IS THERE A LATIN AMERICAN AGRICULTURAL GROWTH PATTERN? FACTOR ENDOWMENTS AND PRODUCTIVITY IN THE SECOND HALF OF THE 20TH CENTURY

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ABSTRACT

In this article, we discuss whether there was a single Latin American pattern of agricultural growth between 1950 and 2008. We analyse the sources of growth of agricultural production and productivity in ten Latin American countries. Our results show that the differences between these countries are too large to establish a single pattern for this region. However, certain common trends may be observed, such as the growing importance of labour productivity as a component of agricultural production growth and the increasing relevance of total factor productivity as a component of agricultural labour productivity growth.

Keywords: Latin American economic history, Latin American agriculture, agricultural productivity, agricultural growth, total factor productivity

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RESUMEN

En este artículo se analiza si hubo en América Latina un modelo único de crecimiento agrario entre 1950 y 2008. Analizamos las fuentes de crecimiento de la producción y la productividad agrícola en diez países latinoamericanos. Nuestros resultados muestran que las diferencias entre estos países son demasiado grandes para establecer un patrón único para esta región. Sin embargo, se pueden observar ciertas tendencias comunes, como la creciente importancia de la productividad laboural como componente del crecimiento de la producción agrícola y la también creciente relevancia de la PTF como componente del crecimiento de la productividad del trabajo en la agricultura.

Palabras clave: Historia económica de América Latina, agricultura de América Latina, productividad agrícola, crecimiento agrícola, productividad total de los factores

1. INTRODUCTION

The relative economic importance of agriculture declined substantially as countries experienced economic development with the consequent structural change. Despite this, agriculture continues to be a strategic sector (Timmer 2009). This is not only because it satisfies one of the basic demands of human beings, namely to be fed, but also because in the economies of developing countries its weight is still sizeable (Alston and Pardey 2014). In addition, agriculture can make a significant contribution to economic growth in developing countries (World Bank 2007).

Since the beginning of the industrial revolution until today the agricultural sector has experienced extremely profound transformations. One such transformation is the growth of agricultural production and productivity, which have received considerable attention because of their importance in feeding a growing world population. The causes of the sharp increase in agricultural production and productivity and the considerable regional differences in these increases have been the themes which, from a long-term economic perspective, have attracted most attention (Hayami and Ruttan 1985; Grigg 1992; Federico 2005; Lains and Pinilla 2009; Martín-Retortillo and Pinilla 2015a; Pinilla and Willebald 2018; Martín-Retortillo *et al*. 2019).

Following World War II, agricultural production grew more quickly than the world's population, thereby simultaneously generating situations

of excess supply in some world regions and of food insufficiency or even hunger in others. This growth in production is largely explained by technical change which, while very deep-rooted, has been extremely unequal from a geographical point of view. Moreover, all countries modified their agricultural policy together with their trade and regional integration policies, which created different systems of incentives to agricultural activity (Anderson 2009). The diversity in the adoption of these transformations, both technical and institutional, gave rise to significant differences in the agricultural development of various countries. Furthermore, in recent years a considerable number of studies have attempted to establish a taxonomy of these experiences of agricultural growth (Timmer 2009; Alston and Pardey 2014).

Given this background, the aim of this paper is to analyse the case of Latin America in the context of the agricultural change that has taken place throughout the world. We discuss whether there is a single Latin American pattern of agricultural growth or whether, in fact, the enormous differences within this region could suggest the existence of several paths. To this end, we have analysed the sources of growth of agricultural production and productivity in ten Latin American countries in the second half of the 20th century. We analyse production as a relationship between the evolution of labour endowment and labour productivity. We interpret labour productivity through the land–labour ratio and land productivity as well as total factor productivity (TFP, henceforth) and production factors per worker.

This paper aims to fill the gap in our knowledge of the subject, making two main contributions. First, the period of analysis starts in the middle of the 20th century, when the available comparative studies begin in the 1960s (Solbrig 2006; Ludena, 2010; Nin-Prat *et al*. 2015; Martín-Retortillo *et al*. 2019). Second, having a time span of almost 60 years has allowed us to relate the evolution of agricultural productivity indicators to the main development models implemented in the region. Thus, this broad time span allows us to contrast the evolution of two very different development strategies; one oriented inwards and another outwards, and to therefore identify the dominant incentives at each stage and their differential influence on the agricultural sector. In this context, a comparative analysis is made that takes into account the national trajectories of the agricultural sector from a long-term perspective.

The results of our analysis of the situation of Latin America against a global backdrop show that, despite the region being characterised by the typical conditions of the agricultural sector in developing countries, it displays a trend similar to the pattern of developed regions.

However, when we disaggregate the whole of Latin America into its different national trajectories, our results reveal that the differences between these countries are too large to establish a single pattern for this region. Despite this, there are certain common trends in the second half of the 20th

century, such as the growing importance of labour productivity, which helps us understand agricultural production growth and the loss in relevance of labour endowment. Another trend which may be observed is the increasing importance of TFP to understand agricultural labour productivity growth, while factor endowment per worker loses significance throughout the period.

Although the study does not enable us to identify a single agricultural growth model in Latin America, we have found, with some nuances, two basic paths. The first corresponds to countries such as Argentina and Uruguay, which, in 1950, already had agricultural sectors with high levels of productivity per worker. In 2008 these levels continued to be very high within the context of the region. Other countries, such as Brazil or Venezuela, converged towards this model, but with a much faster increase in production and TFP.

In the other Latin American countries, although their initial labour productivity increased considerably due to their strong increases in land productivity, in 2008 it was still considerably lower than that of the first group. These countries have faced obstacles that would explain this lower growth in labour productivity. These include insufficient growth in non-agricultural activities with the consequent low capacity to absorb labour, an agricultural structure that has made it difficult for producers to access new technologies or credit markets, very rapid population growth, and a lower level of human capital. In addition, it is necessary to take into account different resource endowments (mainly land availability and its quality) and national innovation systems.

Following this introduction, section 2 develops the conceptual framework used for the empirical analysis, namely the methodology and data sources. Section 3 explains the path of Latin American agricultural growth in the worldwide context. Section 4 analyses the evolution of agricultural production growth and its drivers in Latin American countries in the second half of the 20th century. In section 5, we study agricultural productivity, starting with labour productivity, followed by TFP in Latin American countries. Finally, our conclusions are presented in section 6.

2. ANALYTICAL MODEL AND DATA

In order to identify the growth sources of agricultural production and agricultural labour productivity, this section develops our analytical model based on an accounting growth conceptual framework.

First, let us assume, the following identity of agricultural production (Y) expressed as the multiplication of labour productivity (Y/L) and labour (L):

$$Y = \frac{Y}{L} \times L \tag{1}$$

After applying logarithms to the equation and deriving with respect to time [1], we obtain:

$$y = y/l + l \tag{2}$$

where y, y/l and l are the logarithmic growth of output, labour productivity and labour, respectively[1].

