Extended abtract

EXTENDED ABSTRACT

Title: The role of irrigation on the regional divergences of Spanish agricultural production: Analysis during the second globalization

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Abstract: *(minimum1500 words)*

Short abstract

From the second half of the twentieth century, the Spanish agricultural sector experienced a sustained growth in production, which involved the convergence to Western European levels after years of delay in terms of agricultural production and productivity. This growth was not homogenous among regions, instead, important divergences are observed, mostly associated to the main crops cultivated in each area. More concretely, production moved to the warm and sunny provinces in the south and east of the country that tended to produce high valued crops oriented to foreign markets as fruits, vegetables and olive oil. Scientific literature has pointed to several factors influencing this process. Some of them are technological innovations, the

internationalization of the Spanish agriculture, the internal development of Spain and its subsequent dietary changes, and the development of irrigation. In this framework, the main objective of this paper is to analyse the influence of irrigation in the Spanish agricultural production, deepening into the generation of regional divergences during the second half of the twentieth century. Irrigation was essential, since it allowed growing Mediterranean water intensive crops in the most arid areas of the country. Thus, we will try to establish the quantitative long-term relationship between the regional irrigated area and the regional agricultural production. We will use panel data econometrics to evaluate the specific impact of irrigation, also controlling for other geographical, technological, institutional, economic and social transformations occurred during the period of analysis. The level of disaggregation, in terms of production and regions, will allow to evaluate the robustness of our findings, as well as to define specific regional and crop patterns. This study will also allow shedding light on the environmental impacts of the intense and regionally-divergent development of water infrastructures in Spain.

Extended abstract

1. Introduction

Agricultural production and productivity in Europe have been among the main themes of economic history literature, see e.g. (Alston & Pardey, 2014; Edwards & Smith, 2018; Federico, 2005; Gollin, Lagakos, & Waugh, 2014; Lains & Pinilla, 2009; O'Brien & Prados de la Escosura, 1992), finding important growths in these variables during the second globalization (the second half of the twentieth century). The most common explanations have to do with major technological and institutional transformations in the sector, as well as parallel variables and explanations such as increased access to water, etc.

Spain has some distinct agricultural trends with respect to Europe, with a steady increase in agricultural production and productivity, especially during the second half of the twentieth century (Clar, Martín-Retortillo, & Pinilla, 2018). Besides, Spanish regions have followed different trends among them. So, the study of the Spanish regions is fundamental to understand the role of the Spain in the European agriculture.

It is logical then to think on what may have been the reasons behind, and ultimately wonder, what factors drive or explain agricultural production? Several aspects have

discussed in the literature: the climatic (although until recently we had not seen so large changes in the long-run), institutional, technological, etc.

Empirical and theoretical cases that differences in economic institutions are the fundamental cause of differences in economic development can be found e.g. in (Acemoglu, Johnson, & Robinson, 2004). The role played by institutional factors on Spanish agricultural growth has also been a relevant consideration in many studies (Carmona & Simpson, 2003; Garrabou, 2001; V. Pinilla, 2004). In the period studied, the openness of Spain to other countries provided the access to international agricultural markets and internal industrial development provided agriculture with energetic, continuous and cheap supply, as well as with the technology offered by the "green revolution", helping it to advance rapidly in the agricultural capitalization begun in the 1950s. Meanwhile, rural migration reached an all-time high with two million displaced people between 1960 and 1970. The steady decrease in agricultural income was added to the growing attraction of the industry and services sectors. This led the worst affected landowners first to divide their time between agriculture and more lucrative activities (commerce, industry), and then finally to abandon agriculture (Naredo, 1971)(Clar & Pinilla, 2006).

