How important are the fundamental causes of economic growth? An analysis of the total factor productivity of European agriculture, 1950-2005

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Abstract

The debate about the fundamental causes of economic growth focuses on the role played by institutions, geography, trade, and culture. This debate is central to much of the literature in economics, reflecting a concern with the underlying causes of agricultural productivity growth in Europe. To achieve our objective, we calculate the Total Factor Productivity in the European agricultural sector, and we generate two econometric models to explain the role of fundamental causes in the growth of agricultural productivity.

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1. Introduction

There is a remarkable and lively debate in the economic literature about the causes of modern economic growth. Traditionally, analysts have sought to explain this growth through certain variables, such as physical and human capital, and technology. However, the fundamental causes have attained an important role in the explanation of income differentials from one country to another, in which the underlying factors are institutions, geography, trade, and culture, among others (Acemoglu et al. 2001 and 2005; Frankel and Rommer 1999; Sachs and Warner 1995; Sachs 2000). Economic historians should be involved in this debate, due to their expertise in long-term analysis.

The economic historians, who have studied the European economic growth, have analysed in a comparative perspective the causes of the growth in this continent. The patterns and causes of economic development in European countries over the last two centuries have been one of the most relevant issues. At the same time, the transformations in agriculture and their impact in the economic development have also played a fundamental role in the explanation of these patterns and causes (Van Zanden 1991, O'Brien and Prados de la Escosura 1992, Allen 2009, Lains and Pinilla 2009). One of the main transformations of the agricultural sector was the increase in the agricultural productivity. For that reason, the aim of this work is to discover the fundamental causes of agricultural productivity growth. To do this, we analyse the agricultural Total Factor Productivity (TFP, henceforth) growth in European countries in the second half of the 20th century.

The study of the determinants of agricultural TFP is relatively widespread in the agricultural economics literature (Ball 1985, Kawagoe and Hayami 1985, Ball et al. 2001, Coelli and Rao 2003, Lerman et al. 2003, Headey et al. 2010), and some few economic historians have also made important contributions (Van Zanden 1991, Federico 2005 and 2011), although this kind of analysis is still not common.

The role of public institutions in agriculture has grown considerably in Europe since the Second World War (public intervention in the agricultural sector was virtually absent before the war). On the one hand, market-economy governments in the European Economic Community have intervened via the Common Agricultural Policy, or with similar policies for non-EU members, to protect their agricultural sector (Anderson and Valenzuela 2008, Josling 2009). On the other hand, central and eastern European countries have maintained strong controls over the economy (and a quasi-total public ownership of the means of production) during four decades of communist policy. Since the

collapse of the Soviet hegemony, some of those countries have joined the EU, while others have maintained some level of intervention in the agricultural sector (Anderson and Swinnen 2008 and 2009). Our analysis attempts to clarify the influences of such institutional frameworks on the growth of agricultural productivity.

Another interesting question is, what is the real effect of geography on European agricultural productivity? The European continent presents a range of geographical contexts in which to observe the effects of climate (temperature and rainfall), orography, and annual hours of sunshine, among others, on agricultural productivity. The aridity of the Mediterranean countries and the cold temperatures of the Nordic countries obviously have an impact on agricultural productivity, but it is equally clear that technology makes it possible to overcome such geographical obstacles.

Our results provide some clear answers to these questions and allow a better understanding of the factors driving economic growth and, more specifically, the growth in agricultural productivity. Political rights, civil liberties, public support for agriculture, and an open economy all appear to be key variables in understanding growth. An extreme climate, such as a polar bioclimatic zone, tends to have a lower growth of productivity. On the other hand, the Mediterranean climate enjoys greater agricultural productivity, due, in part, to strong public support for increasing the extent of irrigated land. Also, we find a positive and significant relationship between human capital and agricultural productivity.

2. European agricultural production in the second half of the twentieth century

Europe has witnessed a strong increase in its agricultural production and productivity. The adoption of several innovations has favoured this increase, due to the massive use of agricultural machinery, chemical fertilizers and pesticides, selection and hybridization of seeds, the increment of the rural credit or the expansion of irrigation, especially in the Mediterranean countries (Martín-Retortillo and Pinilla 2015a). All these innovations have allowed European agriculture to raise the production and productivity, employing much less labour during the second half of the twentieth century.

The structural change in the European continent has caused the reduction of the workforce in the whole continent. However, there were differences in this reduction. The rural exodus was totally dependent of the economic development of the whole economy. So, the countries with an earlier industrialization began their structural change before. On the other hand, countries like Mediterranean and Central and Eastern European countries

(CEEC, henceforth) had their peak of these changes in the decades of the second half of the twentieth century. Nevertheless, there was a policy to restrict the mobility in several Central and Eastern countries (Landau and Tomaszewsky 1985, Gregory and Stuart 2001).

The European agricultural production has increased since the Second World War until approximately mid-1980s or the beginning of the 1990s (Martín-Retortillo 2017). The innovations, before mentioned, and a strong political effort explained the increase in these first decades of the second half of the twentieth century. The members of the European Economic Community obtained greater external markets to export their agricultural products, but also the Common Agricultural Policy encouraged the adoption of the innovations, protected for other non-communitarian markets and increased of the production and productivity to guarantee the self-sufficiency in the agricultural products through high prices policy, among others (Gardner 1996, Andreosso O'Callaghan 2003, Martín-Retortillo and Pinilla 2015b, Clar et al. 2017).

On the other hand, Central and Eastern European countries, following central planning economic system, have also augmented the agricultural production and productivity. These countries have raised their agricultural capital, even more than the Western European countries, such as agricultural machinery and chemical fertilizers. Besides, there was a system of subsidies to improve the diet encouraging the livestock products consumption. This system generates high prices paid to producers but low prices for consumers and the subsidies covered the difference (Anderson and Swinnen 2009; Diamond et al. 1983).

However, the situation changed after the mid-1980s or the beginning of the 1990s. After these years, the agricultural production of European agriculture stagnated. The Common Agricultural Policy (CAP henceforth) changed in 1992 with the MacSharry reform. This reform consisted in passing from a high price policy to direct income support, namely, substituting the productivist policy for a policy to maintain the farmers' income. This change was reinforced in the reform of 2003 of the CAP, taking into account a greater concern of the environment (Martín-Retortillo and Pinilla 2015b).

On the other hand, the Central and Eastern European countries saw how their economic system, based on a dependency of the Soviet Union, collapsed at the beginnings of the 1990s. In the 1980s, their economies showed problems, such as tensions in several markets of livestock products to maintain this system of subsidies. The collapse of the Soviet planning system generated several consequences such as the loss of the traditional international markets of COMECON, the monopoly of distributors (which contributed to

increasing the difference between prices received by the producer and retail prices), the decrease in disposable income and the reduction of subsidies to the sector, the increase in productive factor prices at worldwide level, a greater uncertainty provoked by the restructuring of the land market, a lack of experience in private management or a shortage of credit (Trzeciak-Duval 1999). Some of these problems were disappearing during the 1990s or with the incorporation to the European Union in the 2000s, but the agricultural production of this group of countries was slightly reduced or maintained.