Having decomposed the growth of production into improvements in labour productivity and variations in the labour force, we then analyse what lies behind the changes in labour productivity. In order to do this, the analysis is carried out following the identity used by Hayami and Ruttan (1985, p. 139):

$$\frac{Y}{L} = \frac{Y}{T} \times \frac{T}{L} \tag{3}$$

where Y, T and L are agricultural output, land input and labour input, respectively. Expressing equation [3] in logarithmic form, the following equations are derived:

$$\ln\left(\frac{Y}{L}\right) = \ln\left(\frac{Y}{T}\right) + \ln\left(\frac{T}{L}\right) \tag{4}$$

$$\frac{y}{l} = \frac{y}{t} + \frac{t}{l} \tag{5}$$

In equation [5], the term on the left-hand side represents the logarithmic average growth rate of agricultural labour productivity (y/l), which is decomposed into the average logarithmic growth rate of land productivity (y/t) and the average logarithmic growth rate of the land/labour ratio (t/l). This analysis has frequently been used in other studies of historical agricultural labour productivity, such as O'Brien and Prados de la Escosura (1992).

In order to study the evolution of labour productivity in greater depth, we shall decompose it into two factors: TFP and the factor endowment per worker. This analysis allows us to identify whether the growth of labour productivity depends on improvements in productive efficiency or on greater quantities of inputs used per worker.

We can therefore interpret labour productivity growth using these components. To this end, we have followed the decomposition derived from the Cobb–Douglas production function[2]. A function is assumed that displays

[1] We have considered the average logarithmic growth rates.

[2] An approximation of the use of the agricultural production function for the Latin American context can be found in Elías (1985). This function has also been used in Astorga and Bergés (2011) for the economies of six Latin American countries.

constant returns to scale and has three inputs (labour, L; land, T and capital, K). Therefore, equation [6] represents the technological relationships between the amounts of inputs and output:

$$Y = A\, T^{\alpha} K^{\beta} L^{1-(\alpha+\beta)} \tag{6}$$

where A is an efficiency parameter (that represents TFP) and α, β and [1 – $(\alpha + \beta)$] are the output elasticities of land, capital and labour, respectively. After dividing each side of equation [6] by input labour (L) and reorganising in terms of factors of production, the following equation is obtained:

$$\frac{Y}{L} = A\left(\frac{T}{L}\right)^{\alpha}\left(\frac{K}{L}\right)^{\beta} \tag{7}$$

After applying logarithms to equation [7], this is transformed to:

$$\ln\left(\frac{Y}{L}\right) = \ln A + \alpha \ln\left(\frac{T}{L}\right) + \beta \ln\left(\frac{K}{L}\right) \tag{8}$$

Equation [8] could be expressed in terms of productivity efficiency and the variation of the factors of production (in terms of labour). Let us assume that *tfp* is the logarithm of TFP ($\ln A$) and f is the factor of production per worker, namely land and capital per worker in logarithmic terms and adjusted by their respective output elasticities. This means that:

$$f = \alpha \ln\left(\frac{T}{L}\right) + \beta \ln\left(\frac{K}{L}\right) \tag{9}$$

Therefore, equation [8] is expressed as

$$\ln\left(\frac{Y}{L}\right) = tfp + f \tag{10}$$

Finally, f is calculated as a residual:

$$f = \ln\left(\frac{Y}{L}\right) - tfp.$$

However, before calculating f, we must estimate the TFP. The measurement proposed for TFP follows the methodology of growth accounting. This productivity is based on the primary definition of the Solow residual; that is, it is calculated as the difference between the growth of output and

of a combination of production factors. In this analysis, this combination is formed by the land factor, comprised of an aggregation of rainfed, irrigated land and permanent meadows (arable hectares of land and permanent crops, area equipped for irrigation and permanent meadows), labour and capital, which comprises chemical fertilisers, self-propelled machinery and livestock units[3].

This combination is a weighted average in which the weightings are the remunerations that each factor receives in percentage terms over total production (see Appendix for greater detail). The formula employed to obtain the growth of TFP is that proposed by Fuglie (2010, 2012):

$$\ln\left(\frac{\mathrm{TFP}_{i,t}}{\mathrm{TFP}_{i,\,t-1}}\right) = \ln\left(\frac{Y_{i,t}}{Y_{i,\,t-1}}\right) - \sum_{i} (s_{i,\,j,\,t}) \ln\left(\frac{x_{i,j,\,t}}{x_{i,\,j,\,t-1}}\right) \tag{11}$$

where Y and x are vectors of output and inputs respectively; s, weightings; i, countries; j, inputs. $i = 1, \ldots, 10$; $j = 1, \ldots, 5$. Furthermore, the annual weightings are the part of the total production destined to remunerate each input[4]. The weightings used may be found in the Appendix in Tables A3.1, A3.2 and A3.3. The weightings of Mexico and Brazil are from Fuglie (2012), but we believe that these weightings do not accurately represent the agriculture of the Southern Cone. For this reason, we have taken into account other weightings, drawn from Díaz Alejandro (1970) and Elías (1985) to complete the whole period[5].

In order to meet our objectives using the analytical model developed, it has been necessary to build a quantitative annual database for all the countries examined in this study. It is largely formed by the Food and Agricultural Organisation (FAO henceforth) statistics, although a series of estimates also had to be made. The main variables in our study, namely, agricultural production (gross output), labour, land, machinery and livestock units are available from 1961 in FAOSTAT (2012). To achieve a

[3] We have omitted buildings or trees due to the impossibility of obtaining data for these variables in the time and spatial sample. In this way, we are assuming that the capital grew at the same rate as the components for which we have data. Furthermore, chemical fertilisers are included as working capital (Federico 2011, p. 40). The agricultural economics literature includes this variable as this type of capital or as an intermediate input in the measurement of TFP. Our calculation methods of the different variables are explained in the Appendix. Furthermore, we have compared our calculation of the growth of the capital variables with that estimated in databases such as FAOSTAT (2020) or Butzer *et al.* (2010). This comparison revealed robustness, showing a lower volatility in our estimate but a similar growth trend in capital. The graphs and this comparison are available from the authors on request.

[4] We have calculated the TFP annually, taking into account yearly weightings, production and inputs data.

[5] For further details, see the Appendix. We have included our Argentine weightings to specify an agriculture with a greater importance of livestock and fixed capital accurately, especially at the beginning of our sample, when Southern Cone agriculture was more developed.

complete database from 1950, we had to draw the data from FAO (1948-2004)[6]. In this way, we obtained annual series from 1950, which we linked with those of FAOSTAT, which began in 1961[7]. In the case of the chemical fertilisers, we obtained the data from 1961 to 2008 from IFA (2014). Subsequently, we obtained a complete series of chemical fertilisers joining this IFA series with the data from FAO (1948-2004) for the 1950s.

Our TFP estimation is based on Fuglie (2010, 2012), but it is not similar. In fact, Fuglie and Rada (2018) calculated the TFP for the whole world from 1961[8]. However, in Latin American agricultural economic history the import substituting industrialisation (ISI) period after World War II was fundamental which is why we consider it important to include these years.

It is important to bear in mind that the FAO database has some measurement problems (Alston *et al*. 2010). In particular, the data available do not capture changes in the composition and quality of labour, capital, land and machinery. Hence, the empirical findings should be taken with some caution when identifying patterns of output and productivity growth.

