DOCUMENTOS DE TRABAJO
ISSN 2174-4912

THE FUNDAMENTAL CAUSES OF ECONOMIC GROWTH: A COMPARATIVE ANALYSIS OF THE TOTAL FACTOR PRODUCTIVITY GROWTH OF EUROPEAN AGRICULTURE, 1950-2005

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DT-AEHE Nº1912
www.aehe.net

September 2019

asociación española de historia económica

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LAS CAUSAS FUNDAMENTALES DEL CRECIMIENTO ECONÓMICO: UN ANÁLISIS COMPARATIVO DEL CRECIMIENTO DE LA PRODUCTIVIDAD TOTAL DE LOS FACTORES EN LA AGRICULTURA EUROPEA, 1950-2005

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DT- 1912, September 2019
JEL: N54, O13, O47, P51, Q10

RESUMEN

En las últimas décadas, el debate sobre el crecimiento económico se ha centrado en gran medida en sus causas fundamentales, es decir, en el papel que desempeñan las instituciones, la geografía, el comercio y la cultura. En consonancia con esta preocupación, este estudio analiza las causas subyacentes del crecimiento de la productividad agraria en Europa en la segunda mitad del siglo XX. Para lograr este objetivo, se realiza un cálculo del crecimiento de la productividad total de los factores en la agricultura europea y se proponen varios modelos econométricos para determinar la importancia de estas causas fundamentales. Nuestro estudio destaca que las instituciones inclusivas, las políticas de apoyo a la agricultura que no desalientan la innovación, el capital humano cualificado y la plena apertura al comercio internacional son factores clave para favorecer el crecimiento de la productividad en la agricultura.

Palabras clave: Productividad agraria, agricultura europea, causas fundamentales del crecimiento económico, comparación de sistemas económicos.

ABSTRACT

In recent decades, the debate on economic growth has largely focused the role-played by institutions, geography, trade, and culture. In line with this concern, this study analyses the underlying causes of agricultural productivity growth in Europe in the second half of the twentieth century. To achieve this objective, a calculation of the Total Factor Productivity growth in European agriculture is made and an econometric model is proposed to determine the importance of these fundamental causes. Our study highlights that inclusive institutions, policies to support agriculture that do not discourage innovation, qualified human capital and a full openness to international trade are key factors for favouring growth of productivity in agriculture.

Keywords: Agricultural productivity, European agriculture, Fundamental causes of economic growth, Comparative economics.

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THE FUNDAMENTAL CAUSES OF ECONOMIC GROWTH: A COMPARATIVE ANALYSIS OF THE TOTAL FACTOR PRODUCTIVITY GROWTH OF EUROPEAN AGRICULTURE, 1950-2005[1]

1.- Introduction

Adam Smith, the founding father of modern economics presented his masterpiece as a research project on the differences in income between the nations (Smith, 1776). These differences widened considerably after the mid nineteenth century, when some countries developed profound industrialisation processes, while others did not implement similar changes and remained with low levels of income. Thus, successive generations of economists have continued to ask the same question (Acemoglu and Robinson, 2012). In short, one of the most important and lively debates in the economic literature has focused on the discussion about the causes of modern economic growth. Traditionally, analysts have sought to explain this growth through its proximate causes, such as labour, capital, and technology. However, in recent decades, great efforts have been made to determine what lies behind a production function; in other words, the fundamental causes of economic growth. Institutions, geography, trade, and culture, among others, are some of the candidates for explaining the above-mentioned differences and resolving the mystery of economic growth (Acemoglu et al., 2001 and 2005; Easterly, 2002; Frankel and Rommer, 1999; Helpman, 2010; Rodrik, 2004; Sachs and Warner, 1995; Sachs, 2000).

For those who have studied the European economic experience from a long term and comparative perspective, the patterns and causes of economic growth in this continent have constituted one of the most relevant issues. At the same time, the transformations in agriculture and their impact on economic growth 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; Gollin, 2010). The economic history of European countries shows that as agriculture developed it experienced

[1] This study has received financial support from the Ministry of Science, Innovation and Universities of Spain, project PGC2018-095529-B-I00 and the Ministry of Education's FPU Programme, and from the Government of Aragon, through the Research Group S55_17R and FEDER. We are grateful for the comments received on its presentation to the Economic History Seminar at the University of Zaragoza, the Second Quantitative Agricultural and Natural Resources History Conference (Agricliometrics 2015), 11th European Historical Economics Society Conference 2015, the Economic History Seminar at the University of Barcelona and the participants of the Cliometric Session of the 64th Annual meeting of the French Economic Association and for those made by Francisco Beltrán-Tapia, Giovanni Federico, Eva Fernández, and Jaime Reis.

fundamental transformations which, with its modernisation and productivity growth, made a relevant contribution to growth. Therefore, this experience is relevant today for the design of policies in developing countries.

