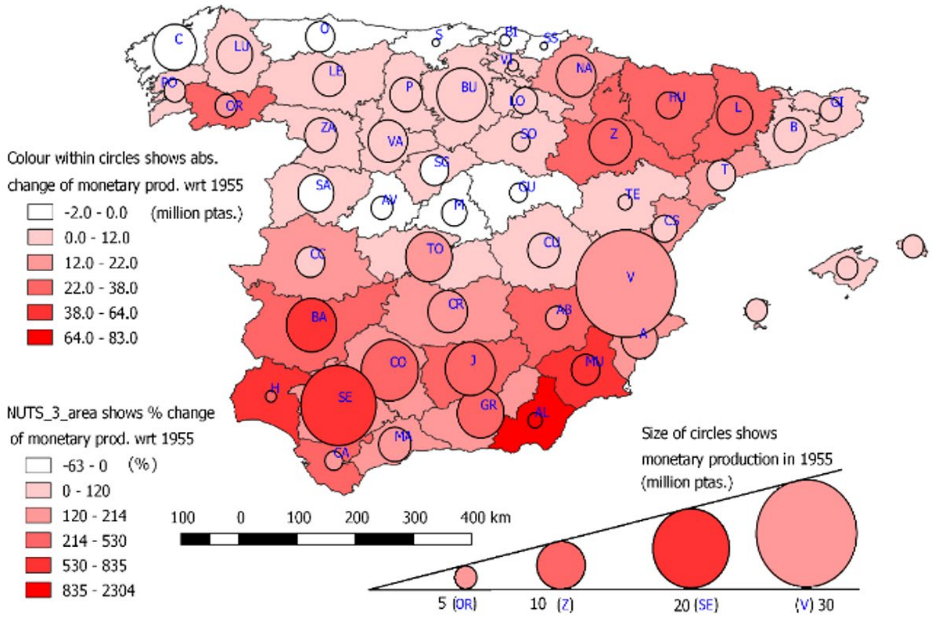

Figure 1. Monetary value of production in 1955 (size of the circles), absolute changes between 1955 and 2005/2010 (colour intensity of the circles) and relative (%) change between 1955 and 2005/2010 (colour of the provinces). Table S1 [suppl.] for the names of the provinces and the relation to wider administrative regions. *Source*: Own elaboration from MAPAMA (1955, 1980, 2005, 2010).

olive oil and wine (the latter up until 1980). Both citrus and non-citrus fruits moved from a share of about 4% to about 7–8% at the end of the period[11] . All of these products are high value-added crops. Besides, fodder crops also increased in importance in crop production, moving from a share of 6% to 11%.

We have then clearly seen this double concentration: reallocation to the south and east of Spain, and specialization in high value-added products. This came about thanks to several factors. First, Spanish exports of vegetables and fruit rose dramatically to become the leading agricultural export products in recent years; they are highly profitable and are the clearest representation of irrigated production (particularly in the southeast of Spain). This is not a new specialization pattern: Spain has traditionally exported fruit and vegetables ever since the last decades of the nineteenth century, when its exports represented approximately one third of the global exports of Mediterranean horticultural products. During the second globalization, the diversification of agricultural exports and the greater importance of transformed products in international trade did not change the preponderance that fruit and vegetables have enjoyed in the agricultural sector. The relative and absolute increase in the production of vegetables, fruit and oil was also driven by internal demand. The rising Spanish population necessitated higher production to meet the food needs. Besides, economic development triggered improvements in the Spanish diet, which moved towards greater consumption of fruit, vegetables and oil. In the case of wine, internal Spanish demand fell abruptly in the second period, despite its increasing export orientation. Thus, Spanish wine production flowed increasingly to the international markets. These decreases in production in a few products go to explain the figure in Table 2 for total production in the last period, which did increase compared to the 1980s, but at a more modest rate than before.

The changing diet of Spaniards also involved greater meat consumption. Moreover, there was a big increase in meat exports, especially after the 1980s. This was reflected in the greater importance of livestock production during the second globalization, which at the same time required larger volumes of animal feed, both domestically produced and imported. During the early decades of the second half of the twentieth century, there was also a marked increase in the production of non-wheat cereals for animal feed, such as barley and maize. As illustration, at the beginning of the 1960s, 39% of cereal production was for animal feed, but by the beginning of the 1980s this figure had reached 72%. Nevertheless, as Table 2 shows, over the period as a whole there was a big decline in the share of cereals – from 47% in 1955 to 14% in 2005/2010. The decline in some low-value products (such as legumes, and other woody crops) was also striking; this

[11] In the case of citrus trees, Valencia is one of the main producers of these products, despite small size of these farms (Reig & Picazo, 2004).