It is essential to recognise that the proposed methodology is not exempt from certain methodological and theoretical problems. In the process of estimating the TFP we can identify three key issues. First, the specification of the relationship between the inputs and the output, that is, the production function that underlies this relationship. Second, the adequate measurement of the inputs and production factors (capital, land, fertilisers, natural resources, and livestock, among others). Third, the allocation of weights to inputs when aggregation is performed (Chen 1997). We are aware that the data required for estimating TFP in an international context are not always available and there are data quality problems that render the international comparison of TFP estimates challenging. Additionally, we are also aware of the theoretical controversies underlying the use of TFP as an indicator of efficiency or technological change[9]. Among the critical issues to be mentioned is the questioning of the neoclassical assumption that production

[6] These yearbooks calculated an annual production index for the ten Latin American countries studied. We have assumed that the agricultural production series during the 1950s follow the same evolution. Besides, FAO yearbooks during the 1950s provide data for certain years for inputs data. With these data we have also calculated an annual series for the inputs.

[7] For further details, see the Appendix. FAO data yields were compared with the microdata in Gollin *et al*. (2014, p. 169). They «find essentially no disagreement between the FAO yield data and the many micro estimates of grain yields».

[8] These authors consider more inputs than our study, such as several types of self-propelled machines or the animal feed. Besides, for some countries we have used Argentine weightings that these authors do not take into account. Therefore, our results are not directly comparable.

[9] The authors thank one of the reviewers for their thorough and comprehensive comments on this topic. For references on TFP limitations, see Cohen and Harcourt (2003), Felipe and McCombie (2014) and Nelson (1981).

factors are paid at a level equal to their marginal physical productivity; Cambridge-England's criticisms of Solow's neoclassical production function; the problems of the accounting identity of the Cobb–Douglas production function and the problem of the production function with natural resources pointed out by Georgescu-Roegen. That said, we consider that, taking into account the constraints of the methodology and interpreting the estimates with great care and caution, the empirical analysis carried out in the paper does, indeed, contribute to the understanding of the evolution of Latin American agricultural productivity in recent decades.

3. LATIN AMERICAN AGRICULTURE IN THE WORLD CONTEXT

This section conducts a comparative analysis on an international scale of the evolution of agricultural production and labour productivity growth, so as to situate Latin American agriculture in the world panorama. We also clarify the principal trends of their evolution.

First, we will examine world trends in agricultural production. Table 1 shows that its growth was far greater in the developing regions than in the developed countries. Thus, in the former its increase in absolute terms, on the whole, exceeded 200 per cent between 1965 and 2005, while in the developed countries the increase was no greater than 100 per cent, and generally lower. In this context, the growth of Latin America fits perfectly within the model of developing countries.

Following the observation of the different production growth rates, it is important to understand how these increases were achieved. To do this, we use equation [2].

Table 1 shows the decrease in agricultural labour in the developed regions, with the exception of the slight increase in Australia and New Zealand. The continuous structural change in these economies played a fundamental role in this decrease. On the contrary, agricultural labour in the developing regions grew, although the diversity in these increases of the workforce was also remarkable. The labour factor in Latin America, the Middle East and North Africa increased by much less than in Sub-Saharan Africa, China or Southern Asia. Normally, within developing economies, those with more advanced processes of industrialisation only increased their agricultural workforce very slightly (Grigg 1992; Timmer 2009).

However, all the regions of the world augmented their agricultural labour productivity, but the differences between these regions were significant (Table 1). The highest increases occurred in the developed regions; in the developing regions growth was more modest, although also remarkable. Once more, of the developing countries the increase in productivity was higher in Latin America, the Middle East and North Africa than in other regions.

TABLE 1
LOGARITHMIC GROWTH RATES OF OUTPUT, LABOUR AND LABOUR PRODUCTIVITY, 1965-2005 (%)

	Agricultural production	Labour	Labour productivity
Eastern Europe	0.52	–2.83	3.35
Western Europe	0.98	–3.25	4.23
North America	1.71	–1.45	3.16
Latin America	2.98	0.41	2.57
Australia + New Zealand	1.66	0.22	1.45
Southern Asia (central and east)	3.05	1.43	1.61
China, mainland	4.32	1.93	2.38
Japan	0.61	–4.73	5.33
Middle East and North Africa	3.08	0.34	2.75
Sub-Saharan Africa	2.67	1.81	0.86

Source: FAO (1948-2004) and FAOSTAT (2014).

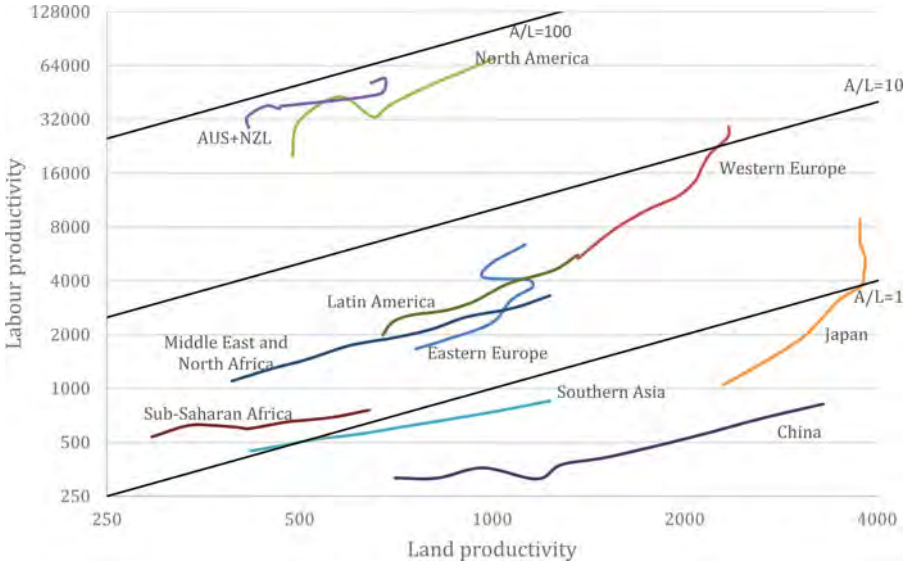
Using the decomposition developed in equation [5], variations in productivity might have been due to highly diverse technological innovations employed in agriculture and also to varied patterns in the use of inputs (Federico 2005). However, in all regions of the world, sharp increases in productivity occurred, whether from labour productivity or land productivity or, often, from both simultaneously. Figure 1 shows the diversity of experiences, taking into account the starting levels and the increase in productivity of land and labour[10].

Thus, there are two very different models of agricultural productivity increases; on the one hand, in the early-industrialised developed countries (including Western Europe, Australia, New Zealand, United States, Canada and Japan), there was a large increase in labour productivity, due both to increases in the productivity of the land and in the land–labour ratio. In this group of regions, a moderate increase in production and strong gains in productivity took place due to biological improvements, a notable increase in mechanisation and decreases in the absolute numbers of the agricultural labour force. These decreases are explained by the strong demand for workers from the rest of the economy.

On the other hand, in developing countries, production grew much faster, although the role of labour productivity was considerably smaller and was based on increases in the productivity of land, normally greater than those of the developed countries, while the land–labour ratio reduced in

[10] See also Table A.1 in the Appendix.

FIGURE 1
LAND AND LABOUR PRODUCTIVITIES (WORLD REGIONS), 1965-2005.
A/L REFERS TO THE SAME LEVEL OF THE LAND PER WORKER RATIO.