Technological and intensification changes ultimately have had an effect on (land) productivity, which is perhaps an interesting factor to consider. According to (European-Commission, 2016) agricultural productivity has gained renewed interest, also for the European Union, with growth which has enabled food to become less scarce (and hence cheaper) in the 20th Century. In that study in which there is an analysis of drivers, via estimating Total Factor Productivity (TFP) it was obtained the change in output that is not directly originating from a more intensive input use, but from changes in technology, efficiency, managerial skills and organisation of the production. E.g. Spain would be the 8th in labour productivity between 2005 and 2015. In Spain, since the 60s a major government initiative of hydraulic works would produce significant effects in agricultural productivity, to the extent that it is reasonable to state that the total production per hectare in affected areas would have at least tripled e.g. in the Ebro Valley (Cazcarro, Duarte, Martín-Retortillo, Pinilla, & Serrano, 2015; Garrabou & Naredo, 1999).

Probably also differentially, the study of irrigation, especially of modernization processes and their effects to water resources, have received notable attention in Spain (Blanco-Gutiérrez, Varela-Ortega, & Purkey, 2013; Dechmi, Playan, Faci, & Tejero, 2003; Dumont, Mayor, & López-Gunn, 2013; Lecina, Isidoro, Playán, & Aragüés, 2010b; Vicente Pinilla, 2006; Reckien, Wildenberg, & Bachhofer, 2013). And actually, our main hypothesis is that the artificial water access, and notably the expansion of irrigated agriculture may have a fundamental role as explanatory factor of the increases in crops production.

Being these quite wide concepts, it should be stressed that many of these factors somehow tend to be linked to the "supply side", but also demand factors have been highlighted. The increasing demand of crops for human consumption (domestically and abroad), but also notably for feeding livestock has also been highlighted for Spain (Clar, 2005; González de Molina et al., 2017).

Despite all that and related literature, as far as we know it does not exist a systematic and comprehensive (temporally and spatially) approach that tries to assess the drivers of crops production changes in Spain since the mid XXth century, trying to find the role of each of the factors. This is what we try to accomplish here, by analyzing the production of 132 crops in the Spanish provinces and associated possible explicative factors in three moments and periods of time starting in 1955.

The importance of understanding the drivers is also very much linked to relating the factors to consequences. In that regard, e.g. the effects on water resources and the derived Land Use Changes of agriculture have been emphasized. In (González de Molina et al., 2017) it was studied whether transformations linked with industrialization of agriculture have also been positive, concluding that it brought profound changes in land uses and in the functionality of the biomass produced, increasing pressure on croplands and, paradoxically, facilitating the abandonment of an important proportion of pasture and croplands. Hence we will also put in relation and discuss the causes and effects of the Spanish agriculture.

The remainder of the article is organized as follows. The second section explains the methods used in the article, notably the econometric specification, and the data sources.

In section 3 we develop a descriptive analysis of our data, followed by the results of the econometric estimations, explained in context. Section 4 offers a conclusion and discussion of the policy relevance for Spanish agriculture, the environment, water infrastructure and irrigated area policies.

2. Methods

2.1. Econometric models

The main equations we test have the following form:

$$log(Prod_{ijt}) = \beta_1 log(AEI_{jt}) + \beta_2 log(Int_{jt}) + \beta_3 \boldsymbol{Z} + \delta_{ij} + \gamma_t + \varepsilon_{ijt}$$

i indicates the crop, j refers to the region and t to the year

$Prod_{ijt}$ is the monetary production at deflated prices with crop, province and year detail.

AEI_{jt} is the area equipped for irrigation (ha) with province and year detail.

$\boldsymbol{Z}$ is a vector with control variables as average temperature, annual precipitation, livestock, type of agricultural societies, etc.

δ_{ij} are crop-provincial dummies to control for the characteristics of the products grown in a specific region constant in time

γ_t are fixed time effect that control for time-variant characteristics common to all products and provinces.

Additionally, in Table 1 of results, other specifications have been estimated using different fixed effects. Nevertheless, according to the model selection criteria shown in Table 1, the one above is our preferred specification. The model is estimated using Least Square Dummy Variables estimator with standard errors robust to heteroscedasticity.

2.2. Data

Data on agricultural production is obtained at the provincial level (132 crop products and 48 Spanish provinces)[1] from the Spain's Agrarian Statistics Yearbooks (Anuario de Estadística Agraria from Ministry of Agriculture). Then, we have obtained the prices for each product to calculate the agricultural production in constant prices.

