On the causes of economic growth in Europe:

Why did agricultural labour productivity not converge between 1950 and 2005?

Miguel Martín-Retortillo* and Vicente Pinilla*

Universidad de Zaragoza

Abstract: The objective of this study is to make a further contribution to the debate on the causes of economic growth in the European continent. It explains why agricultural labour productivity differences did not converge between 1950 and 2005 in Europe. We propose an econometric model, one combining both proximate and fundamental causes of economic growth. The results show that the continuous exit of labour power from the sector, coupled with the increased use of productive factors originating in other sectors of the economy, caused the efficiency of agricultural workers to rise. However, we offer a complete explanation of the role played by institutions and geographical factors. Thus, we detect a direct and inverse relation between membership of the EU and the Communist bloc and the productivity of agricultural labour. In addition, strong support for agriculture affected productivity negatively.

JEL codes: N50, N54, O13, Q10

Keywords: Agricultural labour productivity, European agriculture, European economic history, causes of economic growth

* Department of Applied Economics and Economic History, Faculty of Economics and Business Studies, University of Zaragoza, Gran Vía 4, 50005 Zaragoza, Spain

miguelmr@unizar.es, Tlf: 34-976761000 (ext. 844621), Fax: 34-761841 and vpinilla@unizar.es, Tlf: 34-976 761 786, Fax: 34-976 761 841.

On the causes of economic growth in Europe:

Why did agricultural labour productivity not converge between 1950 and 2005?

1. Introduction

The literature on the causes of modern economic growth has hosted one of the most heated recent debates in economics. Rather than traditional so-called proximate causes, some more innovative research has insisted on the crucial role of fundamental causes, such as geography, institutions, trade or culture (Acemoglu et al. 2001 and 2005; Frankel and Rommer 1999; Sachs and Warner 1995; Sachs 2000). This debate, developed principally by economists, has frequently employed historical data to validate the hypotheses proposed. It is unsurprising, therefore, that its impact has deeply affected economic history research, in which the analysis of the causes of economic growth has habitually been a central topic.

In the case of European economic growth, a significant number of European economic historians have used comparative perspectives to address this question[1]. Such literature addresses this central problem of the causes of and obstacles to modern economic growth by analysing the rhythms and patterns of European economic development over the last two centuries.

For economic historians, European industrialisation and its successes, failures and rhythms have probably been one of the most relevant questions. Nevertheless, in the last two decades, the reasons explaining the extremely rapid growth in the years of the Golden Age and its abrupt ending in the 1970s, have also generated a debate of great interest (Temin 2002; Vonyo 2008; Eichengreen and Ritschl 2009).

[1] A recent synthesis can be found in Broadberry and O'Rourke (2010).

The changes in agriculture and their influence on economic development have occupied a central place in the industrialisation debate (Allen, 2009; O'Brien and Prados 1992; Van Zanden 1991; Lains and Pinilla 2009). Surprisingly, in the discussion regarding economic growth in the Golden Age the debate has only centred on the possible contribution to economic growth made by the exit of labour power from agriculture (Temin 2002; Vonyo 2008). However, the analysis in the second half of the XX century of the causes of changes in the agricultural sector itself and their contribution to general economic growth, from a long-term perspective, have produced less interest. The most notable exception is the seminal study by Federico (2005), which tackles such causes for the world as a whole and from the perspective of two centuries[2]. The same is not true of agricultural economists, for whom agricultural growth in these decades, its causes and international differences have been a central topic (Hayami and Ruttan 1985; Fuglie 2010 and 2012). However, these studies have normally lacked a long-term perspective.

This scanty interest is surprising, bearing in mind that agricultural productivity increased fastest in these years. Furthermore, for many countries on the continent, by the 1960s the agricultural sector still employed most labour power and, additionally, made a substantial contribution to GDP. Moreover, the sector underwent other crucial changes. Firstly, it moved from having weak links with other sectors to becoming a sector in which the majority of inputs came from the industrial sector, which also purchased a very significant part of agricultural output for its subsequent transformation. Secondly, agriculture came to benefit from considerable state intervention. In Western Europe, agricultural policies had a decisive weight in the development of this sector, replacing the market to a considerable degree. In Eastern Europe, collectivization involved total control by the state.

Against this background, the present article aims to make a contribution to explaining the causes of and the differences in economic growth on the European continent, concentrating on the agricultural sector in the second half of the XX century. The principal

---

[2] The studies by Grigg (1982) and Bairoch (1999) have also touched upon this subject.

objective is to determine why the productivity of agricultural labour has not converged in Europe in the last 60 years. This absence of convergence occurred in the period in which the European-wide diffusion of technologies took place, significantly advancing the frontiers of production possibilities. Specifically, the study offers a long-term analysis of agricultural labour productivity differences in Europe. This issue is essential, since agricultural modernisation and its positive contribution to economic development require a substantial increase in productivity, which also permits a significant transfer of labour power to other sectors. It is also extremely important because it offers a good approximation of production and income per worker in this sector. Some recent studies have emphasised that since differences in agricultural productivity are greater than in the economy as a whole, their understanding is key to the comprehension of the differences in income per worker among countries, and especially developing countries (Gollin et al., 2014 a).

As for shorter periods in agricultural economics, the present article systematically compares the evolution of European countries, using econometric techniques to provide explanations. To achieve the objective proposed, in addition to the so-called proximate causes of economic growth we shall also use variables which permit the introduction into the analysis of the role of fundamental causes, especially institutional or geographical factors.

The study period is particularly interesting, as it experienced the greatest growth in agricultural productivity in the last two centuries (Martín-Retortillo and Pinilla, forthcoming). Most previous analyses have employed a highly heterogeneous sample of countries and reduced time periods. The present study extends the usual time horizon and analyses almost all the countries of Europe, except for the former Soviet republics, for which homogenous data are extremely difficult to obtain.

To be able to construct not only the descriptive statistics but also the econometric analyses, we found it necessary to compile a homogeneous database which fully covers the 1950-2005 period and which further includes all the countries of the European continent (with the exception of the ex-Soviet Union and its successor republics) (see Appendix). Our principal source is the FAOSTAT (2009) database and the paper yearbooks of the FAO (1948-2004). As explained in detail in the Appendix, the principal problems we have faced are related to the absence of net agricultural production data for the decade of the 1950s, territorial changes (especially in the case of the two Germanys prior to reunification, for which, additionally, there exist data for neither net production nor other variables) and the calculation of the human capital stock. All this has required the estimation of variables and their homogenisation (see Appendix).

The results show the importance of the land/labour ratio in understanding the lack of convergence in European labour productivity levels. That is to say, factors from outside the agricultural sector itself, namely the capacity of other sectors to attract agricultural workers, are very important for the explanation of labour productivity differences. Also significant were the endowments of fertilizers, machinery, irrigated land or livestock capital per worker. This article argues that the exodus of workers and the far-reaching implementation of new production technologies contributed to increasing productivity levels. Lastly, the institutional framework was also of great importance. Especially in Western European countries, membership of the European Union encouraged high levels of productivity. For Eastern European countries, relatively low productivity levels were maintained, due to the centralised planning of their economies. The policies subsidising agriculture had a negative effect on productivity. In addition, geographical conditions also help to explain productivity differences. In short, we believe that this discussion permits deeper debate regarding the causes of European economic growth in the long term.

The article comprises six sections, including this introduction. Section 2 examines the evolution of agricultural productivity in Europe and analyses absolute convergence. Section 3 presents the theoretical model constructed, the econometric methodology followed and the variables employed. Section 4 discusses the results obtained. In section 5 we perform an analysis of agricultural productivity with a dynamic specification. Finally, Section 6 presents the principal conclusions.

2. The evolution of agricultural labour productivity in Europe

2.1. Agricultural labour productivity changes in Europe

Three stages can be distinguished in the evolution of labour productivity in European agriculture over the last two centuries. The first, between 1800 and 1870, was one of growth which was continuous and moderate but very unequal among countries. New techniques were adopted, such as crop rotations, the introduction of pulses and other fodder crops, the elimination of fallow periods, improved implements, more intensive fertilizing and new fertilizers such as guano (Allen 1992 and 1994; Clark 1987). The average annual growth of labour productivity was 0.93% in developed countries (data from Bairoch 1999).

The second stage was 1870-1950, in which annual growth accelerated to 1.23% in developed countries. The use of chemical fertilizers, biological innovations, reaping and threshing machines, new metal instruments and concentrated feeds were all causes of this growth (Chorley 1981; Van Zanden 1991; Olmstead and Rhode 2002 and 2008; Federico 2003).

The greatest annual growth in productivity (4.73% on average) took place from the Second World War to the end of the XX century in developed countries. This was due to the increasing use of self-propelled machinery, chemical fertilizers and pesticides, the genetic selection and hybridisation of seeds, the development of intensive industrial livestock raising, improved access to agricultural credit and the expansion of irrigated farming in the Mediterranean countries (Grigg 1992; Gardner 1996; Federico 2005a; Josling 2009).

To analyse the period 1950-2005 more precisely, Table 1 offers our own calculation of agricultural labour productivity in Europe as a whole, and its agricultural production and principal productive factors[3]. To obtain labour productivity, we divided net production in dollars at international prices in 1999-2001 by the total active agricultural population.

[3] Farm production does not include forestry products.

Average annual European growth in this period was 4.23%, the highest rate in the last two centuries.

[Table 1]

Labour productivity growth was especially rapid until the early 1980s, increasing somewhat more slowly from then on. This growth was based on a substantial increase in production until the beginning of that decade, after which it rose very slowly. Meanwhile, the fall in the active agricultural population was prolonged and sustained, and especially fast after the 1980s.