Source: As in Table 1.

most world regions. Among the developing regions, it was only in Latin America that the land–labour ratio increased. The growth of labour productivity was therefore based, in almost all the developing regions, on a sharp increase in land productivity, as mechanisation played a minor role due to the strong demographic pressure, as a result of the high population growth experienced by these countries, which meant increases in the absolute number of agricultural workers in all of them (although their percentage with regards to the total active population decreased). However, all the innovations related to the green revolution, as well as hybridisation and the genetic selection of seeds, and the use of fertilisers, pesticides and other chemical inputs explain the key role played by the sharp increase in land productivity on labour productivity (Evenson and Gollin 2002; Pingali 2012; Harwood 2018).

Where can Latin America be placed between these two models? It is a peculiar case, since the region shares characteristics with both and appears to be located in an intermediate situation. It appears to start from a position typical of developing countries and converges towards that of the developed countries. Its growth of production is similar to

that of the developing countries, but its growth of labour productivity has been based as much on an increase in land productivity as on the land–labour ratio. In fact, it is the only region of the developing world in which, in recent years, the numbers of the agricultural workforce have begun to decrease. Furthermore, Latin America was the only developing region in which the land–labour ratio played a positive role in the increase of labour productivity. The evolution of the agricultural labour force in Latin America therefore contrasts with the trajectory followed by the developed countries, with strong falls, but also with the developing countries of Asia and Africa, with very strong increases.

However, an aggregate analysis is unable to clarify the differences between Latin American countries. Latin America is very diverse from a geographical, climatic, social, economic or institutional point of view. As Solbrig (2006, p. 535) stated, within Latin America «diversity was and continues to be a characteristic of the agriculture of this vast region, a result of the variety of climates, topography, history, and societies». We believe, consequently, that a profound understanding of the growth of agricultural production and productivity requires a consideration of the experiences of the different countries, to attempt to determine to what extent a single Latin American pattern exists, or whether the aggregate result mentioned conceals highly diverse trajectories.

4. THE DRIVERS OF AGRICULTURAL PRODUCTION GROWTH IN LATIN AMERICA

In this section, we analyse the growth of agricultural production and its drivers in Latin American countries in the second half of the 20th century using equation [2][11]. To facilitate the analysis, we have further divided

[11] We have taken into account ten Latin American countries: Argentina, Brazil, Chile, Colombia, Honduras, Mexico, Panama, Peru, Uruguay and Venezuela. The availability of the data from the 1950s in FAO (1948-2004) is the main restriction to include more countries. Despite this restriction, we covered between 85 and 90 per cent of total Latin American agricultural production from 1965 to 2005 and they have had several distinctive agricultural specialisations that make them «candidates» for identifying «patterns». Therefore, we refer these countries as our sample. Following the typology proposed by Sain and Ardila (2009), this sample would principally include two types of countries. The first includes Argentina, Brazil, Chile, Mexico and Uruguay. This group stands out for its higher level of economic development (average income per capita) and lower level of rurality (more urbanised countries). Furthermore, there is greater availability of agricultural land across the total area, as a regional average; and these countries show an important development of commercial agriculture, which is connected to international markets. The second group of countries, considered as tropical, includes Colombia, Panama, Peru, Venezuela and Honduras. These countries exhibit a lower level of economic development (average income per capita) and higher level of rurality. In addition, they have a lower availability of agricultural land over the total. Family or subsistence farming is of great importance and agricultural supply is more diversified.

the whole period into three subperiods[12]. The first goes from 1950 to 1973, a period we identify with the implementation phase of the policies of ISI. During this time, there was a considerable expansion of the scope of state action with respect to economic and social conditions which was mainly geared towards the domestic market. According to Bértola and Ocampo (2012), this period includes the «classical» phase of industrialisation in Latin America—from the end of World War II to the mid-1960s—and different strategies were implemented until the first oil shock, when the industrialisation process reached its peak in the region. The international economic crisis began in 1973, following the sharp rise in the price of oil. Therefore, the second subperiod corresponds to the years 1973–1993, coinciding with the crisis and the lost decade of economic growth for Latin America until the beginning of the 1990s, when the majority of the region started deep structural reforms (Thorp 1998)[13]. The last subperiod began in 1993 when the economic development model of the Latin American countries changed substantially as a result of the widespread change in policies in Latin America to overcome the deep economic crisis. This last period coincides with the reintegration of Latin America into international trade and the implementation of structural reforms known as the Washington Consensus. In the following years, the rapid growth of the Asian economies, mainly China, generated an intense demand for raw materials and food, which Latin American countries took advantage of to substantially increase their exports of these products.

Firstly, we can observe that all Latin American countries experienced significant increases in agricultural production during the second half of the 20th century (Table 2 and Figure A.1)[14]. In Latin America as a whole,

[12] This periodisation is based on qualitative considerations and econometric analysis. There is consensus in the historiography with respect to considering 1973 as a watershed year in Latin America. In this year, the Organization of Petroleum Exporting Countries (OPEC) imposed export quotas on its members, and oil prices quadrupled. Latin American countries that were net importers of oil at the time suffered a severe impact. In addition, the industrialisation process reached its peak in Latin America in 1973-1974. From this point on, the importance of the industrial sector began to decline. The selection of a breakpoint in 1993 was based on an econometric exercise to identify a structural change in Latin American agricultural production. The crisis produced a new development strategy with deep structural reforms. In order to find a year that defines the widespread adoption of these policies we have econometrically observed when a structural change occurred in Latin American agricultural production, performing the test proposed by Mohitosh Kejriwal and Pierre Perron, that uses a sequential procedure to determine the number of breaks in trend with an integrated or stationary noise component, showing that there was a structural break in 1993.

[13] With the exception of Chile, Uruguay and Argentina, which began these reforms (programme of stabilisation, trade liberalisation, financial reform, privatisation, etc.) in the 1970s, the other countries implemented such reforms mostly from the beginning of the 1990s.

[14] The scope of this study does to extend to examining the differential growth of each type of product. In any event, the literature indicates that in the ISI phase those products oriented towards the domestic market grew more, while subsequently, particularly after 1990, those oriented towards

production increased at an average annual rate of almost 3 per cent. Particularly important were Brazil, Mexico and Venezuela, with growth far exceeding Latin America taken together. Brazil is surely the most outstanding case, since its agriculture has undergone an incredible transformation. Its backward and low productivity agriculture has become a major front-runner both in terms of production and productivity (Mueller and Mueller 2018; Klein and Vidal Luna 2019).

As stated in the previous section, we will now describe the sources of agricultural production, based on the increases in labour productivity and labour endowment (equation [1]). Table 2 and Figure A.1 show the logarithmic growth rates of agricultural production, labour productivity and labour endowment over the whole period (1950-2008).