Our main explanatory variable is the area equipped for irrigation (AEI henceforth) in hectares. These data are from HYDE (2017), offering data for this variable for the Spanish provinces. This variable is fundamental to understand the agricultural production and there is an abundant literature explaining the agricultural production taking into account the irrigated land (Fuglie, 2012; Fuglie & Rada, 2018; Hayami & Ruttan, 1985; Kawagoe, Hayami, & Ruttan, 1985; Martín-Retortillo & Pinilla, 2015; Mundlak, 1999).

Other variable is the intensification in the Spanish provinces such as the land productivity. We have included this variable to take into account the intensive farming in certain Spanish provinces, namely, the different uses of land with different groups of products. We have obtained the data from the land from the Anuario Estadístico de España (1955, 1980, 2005 and 2010).

Control variables try to incorporate to the analysis proximate and fundamental causes of economic growth, such as technical change or the incorporation of capital input, and on the other hand, institutions or geography. In the case of the proximate causes of economic growth we have included in our analysis the agricultural machinery in horsepower for each province. We have obtained this variable from (INE, 2011). From this source, we have also obtained the livestock units for each province.

Geography has been included in several ways. First of all, we have incorporated the average temperature and the accumulated annual rainfall in each province. Both variables are measured in the capital of each province. Data for 1955 and 1980 is from

[1] We have omitted the Canary Islands provinces because the strong differences with the peninsulan provinces with the role of the irrigation.

(Goerlich Gisbert, 2012). For the average between 2005 and 2010, we have obtained the average temperature from (AEMET (Agencia española de metereología), 2019). However, we have also included two more variables to take into account the geography. We have included the suitability for rain-fed cereals and an index, which measures climate, soil and terrain slope constraints combined from (IASSA & FAO, 2000).

Institutions are also included. We have divided the Spanish provinces into three categories, following the division of (Gallego Martínez, 2007). This author divides the Spanish agricultural societies into latifundia, peasant societies and mixed societies. We have assigned to each province to one of this classes. In case of one province can include two classes of agricultural societies, we have chosen the type of society with a more predominance in the whole province.

We have included in our analysis an economic variable to incorporate the economic development in each province. We have incorporated the industrialization degree, which is the percentage of the province in the national industrial value added divided for the percentage of the provincial population over the national population. (Gallego Martínez, 2007) calculated this degree for 1955. We have calculated this variable with the data from (Carreras & Tafunell, 2005, p. 405) for the data for the industry and the data for population are from INE (2019).

3. Results

3.1. Initial descriptive statistics and graphs

As discussed above, our main interest in this paper is to understand the growth of agricultural production in Spain since the mid-XXth century. This implies understanding the role of growth in Area Equipped for Irrigation (AEI) and other variables capturing the climate, the land intensification, technological and institutional changes. As shown in Figure S1, Figure S2 and Figure S3 of the supplementary material, overall, production and AEI show some parallel growth over the period.

The scatterplot charts placing the show the positive correlation between the area equipped for irrigation and monetary production at the provincial level. In 1955 the dispersion was large and the relationship was not so clear. Then, in 1980, after the construction of the large waterworks during Franco's dictatorship, we can observe a notable direct link. In the years 2005 to 2010 the association kept being positive, but the dispersion grows, possibly given the differences in the trendsof the intensification and technological change among Spanish regions during these years. Today we find:

- provinces where there was an increase in irrigation an also in monetary production. This is the case of internal regions as Badajoz for example and also of the Mediterranean region of Murcia. Both among the regions with the current higher irrigation surface.
- some areas with high monetary production and relatively lower irrigation as Almería in Andalusia.
- Andalusian regions with high AEI and production. See for example the case of Huelva with a large increase in AEI and production between 1980 and 2010.
- North areas with the lowest AEI and monetary production

The figures 1, 2 and3 reveal these aspects for the different (48) provinces, and also illustrate by colours the different agricultural regions in which Simpson (1995) divided Spain, respectively for 1955, 1980, and 2005-2010.