The growth of production in the first stage, 1950-1982, resulted from a sharp increase in the use of modern inputs, such as fertilizers and machinery, while the cultivated land area fell slightly. In the second stage of stagnant production, 1982-2005, cultivated land decreased further, as did the number of livestock units and, particularly, the use of fertilizers. The number of tractors subsequently rose very slowly. This meant that the maintenance of production, while the use of productive factors fell, was only possible as a result of a notable increase in TFP (Martín-Retortillo and Pinilla, forthcoming).

By disaggregating the evolution of labour productivity by countries it is possible to show the very different patterns followed (Table 2).

Throughout the period, Western European countries had productivity levels far above European averages, and productivity growth higher than the Continental norm. Their highest levels of productivity, in 1950, can be explained by their advantage in terms of economic development. They completed their processes of industrialisation earlier, which means that their structural change was also more advanced. This involved a greater exit of the rural population to industry and services and the necessary replacement of the agricultural labour force by machinery. The result is that they started from a higher level of labour productivity, while the adoption of new innovations and the deepening of structural change allowed them to maintain that advantage. These countries display different evolutions. The United Kingdom or the Netherlands have displayed decelerating growth in recent years, despite their high initial level (Brassley 2000). Others, for example France and Denmark, have been able to maintain high growth rates. Swiss productivity had an unusual low growth due to its flat production increase and a lower decrease in the active population than the rest of the Western countries.

The Nordic countries experienced greatly varying levels of agricultural productivity, but ranged around the European average. From 1950 to 2005 their growth was lower than or similar to European growth, which meant a loss of their relative positions on the continent.

[Table 2]

In 1950 productivity in the Mediterranean countries (except Italy) was lower than in Europe as a whole, and two different trajectories are apparent. One is the very strong growth of Spain and Italy, while Greece and Portugal were clearly outpaced by this sharp rise in production.

Lastly, the active agricultural population in the Eastern European countries was much less productive than in Europe as a whole. Growth from 1950 to 2005 was extremely heterogeneous. Despite this heterogeneity, these countries and the Soviet Union incorporated many of the innovations being adopted by other European countries. This led to notable increases in production between 1960 and 1990 (Diamond et al. 1983). Consequently, agricultural labour productivity increased in the Eastern countries prior to the collapse of Communism. In the 1990s, by contrast, agricultural production declined, due to the implosion of the centrally planned economies. The transition to a market economy shows great differences in the evolution of labour productivity, although once such differences had been overcome these countries returned to the path of growth (Macours and Swinnen 2002).

Finally, Table 2 shows that although the growth of labour productivity in different European countries was extremely important, very significant differences persisted in their levels. In 2005 labour productivity in Germany or Western European countries was twice as high as in the Mediterranean or Nordic countries, despite some of the latter having experienced very strong productivity growth. In addition, in Western European countries labour productivity levels were six times higher than the Central and Eastern European countries (CEEC).

[Graph 1]

For a better understanding of these differences, labour productivity can be disaggregated into two components: land productivity and land-labour ratio.

$\left(\frac{Y}{L}\right) \equiv \left(\frac{A}{L}\right) * \left(\frac{Y}{A}\right)$, where Y is output, A is land and L is labour.

Graph 1 (and Table A.1 in the Appendix) show the evolution and levels of productivity per hectare in European agriculture. The highest levels correspond to the countries of Western Europe. Followed at some distance are those of the Mediterranean countries and, especially, those of the Nordic and Central and Eastern European countries. It is reasonable to assume that, to a large degree, these differences could have been due to the distinct agricultural potentialities of the natural resources of the different countries.

[Graph 2]

Graph 2 (and Table A.2 in the Appendix) offer land-labour ratios. They demonstrate that low land-productivity countries, although they tended to increase their land-labour ratios to achieve high labour productivity, did not reach the elevated levels of Western Europe. The Nordic or Spanish land-labour ratios reached the same level as Western countries or Germany, but did not offset their disadvantage in land productivity (Wang et al. 2012). The land-labour ratios of the countries of Central and Eastern Europe and some Mediterranean countries, such as Greece or Portugal, were much lower than the rest of Europe.

2.2. Did the labour productivity of European agriculture converge?

From the general increase in agricultural labour productivity, the massive incorporation of new industrial inputs and the biological innovations adopted, it might be assumed that the differences among countries should have fallen. The access to technology capable of generalised application to the entire continent may have fostered convergence. The task is now to determine whether the productivity levels of agricultural labour converged. Table 3 shows that the dispersion of productivity (σ-convergence) increased gradually or was maintained since the 1950s.

[Table 3]

Table 3 shows that the differences in labour productivity existing within the continent of Europe in 1950 did not decrease until the 1980s. From then on, dispersion displayed small fluctuations or a slight decrease, depending on the measure observed. In the case of the weighted variation coefficient, it is possible to observe similar behaviour to that of the remaining variables, although the change of trend occurred in approximately 1970. Thus, the evolution of the indicators of dispersion in Table 3 permit us to affirm that convergence did not exist in labour productivity. The question is now how to explain why such important differences in agricultural productivity levels in Europe have been maintained until today, without convergence among countries. Consequently, we perform an econometric analysis to observe the variables which explain these differences in levels.

3. Theoretical approach and method

Labour productivity is the partial productivity of agriculture which has grown fastest in Europe since World War II (Henrichsmeyer and Ostermeyer-Schlöder 1988). This growth is directly linked to the exit of the agricultural population to industry and services as a consequence of structural change, since agricultural labour is the denominator of this variable. Consequently, either increased production or reduced labour, or a combination of the two, could have raised productivity.

Many causes determine labour productivity levels, from factor endowment and technology to institutions or geography. As both recent economic history and the literature on economic growth show, there exist both proximate and fundamental causes to explain agricultural productivity variations (Crafts 2010). The present study attempts to combine both types of variables.

Proximate causes are the variables included in any production function of the agricultural sector (land and capital), except, obviously, the labour factor, which is already the labour productivity denominator. These productive factors have normally been included in all estimations of agricultural productivity (Hayami and Ruttan 1985; Kawagoe et al. 1985; Gallup 1998 or Mundlak et al. 1999, among many others). Machinery and fertilisers have significantly increased their importance in the productive process, in line with agricultural development (Grigg 1992; Federico 2005a). The irrigated land area is another crucial variable, because of its importance in overcoming unfavourable geographical conditions in certain semi-arid European regions. Less commonly, livestock variables have been included in the estimation of agricultural productivity. These affect production in two ways: as capital which, in addition to producing goods, lasts more than one financial year, and as a driving force in farming. In the years under analysis, in addition to a radical reduction of the contribution of animals to rural labour, their importance as capital increased, as intensive livestock farming emerged.

The quality of the labour force is also a variable to be taken into account. In fact, human capital is one of the variables most commonly studied to observe differences in agricultural labour productivity (Hayami and Ruttan 1985; Nguyen 1979).

We also introduce $GDPpc_{it}$ as a measure of the development of the whole economy. There are several studies which take this variable into account to measure differences in agricultural productivity (Van Zanden 1991; Mundlak et al. 1999; Ezcurra et al. 2011). Our understanding is that agricultural labour will be more productive in more developed economies. This is due to the influence of the greater technological level, external to agriculture, on its productivity, or the impact on agricultural efficiency of the availability of better infrastructure and access to markets.

The fundamental causes of modern economic growth are also taken into account in the present analysis. Certain institutions can significantly affect productivity, influencing for example the propensity to trade, the adoption of technology, investment incentives or human capital skills. Prominent among these determinants are the functioning of product or factor markets, agricultural credit, foreign trade policy or economic policy.

It is a complex task to measure all the possible channels of institutional influence upon the productivity of such a large sample of countries, and thus the focus here is on those most important and easiest to observe. Membership of either the European Union (formerly the European Economic Community) or of the Communist bloc, led by the Soviet Union, have had extremely significant consequences. For some authors these are essential to the understanding of agricultural output in Western and Eastern Europe (Houpt et al. 2010). In addition, international trade openness and subsidies to agriculture are also important dimensions in the development of the institutional framework of the countries analysed (Anderson and Valenzuela, 2008). Some of these latter institutional dimensions overlap with the former (EU and Communist bloc membership) but, given the number of countries involved and the long time span, undoubtedly make the analysis richer.

EU membership has entailed the adoption of the Common Agricultural Policy (CAP) and access to the common market of member countries. The CAP has radically altered their agricultural perspectives, involving a partial substitution of market mechanisms by public policies (Federico 2009; Spoerer 2010). The creation of, firstly, a customs union and, secondly, a single, strongly protected, market has greatly facilitated import substitution and increased trade among members (Pinilla and Serrano 2009). Measures such as export subsidies and minimum prices have provided help to farmers and supported the agricultural sector by trading at prices above international levels (Tracy 1989; Ritson 1997; Andreosso-O'Callaghan 2003; García Delgado and García Grande 2005).

In the Soviet bloc land was collectivised, rationing was introduced and products were requisitioned; essentially, central planning replaced the market economy. Land was either transferred to the state or maintained in private hands. Owners were obliged to join cooperative enterprises while a small part of their production was allowed to remain strictly private. Collective farms increased mechanisation, yet despite lower labour requirements, the collectivised farms "became employers of last resort, providing a meagre subsistence to women and children, the old and the infirm" (Allen 2003, p. 100). The Soviet countries also threatened peasants failing to comply with planners' orders, producing general discontent with the system and a tendency towards passive protest. Moreover, production did not usually equate with demand. From the economic point of view, socialist agriculture suffered great structural problems of incentivisation. This was because, following collectivisation, all agricultural workers were guaranteed a minimum income, with little incentive to work harder. Similarly, efficient agricultural policies were lacking, further causing state agriculture to perform beneath its potential (Gregory and Stuart 2001; Allen 2003; Federico 2005a and 2005b; Landau and Tomaszewski 1985).