In the period as a whole, 1950-2008, labour productivity was determinant in the growth of agricultural production (with a contribution of approximately 80 per cent), although the increase in the workforce had a minor but important role, especially in Peru, Colombia and Panama (63, 40 and 38 per cent, respectively). The exceptions to this Latin American pattern in the whole period were Argentina and Uruguay. These countries reduced their labour force throughout the second half of the 20th century, owing to structural change in these more advanced economies, and therefore their growth in output can be completely attributed to labour productivity growth. This distinctive evolution of both countries is underpinned by demographic and economic factors. On the one hand, during the 1940s and 1950s (at the beginning of our analytical period), the demographic dynamics of many Latin American countries started to change as part of a process that peaked in the 1950s-1960s (Pellegrino 2014). The main consequence of the demographic transition was an extraordinary increase in the population; from 1955 to 1965, average population growth in the region peaked (at around 3 per cent per year) with a profound urbanisation process (Villa 1992). Argentina and Uruguay, precisely, were the exceptions in the region, because both countries showed an early demographic transition, before 1930, and with characteristics very similar to the European countries at the beginning of the 20th century (Pérez-Brignoli 2010). In a context of advanced demographic transition, high urbanisation and low population growth, the low relevance of labour input in the agricultural expansion is a result to be expected. On the other hand, Argentina and Uruguay specialised in livestock and cereal production (typical outputs of temperate climates) and showed great dynamism during the First Globalisation era (Martín-Retortillo *et al*. 2019; Pinilla and Rayes 2019). This dynamism enabled high levels in land and labour productivities to be reached.

the international market have grown more (CEPAL 1978; Anderson and Valdés 2008; Serrano and Pinilla 2016; Martín-Retortillo *et al*. 2019).

TABLE 2
GROWTH RATES OF AGRICULTURAL PRODUCTION, LABOUR AND LABOUR PRODUCTIVITY (%)

	Output				**Labour productivity**				**Labour**			
	1950-1973	**1973-1993**	**1993-2008**	**1950-2008**	**1950-1973**	**1973-1993**	**1993-2008**	**1950-2008**	**1950-1973**	**1973-1993**	**1993-2008**	**1950-2008**
Argentina	0.69	1.56	2.96	1.57	1.18	1.54	3.11	1.80	–0.50	0.02	–0.15	–0.23
Brazil	3.99	3.50	4.32	3.91	2.33	3.66	5.58	3.63	1.66	–0.16	–1.26	0.28
Chile	1.28	3.47	2.60	2.37	0.89	1.89	2.63	1.68	0.39	1.58	–0.03	0.69
Colombia	2.47	2.84	2.20	2.53	1.02	1.65	2.10	1.52	1.45	1.19	0.11	1.02
Honduras	3.50	2.37	3.16	3.02	3.34	1.23	3.45	2.64	0.15	1.14	–0.29	0.38
Mexico	5.03	2.61	2.59	3.57	3.45	1.45	3.11	2.67	1.58	1.16	–0.52	0.89
Panama	3.27	2.32	3.34	2.96	1.43	1.12	3.44	1.84	1.85	1.18	–0.10	1.11
Peru	2.11	1.34	5.45	2.71	0.74	–0.96	4.04	1.01	1.37	2.30	1.41	1.70
Uruguay	0.35	1.25	2.68	1.27	1.18	0.81	2.96	1.51	–0.84	0.46	–0.28	–0.25
Venezuela	4.27	2.87	2.64	3.36	3.99	2.26	3.51	3.27	0.28	0.61	–0.87	0.10
Latin America	2.83	2.71	3.41	2.94	1.48	2.12	3.93	2.33	1.35	0.59	–0.51	0.61

Source: Calculated with data from FAOSTAT (2012) and FAO (1948-2004).

However, both agricultures experienced intense processes of stagnation when faced with the limitations of a closed agrarian frontier and serious difficulties to incorporate technical progress (which was especially notorious following the 1930s). In fact, at the beginning of our period of analysis, both agricultures were immersed in structural problems that caused them severe difficulties to definitively embark on a new expansion trajectory[15]. This situation would not be overcome until the 1980s with the constitution of a real structural transformation based on the incorporation of a new technology package.

Studying the events in each of the subperiods, we can observe that in the first subperiod (1950-1973), labour factor and agricultural labour productivity were almost equally important in explaining the agricultural output growth of Latin America (48 and 52 per cent, respectively). Between 1950 and 1973, the growth of the labour force played the most important role throughout the second half of the 20th century. This increase in the workforce coincided with a massive incorporation of agricultural machinery and chemical products, which produced a strong growth of agricultural production and labour productivity (Federico 2005). During these years, the Latin American population also experienced very rapid growth, increasing from 161 million inhabitants to 300 million (Yañez *et al*. 2014).

The workforce reduced its role as a component of output growth (to 22 per cent) in the subperiod characterised by the oil crisis and the lost decade of economic growth (1973-1993), while agricultural labour productivity gained importance (78 per cent). However, these two decades were highly diverse in the countries of Latin America, probably due to the differing effects of the oil crisis and its consequences. This remarkable diversity is shown by the fact that in several countries the labour force in agriculture fell compared with the first subperiod, as was the case of Brazil, Colombia or Mexico, but in others it rose, for example in Peru, Uruguay or Venezuela. On the contrary, labour productivity growth also displayed different trends, depending on the country chosen.

The panorama after the beginning of the 1990s was different compared with the four decades analysed previously. There was an overall Latin American pattern after 1993, in which labour productivity growth was determinant in the production growth in all countries and its growth was (with few exceptions) the highest of the second half of the 20th century. In addition, the labour factor fell in the majority of countries, with the exception of Peru and Colombia. This change of trend coincides with structural reforms, trade openness and with the strongest growth in agricultural production. The incorporation of Latin American countries into

[15] See Campi (2012) and Barsky and Gelman (2001) for Argentina; Astori (1984) and Moraes (2008), for Uruguay.

international markets after the lost decade (the 1980s), in which primary and agricultural products played a remarkable role, was fundamental to understanding the development process in this region (Martín-Retortillo *et al*. 2019). The new strategy involved mobilising resources in competitive agricultural export sectors. The result was an increase in agricultural exports and a certain change in their composition towards products with a greater degree of industrial transformation or to meet consumer requirements (Serrano and Pinilla 2014, 2016). This process was, especially from the beginning of the 21st century onwards, a response to the dynamic demand for commodities resulting from the growth of emerging economies (with China at the head of the expansion) (Hanson 2012).

5. UNDERSTANDING AGRICULTURAL LABOUR PRODUCTIVITY IN LATIN AMERICA

5.1 Land Productivity *vs*. Land–Labour Ratio: Towards Two Agricultural Models

We will now continue with the analysis of the evolution of agricultural labour productivity in Latin American countries, employing the same methodology used in the distinct regions of the world.

Table 3 shows the levels of agricultural labour productivity (production per worker), land productivity (production per hectare) and land–labour ratios (hectares per worker)[16]. The variations in the levels of labour productivity between the Latin American countries were huge throughout the second half of the 20th century[17]. By 1950, Argentina and Uruguay already had very high levels of labour productivity compared with the other countries, while Chile, Venezuela and Panama were located at intermediate levels, somewhat above the average for the region, and all the others were clearly below the average. The evolution of labour productivity in the second half of the 20th century consolidated the advantage of the countries with high productivity (Argentina, Uruguay and Venezuela).

On the contrary, the case of Brazil is extraordinary; its labour productivity increased most, at an annual rate of 3.7 per cent, meaning that it ceased to be one of the countries with the lowest productivity, positioning itself above the regional average. Agricultural labour productivity in Brazil not only grew very fast after 1950, but its pace accelerated progressively. From 1993 it did so at an average annual rate of 5.6 per cent, a speed so high that no other country in Latin America came near to matching it in

[16] For the calculation of the land input, see the Appendix.

