

Patterns and causes of the growth of European agricultural production, 1950 to 2005*

by Miguel Martín-Retortillo and Vicente Pinilla

Abstract

The objective of this article is to determine the principal causes of the rapid agricultural growth on the European continent between 1950 and 2005. To this end it is essential to calculate the relative contributions made to the growth of agricultural output by the increase in inputs or in total factor productivity (TFP). Our results identify three different models to explain the growth of European agricultural output. That of the Western European countries was principally based on a rapid growth of TFP. The opposing model is that of the Central and Eastern European countries, where heavy capital investment was crucial and the contribution of TFP was slight. Finally, the Mediterranean and Nordic countries are located in an intermediate position, with a contribution of capital higher than in the Western European countries but clearly lower than in the planned economies.

In recent decades changes in the agricultural sector have permitted a rapid increase in production, replacing the productive factors most commonly used in traditional agriculture (land and labour) by capital; the sector has, in addition, made increasing use of new technologies. This intensive process of agricultural transformation in the developed countries (and also that experienced later by developing countries) has been the subject of close attention by researchers. Many authors, such as Federico (2005 and 2011), Hayami and Ruttan (1985), Mundlak (2000), Gardner and Raussier (2001 and 2002), Evenson and Pinghali (2007 and 2009) and Grigg (1982 and 1992) have contributed to an improved understanding of the modernization of agriculture, from both theoretical and empirical viewpoints.¹ The analysis

* This study has received financial support from the Ministry of Science and Innovation of the Government of Spain, project ECO 2012–33286 and the Ministry of Education's FPU Programme. It has also received backing from the Government of Aragon, through the Research Group 'Agrifood Economic History (19th and 20th Centuries)'. We are grateful for the comments received on its presentation to the ninth European Social Science History Conference and the Economic History seminars at the universities of Lund and Zaragoza. We also wish to thank Joan Rosés for his help.

¹ G. Federico, *Feeding the world: an economic history of agriculture, 1800–2000* (2005), and id., *Breve historia económica de la agricultura [A short economic history of agriculture]* (2011); Y. Hayami and V. Ruttan, *Agricultural development: an international perspective* (1985); Y. Mundlak, *Agriculture and economic growth: theory and measurement* (2000); B. L. Gardner and G. C. Raussier (eds), *Handbook of agricultural economics* (4 vols, 2001 and 2002); R. Evenson and P. Pinghali (eds), *Handbook of agricultural economics* (2 vols, 2007 and 2009); D. Grigg, *The dynamics of agricultural change: the historical experience* (1982) and id., *The transformation of agriculture in the west* (1992).

of European agriculture in the decades prior to 1945 or the years immediately following has generated significant interest on the part of researchers, who have contributed both national case studies and comparative studies of various European countries.²

In the opinion of the present authors, the literature still lacks studies which concentrate, from a long-term perspective, on the transformations which have taken place since the Second World War on the European continent, and which include both the Western countries and those which belonged for many years to the Communist bloc.

Against this background, our objective is to determine the principal causes of agricultural growth, that is to say the relative contribution of inputs and total factor productivity (TFP) on the European continent between the Second World War and the beginning of the twenty-first century. Our effort is part of an attempt, for a significant part of European economic history, to extend the analysis of the evolution of the different national cases by using comparative perspectives that include a considerable number of countries.³ Several previous studies of agricultural economics have estimated and analysed the growth of TFP in European agriculture for shorter time periods but there has been no previous attempt to achieve the overview presented here.⁴

We wish to verify whether Europe fulfils the hypothesis of Federico, namely that agricultural growth in this period has been intensive.⁵ That is to say, it has been based above all on the increase in TFP, as against the model of extensive growth, based on the increase in inputs, which was characteristic of the nineteenth century. We intend to go further and attempt to see whether there was a single pattern of agricultural growth for the European continent or whether different models can be discerned.

To achieve these objectives, we need to calculate the relative contributions made to the growth of agricultural output between 1950 and 2005 by the increase in inputs and by total factor productivity. This requires the previous reconstruction for this time horizon of the

² P. L. Yates, *Food, land and manpower in western Europe* (1960); F. Dovring, *Land and labour in Europe in the twentieth century: a comparative survey of recent agrarian history* (1965); M. Tracy, *Government and agriculture in western Europe, 1880–1988* (1989); J. L. Van Zanden, ‘The first green revolution: the growth of production and productivity in European agriculture, 1870–1914’, *EcHR* 44 (1991), pp. 215–39; P. K. O’Brien and L. Prados De La Escosura, ‘Agricultural productivity and European industrialization, 1890–1980’, *EcHR* 45 (1992), pp. 514–36; P. Lains and V. Pinilla, *Agriculture and economic development in Europe since 1870* (2009); M. Olsson and P. Svensson (eds), *Growth and stagnation in European historical agriculture* (2011).

³ S. Broadberry and K. O’Rourke (eds), *Cambridge economic history of modern Europe* (2 vols, 2010) offers a full and recent synthesis of the economic history of the continent since 1700.

⁴ L. F. Wong and V. Ruttan, ‘A comparative analysis of agricultural productivity trends in centrally planned economies’, in K. R. Gray (eds), *Soviet agriculture:*

comparative perspectives (1990); C. Thirtle and P. Bottomley, ‘Total factor productivity in UK agriculture, 1967–90’, *J. Agricultural Economics* 43 (1992) pp. 381–400; K. O. Fuglie, ‘Is a slowdown in agricultural productivity growth contributing to the rise in commodity prices?’, *Agricultural Economics* 39 (2008), pp. 431–41; V. E. Ball, J. P. Butault, C. San Juan and R. Mora, ‘Productivity and international competitiveness of agriculture in the European Union and the United States’, *Agricultural Economics* 41 (2010), pp. 611–27; K. O. Fuglie, ‘Total Factor Productivity in the global agricultural economy: Evidence from FAO data’, in J. M. Alston, B. Babcock and P. G. Pardey (eds), *The shifting patterns of agricultural production and productivity worldwide* (Ames, Iowa: Midwest Agribusiness Trade and Research Information Center, 2010), pp. 63–95; K. O. Fuglie, ‘Productivity growth and technology capital in the global agricultural economy’, in K. O. Fuglie, S. L. Wang and V. E. Ball (eds), *Productivity growth in agriculture: An international perspective* (2012).

⁵ Federico, *Feeding the world*.

series of variables necessary: inputs (labour, land and capital) and output. Part of these data can be obtained directly from the FAOSTAT databases.⁶ In some cases it has been necessary to undertake additional estimations and calculations. These estimates have been especially important for the 1950s, for countries with centrally planned economies and for Germany until its unification process. The procedure we have used to estimate TFP is that termed the Solow residual, and in particular the methodology of 'growth accounting', which in turn takes into account the possibility that the relative intensity of factor use varies over the study period.

The European continent has certain characteristics which justify our selection and underline its interest. Some of the countries which comprise it were pioneers in the industrial revolution, and thus by 1950 had travelled a long way along the path of economic development. Others, by contrast, had been left behind. In addition, the institutional divergence caused by the division of the continent into two political and economic blocs from 1945 onwards permits us to contrast the importance of institutional factors in the processes of economic growth.

The period on which we shall concentrate, that subsequent to the Second World War, is of great importance. In the agricultural sector, we see the adoption on a substantial scale of agricultural machinery, chemical fertilizers, pesticides and herbicides, the development of intensive livestock breeding, improved breeds of animals, better access to agricultural credit, the genetic selection of seeds and the expansion of irrigated farming.⁷ Furthermore, from the institutional point of view this is a historic period in which the continent was reconstructed following World War II. The European Economic Community – the future European Union – was created and subsequently expanded. Finally, various Central and Eastern European countries remained under a Communist regime for over 40 years in this period, their transition towards a market economy taking place only subsequently.

To achieve our objectives, the article adopts the following structure. First, we analyse the evolution of agricultural production. Next, we examine the patterns and intensity of the use of productive factors. Subsequently, we analyse the causes of the growth of output: technical progress and the increase in TFP.

I

Here we clarify the different trends in agricultural production among the European countries. Table 1 shows that European agricultural production increased sharply from 1950 until the mid-1980s, from when stagnated. The evolution of production can be analysed in greater

⁶ The data for agricultural production in FAOSTAT was in constant prices. FAOSTAT, *FAO Database*. faostat.fao.org. (2009), Accessed June 2009 and April 2010. One recent article 'find(s) essentially no disagreement between the FAO yield data and the many micro estimates of grain yields'. D. Gollin, D. Lagakos and M. E. Waugh, 'Agricultural productivity differences across countries', *American Economic Rev.* 104 (2004), p. 169.

⁷ Grigg, *Transformation*; B. Gardner, *European*

agriculture: policies, production and trade (1996); R. E. Evenson and D. Gollin, 'Assessing the impact of the Green Revolution, 1960 to 2000', *Science* 300 (2003), pp. 758–62; Federico, *Feeding the world*; M. Mazoyer and L. Roudart, *A history of world agriculture: from the Neolithic age to the current crisis* (2006); T. Josling, 'Western Europe', in K. Anderson (ed.), *Distortions to agricultural incentives: a global perspective, 1955–2007* (2009).

TABLE 1. Net production (millions of \$US) (1999–2001 prices)

	<i>Pre-war</i>	1950	1962	1972	1982	1992	2000	2005
Western Europe	30,763	32,945	47,292	56,190	67,629	73,194	73,329	71,238
Mediterranean Europe	23,225	22,797	31,912	38,515	46,586	51,011	54,755	54,144
Nordic Europe	3,604	4,015	4,465	4,478	5,192	4,717	4,848	4,903
Central and Eastern Europe	n.a.	20,059	28,074	36,220	43,109	39,311	36,118	38,031
GFR/Germany	8,846	8,050	13,764	15,540	18,350	24,906	26,342	25,443
GDR	n.a.	3,971	4,206	5,787	6,777	–	–	–
France	14,038	14,272	22,538	26,754	30,588	31,894	33,071	32,425
United Kingdom	5,929	7,213	9,211	10,957	13,411	14,348	13,425	13,075
Italy	12,086	12,610	16,976	19,972	23,782	23,881	23,981	23,663
Spain	7,253	6,214	9,296	12,069	15,128	18,080	21,241	21,482
Poland	n.a.	7,053	9,956	11,934	12,755	13,136	12,386	13,138
European market economies	66,438	67,807	97,433	114,723	137,758	153,828	159,273	155,728
Europe	n.a.	94,412	129,713	156,730	187,643	193,139	195,392	193,760

Note: The data presented, except the pre-war level, are triennial averages centered on the benchmark year. The data for 1950 are the average between 1950 and 1951 for the GDR, Central and Eastern Europe, Poland and Europe. The GFR/Germany row displays data from the Federal Republic of Germany until 1992; from that year on the data are for the reunified Germany. See the Appendix for the composition of the groups and the definition of the pre-war level.