Support to the agricultural sector through highly diverse measures, such as guaranteed prices, direct income transfers to farmers, purchases of surpluses, structural reform policies or protectionist policies may also have had a significant impact on productivity. On the one hand, subsidies to agriculture, by maintaining or raising the income of farmers above the level they would otherwise have had, may have reduced or impeded a greater growth of productivity. It might therefore have limited or deferred the exit of the labour force from the sector, with a negative effect on productivity. It is also possible that as a consequence of offering more stable perspectives to farmers, such policies would have incentivised capital investment in farms, thereby favouring the improvement of productivity.

International trade openness may also have affected agricultural productivity. It is reasonable to believe that in the more open countries it was necessary to increase competitiveness further, in order to be able to maintain their production in an environment of low protection.

Geography is another fundamental cause of growth. Geographic variables may directly affect agriculture through temperature, altitude, rainfall, sunshine, pestilence and diseases, soil, orography or latitude (Gallup 1998; Grigg 1992; Crosby 1986; Asenso-Okyere et al. 2011). As altitude rises temperature falls, harming agricultural output (Grigg 1982; Federico 2005a). More decisive may be the fact that steeper slopes demand greater intensity of labour. Several studies have underlined that a highly uneven terrain prejudices agriculture and other economic activities (Nunn and Puga 2012; Ayuda et al. 2010). A lack of water can also hinder productivity; for some countries it is a clear obstacle to agricultural development (González de Molina 2001; Clar and Pinilla 2009). Water is an essential resource for plant growth, and the impact on its lack of output is huge unless appropriate measures are taken.

Some research includes measurements of the bioclimatic landscape, to determine the disadvantage for tropical, polar or temperate countries (Gallup 1998). Such landscapes are sets of climate, flora and fauna common to a region. Extreme bioclimatic landscapes, such as polar or tropical, produce the greatest disadvantages.

We now explain the method and variables employed to determine which factors influence agricultural labour productivity. We used a linear function to perform the estimation, including the variables in logarithms[4] and employing the panel data technique. The functional form is based on the production function *translog*[5], to which we have added

[4] To make the production function linear and be able to estimate the econometric model we have applied logarithms to it.

[5] The translog production function is a generalization of Cobb-Douglas and is more flexible than the latter. The Cobb-Douglas production function is the same function, assuming $\beta ij= 0$. The production function used (translog) relaxes the implications of additivity and homogeneity (Christensen et al. 1973). Allen (2009) and Pablo-Romero and Gómez Calero (2013) are two recent examples of an estimation of the translog production function.

several institutional and geographical variables. The sample comprises 32 European countries and annual data for 1950-2006[6].

The equation proposed is:

$$\ln(\mathrm{product}_{it}) = \alpha_i \sum_{i=1}^{n} \beta_i \ln(x_{it})\ 0.5 \sum_{i=1}^{n}\sum_{j=1}^{n} \beta_{ij} \ln(x_{it}) \ln\left(x_{jt}\right) + \alpha_1 \ln(\mathrm{khumans}_{it}) + \alpha_2 \ln(\mathrm{GDPpc}_{it})$$

$$+ \alpha_3 \mathrm{communist}_{it} + \alpha_4 \mathrm{EU}_{it} + \alpha_5 \mathrm{subsidies}_{it} + \alpha_6 \mathrm{open}_{it} + \alpha_7 \mathrm{geo}_i + +\gamma_1 z_{1it} + \cdots$$

$$+ \gamma_{T-1} z_{T-1it} + u_{it};\ \ \beta_{ij} = \beta_{ji}\,; x = A, L, F, M, I;\ i = 1, \dots, N;\ t = 1, \dots, T$$

The endogenous variable $Product_{it}$ measures output per worker in the agricultural sector; it is the quotient between net agricultural production at international 1999-2001 prices in dollars and the active agricultural population[7]. The correct measurement of the labour factor would be of hours worked, but data for this variable are not available[8].

The *x* matrices are all those variables aimed at approximating the impact of productive factors on labour productivity (land and capital) and were obtained from FAOSTAT (2009) and FAO (1948-2004) or calculated by ourselves, based on these sources. We divided all the variables forming the x matrix by agricultural labour. $Land_{it}$ (A) is the area of arable land and permanent crops. $Livestock_{it}$ (L) is the stock of live animals, calculated using the weightings of Hayami and Ruttan (1985). $Fertilizer_{it}$ (F) is the sum of

---

[6] See Appendix.

[7] See Appendix.

[8] EUROSTAT offers a variable for European agriculture called the Annual Work Unit. This variable is not available for either all the countries or for the entire time sample. Furthermore, the calculation of this variable takes *ad hoc* assumptions into account. Therefore, in the present study we have preferred to maintain the active agricultural population as the relevant variable. Gollin et al. (2014b) have investigated in depth the possible effects of an inadequate estimation of labour productivity in agriculture. Their conclusion is that even after correcting the errors in the estimation, there persist enormous differences among countries.

the consumption of potassium, phosphate and nitrogen fertilisers. *Machinery*$_{it}$ (M) is the number of tractors. *Irrigation*$_{it}$ (I) is the area per worker equipped for irrigation[9].

The measure of human capital shows the Gross Enrolment Ratio in secondary education (*khumans*$_{it}$). We have calculated this ratio using statistics from the World Development Indicators (2011) and Mitchell (2007)[10].

We obtain GDP per capita from Maddison (2010), expressed in 1990 International Geary-Khamis dollars[11].

Four variables proxy the effect of institutions on productivity. *Comunist*$_{it}$ is a dummy which takes the value of 0 if the country does not have a centrally planned economy and 1 otherwise. *EU*$_{it}$ is another dummy which takes the value of 0 if the country does not belong to the EU (formerly the EEC) and 1 otherwise. *Subsidies*$_{it}$ is a qualitative variable that takes into account whether economic policy supported the agricultural sector (value 1) or not (value 0). This last variable is from the Anderson and Valenzuela (2008) database. We took into account the Nominal Rate of Assistance (NRA), that is to say the change in income after price support and direct income support as a proportion of income in the non-policy situation. We assume a policy of support if the NRA in the agricultural sector is greater than 0.2, to take into account strong support for agriculture[12]. Finally, *Openess*$_{it}$ is a qualitative variable which takes the value of 1 when a country has an open economy and 0 when it is closed. To perform this classification for each year we based ourselves on Sachs and Warner (1995) and their classification of countries into open or closed economies. For those

---

[9] Our variables are measured in dollars, in the case of production and input quantities. We have used a primal analysis. Concerning the possibility of performing the dual analysis with prices, Mundlak (2001, 77) sees several possible reasons for the poor performance of prices, due mainly to the fact that duality is a micro theory, and therefore applications with macro data present additional problems.

[10] See Appendix.

[11] For more details, see Appendix

[12] See Appendix.

countries or years for which these authors do not offer data, we have used, complementarily, the World Development Indicators and Maddison (1991).

Physical geography, geo_i, is measured through the percentage of the area of each country in distinct bioclimatic regions (western, Mediterranean and polar). A bioclimatic zone or biome is a zone of the planet with a common climate, vegetation and fauna. Latitude, temperature, precipitation and altitude define the basic characteristics of the climate of each zone (CIESIN 2007). The estimation omits the so-called western biome, to observe the disadvantage to the other two biomes.

The variables represented by z are the time dummies included in the econometric model. The last year is omitted in these time dummies, to avoid perfect multicollinearity, and estimated as base.

[Table 4]

Table 4 shows the mean and standard deviation for the European continent of the explanatory variables used in the econometric model and the number of countries forming the institutional groups. Firstly, capital endowment per worker (whether in machinery, fertilisers, irrigation or animals) has increased very significantly. The increase in land per worker was also remarkable, rising by 400%. Lastly, the standard deviation of the use per worker of these factors tended to increase, except for human capital at the secondary level of education.

We used the panel data method to obtain the final results; it improves the efficiency of the estimators, since it accumulates more information on variations in the data, controls for individual country heterogeneity and identifies and measures effects which cross-section analyses do not detect. Moreover, it reduces the problem of omitted variables (Baltagi 2005; Hsiao 1999). Consequently, the panel data technique is more precise than its cross-section counterparts.

4. Results

We obtained the econometric results by an OLS estimation with pooled data, and also by random effects and fixed effects, to check which estimation was optimal. We used the Breusch-Pagan LM test and F-test (Greene 1997) to choose between the OLS and random and fixed effects estimations respectively. In both of them we rejected the null hypothesis, which corresponds to an OLS estimation. As a result, the OLS estimation is not included in the results table.

We tackled two relatively common econometric problems, heteroscedasticity and autocorrelation, by the Wald (Greene 1997) and Wooldridge tests (Wooldridge 2002), respectively. We rejected the null hypothesis of homoscedasticity, but the p-value of the autocorrelation test is 0.4670, and thus we did not reject the null hypothesis of non-autocorrelation.

The first column in Table 5 gives the random effects estimation. Furthermore, the Hausman test reveals that the differences between estimators are significant, when comparing columns (1) against the fixed effects estimation (2). This test has a p-value which is null or lower than 0.05, and thus the best estimation is that of fixed effects (column 2). The inconvenience of this procedure is that it omits those geographical variables which are constant over time.

[Table 5]

Heteroscedasticity can be resolved using the estimation in column 3 (Panel Corrected Standard Error). We chose the PCSE estimation, following Beck and Katz (1995), as they compare the standard errors of the PCSE with FGLS (Feasible Generalized Least Squares). The PCSE standard errors are more precise than the other estimations.