[17] Nevertheless, this dispersion fell, as the coefficient of variation was 0.94 in 1950 and 0.79 in 2008.

TABLE 3
LABOUR AND LAND PRODUCTIVITIES AND LAND–LABOUR RATIOS

	Production ($2004-2006 prices) per worker				Production ($2004-2006 prices) per hectare				Hectares per worker			
	1950	1973	1993	2008	1950	1973	1993	2008	1950	1973	1993	2008
Argentina	7,510	9,858	13,402	21,372	568	455	599	801	13	22	22	27
Brazil	836	1,428	2,971	6,861	341	403	360	643	2	4	8	11
Chile	2,263	2,774	4,044	5,995	276	335	826	1,431	8	8	5	4
Colombia	1,509	1,906	2,652	3,633	902	801	1,357	2,333	2	2	2	2
Honduras	708	1,528	1,953	3,276	487	501	660	1,406	1	3	3	2
Mexico	925	2,044	2,732	4,356	178	472	673	964	5	4	4	5
Panama	1,761	2,445	3,061	5,130	952	819	1,061	1,084	2	3	3	5
Peru	964	1,142	942	1,727	409	448	481	1,018	2	3	2	2
Uruguay	5,612	7,362	8,648	13,483	642	694	895	1,097	9	11	10	12
Venezuela	2,209	5,528	8,694	14,712	434	972	1,670	2,446	5	6	5	6
Latin America	1,554	2,185	3,336	6,012	382	472	534	837	4	5	6	7

Triennial averages for the production.
Source: Calculated with data from FAOSTAT (2012) and FAO (1948-2004).

any of the subperiods analysed. In this improvement of productivity, which also coincided with a strong increase in production, an important agricultural research effort played a key role from the early 1970s in searching for appropriate technologies for the different biomes and climates of the country. EMBRAPA (the Brazilian Enterprise for Agricultural Research), created in 1973 by the Ministry of Agriculture, was the steering body of this effort. The public support for agricultural modernisation was fundamental. Particularly noteworthy was the introduction of state-subsidised agricultural loans on a massive scale in the 1970s and 1980s (Klein and Vidal Luna 2019). In addition, in the first decade of the 21st century, stable and open institutions which have provided macroeconomic and political stability have been very important for this improvement in productivity (Mueller and Mueller 2016).

In the case of land productivity, differences between countries, although significant, were fewer than in the case of labour productivity. Colombia was the leader in 1950 and maintained this position at the end of the period when the differences among countries decreased. The leaders in terms of growth were Chile (775 per cent), Mexico (470 per cent) and Venezuela (459 per cent) and the worst performer was Argentina (with an increase of only 28 per cent).

Table 3 also shows that the countries with greater land–labour ratios had higher levels of agricultural labour productivity and low land productivity[18]. The differences between Latin American countries were remarkable, especially between Argentina and Uruguay and the rest of the region. These two countries, as we have seen, only had a very high level of labour productivity in the middle of the century.

However, it is interesting to observe the drivers of labour agricultural growth, following equation [5] used in the previous section. With this objective in mind, we can see the logarithmic growth rates of these three variables in Table 4.

In the case of agricultural labour productivity, Latin American growth was notable throughout the second half of the 20th century and the early years of the 21st century, with an annual rate of increase of 2.3 per cent. Land productivity also increased in this period, although it did so at a lower rate than that of labour productivity (1.35 per cent). The land–labour ratio increased by 0.98 per cent throughout the entire period. Thus, we can interpret labour productivity growth as a result of increases in land productivity, as in the rest of developing regions, but the land–labour ratio accounts for 42 per cent of the explanation of this growth.

It can therefore be said that the differences in the intensity of technical innovations adopted during this period, such as agricultural machinery,

[18] The same process happened in Europe from 1950 (Martín-Retortillo and Pinilla 2015a).

TABLE 4
GROWTH RATES OF AGRICULTURAL LABOUR AND LAND PRODUCTIVITY AND LAND–LABOUR RATIO, 1950-2008 (%)

	Labour productivity				Land productivity				Land–labour ratio			
	1950-1973	1973-1993	1993-2008	1950-2008	1950-1973	1973-1993	1993-2008	1950-2008	1950-1973	1973-1993	1993-2008	1950-2008
Argentina	1.18	1.54	3.11	1.80	−0.96	1.37	1.95	0.59	2.15	0.16	1.16	1.21
Brazil	2.33	3.66	5.58	3.63	0.72	−0.56	3.87	1.09	1.61	4.22	1.71	2.54
Chile	0.89	1.89	2.63	1.68	0.84	4.52	3.66	2.84	0.04	−2.63	−1.04	−1.16
Colombia	1.02	1.65	2.10	1.52	−0.52	2.64	3.61	1.64	1.53	−0.99	−1.51	−0.12
Honduras	3.34	1.23	3.45	2.64	0.12	1.38	5.05	1.83	3.22	−0.15	−1.60	0.81
Mexico	3.45	1.45	3.11	2.67	4.23	1.78	2.39	2.91	−0.79	−0.33	0.72	−0.24
Panama	1.43	1.12	3.44	1.84	−0.65	1.29	0.14	0.22	2.08	−0.17	3.30	1.62
Peru	0.74	−0.96	4.04	1.01	0.40	0.36	4.99	1.57	0.34	−1.32	−0.95	−0.57
Uruguay	1.18	0.81	2.96	1.51	0.34	1.27	1.36	0.92	0.84	−0.47	1.60	0.59
Venezuela	3.99	2.26	3.51	3.27	3.50	2.71	2.54	2.98	0.49	−0.44	0.96	0.29
Latin America	1.48	2.12	3.93	2.33	0.91	0.62	3.00	1.35	0.57	1.50	0.93	0.98

Source: Calculated with data from FAOSTAT (2012) and FAO (1948-2004).

chemical products or the hybridisation and genetic selection of seeds generated significant differences in the components of the growth of productivity in agricultural labour.

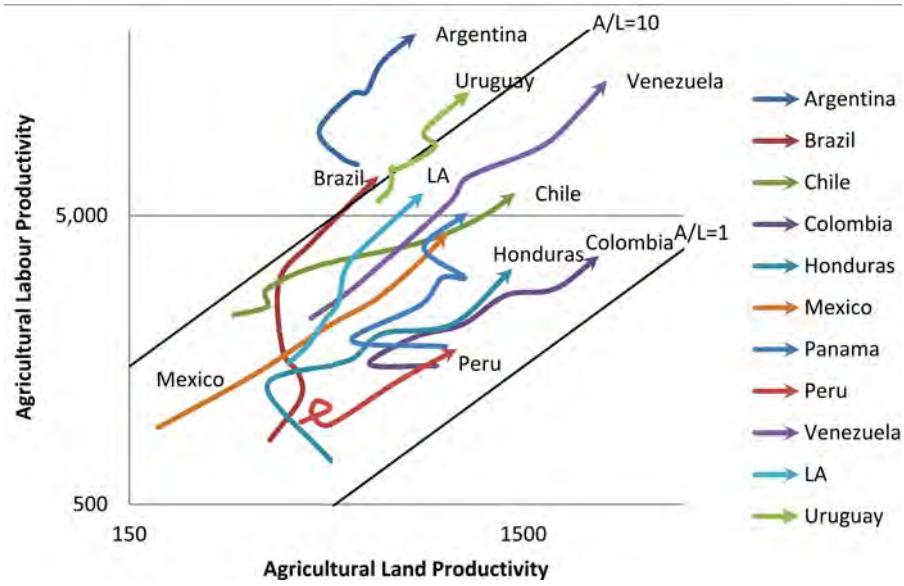
The trends of these two types of productivity and the land–labour ratio are illustrated in Figure 2, to clarify the different patterns among Latin American countries in the second half of the 20th century. This figure depicts the relationship between labour productivity (left-hand axis) and land productivity (horizontal axis) for the ten countries and Latin America as a whole. If we compare the levels and variation of the two types of productivity, it can be observed that the countries which had the highest levels of labour productivity around 1950 did not have especially high levels of land productivity. This was the norm throughout the period and, in fact, in some cases the correlation was negative (as in 1950 and 2008). In turn, and as can be expected, the positive relationship between the two types of productivities was weak for the countries considered individually.