Source: Authors' compilation, using data from *FAO production yearbook*, 1948–1976, *FAO production yearbook*, 1977–1986; *FAO production yearbook*, 1987–2004; FAOSTAT, *FAO Database*.faostat.fao.org. (2009), Accessed June 2009 and April 2010. For details, see the Appendix.

detail. Post-war recovery was rapid despite the serious distortions and destruction caused by the war.⁸ By 1950 the pre-war level of production had not only been regained but exceeded. In general, the greater the involvement of a country in the conflict, the smaller was the increase in its production. Two cases are notable for their slow recovery. The first is that of the German Federal Republic, which by 1950 had not yet recovered its pre-war level. This contrasts with the UK and Switzerland, less affected by the war, in which production was 22 and 9 per cent higher respectively, comparing the pre-war level to 1950. The second is Spain, which did not participate directly in the conflict and had ended its civil war in 1939; it was gravely affected by the subsequent policies of the Franco dictatorship and the international isolation of the country.⁹

Following the recovery immediately after the War, a further sharp increase in production took place in the 1950s. In the market economies the annual growth of production was

⁸ G. Federico, '*Natura non fecit saltus*: The 1930s as the discontinuity in the history of European agriculture', in P. Brassley, Y. Segers and L. Van Molle (eds), *War, agriculture and food: rural Europe from the 1930s to the 1950s* (2012), pp. 15–32.

⁹ E. Clar and V. Pinilla, 'Agriculture and economic development in Spain, 1870–1973', in P. Lains and V. Pinilla (eds), *Agriculture and economic development*, pp. 311–32.

3.07 per cent between 1950 and 1962. In those years there was great institutional preoccupation with resolving the food shortages of the war and subsequent years.¹⁰ The agricultural sector was also considered to have a strategic role to play in the economy. In addition, the sector continued to employ a great number of workers in those years.¹¹ Encouragement was given to improve access to agricultural credit and favour in this way the capitalization of the sector.¹² For example, France, although it was not an isolated case, dedicated part of its resources from the Marshall Plan to distributing fertilizers and mechanical equipment.¹³

In general, the Western European countries implemented policies of support for their agricultural sectors; these increased state intervention in the sector and stimulated production. In imitation of the state intervention in agriculture initiated in the United States during the Great Depression, and continuing the policies of the control of production and consumption developed during World War Two, the Western European countries maintained controlled markets in the agricultural sector.¹⁴ Agricultural policy explicitly sought self-sufficiency in food and an increase in agricultural productivity in the European countries.¹⁵ In this context, the European Economic Community was formed in 1957 and the Common Agricultural Policy (henceforth CAP) in 1962. This meant no radical break with the previous policies of the member states, but instead a homogenization and convergence among them. The objectives for the agricultural sector contained in the Treaty of Rome were the increase of productivity, the guarantee of reasonable prices for consumers, the achievement of an equitable standard of living for farmers, market stability and guaranteed supply. The development of this treaty, through the CAP, left its mark on the agricultural sector for decades, especially until 1992 and the MacSharry reform.

During the first decades of its existence the CAP fixed high prices for a substantial part of agricultural production, normally taking as reference the highest price for each product from among the founding countries. This policy of high prices, generally much higher than those in the international market, stimulated an increase in production. The natural result of this policy was also that agriculture in the European Economic Community needed strong commercial protection.¹⁶

The result of guaranteed high prices, strong protection and the close and deep integration of markets among the member states was a considerable increase in production and productivity,

¹⁰ S. Glynn and A. Booth, *Modern Britain: an economic and social history* (1996) and J. P. Dormois, *The French economy in the twentieth century* (2004).

¹¹ B. Andreosso-O'Callaghan, *The economics of European agriculture* (2003).

¹² B. J. Nordstrom, *Scandinavia since 1500* (2000).

¹³ Dormois, *French economy*; Josling, 'Western Europe'; Nordstrom, *Scandinavia*; K. J. V. Jespersen, *A history of Denmark* (2004) and V. Zamagni, *The economic history of Italy, 1860–1990* (1993); J. Bieleman, *Five centuries of farming: A short history of Dutch agriculture, 1500–2000* (2010).

¹⁴ Federico, 'Natura non fecit saltus'.

¹⁵ J. R. Lampe, *The Bulgarian economy in the*

twentieth century (1986); Z. Landau and J. Tomaszewski, *The Polish economy in the 20th century* (1985); R. Fennell, *The Common Agricultural Policy: Continuity and change* (1997); J. L. García Delgado and M. J. García Grande, 'Nacimiento y desarrollo de una idea: de la Conferencia de Stressa en 1958 a la Reforma MacSharry en 1992', in J. L. García Delgado and M. J. García Grande (eds), *Política agraria común: balance y perspectivas [Common Agricultural Policy: Review and perspectives]* (2005); L. Neal, *The economics of Europe and the European Union* (2007).

¹⁶ Tracy, *Government*; Gardner, *European agriculture*; Andreosso-O'Callaghan, *Economics*; Neal, *Economics of Europe*.

the relatively quick achievement of self-sufficiency in food and a sudden change in the European position in international markets for agricultural products.¹⁷ Technological innovation made it easier for these policies to stimulate a strong increase in production. Agricultural trade among the member countries increased considerably, while there was a significant fall in their participation in international markets as importers.¹⁸

Furthermore, certain countries displayed spectacular growth in that decade. Thus, in the United Kingdom, in the period between the Second World War and the mid-1960s, there took place the greatest growth in agricultural output since the 1870s.¹⁹ Another notable case is that of the Federal Republic of Germany, whose production rose by almost 4 per cent annually; the 1950s and 1960s have been described as an 'economic miracle'.²⁰

In the countries of the Communist bloc the change in agricultural structures was total, as the consequence of the imposition of the Soviet model. Planning also boosted production, specifically at an annual growth rate of 2.84 per cent in the 1950s.²¹ Despite this impulse, there was a continuance of the distortions that began with the institutional changes following the war, due to the processes of collectivization and price and salary regulation.²²

The growth of production continued in the 1960s and 1970s. In the market economies there was some slowing down of the sharp increase in output of the previous decade, which nevertheless grew by 1.65 per cent annually between 1962 and 1972 and by 1.85 per cent in the following decade. The country with the fastest growth was Spain, expanding by 2.46 per cent per annum between 1962 and 1982. This may be explained by the opening of the Spanish economy by the Stabilization and Liberalization Plan in 1959, which produced generalized economic growth and the rapid adoption of Western technology.²³ Another notable case is that of the countries of the Communist bloc, with a rapid annual growth of 2.16 per cent in the 1960s and 1970s, although with many differences among them.²⁴ There were frequent

¹⁷ In some products, this self-sufficiency was achieved as early as the end of the 1950s in some countries forming the European Economic Community, but in the 1960s and 1970s in the remainder. Tracy, *Government*; Fennell, *Common Agricultural Policy*. For the change in the European position in world agricultural markets, see G. Aparicio, V. Pinilla and R. Serrano, 'Europe and the international agricultural and food trade, 1870–2000', in Lains and Pinilla (eds), *Agriculture and Economic Development in Europe*, pp. 52–75.

¹⁸ V. Pinilla and R. Serrano, 'Agricultural and food trade in the European Community since 1963', in K. K. Patel (ed.), *Fertile ground for Europe? The history of European integration and the Common Agricultural Policy since 1945* (2009) pp. 273–300; R. Serrano and V. Pinilla, 'Agricultural and food trade in European Union countries, 1963–2000: a gravity equation approach', *Economies et Sociétés, Série Histoire économique quantitative*, AF 43 (2011), pp. 191–219.

¹⁹ P. Brassley, 'Output and technical change in twentieth-century British agriculture', *AgHR* 48 (2000) pp. 60–84.

²⁰ G. A. Wilson and O. J. Wilson, *German agriculture in transition: society, policies and environment in a changing Europe* (2001).

²¹ The GDR was an exception to this growth, as its annual increase amounted to only 0.48 per cent.

²² I. T. Berend and G. Ránki, *The Hungarian economy in the twentieth century* (1985); Landau and Tomaszewski, *Polish economy*; Lampe, *Bulgarian*; F. L. Pryor, *The red and the green: the rise and fall of collectivized agriculture in Marxist regimes* (1992); K. Anderson and J. Swinnen, 'Eastern Europe and Central Asia', in K. Anderson (ed.), *Distortions to agricultural incentives: a global perspective, 1955–2007* (2009).

²³ E. Reig and A. Picazo, *La agricultura española: crecimiento y productividad* [Spanish agriculture: growth and productivity] (2002); L. Prados, J. R. Roses and I. Sanz-Villarroya, 'Economic reforms and growth in Franco's Spain', *Revista de Historia Económica / J. of Iberian and Latin American Economic Hist.*, 1 (2011), pp. 45–90.

²⁴ P. Gregory and R. Stuart, *Russian and Soviet economic performance and structure* (2001).

increases in livestock products and a change from traditional cultivated products towards fruit and vegetables and vines.²⁵

The 1980s mark a point of inflection, as the growth in output slowed down; in the continent as a whole this increased at an annual rate of only 0.29 per cent. This result is strongly biased by the problems of agriculture in the countries of the Communist bloc, since in market economy countries growth continued, although at a slower pace than in previous decades. In the countries belonging to the Communist bloc the transition crisis affected their economies as a whole, while agriculture gradually accumulated problems.²⁶ Throughout this decade their agricultural output fell at an annual rate of 0.92 per cent.