The results of the econometric model show, firstly, that intensity in the use of productive factors is decisive in explaining the differences in the productivity levels of European agriculture in the second half of the XX century. Especially notable is the importance of the land per agricultural worker variable (*land*), with a significant coefficient and the expected sign. The elasticity of this variable would be 0.49[13]. That is to say, an increase of 1% in this variable would increase productivity by 0.49%. This underlines that the increase in the land/labour ratio was a powerful determinant of labour productivity differences. In the second half of the XX century a highly varied and intensive process of rural exodus in Europe took place (Collantes and Pinilla 2011). In short, and as Table 1 shows, the cultivated land area fell, but by much less than the labour force. As a result, one of the driving forces behind agricultural productivity growth came from outside agriculture itself. The culmination of industrialisation in many countries or its rapid advance in others, together with the growth of the services sector, involved a formidable rural exodus. This reduced, for the first time in the majority of European countries, not only the share of agricultural workers in the total active population, but also their numbers. Agricultural productivity was thus directly conditioned by the rhythm of the economic transformations outside it. This in turn meant an increase in the average size of farms and exploitation of the technology available to intensively mechanize production (Federico 2005a; Fennell 1997). Modern agriculture was thus able to achieve certain economies of scale, replacing workers by machinery.

Naturally, this central role of increased land area per worker demanded fundamental changes in agriculture itself. More land per worker was only viable insofar as fewer workers could perform the same tasks, meaning that workers had to be more efficient. Machinery was from this perspective crucial, and thus the positive sign and significance for tractors per worker are unsurprising in explaining differences in labour productivity (an elasticity of 0.09). The same is true of livestock units per worker (an elasticity of 0.03). New processes in livestock breeding and dairy, poultry, pork and beef production meant the industrialisation of a previously highly labour-intensive activity, one in which substantial economies of scale

[13] To calculate the elasticities in a translog production function, it is necessary to combine the value of the coefficient of each variable with the coefficients of its interactions. Pablo-Romero and Gómez-Calero (2013: 79) give the concrete formula.

were achieved. New livestock breeding methods permitted its disassociation from the soil and the ecological limits for its development in countries with less favourable natural conditions. Briefly, it is also natural for the use of fertilisers to show the expected positive sign and be significant; their contribution to the raising of productivity was considerable (an elasticity of 0.13).

Irrigation is another crucial variable in explaining the differences in agricultural labour productivity, since it has a positive sign and is significant (an elasticity of 0.05). Irrigation meant improving yields in arid or semiarid regions (approximately two thirds of irrigated lands in Europe were concentrated in France and the Mediterranean countries). In Spain, for example, one of the driest countries in Europe, irrigated farming accounted for less than one third of the agricultural land area, but for over two thirds of crop production (Cazcarro et al., forthcoming).

The diffusion of technology throughout agriculture, principally through the incorporation of inputs from the industrial sector, is key to understanding both the levels and growth of labour productivity. The diffusion and adoption of the new technologies followed distinct paths in the European countries. In the countries with centrally planned economies there were clear problems of efficiency in their use, and similarly a certain lag in the adoption of state-of-the-art technologies (Gregory and Stuart 2001, Allen 2003). In the market economies, the boost to public research into R&D and structural reform policies, with the aim of achieving larger and more highly capitalized farms, stimulated technological development (Neal 2007, Houpt et al. 2010). Whatever the case, its diffusion in the agricultural sector was performed unequally, given the biased and localized nature of technological change (Hayami and Ruttan, 1985; Acemoglu, forthcoming).

The variables β_{ij}, listed in Table 5, are the products of the first five inputs. The negative sign in the quadratic coefficients for land, fertilisers and livestock show the decreasing returns of scale for these inputs. In addition, machinery and fertilisers are substitutes, owing to the negative sign of their crossed coefficient[14].

The positive and significant coefficient of the Gross Enrolment Ratio in secondary education shows that the improvement in education in European countries also had a substantial effect upon agricultural productivity. Thus, the distinct educational levels reached are also important in explaining differences in agricultural labour productivity.[15]. A secondary level of education permits the use of more advanced techniques.

The role played by the development of the whole economy is also considerable. The variable $GDPpc_{it}$ is significant and positively related to agricultural labour productivity. This influence means that the agricultural sector is not alien to the economy as a whole, and that the degree of development of the economy is crucial to understanding differences in agricultural labour productivity. Good infrastructure facilitated better access to markets and, in general, a reduction of transaction costs, as well as better integration between the agricultural sector and the agrifood industry. But the high level of economic development also facilitated improved access to credit, the development of agricultural extension and the expansion of general purpose technologies with an impact on agricultural productivity. In summary, all these factors favoured the faster growth of agricultural productivity, thanks to the advantage of integration of the sector into an economy of high incomes and technological capacities.

The econometric model also clearly shows that institutional variables help to understand the differences between distinct levels of agricultural productivity. Membership of either the EU or the Communist bloc are significant at 1% and show the expected sign (positive for the EU and negative for the centrally planned economies). Policies of subsidies

---

[14]Allen (2009, p.425) has explained, regarding these estimated translog parameter values, that “their economic significance lies in their implications for elasticities of substitution”.

[15] We attempted to use Barro-Lee’s average years of schooling from the WDI (2011). This variable is not significant and we prefer to include the Gross Enrolment Ratio in the final regressions.

to agriculture also affected productivity. In this case, the negative sign underlines that they depressed it. Finally, openness is not significant, and thus is not included in the final model. Its lack of effect upon productivity could be due to the fact that this variable represents the opening of the economy as a whole, and not exclusively that of the agricultural sector. In the most developed countries there coincided in that period a strong opening of the industrial sector with high agricultural protectionism. This divergence in sectorial commercial policies may explain the above mentioned lack of statistical significance.

The institutional framework defined by a centrally planned economy implies that this system prejudiced productivity in various ways, for example by land collectivisation and product requisition, the control of production and prices by planners, threats to peasants failing to comply with state plans, or the lack of work incentives (Allen 2003; Federico 2005a). In general, this institutional framework maintained a significant level of redundant labour in both agriculture and other activities; in other words, the agricultural labour force fell, although by less than in Western Europe (Gregory and Stuart 2001).

Membership of the European Union (*EU*) has been of greater importance, generating not only a stable and common institutional framework but also guaranteed minimum prices and subsidies. These were linked, at least until the 1990s, to production levels. Furthermore, EU affiliation has meant the protection of trade for the primary sector in Europe, excellent access to member country markets and subsidies for exports to third countries, causing prices to exceed international market prices (García Delgado and García Grande 2005; Serrano and Pinilla 2011). On the one hand, it is consequently reasonable to assume that this policy encouraged production, providing security, stability and improved incomes for European farmers, who were thus able to adopt the new technologies available at an impressive rhythm. On the other hand, the European Union policy of price support meant that workforce could be retained in the agricultural sector, lowering productivity.

The results of the model, with a negative sign of the variable $Subsidies_{it}$, makes it clear that the policies of the transfer of income to agriculture, by raising the revenue of farmers, permitted the permanence in this activity of a volume of labour power greater than that which would have existed otherwise. Logically, this affected productivity negatively. Nevertheless, it is necessary to make a considerable number of assumptions for the calculation of this variable, given the scarcity of the existing data, requiring us to be very cautious with their interpretation (see the Appendix for a detailed explanation of its calculation).

With regard to the effect of physical geography, although the final model did not permit the inclusion of the variable used to estimate its impact, we do have some indications regarding a possible relevant influence. The results obtained in the first estimation of random effects (column 1 in Table 5) show a significant disadvantage for the polar bioclimatic zone (*parbpolar*) compared to the western zone, which is the reference. Although the coefficient of belonging to the Mediterranean zone (*parbmediter*) displays the negative sign expected, it is not significant. However, we previously confirmed that the irrigated land area per worker was significant and had a positive influence upon productivity. This shows that the enormous development of hydraulic works in the driest countries permitted them to compensate for their unfavourable environmental conditions. Long hours of sunshine, typical of the Mediterranean countries, permitted (with sufficient water) the development of intensive crops of high value and strong demand.

Furthermore, to make our estimation more robust and to avoid possible reverse causality, we estimate an Instrumental Variables regression without the interactions of the translog function in column 4. To perform these estimations we use as instruments the following lagged variables (for two periods): land, livestock, irrigation, machinery, fertilisers, human capital and GDP per capita[16]. In the last column (G2SLS IV regression)

[16] The introduction of even bigger lags would avoid in greater measure the problems of reverse causality. However, as is logical, it is difficult to expect significant effects on productivity from changes in the use of factors in very distant periods.

our estimations of PCSE (column 3) are clearly robust, because the coefficients and significance do not change, with the exception of the variable *Subsidies*.

It has not been possible to introduce any variable to proxy the influence of biological innovations on European agriculture, especially the selection and hybridisation of seeds and the introduction of new varieties (Olmstead and Rhode 2008; Pujol 2011). Nevertheless, it is reasonable to assume that these changes, together with the use of pesticides and herbicides, raised agricultural productivity; this omission could lead to the overrating of the importance of the variables that we have included in our model.

5. Dynamic specification: a further step

We have shown in Section 2 that differences among the European levels of agricultural labour productivity did not decrease after 1950, as sigma convergence does not exist. Nevertheless, we believe it is interesting to investigate whether the different rhythms of the growth in labour productivity were conditioned by their initial level; that is to say, we have attempted to verify the existence of unconditional beta convergence[17]. To do this, we have performed an analysis with a dynamic specification, namely an analysis with the growth of agricultural labour productivity as the endogenous variable and the initial period of the endogenous variable as an explanatory variable. The dependent variable is the quinquennial logarithmic growth rates of agricultural labour productivity[18]. We performed this estimation using panel data methodology and a linear regression. The first column of Table 6 offers our results. The coefficient is negative and significant at 10%, meaning that the initial level of labour productivity affected the growth of this variable, and thus unconditional convergence existed. The speed of convergence was 1.23%.