A comparison with the (darkest) line of Latin America permits two patterns to be visualised. The countries in which the land–labour coefficient is greater are located above the adjustment line; in other words, those economies in which the use of labour is relatively more intense than that of land (where more land per unit of labour is used). There are two countries which clearly display this characteristic—Argentina and Uruguay—, one which displays a trend towards the same direction—Brazil—and another which abandons this group—Chile. The remaining countries reveal a pattern based on the more intensive use of labour. The figure shows that the differences are more important in the levels of labour productivity than in land productivity.

Similarly to the previous section, we will now explain the components of labour productivity in the different subperiods.

In the first two decades of the second half of the 20th century, the growth in the land–labour ratio (0.57 per cent) was fundamental for understanding the growth of labour productivity (1.48 per cent), especially in Argentina, Brazil, Colombia, Panama and Honduras. One explanation of these trends is the sharp increase in the land cultivated in Latin America (2.2 per cent annually in this subperiod), which reduced the potential increase of land productivity in some countries due to technical change, while the land–labour ratio also rose (Martín-Retortillo *et al*. 2019). During this subperiod, three countries, Mexico, Venezuela and Chile, followed a different path to that of Latin America as a whole, with very high increases in land productivity in the first two. In the case of Mexico, this strong increase in the productivity of the land is explained by two reasons: the pioneering role that this country played in the green revolution and the very strong increase in irrigation in its northern region, especially in the 1950s (Yunez 2014). In the 1940s and 1950s the

FIGURE 2
AGRICULTURAL LABOUR PRODUCTIVITY *VS*. AGRICULTURAL LAND PRODUCTIVITY. A/L REFERS TO THE SAME LEVEL OF THE LAND PER WORKER RATIO.



Source: Calculated with data from FAOSTAT (2012) and FAO (1948-2004).

Rockefeller Foundation supported a wheat breeding programme under the direction of Norman Borlaug which, in a few years, obtained new high-yield seeds (HYS) that substantially increased yields. Between 1946 and 1975, the irrigated area increased by more than two and a half million hectares (Cerutti 2015, p. 94). In fact, irrigation and the green revolution formed part of the same technological package.

The situation of Latin American agriculture changed in the second subperiod, characterised by the oil crisis and the lost decade (1973-1993). Land productivity became the source of growth in agricultural labour productivity. That is to say, not only did the use of land increase in Latin America, but it was also increasingly productive, given the intensification of its use (Solbrig 2006). The land–labour ratio in all the Latin American countries, except for Brazil, decreased or increased slightly. The Brazilian case is striking because it did not follow the general path, as overall labour productivity growth was due to increases in the land–labour ratio. In these years, although the labour employed in agriculture fell slightly in this country, the cultivated area increased substantially. This

expansion occurred mainly in the Cerrado savannah, considered until then as unproductive. EMBRAPA was particularly successful with the development of HYS adapted to the physical and climatic environment (Evenson and Rosegrant 2002).

After 1993, the land–labour ratio partially recovered the importance lost in the previous subperiod (24 per cent of labour productivity growth was due to growth in this ratio). Thus, land productivity is key to understanding labour productivity, as in the rest of the developing regions worldwide[19]. In Latin America, with the important Mexican exception, the employment of HYS was delayed somewhat with regards to Asia. However, after the mid-1980s they subsequently made an important contribution to the increase in land productivity (Evenson and Gollin 2002).

Two patterns divided Latin American agriculture in this subperiod: on the one hand, countries such as Chile, Colombia, Honduras and Peru decreased their land–labour ratio and land productivity is the only variable that increased labour productivity. In the case of Chile, this decrease (1.04 per cent) was due to an increasing intensity of the labour factor. The change of specialisation of Chilean agriculture towards labour-intensive crops for export, such as fruits and vegetables, can explain this (Foster and Valdés 2006).

On the other hand, land–labour ratios in countries such as Argentina, Brazil or Uruguay increased, and came to represent a large part of labour productivity (37 per cent for Argentina, 31 per cent for Brazil and 54 per cent for Uruguay). The increase in Brazil (over 1.71 per cent annually) is explained by the fact that the country could be considered as having an open frontier. At the end of the 1980s, Brazil promoted a political strategy of extending the free market, with the elimination of taxes on exports and price control mechanisms, which created new challenges for agriculture. The opening up of the global market, particularly when Asian demand began to grow quickly, stimulated the emergence of modern farming entrepreneurs who, using internal and external loans efficiently, were able to take advantage of the new situation becoming integrated in sophisticated production chains (Klein and Vidal Luna 2019).

5.2 Total Factor Productivity *vs.* Factor Endowment per Worker

Table 5 shows the growth rates of the variables obtained following equation [10], namely TFP and factors of production per worker. For our calculation we applied the weightings of Argentina to Argentina, Chile and Uruguay; those of Mexico to Mexico, Colombia, Honduras and Peru and

[19] However, the Latin American region is the developing area where the land–labour ratio has the greatest importance as a component of agricultural labour growth.

those of Brazil to the rest[20]. To calculate the Latin American averages, we used the weightings of Brazil because this country possesses the most diverse agriculture of our sample. Agriculture in Brazil includes tropical products, temperate crops, industrial crops and livestock and represents an «average» of Latin America[21].

It may be observed that the main source of agricultural labour productivity in the whole period (1950-2008) in Latin American countries was the improvement of efficiency (TFP growth). The remarkable incorporation of innovations into the agricultural sector permitted this increase and was based on an intensive growth of agricultural outputs, such as self-propelled machinery, chemical products and the hybridisation and selection of seeds.

Despite the importance of efficiency gains in the whole region, there are some exceptions in which the sources of factor accumulation per worker were fundamental for understanding agricultural labour productivity growth. The principal exceptions are Argentina and Uruguay, where the main source of agricultural labour productivity was the increase in the factor of production per worker with a very small contribution of TFP growth. The sharp increases in the use of land, especially in Argentina, the maintenance or the reduction of the workforce and the incorporation of capital inputs helps us to understand these exceptions.

However, it is more interesting to observe these sources of growth throughout the subperiods previously used. This analysis allows us to understand the differences in trends of the sources of Latin American agriculture.