Problems arose due to the gap caused by the high prices paid to producers and the low prices demanded by consumers; this gap was covered by direct subsidies. In all these countries the growth in livestock produced distortions, because heavy subsidies were required, as were massive imports of cereal to meet the needs of livestock feeding.²⁷ Trade protection in these countries came to mean equivalent welfare losses of between 50 and 75 per cent of the benefits of direct subsidies to consumers.²⁸ In the German Democratic Republic large collective farms were heavily indebted, due to their inefficiency.²⁹

The evolution of agricultural output during the 1990s was very different in the countries of the market economy and in the Communist bloc, the latter in the midst of dissolution and transition towards a market economy. On the one hand, the free market countries continued to display very slow growth during most of the decade. An essential change took place in 1992 with the MacSharry reform of the CAP. This meant a shift from a pricing policy to one of direct income support. A number of Mediterranean products, such as olives and vines, were excluded from this reform.³⁰ It was also at the beginning of the 1990s that the inclusion of agriculture in the Uruguay Round of the General Agreement on Tariffs and Trade (henceforth GATT) meant the start of a liberalization process in international markets, which affected the European position.³¹ This trend was reinforced with the further reform in 2003 of the CAP and the increasing concern for the environment.³²

²⁵ Landau and Tomaszewski, *Polish economy*; Berend and Ránki, *Hungarian economy*; Lampe, *Bulgarian*.

²⁶ An example of these tensions occurred in the Soviet Union, which was in great need of imported cereals. Due to oil and gas exports there was no problem in financing cereal imports until the mid-1980s, when the prices of energy products fell, harming the financing of these massive imports. K. R. Gray, 'Introduction', in K. R. Gray (ed.), *Soviet Agriculture: comparative perspectives* (1990), pp. 3–22; Anderson and Swinnen, 'Eastern Europe'.

²⁷ Thanks to this boost to the output of livestock activities, per capita consumption of these products increased (and doubled in the USSR between 1950 and 1980), outstripping that of the OECD countries, despite the standard of living being lower. Anderson and Swinnen, 'Eastern Europe'; D. Diamond, L. Bettis, R. Ramsson, 'Agricultural production', in A. Bergson

and H. S. Levine (eds), *The Soviet economy: towards the year 2000* (1983).

²⁸ Gray, 'Introduction'; Anderson and Swinnen, 'Eastern Europe'.

²⁹ B. Forstner and F. Isermeyer, 'Transformation of agriculture in East Germany', in S. Tangermann (ed.), *Agriculture in Germany* (2000), pp. 61–90.

³⁰ M. J. García Grande, 'El último decenio: aplicación y consecuencias de la reforma de la PAC', in García Delgado and García Grande, *Política agraria común* (2005); Neal, *Economics of Europe*.

³¹ European agricultural protection was a constant theme within the GATT and WTO rounds, from Kennedy to Doha. M. Spoerer, "Fortress Europe" in long-term perspective: agricultural protection in the European Community, 1957–2003', *J. of European Integration Hist.*, 16 (2010), pp. 143–62.

³² Animal and plant health, the creation of a network

Elsewhere, the countries of the Communist bloc embarked upon their transition to a market economy at the beginning of the 1990s. This transition involved serious problems for their economies and, therefore, for their agriculture.³³ It was a moment at which the ex-Communist countries had to undertake important institutional reforms, such as price and trade liberalization, reforms of the land market and the restructuring of farms, which coincided with extreme meteorological conditions in some years.³⁴ There are differences between countries in the way in which reforms were implemented, and their effects upon production. These differences can be illustrated by the Hungarian and Romanian cases. In the former, agricultural output, labour, fertilizers and machinery decreased sharply, while in the latter there were increases in crop output, agricultural labour and the use of machinery.³⁵

From 2000 on, and for the first time since the problematic years of the war, European production fell at an annual growth of 0.17 per cent. Evolution in the first quinquennium of the twentieth-first century has not been exactly the same in all regions. The best results have taken place in the ex-Communist countries, whose production increased by an annual rate of 1.04 per cent, recovering part of what had been lost in preceding decades. This was due to the progressive overcoming of the institutional problems derived from the transition which they underwent in the 1990s, and also to the implementation of policies aimed at incorporation into the European Union.

II

The different trends in the use of inputs are essential to understand the sharp increase in production, as has been seen previously. Throughout the nineteenth century, and also in some countries in the earliest decades of the twentieth century, an increase in the use of traditional inputs – land and labour – had been the principal motor of the growth of agricultural production.³⁶ However, after 1950 this tendency changed radically in Europe. Thus, there was a fall in absolute terms in the use of the productive factors which predominated in traditional agriculture as opposed to capital, the importance of which increased considerably. This

Note 32 *continued*

of nature protection, green services provided by agriculture, EU structural and agricultural policies are some questions developed recently in the 1990s and, above all, in the 2000s. A. Oskam, G. Meester and H. Silvis (eds), *EU Policy for agriculture, food and rural areas* (2010).

³³ The problems of the transition from one economic system to another were, among others, the loss of the traditional international markets of COMECON, the monopoly of distributors (which contributed to increasing the difference between prices received by the producer and retail prices), the decrease in disposable income and the reduction of subsidies to the sector, the increase in productive factor prices at worldwide level, a greater uncertainty provoked by the restructuring of the land market, a lack of experience in private

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

³⁴ K. Macours and J. Swinnen, 'Causes of output decline in economic transition: the case of central and eastern European agriculture', *J. Comparative Economics*, 28 (2000), pp. 172–206; K. Macours and J. Swinnen, 'Patterns of agrarian transition', *Economic Development and Cultural Change* 50 (2002) pp. 365–94; K. Anderson and J. Swinnen, 'Introduction and Summary', in K. Anderson and J. Swinnen (eds), *Distortions to agricultural incentives in Europe's transition economies* (2008).

³⁵ Macours and Swinnen, 'Causes'.

³⁶ Federico, *Feeding the world*, p. 221.

TABLE 2. Arable land and permanent crops (thousands of hectares)

	1950	1962	1972	1982	1992	2000	2005
Western Europe	37,134	37,239	33,726	33,263	33,017	32,611	32,847
Mediterranean Europe	43,470	43,140	40,433	39,953	38,492	35,704	33,725
Nordic Europe	7,046	6,976	6,357	6,123	5,956	5,791	5,786
Central and Eastern Europe	49,680	50,978	49,801	48,528	47,104	45,181	42,294
GFR/Germany	8,552	8,466	7,591	7,465	11,809	12,026	12,089
GDR	5,106	5,055	4,842	5,006	–	–	–
France	21,187	21,322	18,674	18,989	19,297	19,561	19,608
United Kingdom	7,428	7,348	7,203	6,979	6,468	5,866	5,928
Italy	16,612	15,531	12,316	12,369	11,620	11,281	10,261
Spain	19,835	20,800	21,110	20,494	19,898	18,225	17,793
Poland	16,223	16,072	15,177	14,826	14,694	14,218	12,741
Europe	150,987	151,854	142,750	140,337	136,378	131,313	126,741

Note: Triennial average data based on the benchmark year, except 1950. This table does not include grasslands because of the difficulties in obtaining the data for grasslands for the whole sample in the 1950s.

Source: As Table 1. For details, see the Appendix.

capitalization took place principally as a consequence of an increase in agricultural machinery and chemical fertilizers.

The first input to be analysed is land (Table 2). Since 1960 the area employed as arable land in European agriculture has fallen from almost 152 million hectares to 127 million hectares. This reduction may be due to various factors. On the one hand, the abandonment of farms produced by the structural change in the economy throughout the entire period was significant. Furthermore, the increase in the average size of farms and in the productivity of land more easily permitted the achievement of economies of scale and the maintenance (or even an increase in production) with a lower quantity of land. On the other hand, there was an increase in the importance of livestock products in total production in the initial decades of the second half of the twentieth century, while the increase in intensive livestock breeding permitted the separation of a part of production from the land factor, especially in countries with less favourable environmental conditions, such as aridity, which traditionally had caused limitations when producing biomass for livestock feed.³⁷ Furthermore, in many parts of Europe, the reduction in the cultivated land area was closely linked to the massive rural exodus

³⁷ M. González de Molina, 'Condicionantes ambientales del crecimiento agrario español (siglos XIX y XX)', in J. Pujol, M. González de Molina, L. Fernández Prieto (eds), *El pozo de todos los males: sobre el atraso en la agricultura española contemporánea* [The well of all evils: on the backwardness in contemporary Spanish agriculture], (2001). Spain was an exception until the 1980s, since it increased its cultivated land area. This was linked to the great increase in its livestock. E. Clar, 'Was Spain different? Agricultural change in Spain in a southern European perspective, 1961 to 1985', *AgHR* 61 (2013), pp. 330–60.

which took place and which involved the abandonment of many farms, especially those least economically viable.³⁸ This was especially the case in mountainous zones, where the reduction in the cultivated land area was especially notable.³⁹

The cultivated land area increased very slightly, at an annual rate of 0.08 per cent, between 1950 and 1962. In fact, this increase only took place in the Central and Eastern European countries. In that decade these countries completed their processes of agricultural reform, and therefore the consolidation of farms.⁴⁰ From then on, the decrease in the number of cultivated hectares was both generalized and constant throughout the last four decades of the twentieth century.

In some cases, such as France, the fall was occasionally more abrupt. An example is the 1960s, when the arable land under cultivation fell by exactly 1.3 per cent annually. This was due to voluntary policies for the consolidation of farms and the payment of supplementary retirement pensions to older farmers.⁴¹ Following this considerable decrease, a slight increase took place until 2005, although it had not by this time recovered to the level of the early 1960s.