[17] For some authors, if sigma convergence does not exist, there is no interest in investigating the existence of beta convergence (Quah, 1993). However, for others, the study of how far the initial levels condition subsequent growth (beta convergence) is interesting in itself (Sala-i-Martin, 1994).

[18] We performed the same estimation with decennial growth rates. The principal results did not change.

This analysis involves accepting the hypothesis that the technologies, environments or institutions of all countries are similar, which is clearly unrealistic, since it would imply that all countries display the same stationary state. Consequently, we have also tried to propose a model to which we add as explanatory variables (at the beginning of each five-year period) the initial level of those used in the model from the previous section. They are in logarithms. Thus, we can test for the existence of conditional convergence. We follow the same estimation procedure as in the previous section. The equation used for the estimation is:

$$\ln(Product_{it}) - \ln(product_{it-1}) = \alpha_i + \beta \ln(product_{it-1}) +$$

$$+ \sum_{i=1}^{n} \gamma_i \ln(x_{it-1}) + \delta_1 \ln(khumans_{it-1}) + \delta_2 ln(GDPpc_{it-1}) + \delta_3 communist_{it-1}$$

$$+ \delta_4 EU_{it-1} + \delta_5 subsidies_{it-1} + \ \delta_6 geo_i + u_{it}$$

The results in Table 6 show that convergence becomes stronger and notably more rapid (6.9%) if we include the explanatory variables for the initial period[19]. In explaining the growth of agricultural labour productivity, the initial level of productivity is negative and significant; that is to say, the lower the initial level of productivity the greater is its growth. The results confirm the existence of different stationary states towards which countries converge, depending on their initial technologies, environments and institutions (Barro and Sala-i-Martin 1992). The variables which determine the different stationary states are the land-labour ratio and machinery per worker. These variables are determinant in explaining the growth of agricultural labour productivity, as they are positive and significant. Thus, the availability of more highly mechanized agriculture and a higher land-labour ratio at the outset facilitate greater agricultural productivity growth. In summary, the use of machinery on large farms helps certain economies of scale to be achieved. This result confirms the argument proposed by O'Brien and Prados (1992, 534), which signals that "by comparison

[19] The Hausman test recommends a fixed effects estimation. Subsequently, we performed the PCSE estimation (column 4).

the long-term growth of most other continental economies seems constrained by a historical legacy of higher population densities coupled with unfavourable land-labour ratios”.

If we include time dummies in the dynamic specification, the principal results do not change, although the percentage of polar land becomes significant. This could reinforce the influence of geography on agricultural productivity. Besides, the non-significance of the Mediterranean area may show that certain geographical obstacles can be solved by investment in irrigation.

6. Conclusions

In recent decades the debate regarding the causes of long-term growth in agriculture has been one of the most intense and lively in economics. Together with the variables which have usually been taken into account, the so-called proximate causes, this debate has broadened its scope by considering further causes, termed fundamental, which are key to explaining such growth. Economic historians have played an important role in the debate, especially if we bear in mind that the contributions of Douglas North and others have been decisive in introducing the role of institutions into the debate regarding growth.

The European economy grew at an extraordinarily fast rate between 1950 and 1973. The oil crisis meant a sharp halt to this trajectory which, although it would restart from the 1980s onwards, would not recover the high rates of the Golden Age. Especially in the explanation of the Golden Age, extensive literature has discussed its causes. In general terms, economic historians, in distinction to agricultural economists, have not paid excessive attention to events in the agricultural sector, despite the importance of its changes. Furthermore, the discussion regarding the reasons stimulating them has not been tackled from a long-term perspective and for the European continent as a whole.

The present study is aimed at filling this void. Our contribution has attempted to connect to the more general discussion regarding the causes of economic growth. In the same way as in the more general debate regarding growth in the Golden Age, technological, institutional, structural change or post-war shock hypotheses have been counterposed; we believe that agricultural growth must be explained by a combination of proximate and fundamental causes. In summary, this requires analysing the income gap which exists among the diverse countries (Gollin et al., 2014 a).

In the last fifty years agriculture has undergone far-reaching transformations, causing the greatest increase in labour productivity in the last two centuries. Agricultural production more than doubled but utilized only twenty per cent of the workers in 2005 compared to 1950. However, although in Europe in this same period productivity growth was extremely rapid, the differences among countries were maintained. The great dispersion of productivities existing in 1950 has not been reduced in the framework of a rapid and generalised increase of such productivities in all countries.

This study has shown that in addition to the variables normally included in a production function, or proximate causes of growth, the so-called fundamental causes also play an important role in explaining differences in agricultural labour productivity.

Among the proximate causes, the results underline the crucial role of land endowment per worker in explaining labour productivity differences. Since the cultivated area fell slightly in most European countries, the sharp differences in the land/labour ratio were marked above all by the distinct intensities of the rural exodus process and by initial differences. These results coincide with those of other studies, whether for Europe in earlier dates or for comparisons with other groups of countries (Sharma et al. 1990; Van Zanden 1991; O'Brien and Prados 1992; Gollin et al., 2014 a).

The increase in land endowment per worker was accompanied by extremely intensive mechanization. Differential capital endowment per worker, fertilisers and, above all, tractors and harvesters, were thus essential. In conclusion, the continuous exodus of labour power from the sector, coupled with the increased use of productive factors originating in other sectors of the economy, caused the efficiency of agricultural workers to rise. The different relative importance of these processes across countries largely explains why labour productivity differences did not decrease and convergence did not exist.

These results enrich the debate on the relationship between economic growth and agricultural transformation. The acceleration of economic growth and the advanced stage of demographic transition generated a strong demand for labour in industry and the service sector (Temin 2002). New technological options (mainly self-propelled machines) meant that the response to the rural exodus was intensive mechanization on Europe's farms. The differences in agricultural labour productivity in Europe were therefore conditioned by distinct levels of development in different countries.

In turn, institutions also affected differences in productivity. We detected a direct relation between membership of the EU and the productivity of agricultural labour. By contrast, this relationship is reversed in the case of Communist bloc membership. Policies of support for agriculture negatively affected agricultural productivity, as they retained active population which otherwise would have abandoned the sector. This demonstrates the importance of the institutional framework in explaining differences in economic growth, and in our case in agricultural productivity. Furthermore, these results clarify the debate on state intervention in agriculture. EU policies tended to raise agricultural productivity, while the total intervention practiced in the centrally planned economies depressed it[20]. Given the contradiction between the boost to productivity of membership of the EU and the negative effect of support for agriculture, subsidising it as in the case of the CAP, it is reasonable to believe that the stimulation of productivity was above all the result of the existence of an integrated market, with the progressive abolition of trade barriers among members. Access to a large market, with the possibility of obtaining certain economies of scale, must have favoured the growth of productivity, stimulating technological improvement. Furthermore,

[20]Obviously, European Union policies also had other effects (e.g. protection or welfare); see Federico (2009).

policies of structural reforms could have played an important role, as they made the achievement of economies of scale and the modernization of farms possible.

The impact of geography on productivity differences, important in traditional agriculture, appears in the second half of the XX century, especially through cold weather and aridity. Furthermore, this latter impact must have been reduced by the extension of irrigated farming to the extremely arid Mediterranean countries, whose high insolation and sufficient water made them highly competitive and substantial producers and exporters of horticultural products. This specialisation, already underway in the second half of the XIX century, was also notably consolidated in the XX century (Pinilla and Ayuda 2010). Lastly, the obstacle for the Scandinavian countries of their extreme climate was not compensated for by the new agricultural technologies employed, which would partly explain the disappointing performance of such countries in terms of labour productivity.

The dynamic model, finally, helps to understand the determinants of agricultural labour productivity growth. The existence of different initial conditions among countries also implies that there are different stationary states. The availability of more highly mechanized agriculture and a higher land-labour ratio at the outset facilitate greater agricultural productivity growth.

Table 1
Labour productivity, production and productive factors in European agriculture, 1950-2005

Europe	Ag. labour productivity ($)	Net ag. prod. ($000,000)	Active ag. pop. (000 people)	Arable land and permanent crops (000 hectares)	Tractors (000 units)	Chemical fertilizers (000 tonnes)	Live animals (000 units of cattle)
1950	1,388	94,319	66,365	150,517	960	6,966	131,849
1962	2,378	129,713	54,592	151,854	4,002	14,803	155,744
1972	3,815	156,730	41,125	142,750	6,530	27,388	163,866
1982	6,173	187,643	30,418	140,337	8,945	31,676	175,453
1992	8,726	193,139	22,143	136,378	9,658	20,865	162,536
2000	11,661	195,392	16,762	131,313	9,520	19,834	148,442
2005	13,627	193,760	14,218	126,741	9,722	19,831	142,230

Annual rates of growth							
1950-1962	4.14	2.69	-1.61	0.07	12.63	6.48	1.40
1962-1972	5.31	1.91	-2.79	-0.62	5.02	6.35	0.51
1972-1982	4.93	1.82	-2.97	-0.17	3.20	1.47	0.69
1982-1992	3.52	0.29	-3.13	-0.29	0.77	-4.09	-0.76
1992-2005	3.49	0.02	-3.35	-0.56	0.05	-0.39	-1.02
1950-2005	4.23	1.32	-2.76	-0.31	4.3	1.92	0.14

Net agricultural production is in millions of international dollars, at 1999-2001 prices. All the data are triennial averages, except agricultural labour productivity, fertilizers, tractors, live animals, arable land and agricultural active population for 1950. The data for production in 1950 is the average between the data for 1950 and 1951. See the Appendix for more details on the data or countries included.
Source: Authors' calculation, from FAOSTAT (2009) and FAO (1948-2004)