3. Methodology: Measurement of the agricultural total factor productivity

In this section, we present the methodology used to calculate agricultural TFP, as well as our main results.

The measurement of agricultural productivity can be partial or total, with the difference being the input and inputs that are taken into account. In our case, we calculate the Total Factor Productivity (TFP), "which is a productivity measures involving all factors of production" (Coelli et al. 2005, 3). This approach to productivity offers an overview of the efficiency of the sector. We compare change in output with changes in all inputs, and we follow the methodology of growth accounting, implementing calculations following the work of Fuglie (2008, 2010 and 2012) and Wang et al. (2013, 242). TFP growth is represented as the ratio between the respective growth rates of output and a combination of inputs, where Y is the output and X is this combination:

$$\frac{d\ln(TFP)}{dt} = \frac{d\ln(Y)}{dt} - \frac{dln(X)}{dt}$$

As Fuglie (2012) pointed out, if producers maximize profits and the market for agricultural products is a long-run competitive equilibrium, then the previous equation could be written as:

$$\ln\left(\frac{TFP_{i,t}}{TFP_{i,t-1}}\right) = \ln\left(\frac{Y_{i,t}}{Y_{i,t-1}}\right) - \sum_i\left(s_{i,j,t}\right) \cdot \ln\left(\frac{x_{i,j,t}}{x_{i,j,t-1}}\right), \text{ i=1,...,N; j=1,...,5; t=1,...,T}$$

in which *Y* is the agricultural gross output, *X* is the vector incorporating the j-input, and *S* are the cost shares to combine the different inputs.

The output data have been sourced from FAOSTAT (2009) and FAO (1948-2004a) and is valued at international 1999-2001 prices in dollars[1]. We have applied Hodrik and Prescott (1997) filters to soften the series.

The vector X includes several inputs: labour, i.e. the active population in agriculture[2], land, which we have taken as arable land and permanent crops in hectares, adding the irrigated land hectares multiplied by 2.145[3], machinery, i.e. agricultural tractors and associated equipment[4], and livestock, a combination of various animals, using Hayami and Ruttan's (1985) weightings. All of these inputs have been sourced from FAOSTAT (2009) and FAO (1948-2004a)[5]. We have also measured the consumption of chemical fertilizers, as the sum of nitrogenous, phosphate and potash fertilizers and these data are from FAO (1948-2004a) and from IFA (2014)[6].

Our methodology is sensitive to the choice of the applied weights for these various inputs. The difficulty in obtaining some of these weights, for each country and for each time period, has encouraged us to look for an alternative solution, and we have followed the cost share data presented by Fuglie (2012), as shown in Table A.1. We have interpolated this data to calculate annual TFP growth[7], employing four different cost shares, distributed among countries as follows. Northern European cost shares for Austria, Belgium-Luxembourg, Denmark, Finland, France, German Federal Republic, Germany (after reunification), Ireland, the Netherlands, Norway, Sweden, Switzerland; Southern European cost shares for Greece, Italy, Portugal and Spain; USSR cost shares for Albania, Bulgaria, Czechoslovakia (and the successor countries after its dissolution), German Democratic Republic, Hungary, Poland, Romania and Yugoslavia (and the successor countries after its dissolution). The United Kingdom has its own cost share.

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[1] Fuglie (2010 and 2012) calculated the output as the sum of all the agricultural products, weighted by their revenue share. The way that we can combine the FAOSTAT's database and the data from the yearbook from FAO are explained in Martín-Retortillo and Pinilla (2015a).

[2] The correct way to measure labour is with hours worked. The lack of availability of data for the whole sample of this variable complicates its use.

[3] Fuglie (2010) used this conversion factor to aggregate the land in developed countries and to take irrigation into account, as a way of considering the quality of this input.

[4] The correlation between the number of tractors and the weighted lineal combination by horsepower of tractors and harvesters in Europe, between 1961 and 2006 is 0.9766.

[5] The omission of certain inputs, such as pesticides or threshing machines, is due to the lack of available data. Despite that, we have assumed that the omitted inputs growth is the same as that of the group of inputs to which they belong. For more details about the calculation of these variables, see Martín-Retortillo and Pinilla (2015a).

[6] The data from IFA (2014) begins in 1961. We have supposed that in the 1950s the evolution of chemical fertilizers is the same as that followed by FAO (1948-2004).

[7] Before 1961, we have assumed that the cost shares are equal to this year.

4. Evolution of Agricultural productivity

Table 1 and graph 1 show the obtained results for agricultural TFP between 1950 and 2006. We have also performed our estimation for two sub-periods, with 1985 being the dividing point of section 2. Our TFP estimations appear in four groups: the UK, Northern European countries, Southern European countries, and Central and Eastern European countries. We have estimated the European TFP with the average cost shares, weighted by agricultural production, and not weighted, to facilitate comparison.

These results provide several conclusions. The first is the acceleration of TFP growth throughout the period. In all countries, the rate is higher in the second sub-period, 1985-2006, than in the first. One explanation for this is the decrease or stagnation of several inputs in the production process, mainly agricultural labour, chemical fertilizers, and the stagnation of the numbers of agricultural machinery. Note that TFP growth can still occur with stagnation of the output in the European countries, with fewer inputs employed.

Another explanation of this higher growth is the increasing importance of certain omitted inputs, such as biotechnology, and the new ICTs adopted by the sector. TFP collects the effect of these inputs, and the growing trend of this productivity could reflect this omission if their use grew faster than the other capital inputs. The development of high-yielding seeds in extreme geographical conditions, for example, has had a significant impact in the sector[8] (Gardner 1996).

Table 1. TFP and output growth (average logarithmic growth rates)

	TFP			Output		
	1950-2006	1950-85	1985-2006	1950-2006	1950-85	1985-2006
UK	1.10	1.37	0.70	1.07	1.84	-0.22
Austria	1.75	1.18	2.64	1.24	1.92	0.11
Belgium-Lux	2.04	1.90	2.20	1.29	1.63	0.73
Denmark	1.92	0.84	3.74	1.06	1.24	0.78
Finland	1.23	1.19	1.33	0.84	1.43	-0.14
France	1.71	1.21	2.53	1.45	2.24	0.13
GFR	-	2.20	-	-	1.81	-
Germany	-	-	2.75	-	-	0.39
Ireland	0.47	0.05	1.39	1.42	1.95	0.53
Netherlands	2.12	2.11	2.18	1.70	2.73	-0.01

[8] Some examples of this biotechnology are high-protein triticales for animal-feeding in Europe, double-zero rapeseed growing in northern climates, nitrogen-fixing genes in non-leguminous crops and high-protein/high lysine content in winter wheat (Gardner 1996).