Table 2. Monetary production value (prices deflated using the base year 1980) by product group (in million pesetas) and annual growth rates (%)

Product group[1]	Monetary production value			Annual growth rate (%)		
	1955	1980	2005/2010	1955-1980	1980-2005/10	1955-2005/10
Oil	22,143	55,483	127,276	3.74	3.12	3.42
Cereals	195,687	270,878	156,887	1.31	-2.00	-0.42
Industrial crops	25,422	69,295	33,185	4.09	-2.69	0.51
Fodder	26,447	85,907	124,578	4.83	1.39	3.03
Citrus fruit trees	16,011	46,039	84,135	4.32	2.26	3.24
Non-citrus fruit trees	16,602	73,739	95,732	6.15	0.97	3.43
Nuts	10,276	23,964	42,915	3.44	2.18	2.79
Vegetables	43,739	170,987	363,843	5.60	2.84	4.16
Legumes	21,836	16,488	7,538	-1.12	-2.86	-2.02
Olive consumption	1,954	5,372	13,851	4.13	3.57	3.84
Other woody crops	4,444	2,418	1,114	-2.41	-2.83	-2.63
Tubers	32,878	58,854	30,504	2.36	-2.40	-0.14
Wine	2,719	76,747	59,489	14.29	-0.94	6.11
Total	420,158	956,170	1,141,047	3.34	0.66	1.94

[1] Oil refers to olive oil, olive consumption are olives that are directly consumed, wine is considered as an individual item. Grapes and raisins for consumption are included as non-citrus fruits. Source: Own elaboration from Spain's Agrarian Statistics Yearbooks for 1955, 1980 and 2005 to 2010 (MAPAMA, 1955, 1980, 2005, 2010).

was mainly due to a fall in their consumption, especially after 1980.

Causes of the double concentration: decomposition results

In this section, we quantify and expand on the causes of the double concentration seen in previous sections. To that end, first we examined the value decomposition, which analyses changes in the volumes and prices as drivers of monetary production. Then we looked at the determinants that triggered the increases in crop production. As indicated in the methodology, the reason for the existence of a price effect is that, although the effect of prices is removed at the aggregate level of whole crop production, the individual prices of products evolved in different ways. These differences may show those crops that experienced higher increases in their value added, which thus encouraged their production and generated additional income.

In Fig. 2a we found a negative price effect for cereals from 1955 to 1980, given that cereal price fell or remained stable. However, we observe a positive quantity effect (*i.e.* there was an increase in physical units of production), which contributed to a net increase in the value of production. In regional terms, this happened in Castile-La Mancha and notably Castile and Leon, two areas with significant cereal production.

Despite the generally stronger impact of the quantity effect, the price effect explained more than 33% of the change, particularly for olive oil and vegetables. Andalusia accounts for an enormous share of these groups of products. In the case of olive oil, the evolution of its production and export was slightly erratic between 1980 and the first years of the twenty-first century.

As for vegetables, during the last decades of our period of study, their production kept increasing via quantity effects, and price effects showed relatively greater importance. These changes were geographically concentrated in Andalusia, Extremadura and Murcia (Extremadura is more in the west, but there was an important concentration in the south and east of Spain), areas with optimal conditions for these crops: a high number of sunshine hours per year and water resources from the expansion of irrigation.[12] Furthermore, increased external demand for this product type generated growing exports. The positive price effect was a strong incentive to produce more

[12] Nevertheless, the aridity of these provinces generates problems of availability of resources, especially water (Cazcarro *et al.*, 2015b).