In this context, the aim of this study is to analyse the fundamental causes of agricultural productivity growth from a comparative perspective. To do this, we will study the underlying causes of agricultural Total Factor Productivity (hereafter TFP) growth in European countries in the second half of the twentieth century. In this way, we believe that we can make a relevant contribution as the European continent offers us the possibility of comparing radically different economic systems, such as centrally-planned economies or market economies after the Second World War, over a long period of time.

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; Fuglie, 2010 and 2012; Fuglie and Rada, 2018), and some economic historians have also made important contributions (Van Zanden, 1991; Federico, 2005 and 2011), although this kind of analysis is still not common. However, most of these works have focused on the proximate causes of growth from a short-term perspective.

Our results provide some clear answers and allow a better understanding of the factors driving economic growth and, more specifically, the growth in agricultural productivity. 'Right' institutions, geography, human capital, agricultural policies, and openness all appear to be key factors in understanding growth.

The paper has the following structure: the next section explains the historical context of European agriculture after the Second World War; in the third section, we explain how we measure the agricultural TFP growth and how we have obtained the data; the evolution of agricultural productivity during the second half of the twentieth century appears in the fourth section; the fifth section explains the econometric model used; the sixth section presents the results of the model; and finally the last section draws the conclusions and establishes some policy implications of our results.

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, such as the massive use of agricultural machinery, chemical fertilizers and pesticides, the selection and hybridization of seeds, the increment of 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 production and productivity, employing much less labour and land during the second half of the twentieth century.

The structural change caused the reduction of the agricultural workforce throughout the whole continent. However, there were differences in this reduction. The

rural exodus was totally dependent on the economic development of the economy as a whole. So, the countries with an earlier industrialization began their structural change before. On the other hand, these changes peaked in Mediterranean and Central and Eastern European countries (CEEC, henceforth) in the second half of the twentieth century (Collantes and Pinilla, 2011). Nevertheless, there was a policy to restrict mobility in several Central and Eastern countries (Landau and Tomaszewsky. 1985; Gregory and Stuart, 2001).

European agricultural production increased after the Second World War until approximately the mid-1980s or the beginning of the 1990s (Martín-Retortillo, 2018). The afore-mentioned innovations and a strong political effort explain 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, protected for other non-communitarian markets, but also the Common Agricultural Policy encouraged the adoption of the innovations, stimulating the increase in production and productivity to guarantee self-sufficiency in agricultural products through high price policies, among other actions (Gardner, 1996; Andreosso O'Callaghan 2003; Federico, 2009; Martín-Retortillo and Pinilla 2015b; Pinilla and Serrano, 2009; Serrano and Pinilla, 2009).

On the other hand, Central and Eastern European countries with centrally planned economic systems also increased their agricultural production and productivity. These countries invested even more capital than the Western European countries in factors such as agricultural machinery and chemical fertilizers. Besides, there was a system of subsidies to improve the diet encouraging the consumption of livestock products. This system generated 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 this point, the agricultural production of European agriculture stagnated. The Common Agricultural Policy (hereafter, CAP) changed in 1992 with the MacSharry reform. This reform consisted in removing the high price policy and implementing direct income support, namely, substituting the productivist policy for a policy to maintain the farmers' income. This change was reinforced in the 2003 CAP reform, taking into account a greater concern for the environment. The new policies caused the agricultural production of European Union countries to stagnate from then (Martín-Retortillo and Pinilla, 2015b).

On the other hand, the Central and Eastern European countries saw how their economic system collapsed at the beginning of the 1990s. In the 1980s, their economies showed signs of problems, such as tensions in several livestock product markets 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 on a global 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 began to disappear during the 1990s or with the incorporation into the European Union in the 2000s, but the agricultural production of this group of countries reduced slightly or remained unchanged.