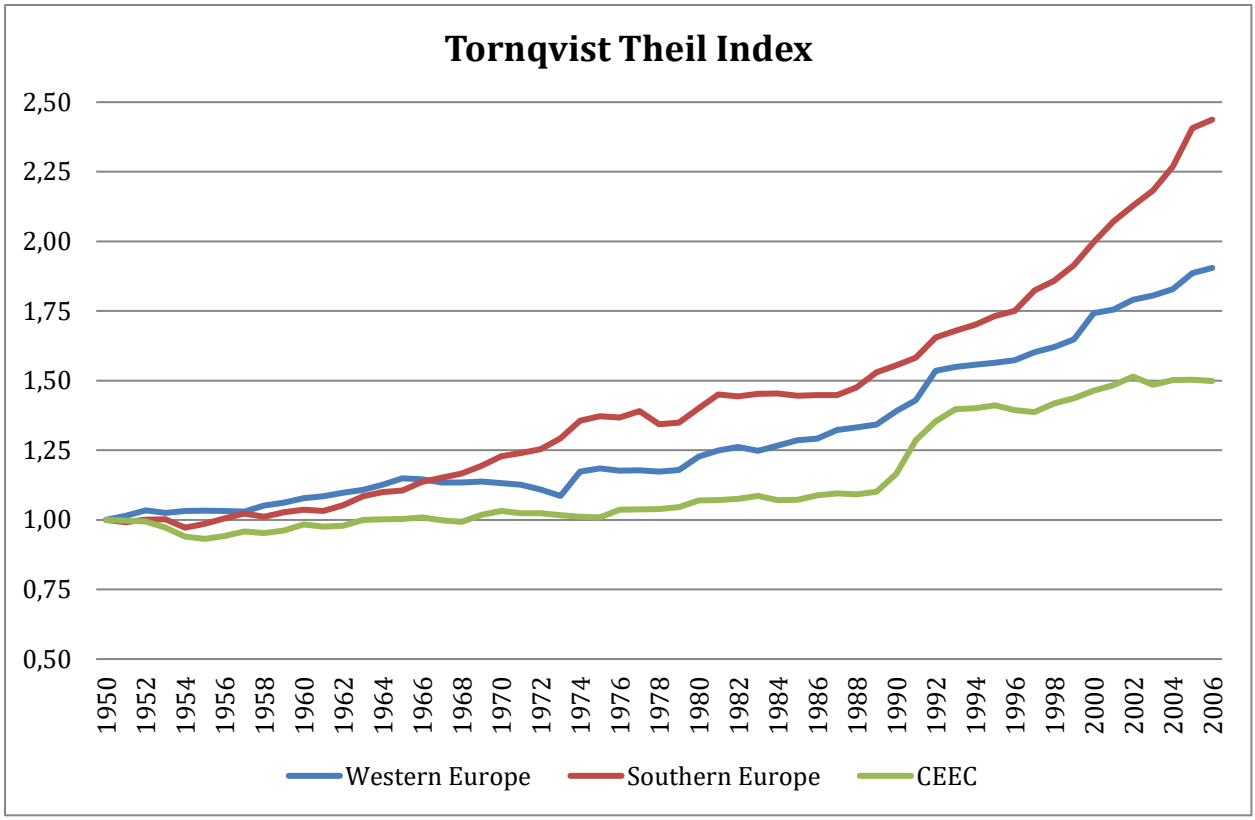
Norway	0.59	0.43	0.99	0.34	0.73	-0.30
Sweden	1.09	0.67	1.95	-0.04	0.18	-0.42
Switzerland	0.67	0.14	1.50	0.62	1.20	-0.35
Western	**1.60**	**1.23**	**2.25**	**1.27**	**1.93**	**0.17**
Greece	1.25	0.63	2.11	1.87	2.75	0.41
Italy	2.01	1.77	2.37	0.88	1.40	0.01
Portugal	0.98	-0.02	2.52	0.78	0.75	0.82
Spain	1.98	1.63	2.45	2.23	2.67	1.49
Southern	**1.73**	**1.37**	**2.25**	**1.43**	**1.89**	**0.67**
Albania	1.33	0.24	2.52	2.60	3.42	1.67
Bulgaria	1.79	1.69	1.92	0.81	3.24	-3.23
Czecholosvakia	0.66	0.48	0.99	0.51	1.87	-1.76
GDR	-	0.69	-	-	1.06	-
Hungary	0.77	0.46	1.45	0.90	2.25	-1.35
Poland	0.09	-0.22	0.52	0.74	1.79	-1.02
Romania	0.18	-1.18	2.23	1.40	2.59	-0.60
Yugoslavia	1.37	1.03	1.99	1.74	3.23	-0.73
CEEC	**0.61**	**0.20**	**1.25**	**1.01**	**2.31**	**-1.14**
Europe (Not weighted)	**1.26**	**0.94**	**1.77**	**1.22**	**2.00**	**-0.08**
Europe (Weighted)	**1.37**	**1.02**	**1.92**	**-**	**-**	**-**

GFR and GDR refer to the period 1950-1989. The German datum is for the 1991-2006. Data for Albania is only available since 1961, and the calculation of the Albanian TFP begins in that year. We have calculated the European aggregates through the average of the cost shares. We have weighted the European aggregate by agricultural production of the four groups of countries.
Source: For the cost shares, Fuglie (2012); Northern and Southern except UK (Ball et al. 2010; capital decomposition from Butzer et al. 2012), USSR (Lerman et al. 2003, 1965-1990; Cungu and Swinnen 2003, after 1992), UK (Thirtle et al. 2008). For the data, from FAO (1948-2004a), FAOSTAT (2009) and IFA (2014).

A further conclusion is the existence of notable differences within the groups of countries. The Western European countries have shown remarkable growth, owing to the earlier adoption of certain technological advances, while structural change and the industrialization of the economy began sooner in this group. Although Southern countries were late in incorporating these changes, considerable growth occurred, especially in Italy and Spain. These countries had a strong agricultural sector and the incorporation of new technologies, once begun, was greater than in Western countries. In other words, the Southern European countries tended to follow the Western technological pattern, but they soon increased their efficiency and experienced a higher growth rate (Martín-Retortillo and Pinilla 2015b)[9].

Graph 1. Agricultural TFP indexes in the four European groups of countries.

[9] The possible differences between the Martín-Retortillo and Pinilla (2015b)'s results and Table 1's is due to in the first ones the calculation of TFP was without taking into account the intermediate years between 1950, 1985 and 2005.



Source: the same as Table 1.