Figure 1: Area equipped for irrigation (logs) versus monetary production at constant prices (logs), 1955

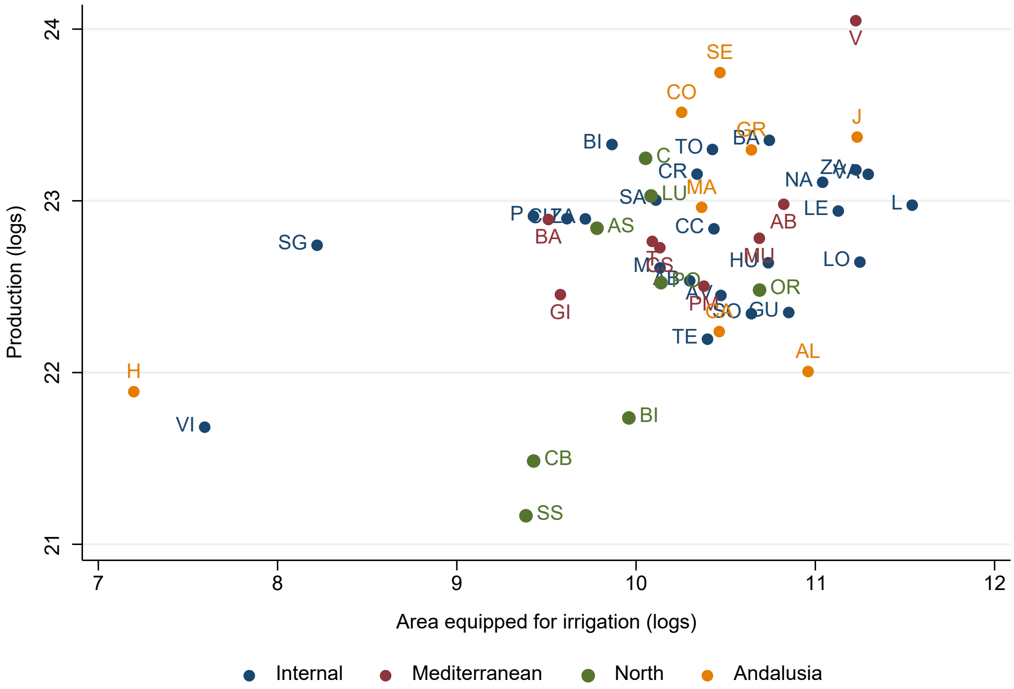


Figure 2: Area equipped for irrigation (logs) versus monetary production at constant prices (logs), 1980