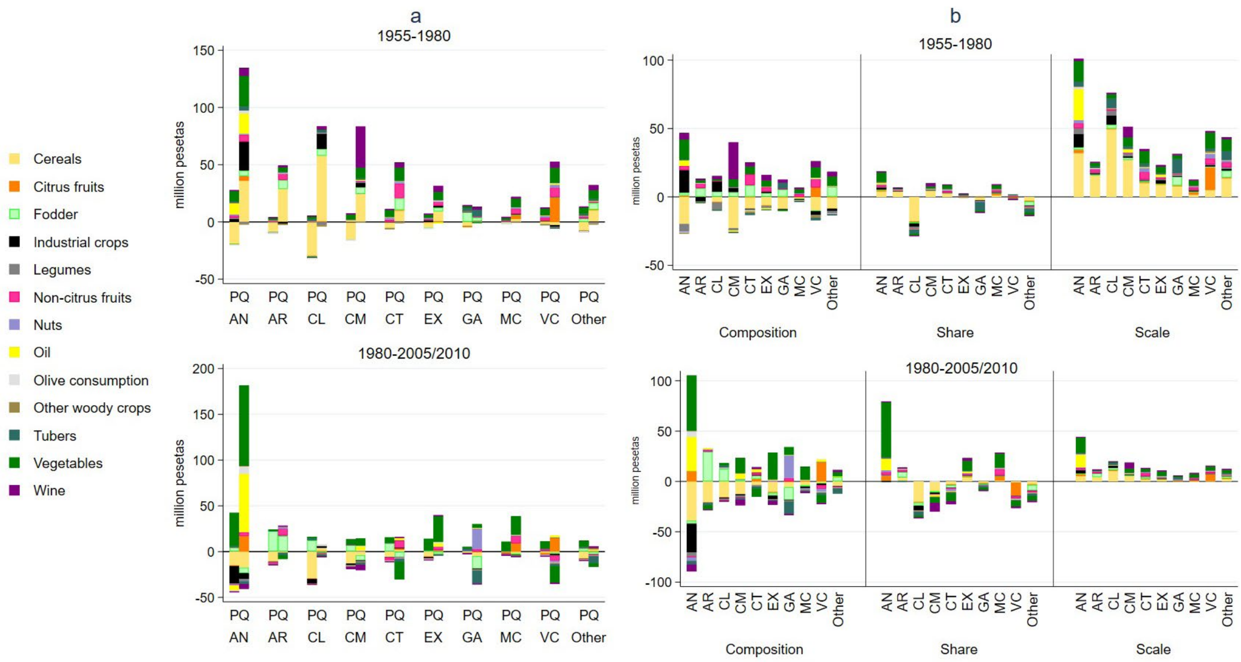

Figure 2. Decomposition of the changes (in million pesetas) into the price and quantity effects (a) and into the composition, share and scale effects by region (b). AN: Andalusia; AR: Aragon; CL: Castile and Leon; CM: Castile-La Mancha; CT: Catalonia; EX: Extremadura; GA: Galicia; MC: Murcia; and VC: Valencian Community. 'Other' comprises small regions (AS: Asturias; CB: Cantabria; IB: Balearic Islands; MD: Madrid; NC: Navarra; PV: Basque Country; and RI: La Rioja) and their graph is shown in Table S1 [suppl.]. Source: Own elaboration (MAPAMA, 1955, 1980, 2005, 2010).

vegetables, substituting low value-added for high value-added products, which reveals concentration in terms of products.

The case of fodder crops is also striking. Despite a fall in the quantity of production, prices boosted the value of production. This happened in northern regions, such as Asturias, Cantabria, Vizcaya, Guipúzcoa and other northern provinces (see Fig. S1a [suppl.]) with high rainfall and high yields. Finally, the value of wine production fell since the 1980s – because of both the quantity and price effects, although the quantity effect was positive from 1955 to 1980. This decrease in monetary wine production from 1980 (Table 2 and Fig. 2a) hinders large regional heterogeneities. According to the information from the Spain's Agrarian Statistics Yearbooks for 1980 and 2005 to 2010 (MAPAMA, 1955, 1980, 2005 & 2010) wine production notably increased in the north/northeast of the country (regions of La Rioja, Navarra, Barcelona and Huesca). However, between 1980 and 2005/2010 important decreases happened in Castilla-La Mancha (for example in the province of Ciudad Real), driving the results at the national level. Cañizares Ruiz & Ruiz Pulpón (2014) explained that the EC regulation entailed the loss of approx. 130,000 ha of vineyards in Castilla-La Mancha from 1987 to 1999 (a fall of around 20% of the existing area). Despite that at the same time there was a considerable expansion of irrigated surface, it was not enough to offset the huge fall of rain-fed area.

The former results can be complemented with the quantification of the changes in regional and crop composition as determinants of the change in Spanish crop production. In Table 3[13] we observe that the Spanish value of crop production increased from 1955 to 2005/2010.[14] The findings from LMDI decomposition indicate that this growth was essentially (84%) explained by the SE. The CE (16%) also goes some way to explaining the change in the value of production; while the share effect was almost non-existent across this long period. Differentiating between the first and the second period studied, we observe how the scale effect was larger in the second period, while the composition effect was larger in the first. Although the figures are small, it is interesting that regional changes led to an increase in the value of monetary production in the first period, but to a decrease in the second.