3.- Measurement of the agricultural total factor productivity

In order to explain the fundamental causes of the growth of agricultural productivity, we first need to measure this productivity. 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), a productivity that contemplates 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:

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

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

First, we downloaded the output data for net production in international dollars at 1999-2001 prices from the FAOSTAT (2009) database[2]. This variable ranges from 1961 to 2006. Subsequently, we had to perform certain calculations to obtain the evolution of net production during the 1950s using the index numbers from the FAO (1948-2004). This is the case of the market economies. We have linked the index numbers for each agricultural market with the series from FAOSTAT. On the other hand, the FAO did not

[2] Fuglie (2010 and 2012) calculated the output as the sum of all the agricultural products, weighted by their revenue share. FAO data yields were compared with the microdata in Gollin et al. (2014: 169). They "find essentially no disagreement between the FAO yield data and the many micro estimates of grain yields". Data from the FAO (1948-2004) are in the production yearbooks and those in the FAOSTAT (2012) are from the online database.

provide this index number of agricultural production for several countries in Eastern and Central Europe. This omission meant that we had to obtain alternatives. To measure the net production of Hungary and Poland in the 1950s we used one index of agricultural production for each country[3]. For Bulgaria, Czechoslovakia, the German Democratic Republic and Romania, we obtained production in quantities during the 1950s from FAO (1948-2004a). We calculated production in 1999-2001 dollars using prices from FAOSTAT (2009). These calculations enabled us to obtain the evolution of agricultural production for each country in the 1950s. We have elaborated an index for each country using this variable in this decade. Thus, we have also obtained net production for the 1950s taking its value in 1961 as a reference. Finally, as FAOSTAT does not disaggregate production between the two Germanys until reunification, we have calculated this[4]. We have applied Hodrik and Prescott (1997) filters to soften the series.

The vector X includes several inputs[5]: labour, i.e. the active population in agriculture[6], land, which we have taken as arable land and permanent crops in hectares, adding the irrigated land hectares multiplied by 2.145[7], machinery, i.e. agricultural tractors and associated equipment[8] 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)[9]. We have also measured the consumption of chemical fertilizers, as the sum of nitrogenous, phosphate and potash fertilizers and these data have been drawn from FAO (1948-2004a) and from IFA (2014)[10].

Our methodology is sensitive to the choice of the weights applied for the various inputs. The difficulty in obtaining some of these weights, for each country and for each time period, encouraged us to look for an alternative solution, and we followed the cost share data presented by Fuglie (2012), as shown in the Appendix (Table A.1). We

[3] Berend and Ranki (1985) and Landau and Tomaszewski (1985).

[4] For the period 1961-1990 we multiplied 40 products by their respective average prices in 1999-2001, to calculate the gross agricultural production of the Federal Republic of Germany and of the German Democratic Republic. To check the reliability of the calculation, we compared the aggregation with the gross production datum provided by FAOSTAT (2009) for Germany, as if it were a single country, in those years.

[5] There are considerable differences with the estimate of Fuglie and Rada (2018). They took into account the pastures, several types of agricultural machinery and the animal feed as agricultural inputs. We cannot take these inputs into account because of the scarcity of these variables in the whole of the European continent in the 1950s.

[6] The correct way to measure labour is with hours worked. The lack of available data for the whole sample of this variable makes it impossible to obtain this information.

[7] 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.

[8] 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.

[9] The omission of certain inputs, such as seeds, pesticides or threshing machines, is due to the lack of available data. Despite this, we have assumed that the omitted inputs growth is the same as that of the group of inputs to which they belong.

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

interpolated this data to calculate annual TFP growth[11], employing four different cost shares, distributed between the 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.

4.- Evolution of agricultural productivity

Table 1 and Graph 1 show the results obtained for agricultural TFP growth between 1950 and 2006. We have also performed our estimation for two sub-periods, with 1985 being the dividing point[12]. 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 insights. 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 in the use of several inputs in the production process, mainly agricultural labour, chemical fertilizers, and the stagnation in the numbers of agricultural machines (Martín-Retortillo and Pinilla, 2015b). Note that TFP growth can still occur with stagnated output in the European countries, with fewer inputs employed.

Another explanation for 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 on the sector[13] (Gardner, 1996).

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

[12] Data on the evolution of agricultural production in Europe show that it stabilized or even decreased in most countries in the mid-1980s. This is the reason for choosing the date of 1985 to divide the whole period. See Martín-Retortillo and Pinilla (2015b).

[13] 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).