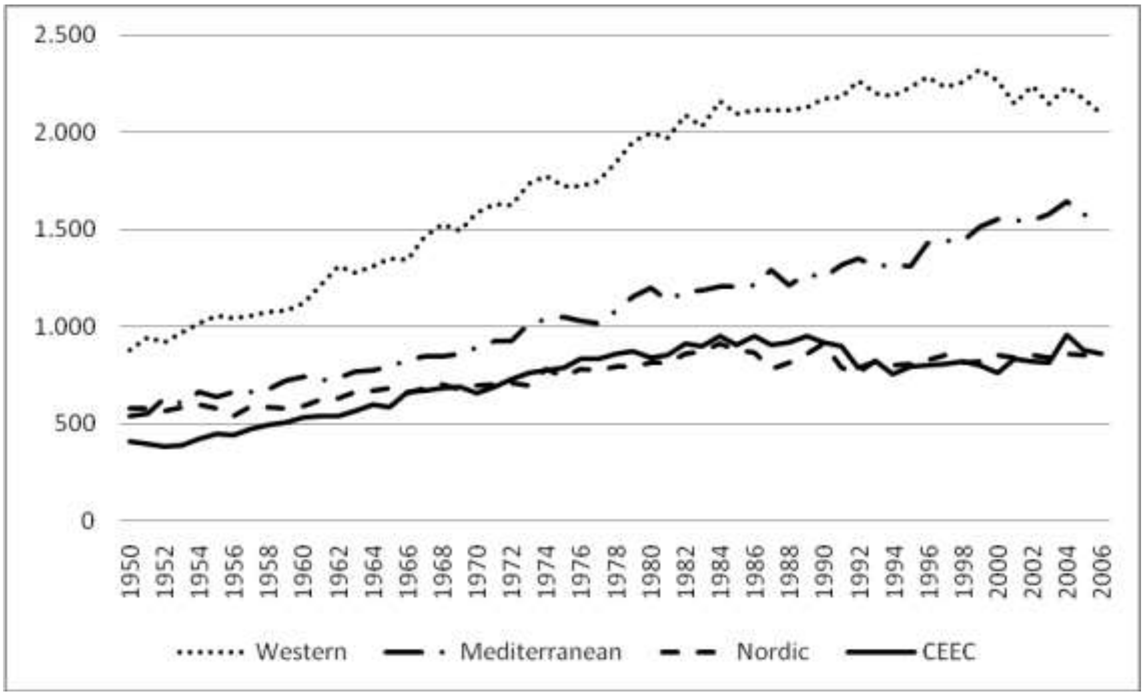
Table 2
Agricultural labour productivity, 1950-2005 (international 1999-2001 prices in dollars per worker) and annual growth rates from 1950 to 2005

	1950	1962	1972	1982	1992	2000	2005	1950-2005
GFR/Germany	1,591	3,988	7,911	12,290	17,237	26,003	31,037	5.45
GDR	1,881	2,985	5,442	7,401	-	-	-	-
Austria	1,207	3,078	5,488	9,539	11,351	16,555	18,284	5.07
Belgium-Luxembourg	4,933	9,906	19,008	30,185	42,341	53,281	58,360	4.59
Denmark	4,661	8,818	11,584	20,757	28,575	40,342	49,308	4.38
France	2,194	5,452	9,597	16,436	25,659	37,584	44,881	5.64
Ireland	2,777	4,435	7,464	12,521	19,671	21,948	21,625	3.80
Netherlands	4,712	9,675	18,142	28,311	32,267	33,997	35,635	3.75
Switzerland	3,581	5,613	7,641	10,494	10,158	11,559	12,859	2.35
United Kingdom	5,775	9,857	15,051	19,119	23,660	25,428	26,132	2.78
Western Europe	**2,935**	**6,285**	**10,756**	**17,397**	**24,040**	**30,522**	**33,774**	4.54
Greece	1,774	1,837	2,974	4,613	6,788	8,057	8,355	2.86
Italy	1,464	2,863	5,290	8,979	12,795	19,122	23,006	5.14
Portugal	1,211	1,752	2,215	1,897	3,490	4,377	4,892	2.57
Spain	1,330	2,017	3,451	6,127	10,361	16,043	18,001	4.85
Mediterranean E.	**1,426**	**2,334**	**3,961**	**6,255**	**9,551**	**13,459**	**15,259**	4.40
Finland	1,093	2,674	3,715	5,705	7,798	10,666	13,476	4.67
Norway	2,115	3,163	4,758	6,453	7,815	9,082	10,190	2.90
Sweden	3,665	5,111	6,883	9,816	11,511	16,050	18,137	2.95
Nordic Europe	**2,140**	**3,634**	**5,004**	**7,374**	**9,186**	**12,197**	**14,297**	3.51
Albania	360	472	593	691	697	1,048	1,191	2.20
Bulgaria	607	1,221	2,597	4,673	6,240	10,195	12,022	5.58
Czechoslovakia	1,324	2,212	3,824	5,156	6,549	6,608	7,576	3.22
Hungary	1,153	1,803	3,386	6,346	7,471	10,018	12,634	4.45
Poland	1,033	1,438	1,835	2,432	2,805	3,290	3,920	2.45
Romania	392	656	1,169	2,182	2,504	3,531	5,835	5.03

Yugoslavia	363	545	888	1,935	3,180	4,038	5,323	5.00
Central and Eastern Europe	**679**	**1,030**	**1,631**	**2,703**	**3,332**	**4,073**	**5,138**	3.75
Europe	**1,388**	**2,378**	**3,815**	**6,173**	**8,726**	**11,661**	**13,627**	4.24

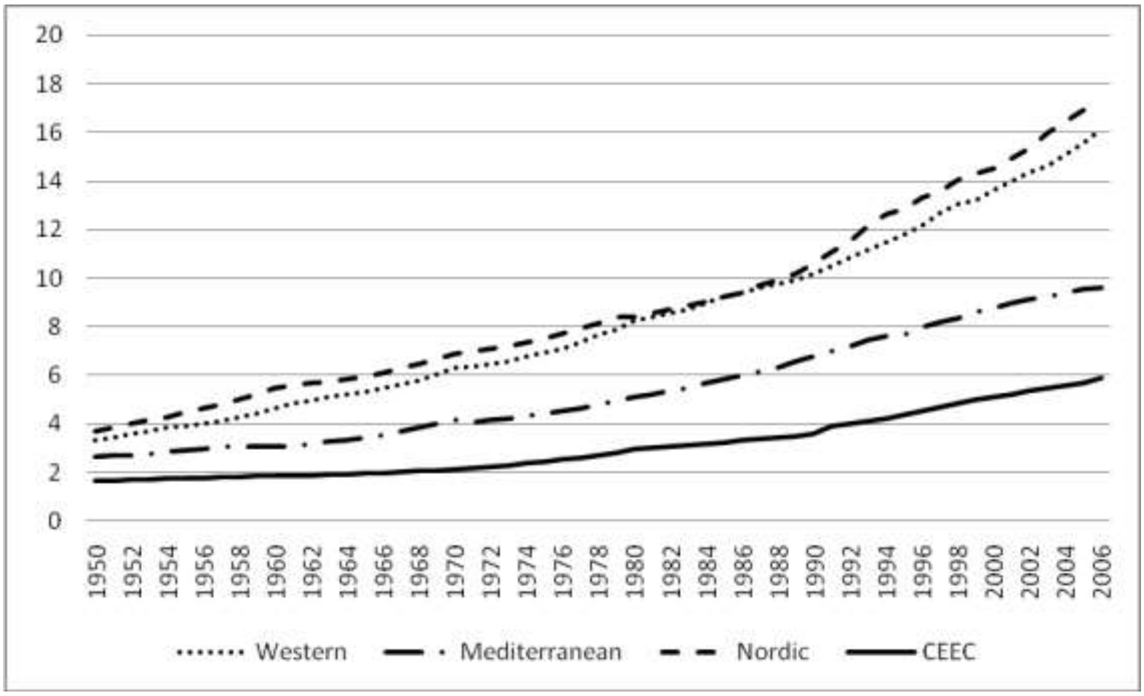
The data for the groups of countries are weighted averages. All the figures are calculated using triennial averages (net production at international prices in dollars for 1999-2001, divided by the total active agricultural population), except for 1950. The calculation for Germany in 1950 has been made considering its productivity as if it were a single country, its value being 1,676. For more details, see the Appendix.
Source: Authors' calculation, from FAOSTAT (2009) and FAO (1948-2004)

Graph 1.Land productivity in European agriculture (international 1999-2001 prices in dollars per hectare)



Source: Authors' calculation, from FAOSTAT (2009) and FAO (1948-2004)

Graph 2. Land-labour ratio in European agriculture, 1950-2005



Source: Authors' calculation, from FAOSTAT (2009) and FAO (1948-2004)

Table 3. Dispersion measures of agricultural labour productivity

	Variance of logarithm of labour productivity	Coefficient of variation	Theil	Herfindahl	Gini	Weighted Coefficient of variation
1950	0.6073	0.7223	0.0763	0.0681	0.2689	0.7466
1955	0.6454	0.7119	0.0754	0.0674	0.2686	0.7665
1960	0.6422	0.7449	0.0802	0.0695	0.2511	0.7941
1965	0.6420	0.7487	0.0807	0.0698	0.2563	0.8327
1970	0.7023	0.7937	0.0884	0.0728	0.2580	0.9044
1975	0.6423	0.7804	0.0846	0.0719	0.2459	0.8497
1980	0.6767	0.8041	0.0894	0.0735	0.2583	0.8546
1985	0.6551	0.7822	0.0861	0.0720	0.2610	0.8589
1990	0.6040	0.7482	0.0797	0.0697	0.2644	0.8478
1995	0.6742	0.7981	0.0890	0.0731	0.2877	0.9132
2000	0.6646	0.7692	0.0846	0.0711	0.2891	0.9014
2005	0.5981	0.7593	0.0811	0.0705	0.2764	0.8727