[13] To evaluate the robustness of these results we calculated the value of crop production in 1955, 1980 and 2005/2010 at constant 1980 prices and applied the same decomposition as in Table 3. The decomposition of the value of crop production using deflated prices (Table 3) is very similar to that using 1980 constant prices. Concretely, for the period 1955-2005/2010 the differences between both approaches range around 1% and 2,5% for the different effects. Thus, the decomposition is robust to the selection of a constant or deflated base year.

[14] This number obviously matches the differences shown in Tables 1 and 2 of value in 2005/2010 of 1,141,047 million pesetas and in 1955 of 420,158 million pesetas.

Table 3. Logarithmic Mean Divisia Index (LMDI-I) multiplicative decomposition of value of crop production changes (million pesetas)

	CE	(%)	RE	(%)	SE	(%)	Prod
1955 to 1980	87,016	16	861	0.2	448,136	84	536,012
1980 to 2005/2010	25,136	14	-1064	-0.6	160,804	87	184,877
1955 to 2005/2010	112,152	16	-203	0.0	608,940	84	720,889

CE: composition effect. RE: share effect. SE: scale effect. Source: Own elaboration from MAPAMA (1955, 1980, 2005, 2010).

We saw in Fig. 2a that monetary production increased in most regions; in Fig. 2b, we see that this is largely explained by scale effects, but that the positive composition effects also play a part. Production tended to move to more valued products or high value-added products. As in Fig. 2a, the case of Andalusia is very illustrative. This region led the growth in value. We can see that although for this region there are purely scale effects (most regions increase their monetary production), there are also notable regional/share effects (production moved to this region) and product composition effects (higher specialization in more valued products).

In this regard, the spatial concentration had a negative share effect in terms of production for regions such as Castile and Leon, Castile-La Mancha, Valencian Community, Cantabria, and many others such as Galicia, Madrid, the Basque country,[15] etc. This means that these regions reduced the production of some crops, not because those crops were less in evidence in Spain's production as a whole, but because production moved elsewhere. As hinted above, this 'elsewhere' included Andalusia, Extremadura, Murcia and Aragon. Although globally share effects seem to have had a small influence on changes in production, they have important explanatory power when we look at the regional detail.

Discussion

In this work, we have analysed the structural changes in agricultural production in Spain during the second half of the twentieth century and the beginning of the twenty-first, in the framework of major transformations in the agricultural sector itself, as well as in the institutional and political context. We assessed how changes in the volume and price of production have conditioned the value of crop production in the long term. Then, we examined changes in crop specialization and regional composition as drivers of monetary crop production. We found strong evidence for the existence of a 'double concentration', in space and crops.

The highly detailed regional and product disaggregation is an important value added of this paper, as it allows in-depth study of the long-term changes experienced in the Spanish agricultural sector. In terms of methodology, after completing the database and deriving the main descriptive trajectories for agricultural production, we used index decomposition analysis (IDA). This technique is useful in providing insights into the factors that lie behind the structural changes experienced by the Spanish agricultural sector. Our article includes empirical evidence on the factors that enabled Spanish agricultural production to grow so conspicuously in European terms. We observe that the heterogeneous growth in Spanish crop production was based on a double concentration: agriculture focused on high value-added products, such as vegetables, fruit and olive oil; and, spatially it was concentrated in the south and east of Spain. The expansion of irrigation, the evolution of internal demand and the progressive integration into international markets all go to explain this double concentration.

In particular, crop production increased at 2% yearly from 1955 to 2005/2010; this growth was particularly intensive between 1955 and 1980, a period when the annual growth rate stood at 3.3%. Thus, production soared (as revealed by the scale effect) and entailed a spatial concentration, notably in the south and east of Spain (as shown by the share effect). Andalusia showed its growing importance in agricultural production, with a share that went from 20.2% of the value of production in 1955 to 31.9% at the beginning of the twenty-first century. The relative increase mostly occurred from 1980. This region bolstered the tradition of cultivating products for export and products with high value-added (Serrano & Pinilla, 2014; Hernández *et al.*, 2016; Aparicio *et al.*, 2018). The expansion of irrigation facilitated increased vegetable production (6% annually throughout the period studied) and olive production (3.6% annually)[16] . Other regions like Extremadura, Murcia or Aragon also specialized in products that enjoyed strong demand, acquiring a greater share of crop production.

[15] See for the small regions (AS: Asturias; CB: Cantabria; IB: Balearic Islands; MD: Madrid; NC: Navarra; PV: Basque Country; and RI: La Rioja) Fig. S1b [suppl.]
[16] Several differences are found between the type of the irrigation (Rodríguez-Díaz *et al.*, 2008).