The CEEC countries had a lower growth in agricultural productivity than the other groups, especially in the decades characterised by centrally-planned systems. This reflects the general lack of efficiency of the soviet-type economies, the agricultural sector being no exception. The large-scale incorporation of agricultural machinery and chemical fertilizers, and the lesser exit of workers led to a lower rate of growth in productivity. Despite large investments of capital, the new inputs from the industrial sector were poorly allocated and had little impact (Gray 1990). Our estimation of agricultural TFP is lower than that of Ofer (1987, 1778) for the period between 1950 and 1985, with lower efficiency in the agricultural sector than in the economy as a whole.

The differences within groups are less clear than among them. In the Western countries, for example, the most productive are those that were at the centre of the industrial revolution in Europe and developed sooner. The more productive countries had earlier structural change and a more timely incorporation of new technologies, especially in the first half of the 20th century (Grigg 1992, Federico 2005).

The Mediterranean countries follow two different trajectories. Italy and Spain had high TFP growth, almost at the same pace as the Western countries, while Greece and Portugal display low productivity growth.

In the Central and Eastern European countries, good results in Bulgaria, Yugoslavia, and Hungary contrast with poor results, in terms of TFP growth, in Czechoslovakia and Poland. Berend and Ranki (1985) and Lampe (1986) point to greater specialization and faster structural change as leading to the better productivity of countries such as Bulgaria and Hungary. Wong and Ruttan (1990) and Macours and Swinnen (2000 and 2002) show significant differences in productivity among these countries before and after the collapse of the central planning system. These authors establish that the primary determinants of the differences are in the initial conditions and in the reform policies during the transition (Macours and Swinnen 2002).

5. Determinants of agricultural productivity

We now specify an econometric model in which the dependent variable is the growth of TFP, and the explanatory variables are an approach to the underlying causes of economic growth, particularly the influence of geography and institutions.

Geographical factors - orography, temperature, rainfall, annual hours of sunshine, soil quality, plagues, pestilence, disease, and altitude – all play a fundamental role in explaining agricultural production and productivity (Grigg 1982 and 1992, Crosby 1986, Federico 2005, Asenso-Okyere et al. 2011). We approach the geographical influence through the percentage that each country has in each bioclimatic area or biome. (A bioclimatic zone consists of a number of variables, such as temperature, rainfall, orography, and annual hours of sunshine.) We use the data offered by CIESIN (2007) and we divide the continent into three zones: Western, Mediterranean, and Polar bioclimatic areas, with the Western area being the reference category.

The institutions are another fundamental factor of modern economic growth, although their influence is sometimes difficult to measure (Bardhan 1991). The degree of openness, the distribution of land property, the political support for the agricultural sector, the membership of regional trade agreements or economic unions, the extent of civil liberties and political rights, and the overall functioning of the economic system, all influence agricultural productivity (Fan and Zhang 2004, Helfand and Levine 2004, Vollrath 2007, Bharati and Fulginiti 2007, Lio and Liu 2009, Fan and Brzeska 2010, Ali et al. 2012).

We measure this institutional influence through several variables. The first two are *Civil liberties* and *Political rights* (Freedom House, 2014), measured on a 7-point scale,

with 1 being the lowest degree of freedom and 7 the highest[10]. In addition, we have included in our analysis the variable *polity*. This variable was obtained from the data from the Center for Systematic Peace (2014), which offer several variables related with the institutional instability. We have used the variable named *Polity2*. This variable is a improved version of Polity, which includes measurements such as competitiveness and openness of executive recruitment, competitiveness of political participation, constraint on chief executive and regulation of participation. This variable ranges from -10 to +10. We have added ten points in this scale to obtain a positive variable. We also include two variables related to economic policy: *Openness* and *Subsidies*. The first is a qualitative variable that takes the value 1 when the country is open and 0 when it is closed (Sachs and Warner, 1995)[11]. The second qualitative variable takes the value 1 if economic policy supports agriculture and 0 if the sector is not supported (Anderson and Valenzuela, 2008)[12]. However, it is necessary to be very cautious interpreting these two variables because of the strong assumptions made in their calculation. In addition, we have included in our analysis the *Agricultural Openness*, which is calculated like a ratio between the agricultural exports and the agricultural production[13].

Human capital also has a significant role in explaining differences in agricultural productivity[14]. Some studies have found a positive relationship, in that higher education encourages greater knowledge, the use of more innovative techniques, and the more appropriate crop for each farm (Nguyen 1979, Kawagoe et al. 1985, Hayami and Ruttan 1985, Gardner 2002). We measure human capital in two ways: first, through the Gross Enrolment Ratio (GER) for secondary school, obtaining the data from World Development Indicators (2011) and Mitchell (2007), and, second, through the total years of schooling with data from Barro-Lee's database (World Development Indicators 2011) and Mitchell (2007) [15].

[10] We have inverted the scale provided by Freedom House to obtain a variable with the highest liberties in the highest values.
[11] We have followed the classification of Sachs and Warner (1995). The main problem is the omission of certain countries in that paper. For the countries for which those authors have no data, we use the World Development Indicators and Maddison data. In cases where neither database allowed us to make a decision, we have supposed that an EU member was an open country.
[12] All the assumptions of this variable are in Martín-Retortillo and Pinilla (2015a: 390).
[13] To see the details about the estimation of the agricultural openness, see the appendix.
[14] The estimated TFP also includes improvement in human capital. Thus, it is essential to include this in our econometric model.
[15] All the assumptions of this calculation for GER secondary are from Martín-Retortillo and Pinilla (2015a). The assumptions for the calculation of Schooling are the same as for GER secondary.