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
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**	**-**	**-**	**-**

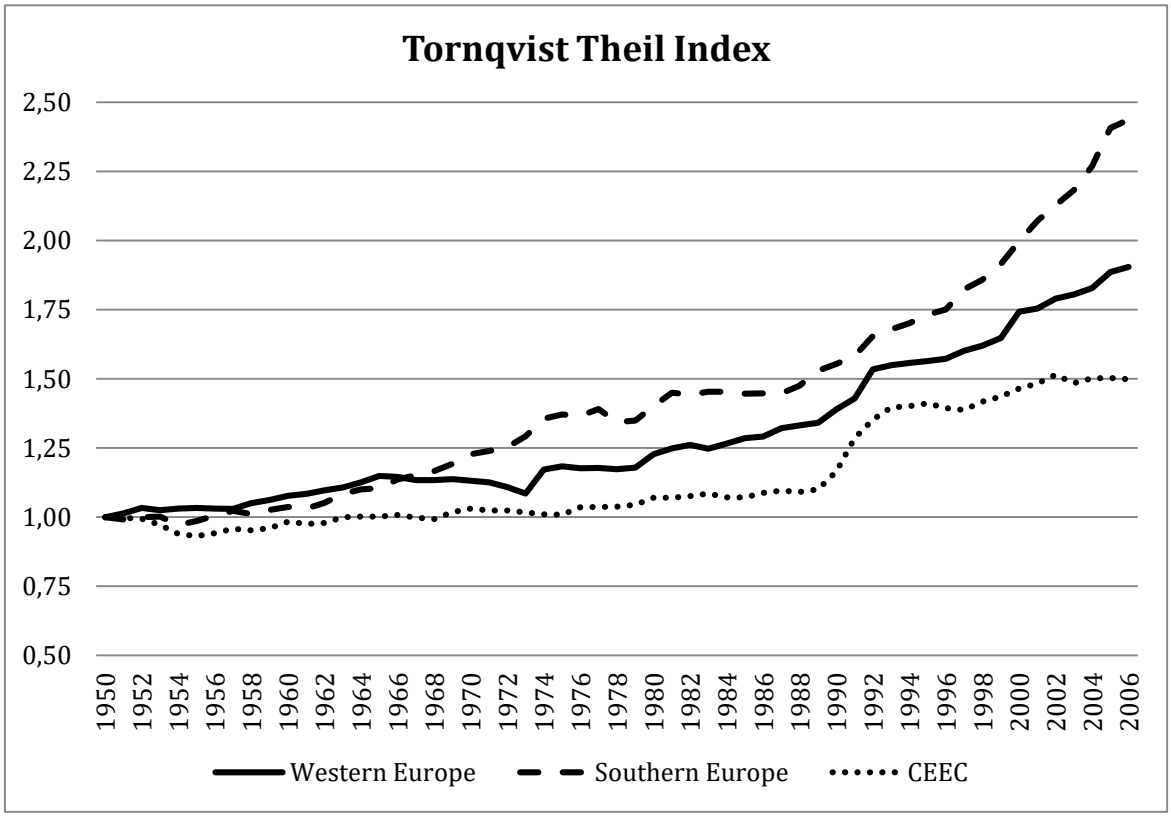
GFR and GDR refer to the period 1950-1989. The German data correspond to 1991-2006. Data for Albania is only available after 1961, and the calculation of the Albanian TFP begins in that year. We have calculated the European aggregates through the average of the cost shares. We have weighted the European aggregate by agricultural production of the four groups of countries.

Source: For the cost shares, Fuglie (2012); Northern and Southern except for the 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). Data drawn 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).

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



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 lower exodus rate 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).

The differences within groups are less clear than between them. In the Western countries, for example, the most productive were those 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 twentieth 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 displayed 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 to explain the better productivity of countries such as Bulgaria and Hungary. Wong and Ruttan (1990) and Macours and Swinnen (2000 and 2002) find significant differences in productivity between these countries before and after the collapse of the centrally-planned 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.- Econometric model: determinants of agricultural productivity growth

We will 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, institutions, trade and policies. As we were unable to take the improvement in the workforce into account in our estimate of the TFP, we have included the educational level as an independent variable. Thus, our econometric analysis is based on this equation:

$$\ln\left(\frac{TFP_{i,t}}{TFP_{i,t-1}}\right) = \alpha_i + \beta_1\,(geo_t) + \beta_2\,(humank_{it}) + \beta_3\,INS_{it} + \beta_4 Openness_{it} + \beta_5 Subsidies_{it} + u_{it} \quad (1)$$

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). 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 other factors, 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 some of these geographical obstacles. The geographical influence has been analysed 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 have used the data offered by CIESIN (2007) and divided the

continent into three zones (*geo* variable in the equation): Western, Mediterranean, and Polar bioclimatic areas, with the Western area being the reference category.