As for crop patterns, production concentrated on vegetables, which moved from 10% of the total production value in 1955 to 32% in 2005/2010. In this regard, we have seen in our analysis that a very important price effect is to be found in high value-added products, such as vegetables, fruit and oil. Spanish production accordingly specialized in these types of crops, as shown by the composition effect.

In the case of olive oil, its growth was not continuous, as we can see in the slight reduction in its production in the first half of the 1990s (Infante, 2012). Accession to the EEC probably generated growing competition with other Mediterranean producers, which would have provoked a moderate fall in the price of oil. This is shown by the negative price effect of Andalusia from 1980 (Fig. 2a). Furthermore, the main innovations in the production of oil occurred from the 1970s (Infante, 2012), reducing the cost of production.

Interesting increases were also witnessed in the cultivation of fodder. This was partly driven by the raising importance of livestock production in Spanish agriculture (*e.g.* in Huesca and Lerida in the Ebro Valley, areas which as shown in Fig. 1 are also of medium-high of crop). According to FAO[17] , the livestock production to total agricultural production increased from 23% to 37% between 1961 and 2008. Fodder crops were largely cultivated in northern regions as Asturias, Cantabria, Vizcaya and Guipúzcoa, which traditionally specialized in livestock production (extensive livestock breeding), being able to feed large numbers of cattle, compared to provinces that found it hard to obtain biomass (González de Molina, 2001). The increased internal demand for animal feed in a country with an incipient livestock farming industry, along with growing external demand from 1986, could lie behind these effects (Contreras, 1997; Clar *et al.*, 2015; Serrano *et al.*, 2015; González de Molina *et al.*, 2017; Langreo & Germán, 2018). Fodder production also increased in the Ebro Valley (mostly in Aragon and Lerida). This fact can be explained by the long-term tradition of managing irrigation systems in this area, together with a specialization in livestock production (especially pig farming and intensive breeding) and the increasing integration in the supply chain with the agroindustry (García Pascual, 1993; Pinilla & Clar, 2011).[18] Thus, as we saw before, the provinces in the Ebro valley (north-east) gained importance in fodder production, while it fell in the Cantabric coast (north west).

By contrast, cereals declined from 47% in 1955 to 14% in 2005/2010. As we saw earlier, the importance of cereals decreased within total production, but in aggregated terms the production of cereal increased in Castile and Leon and Castile-La Mancha until 1980. In fact, its harvested area increased from the 1960s to the 1980s (Clar, 2013), especially barley. Cereal production in these regions benefited from the widespread technical innovations in European agriculture, even in products with a low value-added. From 1980, the two regions also experienced decreasing price effects, which this time clearly led to an overall decline in production. The trend toward producing higher value-added products and the increasing ease of export depressed cereal production, as agricultural resources were devoted to other crops, such as fodder in Castile and Leon or olive oil and vegetables in Castile-La Mancha.

The case of wine production and the results in the decomposition were also striking. Exports boosted the country's share of global wine production, especially in the 1990s and 2000s. Despite that, domestic Spanish consumption of wine decreased sharply after the 1970s (Fernández & Pinilla, 2018).

Overall, then, here we have woven information about the Spanish agricultural sector and its socioeconomics with the historical perspective. This may be useful for a systematic and detailed understanding of the evolution of Spanish agriculture, which has become quite conspicuous in the European Union. Several factors and societal shifts have guided and encouraged certain key changes, such as the identified specialization and spatial concentration, which has boosted economic development in areas of concentration. A policy maker, though, should also probably consider the wider picture, including the social and environmental effects that have been hinted at. For example, in large rural areas of the centre and north of Spain, farming households have seen a reduction in the possibilities they have of making a living. Besides, climate change could further exacerbate the existing environmental and social vulnerabilities related to agriculture (Iglesias *et al.*, 2011).

Furthermore, we believe that these insights, together with the innovation displayed in the application of decomposition methods, could be of further use and interest for their application to different contexts. Open and future lines of research building on this work could include comprehensive studies of the interrelationship of Spanish agriculture with trade balances, openness to trade, comparative advantage and other trade theories, additional specializations and integrations along the supply chain, demand and diets in Spain and abroad, and even the management and productivity of other factors of production and resources, such as labour, energy or capital.

17 http://www.fao.org/faostat/en/

18 This is other example of the concentration of high value-added products. Livestock products present higher operating margin than crop products, explaining the increase of the importance of the products derived from cattle in Spain.

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