Table 2. Results. Dependent variable: Annual TFP growth, 1950-2006

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Estimation	OLS robust	OLS robust	OLS robust	OLS robust	OLS robust	OLS robust	FE	RE robust	OLS robust	RE robust	RE robust	OLS robust
Mediterranean	0.59*	0.44	0.41	0.83***	0.64**	0.66**	Omitted	0.38	0.33	0.81**	0.64*	0.65**
	0.35	0.33	0.34	0.29	0.30	0.29		0.28	0.35	0.34	0.34	0.31
Polar	-0.83*	-0.77*	-0.83*	-0.87*	-0.78*	-0.83*	Omitted	-0.60	-0.65	-0.55	-0.47	-0.53
	0.46	0.46	0.46	0.48	0.47	0.47		0.40	0.46	0.44	0.42	0.48
GER secondary	0.02***	0.02***	0.02***	0.02***	0.02***	0.02***	-	-	-	-	-	-
	0.00	0.00	0.00	0.00	0.00	0.00						
Ln (Schooling)	-	-	-	-	-	-	1.63***	1.09***	0.92***	1.09***	1.14***	0.98***
							0.41	0.26	0.28	0.26	0.26	0.29
Civil Liberties	0.26***	-	-	0.35***	-	-	0.25**	-	-	0.32***	-	-
	0.09			0.07			0.10			0.08		
Pol. Rights	-	0.22***	-	-	0.31***	-	-	0.19*	-	-	0.29***	-
		0.08			0.07			0.10			0.08	
Polity	-	-	0.06**	-	-	0.1***	-	-	0.05*	-	-	0.08***
			.02			0.02			0.03			0.02
Openness	0.60*	0.61*	.73**	-	-	-	0.65*	0.76**	0.88**	-	-	-
	0.34	0.34	.34				0.36	0.36	0.35			
Agri. Openness	-	-	-	-0.00	-0.00	0.00	-	-	-	0.00	0.00	0.00
				0.00	0.00	0.00				0.00	0.00	0.00
Subsidies	-0.86***	-0.80**	-0.69**	-0.83**	-0.81**	-0.62*	-0.82**	-0.70**	-0.59*	-0.76***	-0.76**	-0.57*
	0.33	0.35	0.32	0.33	0.34	0.32	0.38	0.29	0.32	0.28	0.33	.33
Constant	-1.40***	-1.27***	-1.02***	-1.66***	-1.51***	-1.16***	-3.23***	-2.01***	-1.53***	-2.25***	-2.21***	-1.67***
	0.37	0.36	0.31	0.37	0.36	0.32	0.71	0.68	0.59	0.66	0.65	0.58
No. Observs.	1381	1381	1381	1381	1381	1381	1381	1381	1381	1381	1381	1381
R^2	0.0542	0.0529	0.0522	0.0517	0.0504	0.0483	0.1047	0.2153	0.0435	0.2121	0.1997	0.0389

The data below the coefficients are the standard deviations. The coefficients *, ** and *** are significant at 10, 5 and 1% respectively.

To ascertain the importance of the main determinants of European agricultural productivity, we carry out some data panel estimations (Table 2). We have corrected the problems that Headey et al. (2010) point out explaining the evolution of TFP growth. These authors dismiss other objective variables such as the evolution of TFP growth, owing to the volatile and often cyclical nature of agricultural output (Headey et al. 2010, 8). We remember that our agricultural output is filtered by the Hodrick-Prescott filter.

We reject the null hypothesis of homoskedasticity and not autocorrelation, using the Wald (Greene 1997) and Wooldridge tests (Wooldridge 2002), respectively. To solve these problems, we estimate with robust standard deviations in the robust OLS, Random Effects estimation, and Panel Corrected Standard Errors (PCSE). In all cases, we have used the Breusch-Pagan LM test and the F-test (Greene 1997) to test whether the estimations of panel data are preferable, comparing with OLS pooled data. Then, if these test rejected the null hypothesis of 5% of OLS pooled data, we have estimated with panel data and, furthermore we have used the Hausman test to lead to the robust Random effects estimation or to the PCSE. Therefore, the estimations in table 2 are final estimations.

The results show the importance of geography, institutions, and human capital in the growth of agricultural TFP (Table 2). In terms of geography, the polar climate, assumed to be an obstacle to Nordic productivity growth, has negative sign and is significant, but not in all the estimations. The Mediterranean climate, despite its aridity, is significant and shows a positive sign as a result of the regional reliance on irrigation (Cazcarro et al. 2015a and 2015b); the combination of abundant annual sunshine with this irrigation produces rapid agricultural productivity growth[16].

One example of this could be Italy and Spain. These countries encourage strongly the irrigation in their agricultural sectors to overcome the aridity which is typical in the Mediterranean countries. The irrigation allowed these countries to facilitate the convergence in agricultural productivity (Table 1 and Martín-Retortillo and Pinilla 2015b) with the Western European countries, which have the highest productivity level in the continent. These countries have transformed deeply their agricultural sector in these decades, not only adopting the innovations from the industry, like other Western countries, but also incorporating artificial water, increasing the potentialities to increase the production and productivity of these sectors. Furthermore, these countries have

[16] Despite the higher growth in agricultural productivity, there are several environmental problems caused by application of this intensive production process (Cazcarro et al. 2015).

accomplished an agricultural transition, in which the agricultural sector is less dependent of the environmental characteristics[17].

The model also highlights the importance of institutions in productivity growth. On the one hand, the two variables measuring political rights and civil liberties have positive sign and are significant. That is to say, a society with greater civil liberties, more political rights or better institutions encourages a higher agricultural productivity. A country with more such freedoms encourages agricultural TFP, providing farmers, groups, and organizations with a greater power of choice in changing the production process or encouraging the cooperation among agents (Gallego 2007 and 2016). There are several examples of the importance of power of choice in agriculture, such as the inputs used, the different products produced, the distribution channel selected, the modes of interaction, and the possibility of voicing disagreement with agricultural policy decisions. Farm efficiency would be reduced without the farmer's power of choice, and the lack of power of choice in centrally-planned systems goes some way to explain the average agricultural TFP under those systems.

The main differences in civil liberties and political rights in European countries are between the communist countries and the market economies. The centrally-planned economies experienced less structural change than the market economies because of the maintenance by government of the workforce in the agricultural sector (Gregory and Stuart 2001). In the case of labour, the planned economies had serious problems of incentives (Federico 2005). While the large-scale incorporation of technical inputs by the state, primarily machinery and chemical fertilizers, proceeded at more or less the same pace as in the Western countries and the USA, the rate of increase in capital intensity and the allocation of these investments was greater in the market economies (Gray 1990, Harrison 1996). This incorporation was not the same for all state, collective, and private farms, since the government did not take into account the needs of the farms, which reduced the productivity gains that these innovations could contribute to the production process (Landau and Tomaszewski 1985). Specialization in the agricultural sectors in these countries was rare, leading to a loss of productive potential (Gregory and Stuart 2001, Federico 2005), and this affected negatively agricultural productivity, because of less efficient maintenance of farm resources.

[17] In the case of Spain, until 1975 this transition has occurred in an authoritarian context. This context generated this transition was without taking into account the voice of the agricultural agents (Clar et al. 2017).

The more open economies show greater average TFP growth, due to three positive reasons: access to larger markets for agricultural products, ease of buying inputs, especially from the non-agricultural sector, and greater international competition that encouraged the most competitive farmers. The countries of the European Union have these advantages, along with commercial protection in terms of non-EU competition, which provides farmers with a certain level of economic security (Ritson 1997, Andreosso O'Callaghan 2003).

We have also estimated the influence of the agricultural openness in the growth of the TFP. This variable is very close to 0, and in some cases, is not significant. One explanation about this null influence could be that the agricultural sector has gone integrating with the agrifood industry in the second half of the twentieth century. (HAY QUE AMPLIAR O IR POR OTRO LADO, NO ME TERMINA DE CONVENCER, TAMPOCO SÉ SI LE TENEMOS QUE DAR MUCHA MÁS IMPORTANCIA AL NO SER SIGNIFICATIVA)

The variable *subsidies* has negative sign and is significant. This last variable could be negative because strong political support for agriculture could encourage maintaining inputs in the sector, such as labour, land, and capital, which would minimize TFP growth. If this policy did not exist, the maintenance of these inputs would be difficult, probably because of migration to non-agricultural activities.