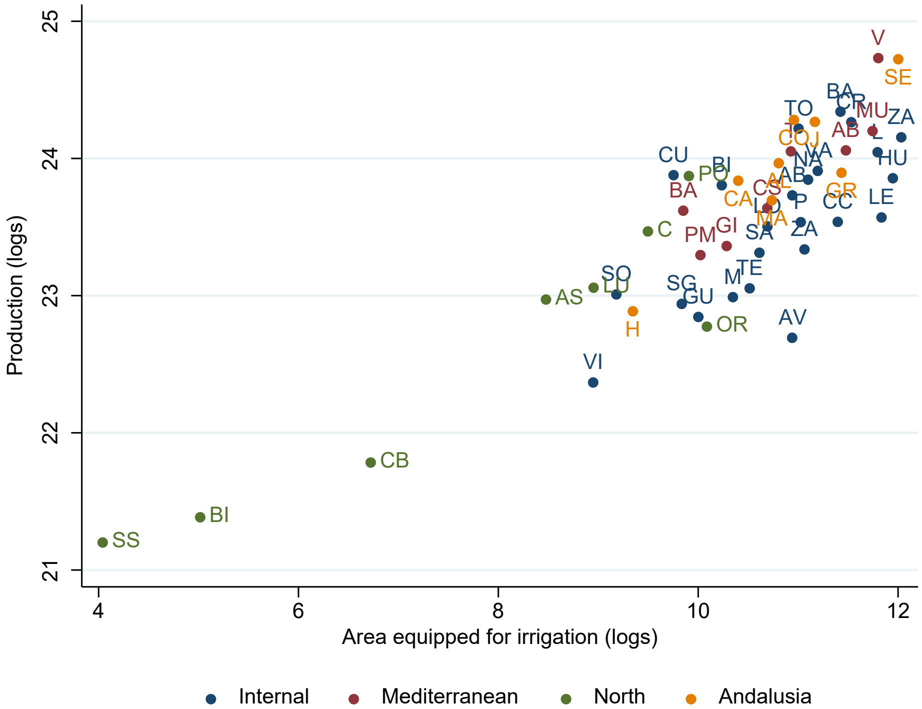
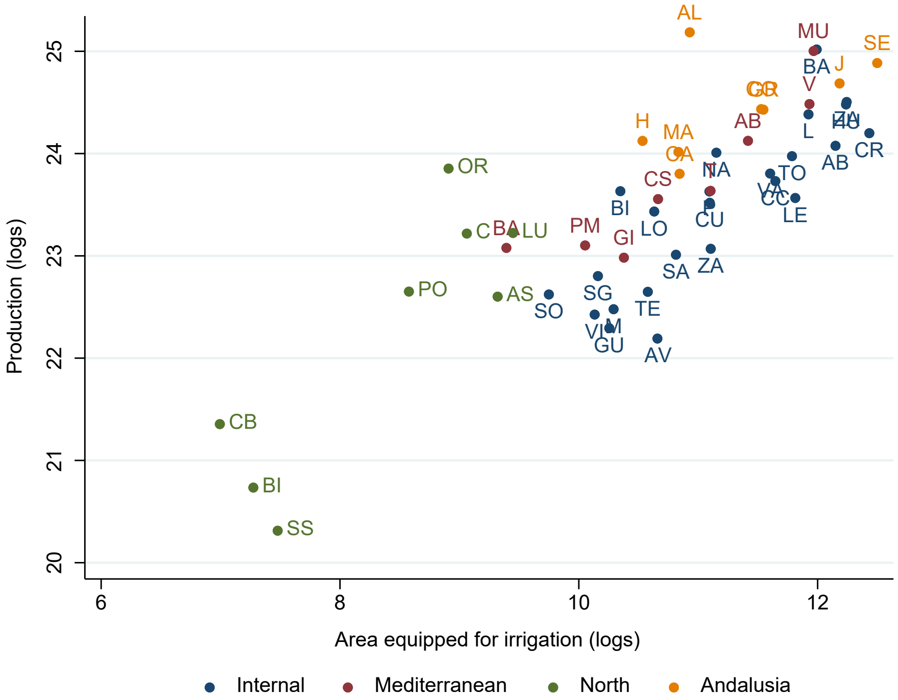


Figure 3: Area equipped for irrigation (logs) versus monetary production at constant prices (logs), 2005-2010



3.2. Econometric results

Given the apparent clear-cut relationship between production and the AEI, with the described model we try to understand more systematically this relation, putting it also in context and in relation to other climatic, technological, institutional and economic variables. Table 1 shows the effect of the within provinces area equipped for irrigation (AEI) variability (as well as of several other variables) on the provincial and crop monetary production. As explained in the methodology section, we try several specifications, including different control variables and fixed effects.

Table 1: Panel data estimation of production for all the Spanish provinces and crops, 1955-2010