In contrast to land, capital had a different trajectory in this period of analysis. In the developed countries, the greater use of capital in agriculture has been highlighted as one of its most important features of the twentieth century.⁴² In the more arid European zones or those with greatest difficulty in making sufficient water available for the cultivation of certain crops, an extraordinary effort was made in this period to increase the irrigated land area or to improve the quality of irrigation. Between 1950 and 2005 the area equipped for irrigation grew in Europe by 1.45 per cent annually (Table 3), although the distribution of this increase was enormously unequal throughout the continent. In some countries of the Central and Eastern European countries, governments made a huge effort to increase irrigated land.⁴³ Countries such as Romania, Greece and France increased their irrigated land area at an annual growth rate of 5.1 per cent, 3.3 per cent and 3.1 per cent respectively, over the whole period from 1950 to 2005. Also notable are the cases of Spain and Italy, which, although having lower rates of growth, in 1961 possessed 10 per cent and 17.9 per cent of the total European land area equipped for irrigation, as a consequence of the policies of the first half of the twentieth century. For these Mediterranean countries, the increase in irrigated land, faster in Spain than at any previous time, was crucial for the growth of their agricultural production.⁴⁴

Livestock forms a very important part of the capital employed in agriculture, because it produces consumer goods such as meat, milk, eggs or wool, and it has been employed as the

³⁸ F. Collantes and V. Pinilla, *Peaceful surrender: the depopulation of rural Spain in the twentieth century* (2011).

³⁹ F. Collantes, 'Farewell to the peasant republic: marginal rural communities and European industrialisation, 1815–1990', *AgHR* 54 (2006), pp. 257–73.

⁴⁰ Berend and Ránki, *Hungarian economy*; Landau and Tomaszewski, *Polish economy*; Lampe, *Bulgarian*; Pryor, *Red and the green*.

⁴¹ F. Bouchet, D. Orden, G. W. Norton, 'Sources of growth in French agriculture', *American J. of*

Agricultural Economics 71 (1989), pp. 280–93. A similar case occurred in Finland during the 1970s and 1980s, especially with dairy farmers reducing their herds between 1965 and 1989 by two thirds. F. Singleton, *A short history of Finland* (1989).

⁴² Federico, *Feeding the world*.

⁴³ Lampe, *Bulgarian*.

⁴⁴ R. Duarte, V. Pinilla and A. Serrano, 'The water footprint of the Spanish agricultural sector: 1860–2010', *Ecological Economics* 108 (2014), pp. 200–7.

TABLE 3. Hectares of land equipped for irrigation (thousands)

	1950	1962	1972	1982	1992	2000	2005
Western Europe.	952	1,009	1,548	2,564	3,373	3,957	3,904
Mediterranean Europe	5,858	6,779	7,762	8,389	9,223	9,674	10,001
Nordic Europe	40	43	101	213	290	363	371
Central and Eastern Europe	1,487	1,796	3,344	4,822	5,481	4,763	4,405
GFR/Germany	270	270	292	316	483	485	485
GDR	124	124	137	165	–	–	–
France	504	532	906	1,460	2,256	2,651	2,675
UK	93	106	86	150	132	243	212
Italy	3,400	3,400	3,400	3,435	3,718	3,844	3,969
Spain	1,341	2,025	2,690	3,105	3,415	3,719	3,834
Poland	200	200	345	340	261	89	118
Europe	8,731	10,021	13,184	16,470	18,849	19,243	19,166

Note: Triennial average data based on the benchmark year, except 1950.

Source: As Table 1. For details, see the Appendix.

motor of agricultural production. Thus, Table 4, which displays the evolution of the number of livestock units, is the result of two opposing trends. On the one hand there is a decrease throughout the second half of the twentieth century in the number of working animals. On the other, the increasing importance of livestock for the production of meat or milk, especially in countries in which it had been relatively unimportant, as a consequence of their inadequate environmental/ecological conditions. The result was that until the early 1980s there was a notable increase in livestock numbers in Europe, visible in all its regions with the exception of the Nordic countries.

Consequently, in Europe in general, livestock tended to gain importance in agricultural production as a whole until the early 1980s. This improvement in its participation was much more important in those regions where the initial share was smaller, such as the Mediterranean countries or those of Central and Eastern Europe.

From the beginning of the 1980s an appreciable reduction in livestock numbers took place. Some livestock production was affected in Western Europe by serious problems of oversupply and the change of philosophy in the CAP, with a greater environmental/ecological concern for the control of intensive livestock breeding.⁴⁵ The introduction of milk quotas in 1984 also played an important role in this reduction.

The principal exception to the general pattern of livestock decrease in the market economies was the continued increase after 1980 of livestock numbers in the area least specialized in this activity, the Mediterranean countries. Thus, in Spain, livestock breeding continued to

⁴⁵ Gardner, *European agriculture*; Andreosso O'Callaghan, *Economics*; García Grande, 'CAP'; Anderson and Swinnen, 'Eastern Europe'.

TABLE 4. Livestock units (thousands of units)

	1950	1962	1972	1982	1992	2000	2005
Western Europe	47,383	58,456	63,247	66,921	67,767	67,141	63,142
Mediterranean Europe	23,383	26,350	25,605	27,102	28,181	28,949	29,229
Nordic Europe	6,638	6,226	5,208	5,325	4,683	4,444	4,263
Central and Eastern Europe	37,190	43,004	46,311	50,329	40,356	28,977	27,933
GFR/Germany	13,067	15,347	16,520	17,863	21,550	18,930	17,664
GDR	4,658	6,362	6,976	7,913	–	–	–
France	18,019	22,462	23,319	25,115	23,327	23,727	22,319
United Kingdom	11,654	15,024	16,913	15,757	17,002	16,219	15,123
Italy	11,235	11,502	11,480	11,629	11,229	9,960	9,568
Spain	7,888	9,164	8,778	9,828	11,855	13,826	14,560
Poland	10,495	13,954	16,391	15,712	12,479	9,562	9,883
Europe	131,584	155,744	163,866	175,453	162,536	148,442	142,230

Note: Triennial average data based on the benchmark year, except 1950. Livestock units are the number of animals aggregated with the weightings of Hayami and Ruttan (1985). Consult the Appendix to see which animal species have been taken into account in the calculation of the variable.

Source: As Table 1. For details, see the Appendix.

increase until it almost doubled its units, principally due to the enormous growth of intensive livestock breeding processes.⁴⁶ This resulted in part from the possibilities offered by such processes; they permitted the overcoming of environmental obstacles traditionally faced by livestock.⁴⁷

On the other hand, it is necessary to underline the significant reduction of livestock numbers – by almost 50 per cent in a decade – experienced by the countries of Central and Eastern Europe from the mid-1980s on. The differences which existed in this system between the low prices paid by the consumer and the high prices paid to the producers, which were covered by direct subsidies, brought about a livestock boom, which was unsustainable once the discipline of the market was imposed.

Lastly, within the capital utilized, there was a considerable increase in the purchase of inputs from other sectors of the economy. From an agriculture that basically used agricultural inputs, there was a change to another in which purchases from other sectors of the economy were dominant. Principally, these were the purchase of machinery, fertilizers, pesticides, seeds, fuel or services from other non-agricultural companies.

⁴⁶ R. Domínguez, 'Las transformaciones del sector ganadero en España (1940–1985)', *Ager, Revista de Estudios sobre Despoblación y Desarrollo Rural* / *Ager, J. of Depopulation and Rural Development Studies*, 1 (2001), pp. 47–83.

⁴⁷ V. Pinilla and E. Clar, 'The modernization of

agriculture under tough environmental constraints: one hundred years of Aragonese agricultural production, 1885–1985', in M. Olsson and P. Svensson (eds), *Growth and stagnation in European historical agriculture* (2011), pp. 37–70.

TABLE 5. Kilograms of chemical fertilizers consumed per hectare

	1950	1962	1972	1982	1992	2000	2005
Western Europe	83	164	299	333	287	253	234
Mediterranean Europe	20	45	86	109	118	127	113
Nordic Europe	67	103	199	202	144	133	138
Central and Eastern Europe	8	49	154	213	67	77	118
GFR/Germany	161	295	427	425	240	233	211
GDR	159	202	340	305	–	–	–
France	49	124	287	298	254	223	186
United Kingdom	111	195	257	356	322	320	282
Italy	29	56	119	165	167	145	123
Spain	11	36	68	70	88	122	107
Poland	11	58	204	224	82	110	186
Europe	46	97	192	226	153	151	156

Note: Triennial average data based on the benchmark year, except 1950.

Source: As Table 1. For details, see the Appendix.

Table 5 shows the evolution of the consumption of chemical fertilizers per hectare. From 1950 until the 1980s there was a very sharp increase in the use of fertilizers in European agriculture. Although growth was generalized, the Western and Nordic countries already had by 1950 much higher levels than the Mediterranean and Central and Eastern countries, as the former had already introduced this innovation to a greater extent prior to the Second World War.⁴⁸ Thus, the greatest increase in the consumption of fertilizers per hectare occurred in the countries of Central and Eastern Europe (10.8 per cent annually), which in 1950 had had the lowest level in the entire continent, while in the Western countries the figure was 4.4 per cent.

By contrast, from the mid-1980s until the beginning of the twenty-first century the level of chemical fertilizers used per hectare fell throughout the continent. The Western, Mediterranean and Nordic countries reduced their consumption, due to environmental/ecological problems caused by the excessive use of these inputs.⁴⁹ Furthermore, in the 1990s directives reflecting the increasing concern for the environment, such as the Nitrate Directive in 1991, came into effect.⁵⁰ On the other hand, the Central and Eastern European countries also drastically reduced their consumption of off-farm inputs, because of the liberalization of the factor markets, causing nominal input prices to increase by more than nominal output prices, and because of the problems which they suffered in general during their transition to market economies.⁵¹

⁴⁸ The United Kingdom was already consuming almost 1.5 million tons of artificial fertilizers by the second half of the 1930s, while by 1950–1 use had increased to over four million tons. Brassley, 'Output'.

⁴⁹ Gardner, *European agriculture*.

⁵⁰ F. Brouwer and H. Silvis, 'Rural areas and the environment', in Oskam *et al.*, *EU Policy*.

⁵¹ Anderson and Swinnen, 'Eastern Europe'; Forstner and Isermeyer, 'Transformation'; Trzeciak-Duval, 'Decade of transition'.