The institutions are another fundamental factor of agricultural growth, although their influence is often difficult to measure (Bardhan 1991). The distribution of land ownership, 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).

The institutions, meanwhile, are fundamental for explaining the public policies adopted in the agricultural sector (Swinnen, 2018). Public intervention in the agricultural sector was virtually absent before the 1930s, but the Great Depression and the war gave rise to a considerable increase in public intervention. Since the Second World War, on the one hand, market-economy governments in the European Economic Community have intervened through the Common Agricultural Policy, or with similar policies for non-EU members, to protect their agricultural sector (Anderson and Valenzuela, 2008; Josling 2009; Swinnen, 2018). On the other hand, central and eastern European countries maintained strong control over their economies (and a quasi-total public ownership of the means of production) for 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.

We measure the institutional framework and the policies developed 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[14]. In addition, we have included in our analysis the variable *polity*. This variable has been obtained from the data from the Center for Systemic Peace (2014), which offer several variables related to institutional instability. We have used the variable named *Polity2*. This variable is an 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 (*INS* in the equation of the determinants).

We also include a variable related to economic policy: *Subsidies*. It is a qualitative variable taking the value 1 if economic policy supports agriculture and 0 if the sector is not supported (Anderson and Valenzuela, 2008)[15].

[14] We have inverted the scale provided by Freedom House to obtain a variable with the highest liberties in the highest values.

[15] See Appendix.

In order to estimate the importance of an openness to international trade for productivity, we have used the degree of openness, *Openness*. This is a qualitative variable that takes the value 1 when the country is open and 0 when it is closed (Sachs and Warner, 1995)[16]. In addition, we have included *Agricultural Openness* in our analysis, which is calculated as a ratio between agricultural exports and agricultural production[17]. In this case, our objective is to determine whether a strong commitment to international agricultural product markets also specifically influences productivity.

However, caution should be taken when interpreting these variables because of the strong assumptions made in its calculation.

Human capital also plays a significant role in explaining differences in agricultural productivity. Some studies have found a positive relationship, in that higher education encourages greater knowledge, the use of more innovative techniques, and ensures the most 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)[18]. Both measurements are represented in the equation of the determinants of the TFP as *humank*.

6.- Results

To ascertain the importance of the main determinants of European agricultural productivity, we have carried out some panel data 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 should remember that our agricultural output is filtered by the Hodrick-Prescott filter.

We reject the null hypothesis of homoskedasticity and non-autocorrelation, using the Wald (Greene, 1997) and Wooldridge tests (Wooldridge, 2002), respectively. To resolve these problems, we performed estimates using robust standard deviations in the robust OLS, Random Effects estimation, and Panel Corrected Standard Errors (PCSE). In all cases, we used the Breusch-Pagan LM test and the F-test (Greene, 1997) to test

[16] 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 assumed EU members to be open countries.

[17] For the details about the estimation of the agricultural openness, see the appendix.

[18] All the assumptions of this calculation for GER secondary are drawn from Martín-Retortillo and Pinilla (2015a). The assumptions for the calculation of Schooling are the same as for GER secondary.

whether the estimations of panel data are preferable, comparing them with OLS pooled data. If these test rejected the null hypothesis of 5% of OLS pooled data, we conducted a panel data estimate and, furthermore we 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.

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%

Table 2 shows the impact of geography, institutions and policies, trade, and human capital on the growth of agricultural TFP (Table 2). In terms of geography, the polar climate, assumed to be an obstacle to Nordic productivity growth, has a 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; the combination of abundant annual sunshine with this irrigation produces rapid agricultural productivity growth (Cazcarro et al., 2015a and 2015b)[19]. One example could be Italy and Spain. These countries strongly encourage irrigation in their agricultural sectors to overcome the aridity. Irrigation has allowed these countries to converge, in terms of agricultural productivity (Table 1 and Martín-Retortillo and Pinilla, 2015b), with the Western European countries, which have the highest productivity levels in the continent. These countries have profoundly transformed their agricultural sectors over these decades, not only adopting the innovations from the industry, like other Western countries, but also incorporating the artificial application of water, increasing production, productivity and exports.