	M1	M2	M3	M4	M5	M6	M7
log(area equipped for irrigation)	0.313***	0.246***	0.202***	0.0742*	0.0650*	0.0764***	0.107***
	(0.0211)	(0.0220)	(0.0280)	(0.0408)	(0.0338)	(0.0278)	(0.0288)
log(land productivity)		0.265***	0.261***	0.245***	0.243***	0.280***	0.391***
		(0.0309)	(0.0365)	(0.0537)	(0.0440)	(0.0382)	(0.0575)
log(soil quality)			0.475*				
			(0.253)				
log(average temperature)			0.209	-1.796***	-2.376***	-2.787***	-1.065**
			(0.212)	(0.419)	(0.326)	(0.248)	(0.462)
log(annual precipitation)			0.00105	-0.393***	-0.363***	-0.286***	-0.278***
			(0.0894)	(0.140)	(0.106)	(0.0858)	(0.0944)
peasant societies			-0.0488	-0.544	-0.485*		
			(0.0747)	(0.332)	(0.262)		
landowners societies			0.254***	0.277	0.609**		
			(0.0818)	(0.332)	(0.262)		
log (livestock)			0.121***	0.0461	0.0530	-0.0422	-0.00454
			(0.0462)	(0.0961)	(0.0747)	(0.0667)	(0.0685)
Observations	10,007	9,931	9,931	9,931	9,931	9,931	9,931
Adjusted R2	0.0208	0.0285	0.034	0.0478	0.435	0.707	0.710
AIC	47316.54	46914.9	46869.72	46767.59	41530.05	29277.55	29192.39
BIC	47330.96	46936.51	46934.55	47156.58	42869.89	29320.77	29250.02
p-value RESET	0	0.0002	0.0004	0.0487	0	0.001	0.120
Provincial FE	NO	NO	NO	YES	YES	NO	NO
Product FE	NO	NO	NO	NO	YES	NO	NO
Provincial-Product FE	NO	NO	NO	NO	NO	YES	YES
Time FE	NO	NO	NO	NO	NO	NO	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

As Table 1 depicts, the area equipped for irrigation positively influenced the Spanish monetary production between 1955 and 2010. This result is robust to every model, with its effect ranging from 0.0650 to 0.313. Note that the effect decreases when we control for the provincial specific characteristics by including fixed effects (compare M1 to M3 with M4 to M7). The adjusted R2, the RESET test together with the AIC and BIC criteria indicate that model 7 is our preferred specification. It shows an irrigation elasticity of 0.107, indicating that a 1% increase in the AEI led to a 0.107% increase in the value of the Spanish monetary production. Additionally, we also find that the strong intensification of production happened during these years, proxied in our model as the production per utilised area, also triggered the growth found in agricultural production. This effect is larger compared to the elasticity found for irrigation.

Regarding the results on precipitation and temperature, we find of most importance this paragraph of (Clar & Pinilla, 2006): "The predominantly Mediterranean type climate leads to low and irregular yields in unirrigated areas and, in contrast, high productivity in irrigated areas due to the combination of sufficient water, high levels of sunshine and moderate temperatures. Logically, this difference in productivity has meant a constant effort, over hundreds of years, to bring irrigation to dry areas through the construction of costly infrastructures.". That is, the sign of temperature in which less temperature leads to higher production, can be related to the smaller water needs due to higher evapotranspiration especially with extremely hot weather (considering the fact that AEI and Precip are already capturing the potential positive effects of water, especially of that supplied with infrastructure, to increase productivity, etc.)

Once we have chosen our preferred model, on the basis of M7, we deepen into our data, looking for some heterogeneous effects of AEI on monetary production. Firstly, Table 2 shows the estimates for the period 1995 to 1980 and for 1980 to 2010, including also the results for the whole sample. Again, we find that the expansion of irrigation directly influenced the Spanish monetary production. However, the effect is only significant between 1955 and 1980. This can be explained because most water infrastructures were constructed until 1980, mainly in the interior provinces of the country. The effect of agricultural intensification (in terms of land productivity) was positive and significant, with its impact being 5 times larger during the first period compared to the second one. The inverse relation of precipitation with the production may seem counterintuitive in the beginning. However, probably the relation is indirect.

Table 2: Panel data estimation of production for all the Spanish provinces and crops in different periods