TABLE 6. Tractors per hundred workers

	1950	1962	1972	1982	1992	2000	2005
Western Europe	4.97	23.79	50.21	78.90	97.36	114.61	125.89
Mediterranean Europe	0.51	3.19	11.53	26.38	48.35	73.24	92.59
Nordic Europe	4.58	25.33	49.59	78.76	101.49	119.13	137.80
Central and Eastern Europe	0.27	1.36	3.56	10.92	18.80	26.23	32.04
GFR/Germany	2.72	28.87	71.64	98.25	94.97	97.56	115.26
GDR	0.69 ^a	7.12	13.74	16.40	–	–	–
France	2.19	19.49	46.68	80.11	111.52	143.99	163.09
United Kingdom	26.16	50.02	63.80	74.40	82.47	94.77	99.94
Italy	0.66	5.17	18.54	42.96	77.78	132.00	181.58
Spain	0.33	2.02	8.76	23.12	43.91	68.16	82.38
Poland	0.23	1.21	4.34	13.58	24.96	34.71	42.20
Europe	1.44	7.34	15.89	29.43	43.63	56.84	68.42

Notes: Triennial average data based on the benchmark year, except 1950.

^a The datum for tractors is an average between 1949 and 1952.

Source: As Table 1. For details, see the Appendix.

With regard to the use of machinery, well represented by the number of tractors in service per agricultural worker, Table 6 shows an enormous growth throughout the second half of the twentieth century (a 73 per cent annual increase between 1950 and 2005). In the 1950s the growth in the number of tractors per worker was spectacular (14.6 per cent annually between 1950 and 1962).⁵² In the 1960s and 1970s the number of tractors per agricultural worker also increased, although at a slower pace than in the preceding decade. In the following decades their use increased still further, despite the rate of growth falling once more. The probable reasons explaining this progressively lower growth are the increase in the power of tractors over time and a gradual optimization of agricultural machinery, due to the increase in farm size.⁵³

The Western and Nordic countries were the first to introduce this innovation, because the development of their economies preceded that of the Mediterranean, Central and Eastern European countries. By 1950 they already had, as with fertilizers, a far higher level than in the remaining countries. In the United Kingdom the level was already extremely high in 1950 and the adoption of this input having taken place during the 1940s, when the number of tractors quintupled.⁵⁴ The security provided by high prices, due to trade protection and subsidies from

⁵² For example, in the Spanish case the number of tractors increased by 163 per cent annually between 1950 and 1962, a considerable increase and above average annual European growth, despite the administrative barriers which existed. E. Clar, 'Contra la virtud de pedir ... Barreras administrativas a la difusión de tractores en España: 1950–1960', *Investigaciones en*

Historia Económica 5 (2009), pp. 97–132.

⁵³ A growing complexity in the types of agricultural machinery could have influenced this lower growth. We have only taken into account tractors, because of the problems in obtaining data for other agricultural machinery.

⁵⁴ Brassley, 'Output'.

national policies prior to the subsequent CAP allowed investment in machinery to be high.⁵⁵ The development of a rural credit market, principally in market economies, also played a fundamental role in the growing purchase of agricultural machinery.⁵⁶

During their Communist stage, the countries of Central and Eastern Europe implemented a policy of the massive capitalization of agriculture, especially of collectivized farms, permitting them to increase the number of tractors per worker at the same rate as other countries with market economies.⁵⁷ Following the transition, this proportion fell slightly (moving from 20.06 in 1990 to 18.07 in 1992), but rapidly increased once more, due also to the decrease in the number of workers (Table 6).

It is important, lastly, to underline the weight of biological innovations in this process of technological change. The increase in crop yields due to the process of the genetic selection and hybridization of seeds is fundamental to understanding the sharp increase in agricultural production and productivity.⁵⁸

Agricultural labour is the last principal input analysed in this section. In the second half of the twentieth century European agriculture used a progressively smaller labour force. As Table 7 shows, this fall was very intensive, from over 66 million workers to fewer than 15 million between 1950 and 2005. All European regions were severely affected by the rural exodus. Although their rates were different, the decrease in the labour force in agriculture in the entire period does not offer great contrasts. In Western Europe and the Nordic countries, the reduction of labour employed in agriculture was 81 per cent between 1950 and 2005. In Mediterranean countries it was 78 per cent and in the countries of Central and Eastern Europe 75 per cent. In this decline, two periods stand out: the first between 1950 and the mid-1980s and the second from the mid-1980s until today. In the first period, the average annual decrease was lower (–2.5 per cent), but in absolute terms almost 37 million people on the continent ceased working in agricultural activities. In turn, from 1982 until 2005 this annual decrease was somewhat greater (–3.3 per cent). This accelerated fall in the active population in agriculture in the second period is probably due principally to the continuation of the process of rural exodus in the Mediterranean, Central and Eastern countries of Europe. Furthermore, the Central and Eastern countries, in particular Poland, the Czech Republic, Slovakia and Hungary experienced considerable exits of workers between 1989 and 1995.⁵⁹

The exit of workers from European rural zones was directly determined by the need for

⁵⁵ S. Houpt, P. Lains and L. Schön, 'Sectorial developments, 1950–2000', in Broadberry and O'Rourke (eds), *Cambridge economic history of modern Europe*, II, pp. 333–59.

⁵⁶ Josling, 'Western Europe'.

⁵⁷ Diamond *et al.*, 'Agricultural production'; Berend and Ránki, *Hungarian economy*; Landau and Tomaszewski, *Polish economy*; Lampe, *Bulgarian*; Gregory and Stuart, *Russian*.

⁵⁸ The improvement of yields in, for example, wheat or maize, was substantial from the 1950s onwards. A. L. Olmstead and P. W. Rhode, *Creating abundance: biological innovation and American agricultural*

development (2008); J. Pujol, 'Wheat varieties and technological change in Europe, 19th and 20th centuries', *Historia Agraria*, 54, (2011), pp. 71–103.

⁵⁹ The *länder* corresponding to the former German Democratic Republic lost many workers following the transition, since this sector had previously had an excessive labour supply. The exception to these countries was Romania, which experienced an annual increase in its agricultural labour force of 2.4% between 1989 and 1995. U. Huber, 'Agriculture in Germany – production and structure', in S. Tangermann (ed.), *Agriculture in Germany* (2000), pp. 17–37; Macours and Swinnen, 'Causes'.

TABLE 7. Active population in agriculture (thousands)

	1950	1962	1972	1982	1992	2000	2005
Western Europe	11,179	7,532	5,228	3,889	3,047	2,402	2,109
Mediterranean Europe	16,391	13,691	9,734	7,454	5,345	4,071	3,548
Nordic Europe	1,904	1,229	895	705	515	398	343
Central and Eastern Europe	30,134	27,262	22,239	15,958	11,790	8,877	7,397
GFR/Germany	5,114	3,466	1,965	1,497	1,446	1,014	820
GDR	2,112	1,411	1,064	916	–	–	–
France	6,335	4,139	2,792	1,863	1,244	880	723
United Kingdom	1,242	935	728	702	607	528	500
Italy	8,588	5,937	3,779	2,652	1,870	1,255	1,029
Spain	4,853	4,616	3,505	2,471	1,746	1,326	1,193
Poland	7,090	6,923	6,508	5,245	4,684	3,766	3,351
Europe	66,834	54,592	41,125	30,418	22,143	16,762	14,218

Notes: Triennial average data based on the benchmark year, except 1950.

Source: As Table 1. For details, see the Appendix.

labour in other sectors. For the less developed countries the national pull effect was complemented by the expansion of labour demand in other, more developed parts of Europe, which favoured rural emigration abroad. In fact, the powerful pull effect (derived from the high general economic growth of this period) was combined to a similarly powerful push effect (derived from labour-saving innovation in agriculture). The result was an unprecedented rise in the productivity of those farmers and labourers remaining in the agricultural sector.⁶⁰

The most advanced countries in Western Europe had already experienced, prior to the Second World War, a very significant transfer of workers from rural to urban zones. Following the end of the conflict, the intense economic growth which took place proved capable of absorbing new and significant contingents of rural labour, especially in the 1950s and 1960s.⁶¹ The greater attraction of the urban environment for young generations in these advanced countries contributed to increasing yet further the exit of youths from the rural environment.⁶²

The lower level of economic development in the Mediterranean, Central and Eastern European countries meant a less important rural exodus prior to 1945. Nevertheless, especially in the initial decades of the twentieth century, internal migrations were quite intense in countries

⁶⁰ M. Martín-Retortillo and V. Pinilla, 'On the causes of economic growth in Europe: Why did agricultural labour productivity not converge between 1950 and 2005?', *Cliometrica* (forthcoming); Collantes and Pinilla, *Peaceful Surrender*, pp. 159–62.

⁶¹ B. A. Holderness, 'Apropos the Third Agricultural

Revolution: How productive was British agriculture in the Long Boom, 1954–1973?', in P. Mathias and J. A. Davis (eds), *Agriculture and industrialization from the eighteenth century to the present day* (1996).

⁶² Josling, 'Western Europe'.

such as Spain or Italy.⁶³ Immediately after 1945 the exit of agricultural workers from them was still of little importance, with the exception of Italy, but from 1960 onwards accelerated sharply. In the countries of the Communist bloc, certain policies delayed the replacement of workers by machinery and introduced migratory controls to restrict the mobility of labour power.⁶⁴

III

In this section, our objective is to unravel the growth of European agricultural output. We have seen so far how European agricultural production increased spectacularly from the early 1950s until the mid-1980s. These four decades of expansion of agricultural output were followed by decades in which the most common experience was stagnation. We now wish to analyse what has been most decisive in the long-term growth of agricultural production.

In the previous section we were able to establish clearly that in the long term the use of traditional agricultural inputs, land and labour, has decreased notably. This fall in the use of both inputs, linked to the increase in production, has meant a sharp rise in both land and labour productivity.⁶⁵ Consequently, the increase in production can only be explained by a greater use of capital or by efficiency gains in the use of inputs. Disentangling which of these factors has been more important requires the estimation of first, how total factor productivity has varied, and, second, of the rate at which the use of capital in European agriculture has increased.