All the figures are calculated using triennial averages, except for 1950. Furthermore, the same number of countries has been maintained, aggregating the individual country data following the dissolution of Yugoslavia and Czechoslovakia. The active agricultural population percentages for each country as a proportion of the total are used as weightings in the weighted coefficient of variation.
Source: Authors' calculation, from FAOSTAT (2009)

Table 4.Summary statistics of the explanatory variables and number of countries within each institutional variable

		1950	1962	1972	1982	1992	2000	2005
Land per worker	Mean	2.69	3.48	4.51	5.64	7.39	9.59	11.14
	St. Dev.	1.42	2.08	2.70	3.43	4.39	6.01	7.30
Fertilizers per worker	Mean	0.20	0.50	1.12	1.57	1.47	1.65	1.95
	St. Dev.	0.23	0.48	0.89	1.13	1.28	1.38	1.47
Tractors per worker	Mean	0.03	0.14	0.30	0.48	0.62	0.75	0.87
	St. Dev.	0.06	0.14	0.25	0.36	0.43	0.50	0.60
Live animals per worker	Mean	3.32	5.12	7.43	10.16	12.51	15.18	16.48
	St. Dev.	2.53	4.32	6.74	9.01	11.45	14.58	15.28
Irrigation (ha.) per worker	Mean	0.12	0.17	0.34	0.59	0.89	1.23	1.35
	St. Dev.	0.16	0.21	0.34	0.60	0.86	1.17	1.41
Human capital (secondary)	Mean	32.00	57.93	75.12	85.31	96.11	102.39	99.81
	St. Dev.	17.53	24.19	16.06	13.29	13.75	19.04	11.10
GDPpc	Mean	3,774	5,823	8,588	10,437	12,031	14,709	16,402
	St. Dev.	2,190	3,005	3,932	4,468	6,085	7,252	7,595
Institutions (number of countries)	Communist	7	8	8	8	2	1	0
	EU	0	5	5	9	11	14	19
	Subsidies	11	13	12	14	17	20	17
	Open	5	15	16	16	24	28	28

Source: Authors' calculation, from FAOSTAT (2009) and FAO (1948-2004).
The data are triennial averages, except for 1950 and the data for institutions. Albania is omitted in 1950 because of the non-availability of data. To construct this table, we maintain the same number of countries, except for secondary human capital after 1992, since we cannot aggregate the gross enrolment ratio.

Table 5. Econometric results

	RE	FE	PCSE	G2SLS (IV)
Land (a)	-.0957	.4866***	.6576***	.5309***
	.0797	.1003	.0959	.0283
Livestock (l)	.0800***	.0464***	.0512***	.0063***
	.0059	.0042	.0035	.0011
Fertilizer (f)	.2223***	.1655***	.0685**	.1033***
	.0593	.0481	.0308	.0109
Machinery (m)	.3502***	.0775**	.1372***	.0853***
	.0349	.0308	.0413	.0107
Irrigation (i)	.1050***	.0948***	.0595**	.0185***

	.0206	.0256	.0244	.0069
Human Capital	.0573***	.1371***	.0821***	.1519***
	.0056	.0146	.0105	.0161
Communist	-.1675***	-.1058***	-.1187***	-.1290***
	.0203	.0209	.0184	.0191
EU	.0900***	.0538***	.0580***	.0225*
	.0170	.0120	.0107	.0135
Subsidies	-.0655***	-.0323***	-.0295**	-.0134
	.0181	.0125	.0125	.0142
GDPpc	.2637***	.1191***	.1956***	.2378***
	.0187	.0307	.0259	.0294
βaa	.1738***	-.0379	-.0907**	-
	.0369	.0449	.0448	
βff	-.0464**	-.0462***	-.0425***	-
	.0217	.0148	.0127	
βmm	.0133**	-.0021	-.0034	-
	.0066	.0055	.0053	
βll	.0002	-.0006***	-.0006***	-
	.0002	.0001	.0001	
βii	.0121***	.0218***	.0205***	-
	.0025	.0039	.0038	
βam	-.1152***	-.0238**	-.0171	-
	.0132	.0119	.0120	
βaf	.0313	-.0024	.0042	-
	.0213	.0155	.0138	
βal	-.0231***	-.0047**	-.0060***	-
	.0023	.0019	.0017	
βmf	-.0703***	-.0417***	-.0464***	-
	.0148	.0102	.0098	
βml	.0082***	.0024	.0018	-
	.0020	.0015	.0015	
βfl	-.0028	.0007	.0006	-
	.0021	.0014	.0012	
βia	-.0164**	-.0196*	.0041	-
	.0078	.0105	.0096	
βim	.0107***	-.0053*	-.0080***	-
	.0033	.0029	.0030	
βif	-.0015	-.0050	-.0071**	-
	.0060	.0041	.0036	
βil	.0021***	.0019***	.0019***	-
	.0007	.0005	.0004	
Parbpolar	-.5736***	-	-	-
	.0254			
Parbmediter	-.0138	-	-	-
	.0256			
Constant	6.6418***	7.9223***	.0002	7.0712***
	.2161	.3845	.0024	.3522
R^2 within	0.9669	0.9795	0.8982	0.9643
No. observations	1,411	1,411	1,411	1,347

The data below the coefficients are the standard deviations. The coefficients *, ** and *** are significant at 10, 5 and 1% respectively. The variables in the PCSE estimation are transformed into deviations according to their individual, temporal and overall average. The interaction coefficients β have a subscript corresponding to the first five variables. The letters in parentheses, close to the name of the variables, correspond to the sub-index in the group of β. All the variables are in logarithms, except *parbpolar*, *parbmediter*, *comunist*, *eu* and *subsidies*. We have not included in the table the elevated number of time dummies in the model. The coefficients and their standard deviations are available on request. The value of R^2 within the PCSE estimation corresponds to R^2.

Table 6. Results of dynamic specification

	PCSE	RE	FE	PCSE	RE robust
Productivity	-.0123*	-.0446***	-.0839***	-.0691***	-.0435***
	.0072	.0133	.0161	.0163	.0146
Land	-	.0319***	.0636***	.0628***	.0305**
		.0111	.0176	.0197	.0149
Livestock	-	.0001	.0001	-.0001	-.0001
		.0006	.0006	.0004	.0004
Fertilisers	-	-.0001	-.0001	.0017	.0033
		.0053	.0054	.0042	.0048
Machinery	-	.0126***	.0173***	.0235***	.0178**
		.0042	.0052	.0078	.0084
Irrigation	-	-.0045*	-.0044	-.0053	-.0025
		.0026	.0040	.0030	.0024
GDPpc	-	.0028	-.0067	-.0034	.0092
		.0115	.0146	.0162	.0146
Human capital	-	.0018	.0149*	-.0049	.0064
		.0043	.0088	.0057	.0051
Communist	-	-.0033	.0050	.0147	-.0025
		.0101	.0112	.0133	.0159
EU	-	-.0042	-.0013	-.0012	-.0037
		.0074	.0075	.0067	.0087
Subsidies	-	-.0025	-.0089	-.0098	-.0084
		.0074	.0075	.0072	.0110
Parbpolar	-	-.0404	-	-	-.0567***
		.0250			.0195
Parbmediter	-	.0005	-	-	.0121
		.0224			.0229
Constant	.0000	.3839***	.8880***	-.0002	.3487**
	.0019	.1327	.2168	.0017	.1479
Time dummies	No	No	No	No	Yes
R^2 within	0.0145	0.1588	0.1833	0.1423	0.1866
No. observations	303	303	303	303	303

The data below the coefficients are the standard deviations. The coefficients *, ** and *** are significant at 10, 5 and 1% respectively. The variables in the PCSE estimation are transformed into deviations according to their individual, temporal and overall average. All the variables are in logarithms, except *parbpolar*, *parbmediter*, *communist*, *eu* and *subsidies*. We have not included in the table the high number of time dummies in the model. The coefficients and their standard deviations are available on request. The value of R^2 within the PCSE estimation corresponds to R^2.

Acknowledgements:

This study has received financial support from the Ministry of Science and Innovation of Spain, project ECO 2012-33286 and the Ministry of Education's FPU Programme, and from the Government of Aragon, through the Research Group ‘Agrifood Economic History (19th and 20th Centuries)’. We are grateful for the comments received from the editor and from the anonymous referees as well as the participants in the Economic History Seminar at the University of Zaragoza, the Rural History 2010 Conference (University of Sussex), the First Annual Conference of the Spanish Agricultural History Society (SEHA), the First Quantitative Agricultural and Natural Resources History Conference (Agricliometrics I, 2011), the Agriculture and Economic Development in Europe Conference organized by the Russian Academy of *National Economy*, the Gaidar Forum and the New Economic School of Moscow (2012), the VII European Historical Economics Society Summer School and for those made by Bob Allen, Ernesto Clar, Domingo Gallego, Peter Moser, Cormac Ó Gráda, Josep Pujol, Joan Rosés, Mar Rubio and Daniel Tirado. We also wish to thank Ana Angulo, Francisco Beltrán, Fernando Collantes, Michael Kopsidis and Mark Spoerer for their help, and Roberto Serrano for his work with the geographical variables.

References

Acemoglu D (forthcoming) Localized and Biased Technologies: Atkinson and Stiglitz’s New View, Induced Innovations, and Directed Technological Change. Economic Journal.