The existence of strong policies in support of agriculture, as in the Common Agricultural Policy (CAP henceforth), encourages maintaining workers, and other resources in the agricultural sector, reducing growth in agricultural TFP. Although this policy promotes increasing agricultural production, the maintenance of certain resources diminishes productivity growth. Features of the CAP, such as export subsidies and minimum prices (Tracy 1989; Ritson 1997; Andreosso-O'Callaghan 2003; García Delgado and García Grande 2005, Neal 2007), encourage farmers to remain in the sector. In the case of CEEC countries, increases in agricultural support brought with it inefficiencies and cost increases (Gray 1990).

Human capital has an important role in explaining the determinants of agricultural productivity growth. In the case of measurement of the Gross Enrolment Ratio in secondary education, this variable is always significant and has a positive sign; that is to say, the higher the gross enrolment ratio, the greater the growth in agricultural TFP. The other measurement of human capital, years of schooling, is positive and significant. In the case of the countries with skilled societies and the specialization of the farmers are bigger because of the human capital, the agricultural productivity are higher.

In addition, the influence of the human capital can show the importance of the development of a welfare state, in which the education is a fundamental key. The European countries generated public policies to guarantee the citizens a certain level of education and health system. Also, in these decades the tertiarization of the European economies have increased, meanwhile the levels of human capital and assistance in a health system augmented. The improvement of the quality of life of the population could increased the agricultural productivity.

4. Conclusions

Agricultural productivity has been the subject of many analyses in the agricultural economics and economic history literature, and the determinants of the variable have been a special focus, but analysis of the underlying causes of productivity growth is much less common in the European context. In this work, we concentrate on Europe in the second half of the 20th century, a period of strong growth in agricultural productivity.

We have calculated TFP growth in the agricultural sector since the Second World War, and estimated an econometric model to analyze the main determinants of this variable with a panel data analysis with annual agricultural TFP growth as the dependent variable.

The model shows that the fundamental causes have a remarkable role in explaining the differences in agricultural TFP growth. It turns out that institutions significantly affect our target variable, and the existence of civil liberties, property rights and better institutions in society encourage greater agricultural productivity. Furthermore, a more open economy leads to increases in agricultural productivity, while strong political support for the agricultural sector allows resources to be maintained that actually reduce productivity growth.

This paper shows the importance of the fundamental causes of modern economic growth, not only to explain the agricultural productivity, but also, other kind of economic variables, such as the agricultural productivity. These causes affect the whole economic and social system. Therefore, they have to be included in the economic analysis. Besides, other lesson could be that improving the quality of life of the population, not only in the developed countries, implies to give power of choice to the population in a democratic context, especially in the countries in where the agricultural sector is so important.

Geography is also a major influence on agricultural productivity. Having more land in a polar bioclimatic zone discourages agricultural TFP growth because of the extreme temperatures during much of the year, while the Mediterranean climate has a positive influence on agricultural productivity, especially when paired with irrigation infrastructure.

Appendix

Table A.1. Cost Shares employed to obtain agricultural TFP

NorthWestern Europe except UK	1961-1970	1971-1980	1981-1990	1991-2000	2001-2010
Labor	0.334	0.334	0.244	0.235	0.22
Land	0.04	0.04	0.074	0.079	0.069
Livestock	0.261	0.02	0.024	0.017	0.013
Machinery	0.073	0.073	0.104	0.134	0.134
Chemicals	0.292	0.533	0.554	0.535	0.564
Southern Europe	1961-1970	1971-1980	1981-1990	1991-2000	2001-2010
Labor	0.577	0.577	0.45	0.404	0.469
Land	0.085	0.085	0.124	0.154	0.096
Livestock	0.016	0.016	0.018	0.014	0.01
Machinery	0.059	0.059	0.076	0.114	0.105
Chemicals	0.263	0.263	0.331	0.313	0.319
CEEC	1961-1970	1971-1980	1981-1990	1991-2000	2001-2010
Labor	0.104	0.104	0.104	0.19	0.19
Land	0.257	0.257	0.257	0.23	0.23
Livestock	0.453	0.453	0.453	0.42	0.42
Machinery	0.043	0.043	0.043	0.09	0.09
Chemicals	0.143	0.143	0.143	0.07	0.07
UK	1961-1970	1971-1980	1981-1990	1991-2000	2001-2010
Labor	0.327	0.164	0.136	0.137	0.137
Land	0.084	0.126	0.179	0.216	0.216
Livestock	0.251	0.333	0.284	0.235	0.235
Machinery	0.183	0.199	0.202	0.204	0.204
Chemicals	0.155	0.178	0.199	0.209	0.209

Source: Fuglie (2012); Northern and Southern except UK (Ball et al. 2010; capital decomposition from Butzer et al. 2012), USSR (Lerman et al. 2003, 1965-1990; Cungu and Swinnen 2003, after 1992), UK (Thirtle et al. 2008).

The construction of the agricultural openness:

This variable is a quotient between agricultural exports and production. To obtain the agricultural exports, we follow the next steps. We have obtained the *Export Value Base*

Price variable from FAOSTAT (2009). We have to complete the series since 1951, however this variable from FAOSTAT begins in 1961. We have completed this variable with the data from FAO (1948-2004b) during the 1950s and more decades, in some specific cases.

These data from FAO are the addition to food and agricultural products excluding forest products exports in current values. Then, we have transformed into constant values into 2000 constant prices in dollars. Furthermore, the obtained series is linked to the FAOSTAT series to achieve a whole series from 1951 to 2006.

There are some specific cases, which FAO yearbook does not offer data. These cases are Albania, Czechoslovakia, German Democratic Republic, Greece, Hungary, Poland, Romania and Switzerland. In these cases, we have built a series of agricultural exports based on the sum of exports of several products: wheat, barley, sugar, potato, oranges, apple, beef, pork, poultry, mutton, cheese, wine and olive oil. Then, we have transformed these exports into 2000 constant prices in dollars.

Finally, we have divided the agricultural exports and the agricultural production (2000 prices in dollars) to obtain the agricultural openness.