	1955-1980	1980-2010	1955-2010
log(area equipped for irrigation)	0.0934***	0.0948	0.107***
	(0.0354)	(0.0628)	(0.0288)
log(land productivity)	0.506***	0.151**	0.391***
	(0.105)	(0.0766)	(0.0575)
log(average temperature)	4.564***	-1.549***	-1.065**
	(1.691)	(0.508)	(0.462)
log(annual precipitation)	-0.0198	-0.485***	-0.278***
	(0.148)	(0.130)	(0.0944)
log (livestock)	-0.130	0.271**	-0.00454
	(0.0926)	(0.121)	(0.0685)
Observations	6,858	6,547	9,931
Adjusted R2	0.7692	0.7703	0.710
p-value RESET	0.056	0.563	0.120
Provincial FE	NO	NO	NO
Product FE	NO	NO	NO
Provincial-Product FE	YES	YES	YES
Time FE	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Now, we move onto the divergences of the effect of AEI in monetary production between regions. In Table 3, we present the estimation for the different agricultural regions in which Simpson (1995) divides Spain, including also the estimates for some specific provinces. In general, we can see that the expansion of irrigation had a positive effect in the interior and north regions. However, it was no significant in the Mediterranean and Andalusian areas. Again, the effect of agricultural intensification was also of great importance, particularly in the Mediterranean provinces, where a 1% increase in the production per utilised area led to a 0.9% of monetary production growth. This variable is also not significant in Andalusia. Looking at some particular provinces, Table 3 shows the large impact exerted by irrigation in provinces as Badajoz and Zaragoza, arid areas where irrigation allowed growing water intensive and high value added crops that made its monetary production to increase. Besides, the effect of intensification was negative in these areas, particularly in Badajoz.

Table 3: Panel data estimation of production by agricultural areas and particular provinces for 1955-2010

	Simpson (1995) agricultural regions				Particular provinces	
	Interior	Mediterranean	Andalusia	North	Zaragoza	Badajoz
log(area equipped for irrigation)	0.310***	0.0245	-0.121	0.118**	1.417*	6.854**
	(0.0657)	(0.219)	(0.101)	(0.0555)	(0.807)	(2.794)
log(land productivity)	0.649***	0.890***	-0.0296	0.718***	-0.266	-3.929**
	(0.125)	(0.212)	(0.106)	(0.173)	(0.513)	(1.781)
log(average temperature)	-1.534*	-0.291	0.143	-3.300**		
	(0.847)	(0.899)	(2.014)	(1.360)		
log(annual precipitation)	-0.223	-0.714*	-0.527**	-1.657**		
	(0.160)	(0.374)	(0.214)	(0.798)		
Observations	4,841	1,973	1,935	1,182	213	239
Adjusted R2	0.724	0.723	0.674	0.713	0.680	0.696
p-value RESET	0	0.729	0.005	0.389	-	-
Provincial FE	NO	NO	NO	NO	NO	NO
Product FE	NO	NO	NO	NO	NO	NO
Provincial-Product FE	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

To finish with our heterogeneous effects, we show the effect of irrigation on agricultural monetary production considering some groups of products. The expansion irrigation increased the monetary value of production, particularly of products as fruits, wine and cereals. As for vegetables the magnitude of the irrigation coefficient is relatively lower, compared to the rest of groups of products. As for the effect of land productivity (agricultural intensification), our estimates highlight mostly citrus fruits, with an elasticity larger than one, followed by vegetables and non-citrus fruits. This effect is non-significant for wine, cereals and industrial crops, the latter ones being negative. This shows the existing heterogeneity in the results, deviating in some cases from general aggregate trends.

Table 4: Panel data estimation of production and explanatory variables by specific groups of products

	Cereals	Vegetables	Non-citrus fruits	Citrus fruits	Wine	Industrial crops
log(area equipped for irrigation)	0.249**	0.0728**	0.175***	0.459*	0.322**	0.834***
	(0.111)	(0.0369)	(0.0511)	(0.235)	(0.145)	(0.312)
log(land productivity)	-0.149	0.679***	0.523***	1.086***	0.0480	-0.354
	(0.164)	(0.0841)	(0.110)	(0.248)	(0.183)	(0.379)
log(average temperature)	-2.247	-1.006*	0.219	-0.420	4.373**	-2.384
	(1.412)	(0.599)	(0.966)	(2.382)	(1.905)	(3.730)
log(annual precipitation)	-1.340***	0.509***	-0.548***	0.133	0.0532	-2.068***
	(0.293)	(0.122)	(0.209)	(0.509)	(0.381)	(0.554)
Observations	873	3,107	1,527	256	143	543
Adjusted R2	0.799	0.699	0.744	0.886	0.902	0.755
p-value RESET	0.003	0.498	0.289	0.875	0.134	
Provincial FE	NO	NO	NO	NO	NO	NO
Product FE	NO	NO	NO	NO	NO	NO
Provincial-Product FE	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4. Conclusion and discussions

The main objective of this paper has been to analyse, making use of panel data econometrics, the influence of irrigation in the Spanish agricultural production, deepening into the generation of regional divergences during the second half of the twentieth century. Mediterranean water intensive crops were grown in the most arid areas of the country. The level of disaggregation, in terms of production and regions, allowed to evaluate the robustness of our findings, as well as to define specific regional and crop patterns.