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

Allen RC (1992) Enclosure and the Yeoman: the Agricultural Development of the South Midlands 1450-1850. Oxford University Press, Clarendon Press, Oxford; New York; Toronto and Melbourne

Allen RC (1994) Agriculture during the Industrial Revolution. In: Floud R, McCloskey DN (eds) The Economic History of Britain since 1700, vol 1. Cambridge University Press, Cambridge, pp 96-122

Allen RC (2003) Farm to factory: A reinterpretation of the Soviet industrial revolution. Princeton Economic History of the Western World Series. Princeton University Press, Princeton and Oxford

Allen RC (2009) Engels' Pause: Technical Change, Capital Accumulation and Inequality in the British Industrial Revolution. Explorations in Economic History 46 (4):418-435. doi:http://www.sciencedirect.com/science/journal/00144983

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

Andréosso-O'Callaghan B (2003) The economics of European agriculture. Palgrave Macmillan, 2003, Houndmills

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

Ayuda MI, Collantes F, Pinilla V (2010) From locational fundamentals to increasing returns: The spatial concentration of population in Spain, 1787-2000. Journal of GeographicalSystems 12 (1):25-50. doi:10.1007/s10109-009-0092-x

Bairoch P (1999) L'agriculture des pays développés: 1800 à nos jours. Economica, cop. 1999, Paris

Baltagi BH (2005) Econometric analysis of panel data. John Wiley & Sons, 2005. 3rd ed, Chichester.

Barro RJ, Sala-I-Martin X (1992) Convergence. Journal of Political Economy:223-251

Beck N, Katz JN (1995) What to Do (and Not to Do) with Time-Series Cross-Section Data. American Political Science Review 89 (3):634-647. doi:http://journals.cambridge.org/action/displayBackIssues?jid=PSR

Brassley P (2000) Output and technical change in twentieth-century British agriculture. Agricultural History Review 48 (1):60-84

Broadberry S, O'Rourke K (2010) The Cambridge Economic History of Modern Europe. Vol. 2, 1870 to the present. Cambridge University Press, New York

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

Chorley GPH (1981) The Agricultural Revolution in Northern Europe, 1750-1880: Nitrogen, Legumes, and Crop Productivity. Economic History Review 34 (1):71-93

Christensen LR, Jorgenson DW, Lau LJ (1973) Transcendental Logarithmic Production Frontiers. Review of Economics & Statistics 55 (1):28

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, Pinilla V (2009) Agriculture and Economic Development in Spain, 1870-1973. In: Lains P, Pinilla, V (ed) Agriculture and Economic Development in Europe since 1870. Routledge, London, pp 311-332

Clark G (1987) Productivity Growth without Technical Change in European Agriculture before 1850. Journal of Economic History 47 (2):419

Collantes F, Pinilla V (2011) Peaceful Surrender: The Depopulation of Rural Spain in the Twentieth Century. Cambridge Scholars Publishing, Newcastle

Crafts N (2010) The Contribution of New Technology to Economic Growth: Lessons from Economic History. Revista de Historia Economica 28 (3):409-440. doi:http://journals.cambridge.org/action/displayBackIssues?jid=RHE

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

Diamond D, Bettis L, Ramsson R (1983) Agricultural Production. In: Bergson A, Levine HS (eds) The Soviet Economy: toward the year 2000. Allen & Unwin, Boston

Eichengreen B, Ritschl A (2009) Understanding West German economic growth in the 1950s. Cliometrica 3 (3):191-219. doi:10.1007/s11698-008-0035-7

Ezcurra R, Iráizoz B, Pascual P, Rapún M (2011) Agricultural productivity in the European regions: Trends and explanatory factors. European Urban and Regional Studies 18 (2):113-135. doi:10.1177/0969776410381037

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

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

Federico G (2003) A capital intensive innovation in a capital-scarce world: Steam-threshing in nineteenth century Italy. Advances in Agricultural Economic History 2:75-114.

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

Federico G (2005b) Why are we all alive? The growth of agricultural productivity and its causes, 1800-2000. Paper presented at the Sixth Conference of the European Historical Economics Society, Istanbul, 9-10 September 2005

Federico G (2009) Was the CAP the worst agricultural policy of the 20th century? In: Patel KK (ed) Fertile Ground for Europe? The History of European Integration and the Common Agricultural Policy since 1945. Nomos, Baden-Baden, pp 257-272

Fennell R (1997) The Common Agricultural Policy: Continuity and Change. Clarendon Press, Oxford

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

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,

Gallup JL (1998) Agricultural Productivity and Geography. Unpublished work

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

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

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

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

González de Molina M (2001) Condicionamientos ambientales del crecimiento agrario español (siglos XIX y XX). In: Pujol-Andreu J, Gónzalez de Molina M, Fernández-Prieto L, Gallego D, Garrabou R (eds) El pozo de todos los males: Sobre el atraso de la agricultura española contemporánea. Crítica, Barcelona,

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

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

Henrichsmeyer W, Ostermeyer-Schlöder A (1988) Productivity growth and factor adjustment in EC agriculture. European Review of Agricultural Economics 15 (2/3):137-154

Houpt S, Lains P, Schön L (2010) Sectorial Developments, 1950-2000. In: Broadberry S, O'Rourke K (eds) Cambridge Economic History of Modern Europe. Volume II: 1870 to the Present. Cambridge University Press, Cambridge, pp 333-359

Hsiao C (1999) Analysis of panel data. Cambridge University Press, Cambridge

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 intercountry agricultural production function and productivity differences among countries. Journal of Development Economics 19 (1-2):113-132

Lains P, Pinilla V (2009) Agriculture and economic development in Europe since 1870. Routledge, London and 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, London

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

Maddison A (1991) Dynamics Forces in Capitalist Development. A long-run comparative view. Oxford University Press, New York

Maddison A (2010) Historical Statistics of the World Economy: 1-2008 AD. http://www.ggdc.net/maddison/Maddison.htm

Martín-Retortillo M, Pinilla V (forthcoming) Patterns and causes of growth of European agricultural production, 1950-2005. Agricultural History Review.

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

Mundlak Y (2001) Production and Supply. In: Gardner BL, Rausser GC (eds) Handbook of agricultural economics. Volume 1A. Agricultural production. Handbooks in Economics, vol. 18. Elsevier Science, North-Holland, Amsterdam; London and New York, pp 3-85

Mundlak Y, Larson DF, Butzer R (1999) Rethinking within and between Regressions: The Case of Agricultural Production Functions. Annales d'Economie et de Statistique (55-56): 475-501. doi:http://annales.ensae.fr/

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

Nunn N, Puga D (2012) Ruggedness: The blessing of bad geography in Africa. Review of Economics and Statistics 94 (1):20-36. doi:10.1162/REST_a_00161

O'Brien PK, Prados de la Escosura L (1992) Agricultural Productivity and European Industrialization, 1890-1980. Economic History Review 45 (3):514-536. doi:http://www.wiley.com/bw/journal.asp?ref=0013-0117&site=1

Olmstead AL, Rhode PW (2002) The Red Queen and the Hard Reds: Productivity growth in American wheat, 1800-1940. Journal of Economic History 62 (4):929-966. doi:10.1017/s0022050702001602

Olmstead AL, Rhode PW (2008) Creating Abundance: Biological Innovation and American Agricultural Development. Cambridge University Press, Cambridge and New York

Pablo-Romero MDP, Gómez-Calero MDLP (2013) A translog production function for the Spanish provinces: Impact of the human and physical capital in economic growth. Economic Modelling 32 (1):77-87. doi:10.1016/j.econmod.2013.01.040

Pinilla V, Ayuda MI (2010) Taking advantage of globalization? Spain and the building of the international market in Mediterranean horticultural products, 1850-1935. European Review of Economic History 14 (2):239-274. doi:10.1017/s136149161000002x

Pinilla V, Serrano R (2009) Agricultural and Food Trade in the European Community since 1963. In: Patel KK (ed) Fertile Ground for Europe? The History of European Integration and the Common Agricultural Policy since 1945. Nomos, Baden-Baden, pp 273-300

Pujol-Andreu J (2011) Wheat varieties and technological change in Europe, 19th and 20th centuries: New issues in economic history. Historia Agraria (54):71-103

Quah D (1993) Galton's Fallacy and Tests of the Convergence Hypothesis. Scandinavian Journal of Economics 95 (4):427-443

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

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

Sala i Martin X (1994) Apuntes de crecimiento económico. Antoni Bosch, Barcelona

Serrano R, Pinilla V (2011) Agricultural and food trade in European Union countries, 1963-2000: A gravity equation approach. Economies et Sociétés 43:191-219

Sharma KC, Prasada Rao DS, Shepherd WF (1990) Productivity of agricultural labour and land: An international comparison. Agricultural Economics 4 (1):1-12

Spoerer M (2010) "Fortress Europe" in long-term perspective: agricultural protection in the European Community, 1957-2003. Journal of European Integration History 16 (2):143-162

Temin P (2002) The Golden Age of European Growth Reconsidered. European Review of Economic History 6 (1):3-22. doi:http://ereh.oxfordjournals.org/content/by/year

Tracy M (1989) Government and agriculture in Western Europe, 1880-1988. 3rd edn. Harvester Wheatsheaf, New York

Van Zanden JL (1991) The First Green Revolution: The Growth of Production and Productivity in European Agriculture, 1870-1914. Economic History Review 44 (2): 215-239. doi:http://www.wiley.com/bw/journal.asp?ref=0013-0117&site=1

Vonyo T (2008) Post-war Reconstruction and the Golden Age of Economic Growth. European Review of Economic History 12 (2):221-241. doi:http://ereh.oxfordjournals.org/content/by/year

Wang SL, Schimmelpfennig D, Fuglie KO (2012) Is agricultural productivity growth slowing in western Europe? In: Fuglie KO, Wang SL, Ball VE (eds) Productivity Growth in Agriculture: An International Perspective. CABI Publishing, Oxfordshire, pp 109-125

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

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