Bibliography

Acemoglu D, Johnson S, Robinson JA (2001) The colonial origins of comparative development: An empirical investigation. American Economic Review 91 (5):1369-1401

Acemoglu D, Johnson S, Robinson JA (2005) Institutions as a Fundamental Cause of Long-Run Growth. In: Aghion P, Durlauf SN (eds) Handbook of Economic Growth, vol 1. pp 385-472. doi:10.1016/s1574-0684(05)01006-3

Ali A, Mushtaq K, Ashfaq M, Abedullah, Dawson PJ (2012) Macro Determinants of Total Factor Productivity Growth of Agriculture in Pakistan. Pakistan Journal of Applied Economics 22 (1-2):1-18. doi:http://www.aerc.edu.pk/pakistan-journal-of-applied-economics-pjae-20-6.aspx

Alston JM, Pardey PG (2014) Agriculture in the global economy. Journal of Economic Perspectives 28 (1):121-146. doi:10.1257/jep.28.1.121

Anderson K, Swinnen J (2008) Introduction and Summary. In: Anderson K, Swinnen J (eds) Distortions to agricultural incentives in Europe's transition economies.

Anderson K, Swinnen J (2009) Eastern Europe and Central Asia. In: Anderson K (ed) Distortions to agricultural incentives: a global perspective, 1955-2007.

Anderson K, Valenzuela E (2008) Estimates of Distortions to Agricultural Incentives, 1955 to 2007. www.worldbank.org/agdistortions, Washington DC

Asenso-Okyere K, Tarekegn J, Andam KS, Asante FA (2011) A review of the economic impact of malaria in agricultural development. Agricultural Economics 42 (3):293-304. doi:10.1111/j.1574-0862.2010.00515.x

Ball V, Butault J, Juan C, Mora R (2010) Productivity and international competitiveness of agriculture in the European Union and the United States. Agricultural Economics 41 (6):611-627

Bardhan P (1991) The economic theory of agrarian institutions. Clarendon, Oxford

Berend TI, Ránki G (1985) The Hungarian economy in the twentieth century. Croom Helm, London

Bharati P, Fulginiti L (2007) Institutions and Agricultural Productivity in Mercosur. MPRA Paper 9669.

Cazcarro I, Duarte R, Martín-Retortillo M, Pinilla V, Serrano A (2015a) Water scarcity and agricultural growth in Spain: from curse to blessing? In: Badía-Miro M, Pinilla V, Wilebald H (eds) Natural Resources and Economic Growth: Learning from History. Routledge, London and New York.

Cazcarro, I., R. Duarte, M. Martín-Retortillo, V. Pinilla and A. Serrano, (2015b). 'How sustainable is the increase in the water footprint of the Spanish agricultural sector? A provincial analysis between 1955 and 2005-2010'. Sustainability, 7 (5): 5094-119.

Center for Systemic Peace (2014) Polity IV Annual Series. http://www.systemicpeace.org/inscrdata.html. Downloaded at June 2016.

CIESIN (2007) National Aggregates of Geospatial Data: Population, Landscape and Climate Estimates, v.2 (PLACE II). http://sedac.ciesin.columbia.edu/place/, New York, Columbia

Clar E, Martín-Retortillo M, Pinilla V (2017) The Spanish path of agrarian change: from the authoritarian to export-oriented productivism. *Journal of Agrarian Change*

Coelli TJ, Prasada Rao DS, O'Donnell CJ, Battesse GE (2005) An Introduction to Efficiency and Productivity Analysis. Springer Science & Business Media, New York

Crosby AW (1986) Ecological imperialism : the biological expansion of Europe, 900-1900. Cambridge University Press, New York,

Cungu A, Swinnen J (2003) Transition and total factor productivity in agriculture, 1992-1999. Working Paper 2003/2, Research Group on Food Policy, Transition and Development. Katholieke Universiteit Leuven, Belgium

D. Diamond, L. Bettis, R. Ramsson, (1983) 'Agricultural production', in A. Bergson and H. S. Levine (eds), *The Soviet economy: towards the year 200.*

Fan S, Brzeska J (2010) Chapter 66 Production, Productivity, and Public Investment in East Asian Agriculture. In: Pingali P, Evenson R (eds) Handbook of Agricultural Economics, vol 4. pp 3401-3434. doi:10.1016/s1574-0072(09)04066-3

Fan S, Zhang X (2004) Infrastructure and regional economic development in rural China. China Economic Review 15:203-214

FAO (1948-2004a) FAO Production Yearbook. FAO, Rome.

FAO (1948-2004b) FAO Trade Yearbook. FAO, Rome.

FAOSTAT (2009) FAO. Accessed June 2009, April 2010, October 2011 and June 2016.

Federico G (2005) Feeding the world: an economic history of agriculture, 1800-2000. Princeton University Press, Princeton

Federico G (2011) Breve historia económica de la agricultura. Monografias de historia rural: 8. Prensas Universitarias de Zaragoza: Institución Fernando el Católico, Zaragoza

Frankel JA, Romer D (1999) Does trade cause growth? American Economic Review 89 (3):379-399

Fuglie KO (2008) Is a Slowdown in Agricultural Productivity Growth Contributing to the Rise in Commodity Prices? Agricultural Economics 39:431-441. doi:http://onlinelibrary.wiley.com/journal/10.1111/%28ISSN%291574-0862/issues

Fuglie KO (2010) Total Factor Productivity in the Global Agricultural Economy: Evidence from FAO Data. In: Alston JM, Babcock B, Pardey PG (eds) The Shifting Patterns of Agricultural Production and Productivity Worldwide. Midwest Agribusiness Trade and Research Information Center Ames, Iowa, pp 63-95

Fuglie KO (2012) Productivity growth and technology capital in the global agricultural economy. In: Fuglie KO, Wang SL, Ball VE (eds) Productivity growth in agriculture: an international perspective. CABI, Wallingford; UK,

Gallego D (2007) Más allá de la economía de mercado : los condicionantes históricos del desarrollo económico. Prensas Universitarias de Zaragoza; Marcial Pons, Zaragoza; Madrid

Gallego D (2016) Agricultura, desarrollo económico y democracia. In: Gallego D, Germán L, Pinilla V (eds.) Estudios sobre el desarrollo económico español. Zaragoza: Prensas Universidad de Zaragoza

García Delgado JL, García Grande MJ (2005) Política agraria común: balance y perspectivas / José Luis García Delgado, M. Josefa García Grande, directores. Colección Estudios Económicos: 34. La Caixa, Servicio de Estudios, 2005., Barcelona

Gardner B (1996) European agriculture: policies, production, and trade. Routledge, London; New York

Gardner BL (2002) American agriculture in the twentieth century : how it flourished and what it cost / Bruce L. Gardner. Cambridge, Massachussetts: Harvard University Press, cop. 2002.,

Gollin D, Lagakos D, Waugh ME (2014) Agricultural Productivity Differences across Countries. American Economic Review 104 (5):165-170. doi:http://www.aeaweb.org/aer/

Gollin D, Lagakos D, Waugh ME (2014) The agricultural productivity gap. Quarterly Journal of Economics 129 (2):939-993. doi:10.1093/qje/qjt056

González Esteban Á (2014) Nuevos paradigmas agrarios: una aproximación a los fundamentos teóricos de la «soberanía alimentaria». Historia Agraria 64