The importance of irrigation for the development becomes stressed without doubt for Spain. However, it does not go without challenges, especially in terms of environmental ones. The limits towards increasing irrigation in Spain have been discussed in (EU, 2000; Expósito & Berbel, 2017; Lecina et al., 2010b; Rodríguez-Díaz, Pérez-Urrestarazu, Camacho-Poyato, & Montesinos, 2011).

Livestock not significant. It should be noticed that it is somehow more of a "demand factor" rather than "supply factor" as most others, and demand factors increasingly have effects beyond the frontiers, especially if they are as small as provinces. In that regard, these are factors that probably should be studied with models suited to analyse those aspects, such as the Leontief input-output models, with extensions such as the Structural Decomposition Analysis (Dietzenbacher & Los, 1998, 2000), etc.

More generally, as highlighted in the introduction, according to (González de Molina et al., 2017) "in recent decades Spain has accentuated its role as a net importer of biomass from a biophysical perspective, with very significant impacts on third party countries, particularly in Latin America. From a biophysical perspective, the industrialization of Spanish agriculture has entailed negative consequences that threaten the sustainability of Spanish agroecosystems and also negatively affect the sustainability of other territories". In this regard,

In this line, globally, results of (Jägermeyr, Pastor, Biemans, & Gerten, 2017) indicate that 41% of current global irrigation water use (997km3 per year) occurs at the expense of environmental flow requirements (EFRs). If these volumes were to be reallocated to the ecosystems, half of globally irrigated cropland would face production losses of 10%, with losses of 20–30% of total country production especially in Central and South Asia. They explicitly show that improvement of irrigation practices can widely compensate for such losses on a sustainable basis, notably, integration with rainwater management can even achieve a 10% global net gain. In Spain, it has been shown also that EFRs are not secured or achieved in some river reaches (see e.g. (Blanco-Gutiérrez et al., 2013).

According to (Lecina et al., 2010b), irrigation modernization linked to an increase in land productivity involves additional water depletion if the location of the irrigated areas and the quality of the irrigation return flows allow their reuse.

This means that some explanatory factors until now, e.g. increased irrigated land, right now are facing physical and environmental limits (e.g. limits to dams), costs trade-offs which might imply that either such expansion is not feasible anymore, or that other factors or variants take a more dominant role (e.g. energy for pumping water to expand irrigation, rather than with new large infrastructure such as large dams and lakes as in the second half of the XXth century). In any case, one cannot put the eggs in the basket of technology, since the improvements in irrigation with the modernization process has proven that although it may have achieved higher productivity (Lecina, Isidoro, Playán, & Aragüés, 2010a), one of the main arguments, water saving, has not been really accomplished (Berbel, Gutiérrez-martín, & Rodríguez-díaz, 2015) given also some indirect (perhaps not exactly "rebound") effects (Dumont et al., 2013).

The learnings from Climate Change studies make us think that temperature should increasingly play a role (potentially also irregular rainfall), potentially with also less water availability in Spain as hinted e.g. in (T. Estrela, Pérez-Martin, & Vargas, 2012; Teodoro Estrela, 2008; García-Ruiz, López-Moreno, Vicente-Serrano, Lasanta–Martínez, & Beguería, 2011; López-Moreno, Beniston, & García-Ruiz, 2008; Vargas, 2016; P.-A. Versini, Pouget, McEnnis, Custodio, & Escaler, 2016; P. A. Versini, Pouget, McEnnis, Custodio, & Escaler, 2016). Today's policy hence requires framing the decisions considering the Water-Energy-Food nexus.

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