We shall calculate TFP in accordance with its primary definition, that is to say, as the Solow residual.⁶⁶ This definition stems from the methodology of growth accounting.⁶⁷ We measure TFP indirectly as a residual component of the growth in output which cannot be explained by the growth of production inputs. This difference is calculated by subtracting from the annual growth rate of production between two years the rate of a combination of inputs. This combination comprises land, measured in hectares of arable land (A); labour, represented by the active population in the agricultural sector (L); and physical capital (K), measured as an average among the rates of growth of the number of tractors, tonnes of consumption of fertilizers, hectares of area equipped for irrigation and number of livestock (Table 3, 4, 5 and 6).⁶⁸

⁶³ J. Silvestre, 'Internal migrations in Spain, 1877–1930', *European Rev. of Economic Hist.*, 9 (2005), pp. 233–65.

⁶⁴ Landau and Tomaszewski, *Polish economy*.

⁶⁵ L. F. Wong and V. Ruttan, 'A comparative analysis of agricultural productivity trends in centrally planned economies', in K. R. Gray (ed.) *Soviet agriculture: comparative perspectives* (1990), pp. 23–47; Martín-Retortillo and Pinilla, 'On the causes'.

⁶⁶ R. Solow, 'Technical change and the aggregate production function', *Rev. Economics and Statistics* 39 (1957), pp. 312–20.

⁶⁷ Crafts states that the methodology of 'growth accounting' is the most appropriate to quantify the impact of a new technology on productivity. N. Crafts,

'The contribution of new technology to economic growth: lessons from economic history', *Revista de Historia Económica / J. of Iberian and Latin American Economic Hist.*, 28 (2010), pp. 409–40.

⁶⁸ Fertilizers are considered working capital, because they are included 'in the amount of outlays for productive expenditures'. Federico, *Feeding*, p. 52. This combination is based on that used by Federico for his calculation of TFP. Furthermore, we have replaced the geometric average by the arithmetical average to calculate capital growth rates, due to growth rates being negative for some periods or inputs. It should be observed that our estimation of capital growth, since it does not use other forms of capital, such as seeds, fuel and purchases of inputs from other sectors, involves assuming

This combination of inputs, according to the determinist methodologies of growth accounting, uses as weightings the fraction of the output employed to remunerate each productive factor.⁶⁹ Based on Dias Avila and Evenson⁷⁰:

$$GTFP = GY - CLGL - CAGA - CKGK$$

where G represents annual growth rates in variables and C are weightings. To simplify our calculation, and faced with the difficulty of obtaining for each country the remunerations of the productive factors, we have used the weightings proposed by Federico, which means that in the initial year of the calculation the distribution was 40 per cent each for land and labour and the remaining 20 per cent for capital, while for the final year the remunerations of the inputs were equivalent.⁷¹ Thus, we obtain the TFP, which is calculated as the average/mean of the weightings of the initial year and those of the final year for each input.⁷²

The TFP of European agriculture, shown in Tables 8 to 10, experienced an enormous increase throughout the period.⁷³ Nevertheless, its rates of growth and its contribution to the increase in output show significant regional contrasts. For the whole period 1950–2005 (Table 8), the growth of production is explained by the increase in TFP and the use of capital, which more than compensated for the fall in the use of land and labour.⁷⁴ Our results show that regional differences in Europe were similar to the estimations of Fuglie (who calculates TFP growth for the period 1961–2007).⁷⁵ In most Western European countries, the contribution of TFP was lower than the increase in the use of capital, although the two rates were similar. However, there are two exceptions within this group of countries; the United Kingdom and Netherlands

Note 68 *continued*

that its growth was similar to that obtained with those variables we do use. Despite this, TFP measurement includes the possible adjustment of quality in some inputs. Federico, *Breve historia económica*, pp. 62–6.

⁶⁹ M. Del Gatto, A. Di Liberto and C. Petraglia, 'Measuring productivity', *J. of Economic Survey* 25 (2011), pp. 952–1008.

⁷⁰ A. F. Dias Avila and R. E. Evenson, 'Total Factor Productivity growth in agriculture: The role of technological capital' in P. Pinghali and R. E. Evenson (eds), *Handbook of Agricultural Economics* (4 vols, 2010), pp. 3769–3822.

⁷¹ Federico, *Breve historia económica*, pp. 62–6. Changes in input shares show the trend of technical change, S. L. Wang, D. Schimmelpfennig and K. O. Fuglie, 'Is agricultural productivity growth slowing in Western Europe?', in Keith O. Fuglie, Sun Ling Wang, and V. Eldon Ball (eds), *Productivity growth in agriculture: An international perspective* (2012), pp. 109–25.

⁷² D. W. Jorgenson, 'Productivity and economic growth', in E. R. Berndt and J. E. Triplett (eds), *Fifty years of economic measurement: the jubilee of the conference on research in income and wealth* (1991), pp. 19–118; J. A. Olavarria, B. E. Bravo-Ureta and H. Cocchi,

'Productividad total de los factores en la agricultura chilena, 1961–96', *Economía Agraria y Recursos Naturales* 4 (2004), pp. 121–32.

⁷³ Our estimate may suffer from a problem of over-estimation, as the increase in part-time work in the period means that the reduction in the use of the labour factor was less marked. The ideal measurement of labour would be in hours worked, yet the only database to include this variable is EUROSTAT, but does so neither for all countries nor for the whole period.

⁷⁴ We have also estimated annual TFP growth, with logarithmic growth rates of output and inputs and distinct weights based on Fuglie, 'Shifting Patterns' and 'Productivity' and Federico 'Breve historia económica'. The differences among countries in TFP growth in this case are not large, in comparison with our main calculation, although obviously there are differences in the rates of TFP.

⁷⁵ Their results of TFP annual rates of growth are: 1.59 for north-western countries, 1.15 for the southern European region and 1.03 for eastern Europe as a whole. Fuglie, 'Shifting Patterns' and 'Productivity'. The estimations by sub-regions in Europe, either each ten years or with other year periods to present the results as annual indexes hinders comparison with our results in the references appearing in n. 4.

experienced a greater increase in TFP than in the use of capital in the whole period.⁷⁶ The Mediterranean countries have a slightly higher TFP growth than the European average, but their use of capital increased much more than the wider European level. Furthermore, the difference between the rates of TFP and the use of capital was higher than in the Western countries. In the Nordic countries, the increase in TFP and in the use of capital was lower than in Western Europe. Lastly, in the Central and Eastern countries the increase in the use of capital was much higher than in other European groups of countries and almost three times more important than TFP. The fastest increase in TFP took place in the countries of Western Europe and in Spain. The lowest growth rates corresponded to the remaining Mediterranean countries, the Nordic countries, Switzerland and the Central and Eastern countries.

We can now analyse the evolution of TFP, and also that of output and inputs, by sub-periods. Table 9 underlines that in the period between 1950 and 1985 the strong growth of output was essentially explained by a very marked capitalization, especially as a consequence of the generalization of the use of self-propelled machines, chemical fertilizers, high-yielding seed varieties and pesticides, added to the sharp increase in livestock units in some countries such as Benelux, Denmark, Greece, France and Spain.⁷⁷ An improvement (very significant in the countries of Western Europe and more moderate in the rest) in efficiency in the European agricultural system as a whole also contributed to the strong rise in production, which was achieved while the use of land and labour were already falling.

The relative contributions of capital and TFP vary according to country type. In the Western countries and the German Federal Republic, TFP growth was higher than the European average. In the Mediterranean countries, this growth was slightly lower than Europe as a whole because of a stronger capitalization process than in the Western countries, as these had advanced this process further before the war. In the Nordic countries the TFP contribution was lower than the average European level, but their output growth was the lowest on the continent. In the centrally planned economies, the contribution of capital was the highest on the European continent, but TFP increased, although slightly, as capital growth was almost five times higher than TFP growth. This was due to the majority of countries having concluded the collectivization process, which permitted farmers to enjoy a certain institutional stability.⁷⁸ However, Federico demonstrates a lack of incentives to work on collectivized farms, and similarly a reformulation of agricultural policy due to the excessive use of capital in a still backward agriculture.⁷⁹

⁷⁶ The agricultural sector in the UK and the Netherlands was of lesser importance in the economy, due to the early industrialization processes in these countries. This sector had incorporated more technical inputs, as can be seen for the UK in Table 6.

⁷⁷ The reason to divide the sub-periods in 1985 is because European agricultural production followed a growing trend until 1985, after which it stagnated. Thus, we need to explain two different trends in European agricultural production.

⁷⁸ In countries such as Poland this institutional stability was absent, due to various legislative modifications

regarding the incentives to invest in collective farms, the dissolution of a number of cooperatives following a process of forced collectivisation, and similarly the loss of consistency in government action, which permitted farmers to acquire land for crops to avoid urban growth and a rural exodus; in fact, this policy only incentivised the purchase of land for the socialized farms. Landau and Tomaszewski, *Polish economy*; Pryor, *Red and the green*.

⁷⁹ Federico, *Feeding the world* and *Breve historia económica*.