The model also highlights the key role of institutions in productivity growth. On the one hand, the two variables measuring political rights and civil liberties have a 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 cooperation among agents (Gallego, 2007 and 2016). There are several examples of the importance of the 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 this in centrally-planned systems goes some way to explain the lower agricultural TFP growth under those systems. Furthermore, when the institutions allow an appropriate control by governments this induces fewer price distortions (Masters and Garcia, 2010)

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 the governments maintained 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

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

allocation of these investments were 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 had a negative effect on agricultural productivity, because of a less efficient maintenance of farm resources.

The *subsidies* variable has a negative sign and is significant. This last variable could be negative because strong political support for agriculture could encourage the maintenance of inputs in the sector, such as labour, land, and capital, and provide less incentive to increase competitiveness 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. Lower levels of subsidies would also result in the inability of less competitive farms to survive.

The existence of strong policies in support of agriculture, as in the Common Agricultural Policy (hereafter, CAP), encouraged 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, mostly before the McSharry reforms, such as export subsidies and minimum prices (Tracy, 1989; Ritson, 1997; Andreosso-O'Callaghan, 2003; García Delgado and García Grande, 2005; Neal, 2007), encouraged farmers to remain in the sector. In the case of CEEC countries, increases in agricultural support brought about inefficiencies and cost increases (Gray, 1990).

The openness variable has a positive sign and is significant in all the models in which it is included. The more open economies show greater average TFP growth, due to three reasons: access to larger markets for agricultural products, ease of buying inputs, especially from the non-agricultural sector, and greater international competition that favours the most competitive farmers. The countries of the European Union have these advantages, along with trade 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 effect of agricultural openness on the growth of the TFP. This variable is very close to 0, and in some cases, is not significant. One explanation for this null influence could be that over the second half of the twentieth century, the agricultural sector became increasingly integrated with the agrifood industry. Therefore, this variable would not be measuring openness adequately. This result may also show that having an internationally-oriented agricultural sector is not enough; in modern agriculture access to advanced technologies from other countries plays a more essential role.

Human capital is fundamental in explaining the determinants of agricultural productivity growth. In the case of the measurement 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 countries with skilled societies, the specialization of the farmers is greater and the agricultural productivity higher.

In addition, the effect of human capital can show the importance of the development of a welfare state, in which education is fundamental. The European countries generated public policies to guarantee the citizens a certain level of education and health. The improvement of the quality of life of the population could have increased the agricultural productivity.

7.- Conclusions and policy implications

The debate on the fundamental causes of economic growth, particularly those that generate incentives that drive technological innovation and improvements in production efficiency have occupied a prominent place in the economic literature in recent decades. Agriculture has played a decisive role in economic growth. Therefore, it is important to examine the underlying causes of the increase in agricultural productivity. Historical experience can provide us with comparative visions about different economic systems and important useful lessons for developing countries today. Therefore, in this study, we concentrate on Europe in the second half of the twentieth 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 play 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.

Therefore, this study has important implications for favouring the increase in agricultural productivity in developing countries, where this sector constitutes a relevant part of their economies. Undoubtedly, the need to have institutions that favour economic growth is fundamental. Inclusive institutions (Acemoglu et al., 2005) are essential as they encourage the participation in economic activities of the highest possible number of

people, they guarantee rights to ownership and provide public services that facilitate this participation. This is how innovation can be disseminated more easily. Furthermore, a good education and health systems give rise to better qualified and efficient farmers. Graduated support to farmers is also important as it enables them to improve their incomes but does not generate disincentives to the improvement of efficiency. A high degree of openness to international trade also facilitates improvements in productivity.

Geography also has a major impact 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. The European case has also shown us that what used to be a major disadvantage for Mediterranean countries, that is, their aridity, could be an advantage if the supply of irrigation water enables the high levels of sunshine of this climate to be taken advantage of, converting these countries into efficient producers of certain goods that have a high demand in the international market (Clar et al., 2018). Therefore, it is fundamental to select products that can make the most of the natural conditions and to invest in facilitating their development.

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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 have followed the steps below. We have obtained the *Export Value Base Price* variable from FAOSTAT (2009). We have to complete the series after the year 1951. However this variable from FAOSTAT begins in 1961. We have completed this variable with the data from the FAO (1948-2004b) during the 1950s and more decades, in some specific cases.

These data from the FAO are the sum of food and agricultural products excluding forest product exports in current values. We then transformed them 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, for which the 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.