Gray KR (1990) Introduction. In: Gray KR (ed) Soviet agriculture: Comparative perspectives. Iowa State University Press, Ames, pp 3-22

Greene WH (1997) Econometric analysis 3rd edn. Prentice-Hall International, Upper Saddle River (New Jersey)

Gregory PR, Stuart RC (2001) Russian and Soviet economic performance and structure. 7th edn. Addison-Wesley, Boston

Grigg D (1982) The dynamics of agricultural change : the historical experience. Hutchinson, London

Grigg DB (1992) The transformation of agriculture in the West. New perspectives on the past. Blackwell, Oxford, UK ; Cambridge, USA

Harrison M (1996) Soviet Agriculture and Industrialization. In: Mathias P, Davis JA (eds) Agriculture and Industrialization: from the XVIII century to the present day. Blackwell Publishers, Cambridge, MA,

Hayami Y, Ruttan VW (1985) Agricultural development; an international perspective. Johns Hopkins University Press, Baltimore, MD; USA

Headey D, Alauddin M, Rao DSP (2010) Explaining agricultural productivity levels and growth: an international perspective. Agricultural Economics 41:1-14

Helfand SM, Levine ES (2004) Farm Size and the Determinants of Productive Efficiency in the Brazilian Center-West. Agricultural Economics 31 (2-3):241-249. doi:http://onlinelibrary.wiley.com/journal/10.1111/%28ISSN%291574-0862/issues

Hodrick RJ, Prescott E (1997) Post-War U.S. Business Cycles: An Empirical Investigation. Journal of Money, Credit and Banking 29 (1):1-16

House Freedom (2014) Country Ratings and Status, FIW 1973-2004.

IFA (2014) International Fertilizer Industry Association http://ifadata.fertilizer.org/ucSearch.aspx

Josling T (2009) Western Europe. In: Anderson K (ed) Distortions to Agricultural Incentives: A Global Perspective, 1955-2007. World Bank and Palgrave Macmillan, Washington, D.C. and New York, pp 115-176

Kawagoe T, Hayami Y, Ruttan VW (1985) The inter-country agricultural production function and productivity differences among countries. Journal of Development Economics 19 (1-2):113-132

Lampe JR (1986) The Bulgarian economy in the twentieth century / Jonh R. Lampe. St. Martin's Press, New York

Landau Z, Tomaszewski J (1985) The Polish economy in the twentieth century Croom Helm series on the contemporary economic history of Europe. Croom Helm, c 1985., London

Lerman Z, Kislev Y, Biton D, Kriss A (2003) Agricultural Output and Productivity in the Former Soviet Republics. Economic Development and Cultural Change 51 (4):999-1018. doi:10.1086/376884

Lio M, Liu M-C (2008) Governance and Agricultural Productivity: A Cross-National Analysis. Food Policy 33 (6): 504-512. doi:http://www.sciencedirect.com/science/journal/03069192

Macours K, Swinnen JFM (2000) Causes of Output Decline in Economic Transition: The Case of Central and Eastern European Agriculture. Journal of Comparative Economics 28 (1):172-206. doi:10.1006/jcec.1999.1643

Macours K, Swinnen JFM (2002) Patterns of Agrarian Transition. Economic Development & Cultural Change 50 (2):365

Maddala GS, Wu S (1999) A Comparative Study of Unit Root Tests with Panel Data and a New Simple Test. Oxford Bulletin of Economics and Statistics 61:631-652. doi:http://onlinelibrary.wiley.com/journal/10.1111/%28ISSN%291468-0084/issues

Martín-Retortillo, M.; 'Transformaciones agrarias desde la historia económica cuantitativa: una visión de la producción y productividad agraria europea, 1950-2005' *Mimeo*

Martín-Retortillo M, Pinilla V (2015a) On the causes of economic growth in Europe: why did agricultural labour productivity not converge between 1950 and 2005? Cliometrica, 9, III, pp. 359-396.

Martín-Retortillo M, Pinilla V (2015b) Patterns and causes of growth of European agricultural production, 1950-2005. Agricultural History Review, 63, pp. 132-159.

Mitchell BR (2007) International Statistics: Europe, 1750-2005. Palgrave MacMillan., Houndmills

Neal L (2007) The Economics of Europe and the European Union. Cambridge University Press, Cambridge

Nguyen D (1979) On Agricultural Productivity Differences among Countries. American Journal of Agricultural Economics 61 (3):565

Ofer G (1987) Soviet Economic Growth: 1928-1985. Journal of Economic Literature 25 (4):1767-1833

Olavarría JA, Bravo-Ureta BE, Cocchi H (2004) Productividad total de los factores en la agricultura chilena: 1961-1996. Economía Agraria y Recursos Naturales 4 (8):121-132

Pesaran MH (2007) A simple panel unit root test in the presence of cross-section dependence. Journal of Applied Econometrics 22 (2):265-312. doi:10.1002/jae.951

Ritson C (1997) Introduction. In: Ritson C, Harvey D (eds) The Common Agricultural Policy. CAB International, Wallingford, Oxon; UK, pp 1-9

Ruttan VW (2002) Productivity Growth in World Agriculture: Sources and Constraints. The Journal of Economic Perspectives 16 (4):161-184

Sachs JD (2000) Tropical Underdevelopment. Center for International Development at Harvard University, CID Working Papers,

Sachs JD, Warner A (1995) Economic Reform and the Process of Global Integration. Brookings Papers on Economic Activity (1):1-118

Thirtle C, Bottomley P (1992) Total Factor Productivity in UK Agriculture, 1967-90. Journal of Agricultural Economics 43 (3): 381-400. doi:http://onlinelibrary.wiley.com/journal/10.1111/%28ISSN%291477-9552/issues

Trzeciak-Duval, A (1999) 'A decade of transition in central and eastern European agriculture', European Rev. of Agricultural Economics 26, 3, pp. 283–304.

Vollrath D (2007) Land Distribution and International Agricultural Productivity. American Journal of Agricultural Economics 89 (1):202-216

Wang SL, Tuan F, Gale F, Somwaru A, Hansen J (2013) China's Regional Agricultural Productivity Growth in 1985-2007: A Multilateral Comparison. Agricultural Economics 44 (2):241-251. doi:http://onlinelibrary.wiley.com/journal/10.1111/%28ISSN%291574-0862/issues

WDI (2011) World Development Indicators: database. http://data.worldbank.org/data-catalog/world-development-indicators

Wong L-F, Ruttan VW (1990) A Comparative Analysis of Agricultural Productivity Trends in Centrally Planned Economies. In: Gray KR (ed) Soviet Agriculture: comparative perspectives. Iowa State University Press, Ames,

Wooldridge JM (2002) Econometric Analysis of Cross Section and Panel Data / Jeffrey M. Wooldridge. Camdridge (Massachusetts): Massachusetts Institute of Technology, cop. 2002.