TABLE 8. Annual growth rates of outputs, inputs and TFP between 1950 and 2005

	<i>Output</i>	<i>Labour</i>	<i>Land</i>	<i>Capital</i>	<i>TFP</i>
Germany	1.24	-3.88	-0.22	1.00	2.48
Austria	1.35	-3.35	-0.44	3.37	1.84
Belgium-Luxembourg	1.44	-3.18	-0.34	2.75	2.00
Denmark	1.18	-3.13	-0.27	2.13	1.86
France	1.48	-3.87	-0.14	2.43	2.31
Ireland	1.47	-2.09	-0.18	2.52	1.63
Netherlands	1.84	-1.87	-0.11	1.84	2.08
Switzerland	0.63	-1.53	-0.23	1.22	0.95
UK	1.06	-1.64	-0.41	1.04	1.54
Western Europe	1.37	-2.98	-0.22	1.95	2.02
Greece	2.07	-1.16	0.13	3.16	1.61
Italy	0.89	-3.78	-0.87	3.08	1.78
Portugal	0.90	-1.73	-1.09	2.24	1.34
Spain	2.34	-2.52	-0.20	3.64	2.37
Mediterranean Europe	1.48	-2.74	-0.46	3.06	1.84
Finland	0.87	-3.66	-0.18	3.18	1.43
Norway	0.42	-2.36	0.12	2.20	0.65
Sweden	-0.01	-2.85	-0.61	1.31	0.91
Nordic Europe	0.32	-3.07	-0.36	1.88	1.08
Albania ^a	2.60	0.37	0.81	2.33	1.55
Bulgaria	0.43	-5.01	-0.45	1.07	2.15
Czechoslovakia	0.58	-2.38	-0.28	1.37	1.19
Hungary	0.99	-3.10	-0.34	2.76	1.52
Poland	0.63	-1.35	-0.44	3.01	0.49
Romania	1.47	-3.44	-0.02	4.85	1.45
Yugoslavia	1.72	-3.35	-0.32	4.22	1.94
Central and Eastern Europe	0.94	-2.65	-0.30	3.29	1.15
Europe	1.26	-2.76	-0.31	2.18	1.80

Note: Triennial averages have been used, based on the benchmark year, for the calculation of all growth rates, except for the active population, arable land and tractors for the year 1950 and for livestock units for Bulgaria, Czechoslovakia, Hungary, Romania, Spain and Portugal in the year 1950. When taking into account the data for 1950 and 2005 for the calculation of TFP, it was necessary to aggregate the data for the GDR and GFR to obtain a measurement for Germany.

^a The growth rates refer to the period 1962–2005 because there are no data for Albania in the 1950s.

Source: As Table 1. For details, see the Appendix.

TABLE 9. Annual growth rate of output, inputs and TFP between 1950 and 1985

	<i>Output</i>	<i>Labour</i>	<i>Land</i>	<i>Capital</i>	<i>TFP</i>
GDR	1.72	-2.63	-0.07	2.83	1.96
GFR	2.35	-3.90	-0.39	2.72	3.20
Austria	2.07	-3.70	-0.56	5.22	2.24
Belgium-Luxembourg	1.86	-3.60	-1.03	4.55	2.34
Denmark	1.49	-3.08	-0.09	4.10	1.57
France	2.29	-3.72	-0.28	4.08	2.66
Ireland	2.12	-2.51	-0.68	3.82	2.27
Netherlands	2.93	-2.36	-0.60	3.17	3.17
Switzerland	1.21	-1.74	-0.49	2.53	1.35
UK	1.85	-1.73	-0.16	1.81	2.06
Western Europe	2.14	-3.14	-0.28	3.26	2.53
Greece	3.02	-0.62	0.36	5.02	1.78
Italy	1.32	-3.53	-0.89	5.11	1.58
Portugal	0.87	-1.20	-0.33	3.38	0.54
Spain	2.92	-2.20	0.09	5.00	2.36
Mediterranean Europe	1.94	-2.48	-0.26	4.58	1.73
Finland	1.56	-3.50	-0.24	5.57	1.45
Norway	0.79	-2.34	0.16	3.45	0.67
Sweden	0.35	-2.76	-0.71	2.20	1.04
Nordic Europe	0.77	-2.99	-0.43	3.19	1.18
Albania ^a	3.42	1.87	1.67	5.56	0.64
Bulgaria	2.48	-3.70	-0.15	5.53	2.41
Czechoslovakia	1.88	-2.17	-0.18	3.66	1.76
Hungary	2.30	-2.76	-0.25	5.25	2.01
Poland	1.62	-0.87	-0.25	5.80	0.49
Romania	2.78	-2.67	0.30	9.37	1.15
Yugoslavia	3.12	-2.24	-0.01	7.50	1.94
Central and Eastern Europe	2.18	-2.08	-0.08	6.34	1.28
Europe	2.07	-2.41	-0.20	3.92	1.98

Notes: Triennial averages have been used, based on the benchmark year, for the calculation of all growth rates, except for the variables of active population, arable land and tractors for the year 1950 and for livestock units for Bulgaria, Czechoslovakia, Hungary, Romania, Spain and Portugal in the year 1950.

^a The growth rates are for the period 1962–1985 because there are no data for Albania in the 1950s.

Source: As Table 1. For details, see the Appendix.

TABLE 10. Annual growth rates of output, inputs and TFP between 1985 and 2005

	<i>Output</i>	<i>Labour</i>	<i>Land</i>	<i>Capital</i>	<i>TFP</i>
Germany	-0.41	-4.60	-0.14	-1.93	1.84
Austria	0.09	-2.72	-0.23	0.25	1.11
Belgium-Luxembourg	0.73	-2.44	0.89	-0.30	1.38
Denmark	0.63	-3.20	-0.59	-1.21	2.34
France	0.10	-4.14	0.10	-0.36	1.67
Ireland	0.35	-1.35	0.70	0.34	0.50
Netherlands	-0.03	-1.01	0.75	-0.44	0.18
Switzerland	-0.38	-1.15	0.23	-1.01	0.23
UK	-0.30	-1.48	-0.84	-0.26	0.62
Western Europe	0.03	-2.70	-0.12	-0.30	1.15
Greece	0.43	-2.11	-0.26	0.06	1.28
Italy	0.14	-4.23	-0.84	-0.30	2.08
Portugal	0.96	-2.64	-2.41	0.30	2.73
Spain	1.33	-3.08	-0.69	1.33	2.36
Mediterranean Europe	0.67	-3.21	-0.81	0.48	2.02
Finland	-0.33	-3.96	-0.07	-0.84	1.37
Norway	-0.24	-2.39	0.04	0.08	0.60
Sweden	-0.65	-3.00	-0.44	-0.23	0.68
Nordic Europe	-0.47	-3.20	-0.23	-0.37	0.89
Albania	1.67	-1.33	-0.18	-1.18	2.54
Bulgaria	-3.05	-7.27	-0.97	-6.22	1.62
Czechoslovakia	-1.65	-2.74	-0.46	-2.47	0.18
Hungary	-1.26	-3.69	-0.48	-1.23	0.60
Poland	-1.07	-2.19	-0.76	-1.68	0.46
Romania	-0.79	-4.77	-0.60	-2.42	1.83
Yugoslavia	-0.69	-5.26	-0.86	-1.14	1.86
Central and Eastern Europe	-1.19	-3.64	-0.69	-1.82	0.89
Europe	-0.15	-3.37	-0.50	-0.77	1.48

Note: Triennial averages, based on the benchmark year, have been used for the calculation of the growth rates. Data for Czechoslovakia and Yugoslavia were aggregated following their dissolution.

Source: As Table 1. For details, see the Appendix.

Finally, Table 10, with regard to 1985–2005, displays a change with respect to the situation observed thus far. The growth of TFP in this period is somewhat lower. The real change was produced because capital began to decrease, as had occurred previously with the other productive factors. Furthermore, output growth halted in Europe as a whole (as the result of the stagnant growth of Western Europe and a fall in that of Germany, the Nordic countries and Central and Eastern Europe). Only the Mediterranean countries, particularly Spain, had somewhat higher annual growth rates of production. These two changes are related. The limitation on the use of composts and fertilizers, due to abuse in preceding decades and the environmental problems it produced, affected production. In fact, this fall in the use of fertilizers is reflected in the negative growth of capital, also produced partly by the slight decreases in the number of animals and of tractors. Thus, it is efficiency gains in the agricultural sector as a whole which permitted slight increases in production, given a lower use of all productive factors. The less developed countries of the European market economies, namely the Mediterranean ones, are those which displayed different behaviour. Their TFP growth was even higher than in the previous period.

A different case is that of the countries of Central and Eastern Europe, which experienced a sharp fall in their agricultural production, and similarly in the use of inputs, especially labour and capital. This is due to the range of problems caused by the economic transition from a centrally planned economy to a market one.⁸⁰

So, to summarise. European agricultural production grew strongly until the mid-1980s, stagnating from then on. During the first stage of rapid growth, a process of intensive capitalization of the sector occurred, as against reductions in the use of labour and land. Furthermore, sharp increases in productivity permitted the improvement of efficiency in this sector.

In turn, from the late 1980s onwards, the transformation of the productivist model of the CAP to another in which agricultural income support was partially decoupled from production, and similarly the transition from a centrally planned system to a market one in the countries of the ex-Communist bloc, affected production; this continued to reduce the use of land and labour and, in turn, maintained or reduced the role of capital. Faced with these reductions in factor employment, it was the increases in the total productivity of these same factors which permitted production to be maintained.

IV

The present study has highlighted diverse ways of accomplishing high production growth in the long term. From our perspective we can distinguish two different models and one intermediate one. The first is characteristic of the countries of Western Europe and Germany. At the

⁸⁰ There also existed problems in the German Democratic Republic in comparison with the Federal Republic of Germany. In the mid-1990s there were differences between capital, labour and livestock per hectare, and also between yield per hectare and input quality between the two Republics. Inefficiency in the GDR resulted from the assignation of inputs and the size of farms, not from ownership type. H. Thiele and C. M. Brodersen, 'Differences in farm efficiency in market and transition economies: empirical evidence from West and East Germany', *European Rev. of Agricultural Economics* 26 (1999), pp. 331–47; Macours and Swinnen, 'Causes' and 'Patterns'.

beginning of the period, these countries had a more advanced level of economic development and higher capitalization of their agriculture. These were based on strong increases in agricultural efficiency, with an annual mean growth rate which exceeded 1.5 per cent in the 55 years studied. The increase in the use of capital played a very important role, although its significance waned by the end of the period. Capital investment grew extraordinarily quickly in the 1950s, decelerated in the 1960s and 1970s (although it continued to increase significantly) and fell from the 1990s on. This model combined, therefore, a considerable fall in the use of land and, above all, labour, with a significant growth of capital, while efficiency improvement played a prime role.

The opposing model is that of the countries with centrally planned economies. In them the key to growth in agricultural production was the very strong increases in the use of capital, much higher than those of the Western countries, while the use of land and labour similarly diminished. The efficiency of the system improved, but by considerably less than in the rest of Europe. In short, their model of agricultural growth resembled that of their economies as a whole, in which efficiency considerations played a secondary role compared to the accumulation of the capital factor (and labour in non-agricultural activities).⁸¹ The transition to a market economy seriously affected their production, and also upset their model of growth, by significantly reducing the use of capital and maintaining efficiency improvement. A certain, although still slight, convergence towards the Western model took place.

The intermediate situation is that of the lesser developed countries in the southern European periphery and the Nordic countries, although between these two groups there were also important differences. Their development model was based more on the increase in capital than on efficiency improvement, but unlike those of the Soviet bloc, they tended to converge much earlier with the model of the Western countries. In the 1950s their growth was based very unequally on the increase in capital, as against efficiency. By contrast, from 1960 onwards, although the use of capital grew rapidly, so did efficiency, at a rate which approximated that of the Western countries. From 1985, although in distinction to the Western countries the use of capital continued to increase in the Mediterranean countries, its rate was slow and efficiency increased even more quickly than the Western countries, showing a tendency to converge, especially in Spain and Portugal. In the Nordic countries the use of capital also fell from 1985 on, as in the Western countries.

In summary, the growth of agricultural production in Europe shows paths which differ but which tended to convergence. A model strongly based on efficiency increase was categorically followed by the more advanced countries since the early 1960s and by the more backward countries of the southern periphery from the early 1980s. The countries of Central and Eastern Europe had to wait for their transition to market economies in the mid-1990s before they could adopt a similar model.

But what is there behind such an important role for efficiency improvement in European agriculture in the second half of the twentieth century? In great measure, this strong growth was derived from the massive adoption of technologies which permitted land and labour to be saved, while production was maintained or even increased. Technology and technical progress,

⁸¹ A. Maddison, *The World Economy in the twentieth Century* (1989).

as we have seen, played a fundamental role in European agriculture throughout this period. Technological innovation materialized in a significant and growing use of capital inputs, which, despite having been introduced before the Second World War in the most advanced countries, now spread to an unprecedented degree. The adoption of technological change and the conditions which permitted its generation were without a doubt closely linked to the type of economy and society which developed in Europe following the Second World War.⁸² In this way, high-income economies, characterized by a continuous adoption of innovations oriented towards efficiency improvement, steered agriculture towards a model of growth which was not significantly different from the general model of economic growth.

Perhaps the principal difference was the importance to agriculture of public policies oriented towards the maintenance of agricultural incomes, which considerably limited the role of the market. It is not that the public sector and government policies were not important in the remaining economic activities, but rather that in agriculture their role was much more decisive, due not only to the establishment of prices or the protection of the internal market, but also more dynamically, such as the stimuli supplied by public research efforts. Investigation into creating and improving machinery, into chemical fertilizers and into the genetic selection of seeds to improve yields, among other research, meant a very strong boost to technical processes and, therefore, to TFP. Agricultural extension services facilitated the diffusion of new technologies, coming to play an important role in the increase in TFP.

The countries with centrally planned economies departed from this model. Their strategy of a huge use of the capital factor in agriculture and a certain disdain for efficiency is congruent with their general model of economic growth. The countries of the southern European periphery, although they also initially based their agricultural growth on heavy injections of capital, attempted from a relatively early period to improve their efficiency, following (although with limitations) the model of agricultural development previously employed by the countries of Western Europe. Yet this growth of TFP does not only show technical progress, but also a measurement of efficiency in the system as a whole. Its TFP growth was also based on an improvement in factor allocation, that is to say sound economic policies.⁸³

In conclusion, it can be stated that although the present study validates the general hypothesis, originally proposed by Federico in 2005, regarding the highly intensive agricultural growth in this period, the European case qualifies the hypothesis in two directions. Firstly, it highlights the close interconnection between TFP growth and the use of modern capital inputs. Secondly, at the regional level in Europe it can be concluded that there were significant differences in the contribution to output growth of capital and TFP.

⁸² D. Gallego, *Más allá del Mercado: Los condicionantes históricos del desarrollo económico* [Beyond the Market: The historical conditions of economic

development] (2007).

⁸³ Federico, *Breve historia económica*, p. 66.

Appendix

Groups of countries: The countries which constitute the Western Europe group are: Austria, Belgium-Luxembourg, Denmark, France, Ireland, the Netherlands, Switzerland and the United Kingdom.⁸⁴ The countries included in the Mediterranean group are: Greece, Italy Portugal and Spain. Three countries comprise the Nordic group: Finland, Norway and Sweden. The market economies group is formed by these three groups of countries. The last and final group, Central and Eastern Europe, is constituted by Albania, Bulgaria, Czechoslovakia, Hungary, Poland, Rumania and Yugoslavia. The data for Czechoslovakia and Yugoslavia are aggregated after their dissolution in 1992 and 1993, respectively.

Data sources for the tables: Authors' compilation, using FAOSTAT as a base.⁸⁵ The 1950 data for all the variables has been elaborated using the *FAO Production Yearbook*.⁸⁶ Data for the two Germanies prior to 1992 are the authors' compilation, based on the *FAO Production Yearbook*.

Calculation of variables: If there are no data for some years we have obtained them through linear interpolation from among the statistics available from the data sources.

Production: The data are for net production, which is gross production minus seeds and feedstuffs. The data have been extracted from FAOSTAT and the *FAO Production Yearbook* in the following way. The data from 1962 to 2005 were downloaded from FAOSTAT. These represent the level of net production at 1999–2001 prices in international dollars. The only exception to this procedure was the case of Germany. The data corresponding to the Federal Republic of Germany and to the German Democratic Republic have been calculated using the 1999–2001 prices from Germany, downloaded from FAOSTAT and multiplied by physical production extracted from the *FAO Production Yearbook*.⁸⁷ Prior to 1961 FAOSTAT does not offer production data, but the annals of *FAO Production Yearbook* do however facilitate numerous indices of gross production from 1948, with a base firstly at the pre-war level and later in 1953.⁸⁸ To obtain a complete annual series from 1948, we have employed the evolution of those statistics indicating the indices of gross production, comparing the 1961 value of net production with the index number for the same year. Obviously, we are assuming that the evolution of the gross production and net production are equivalent. In this way we calculate net production until 1953. Prior to that year the base level in the numerous indices calculated by the *FAO Production Yearbook* is the pre-war level. Thus, we calculate the evolution between 1948 and 1953 by comparing the production level obtained in 1953 with the index number of the same year with its base at the pre-war level.

⁸⁴ The data for Belgium-Luxembourg are aggregated in the FAO and FAOSTAT databases until 2000. We then aggregated the data to homogenize an annual series.

⁸⁵ FAOSTAT, *FAO Database*, faostat.fao.org (2009), Accessed June 2009 and April 2010

⁸⁶ *FAO Production Yearbook*, 1948–2004.

⁸⁷ *FAO Production Yearbook*, 1948–1976; *FAO Produc-*

tion Yearbook, 1977–1986; *FAO Production Yearbook*, 1987–2004.

⁸⁸ The index offered by FAO is the production of crops and livestock products for human consumption, adding fibres, tobacco, industrial oilseeds and rubber and subtracting crops and skim milk used as feed in livestock production.

In FAO yearbooks there are no indices of agricultural production for the Central and Eastern European countries. We have had to obtain data to measure their net production in the 1950s differently to the market economies and Yugoslavia. For Hungary and Poland, we have used one index of agricultural production for each country; the sources are Berend and Ranki (1985) and Landau and Tomaszewski (1985) respectively. We have taken as reference net production in 1961 and assumed that the evolution of agricultural production in the 1950s followed the trend given in these indexes. For Bulgaria, Czechoslovakia, the German Democratic Republic and Romania, we have obtained production in quantities during the 1950s from FAO (1948–2004). We have calculated production in 1999–2001 dollars using prices from FAOSTAT (2009). Such calculations have permitted us to obtain an 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 obtained production for the 1950s taking net production in 1961 as reference.

The pre-war index number base period for FAO is 1934–38, with the exceptions of West Germany and Greece (1935–38) and Spain (1931–35).

For the case of Albania, we have assumed that agricultural production between 1950 and 1961 followed the evolution of crop production, which is available for the 1950s in the FAO Yearbooks.

Agricultural workers: The population censuses do not permit us to establish the number of part-time workers in agriculture. Similarly, it is not possible to determine whether the workers registered in the sector dedicated all their time to farm work. Consequently, it would be convenient to measure the active agricultural population in hours worked.⁸⁹ Faced with the difficulty of finding reliable databases for broad spatial and temporal samples of this variable, we decided to measure the active population in agriculture by the number of workers. This variable, although it differs from the true labour force, can describe in broad outlines the sharp decrease in the real human labour force which agriculture experienced after 1945.

The datum for Albania in 1950 has been estimated. We have assumed that the active population and the number of tractors (Tables 6 and 7) follow the same evolution as Yugoslavia between 1950 and 1961.

Land: The datum for Albania in 1950 is that of 1959.

Area equipped for irrigation: the FAOSTAT database begins in 1961. We have completed the decade of the 1950s with data from the *FAO Production Yearbook* for Greece and Spain. For the rest of the countries either there are no data or the data offered by FAO and FAOSTAT display significant differences in their definition, and consequently we have assumed that this variable remains constant.

The datum for Albania in 1950 is that of 1953 taken from the *FAO Production Yearbook*.

Livestock units: This is a weighted average in which the weightings are obtained from Hayami and Ruttan, and the species taken into account, together with the weightings in parentheses,

⁸⁹ Federico, *Feeding the World* and *Breve historia económica*.

are: donkeys or asses (0.8), buffalos (1), horses (1), goats (0.1), pigs (0.2), chickens (0.01), cattle (0.8), geese (0.01), mules (1), sheep (0.1), ducks (0.01) and turkeys (0.01).⁹⁰

There are no data for Portugal before 1957. We have assumed that the growth between 1950 and 1956 was at the same annual rate as in the period 1957–61.

In the case of Bulgaria there are no data for chickens before 1952. We have assumed that the figures for 1950 and 1951 grew at the same annual rate as in the period 1952–56.

The datum for Albania in 1950 is that of 1957.

Fertilizers: The datum for Albania in 1950 is that of 1959.

Machinery: The datum for Albania in 1950 is the average of 1949–1952.

⁹⁰ Hayami and Ruttan, *Agricultural development*.