The first period was dominated by the importance of the augmentation of inputs in the agricultural sector. This process was predominant, due to the increasing incorporation into the production process of agricultural machinery, chemical products and land[22]. This incorporation was higher than the growth of labour, producing the increase in the ratio. Despite this general trend, Mexico and Venezuela did not follow the Latin

[20] See the Appendix.

[21] However, we have calculated the TFP of the whole of Latin America with the other two weightings, namely from Argentina and Mexico, to check the robustness of our results. See the Appendix.

[22] This period is characterised by the ISI policies that penalised export-led agriculture. During the ISI period a set of economic measures that affected the profitability of the agricultural activity was implemented. On the side of agricultural policies, an attempt was made to ensure a cheap food basket for the emerging industry. To this end, price controls were established, to which export taxes or quotes were added. The effect of these measures was negative on the domestic terms of trade (price of agricultural commodities relative to price of non-agricultural commodities). Additionally, real exchange rate overvaluation took place, as part of the macroeconomic and industrial policies, causing a decrease in the terms of trade of agriculture. (Kay 2002). This could suggest that a scenario of worsened terms of trade, both in domestic and external markets, caused a move against the agricultural sector. This brought about the erosion of the incentives to modernise farming activities and a negative impact on TFP performance.

TABLE 5
GROWTH RATES OF TFP AND FACTORS OF PRODUCTION PER WORKER (%)

	1950-2008		1950-1973		1973-1993		1993-2008	
	TFP	Factors of production per worker	TFP	Factors of production per worker	TFP	Factors of production per worker	TFP	Factors of production per worker
Argentina	0.00	1.91	–0.62	2.32	0.08	1.34	0.84	2.01
Brazil	1.76	1.93	0.95	1.63	1.28	2.32	3.64	1.90
Chile	1.33	0.44	0.09	1.21	1.93	–0.40	2.44	0.36
Colombia	1.23	0.31	–0.31	1.59	1.86	–0.43	2.76	–0.69
Honduras	0.96	1.70	0.00	3.34	0.71	0.58	2.78	0.67
Mexico	2.04	0.74	3.11	0.66	0.20	1.27	2.85	0.17
Panama	1.20	0.68	–0.02	1.61	1.11	0.01	3.19	0.11
Peru	1.14	–0.14	–0.33	1.12	0.98	–1.52	3.61	–0.24
Uruguay	0.26	1.12	–0.82	1.86	0.44	0.29	1.68	1.09
Venezuela	2.32	1.04	2.81	1.37	1.67	0.67	2.43	1.02
AL BRA	1.38	1.02	0.83	0.96	0.97	1.09	2.76	1.06
AL MEX	1.00	1.40	0.38	1.41	0.38	1.68	2.76	1.06
AL ARG	0.88	1.52	0.07	1.72	0.54	1.52	2.56	1.26

Source: Calculated with data from FAOSTAT (2012) and FAO (1948-2004).

American pattern in this subperiod. In these countries, between 1950 and 1973, TFP provided the main explanation for agricultural labour productivity. In the case of Mexico, the development of the Green Revolution in this period strongly affected the growth of TFP.

In Venezuela, after the hegemony of coffee and cocoa exports, agriculture fell into decline before the oil boom that began in the 1930s. Venezuela is an example of a country with a rentier state that depends on the income generated by the export of oil. A consequence of this fact is the appreciation of the exchange rate which encourages imports and discourages the promotion of non-oil exports and local production (Thorp 1998). Between World War II and the 1960s, ISI became the dominant strategy. This consisted of replacing the import of agricultural products processed by their raw materials. As a result of this approach, wheat, sugar, animal feed, fats, oils, cattle and milk production were developed. In order to achieve agricultural modernisation, two fundamental measures were carried out. The first was an agrarian reform that extended the agricultural frontier through the use of public and private lands. The second measure was an agricultural policy, whereby the state financed and sustained agricultural expansion through cheap credits and inputs and a

price policy that guaranteed low prices for domestic consumers. In addition to this, the state was responsible for technological development (research, extension and technical assistance).

During the period 1958-1968, agriculture exhibited its greatest dynamism in Venezuela, and this was reflected in the remarkable TFP performance. However, the years between 1969 and 1973 constituted a deceleration phase, which was later reversed by the extraordinary revenues of the oil boom and public investment regained its expansion rate in the agricultural sector. The following periods were marked by alternating periods of economic crisis, adjustment, recovery, sector expansion, with the vicious cycle repeating itself. At the end of the 1970s, the development model was scaled down and the macroeconomic instability of the 1980s and 1990s, the adjustment programmes and the volatility of state revenues defined the destination and the limited options for sustained agricultural expansion. This reality has changed little in spite of the political changes that began in 1999 and led to the modification of the Constitution which explicitly mentions the development of agriculture, food production, rural development and food security of the population as a national priority (Hernández 2008, 2009).

Therefore, the strategy of the various governments, with the exception of periods of falling oil income and economic crisis, has been to encourage agricultural production through massive transfers (subsidised loans, price controls, technical transfer, etc.). The result has been the development of a modern agriculture, intensive in the use of fertilisers and agricultural machinery but with little incentive to improve efficiency. However, this model of agricultural expansion is highly vulnerable insofar as it depends on state support and protectionist policies (Gutierrez 1997).

In the intermediate subperiod, 1973-1993, in Latin America, TFP growth was higher and the factors of production per worker declined in importance in explaining agricultural labour productivity. TFP gained weight in all countries except for Mexico and Peru. In the case of Peru, this can be attributed to the difficult economic and political situation experienced in those years which was characterised by a serious external debt crisis, the spread of political violence and hyperinflation.

Generally, the incorporation of inputs was lower, but the growth of output stagnated in the entire region. The adjustment programmes had an impact upon agriculture. On the one hand, there was a fall in the provisions for agricultural development, the supply of subsidised inputs, state purchases with guaranteed prices, technical assistance or the subsidising of rural credit. Consequently, both private and public agricultural investment was reduced. Moreover, countries in which agricultural products accounted for a substantial part of their exports were seriously affected by the sharp deterioration of international agricultural prices in this period. In addition, the drop in real prices was more important in those

products in which the agricultural export sector of Latin America was specialised: basic products and plantation products (except for tobacco) (Serrano and Pinilla 2011, p. 221).

Therefore, efficiency and factors of production contribute equally to our understanding of agricultural labour productivity growth in the years of the oil crisis and the lost decade.

Nevertheless, in these two decades there were several countries (Chile, Colombia and Peru) in which TFP growth fully explicated labour productivity growth. This is striking because these three countries also increased their land productivity and decreased their land–labour ratio. This could be explained by the fact that the path followed by these countries to raise their labour productivity was based on the intensification of the use of land.

The trends followed by the sources of labour productivity in the last 15 years of our sample intensified the direction taken in the intermediate subperiod. The principal source of agricultural labour productivity growth between 1993 and 2008 significantly raised TFP in most Latin American countries, with the exception of Argentina[23]. TFP growth accounted for between 65 and 71 per cent of the agricultural labour productivity growth in the whole region. The higher growth of TFP coincides with the reforms leading to trade integration. Consequently, these reforms produced an exit of resources to non-agricultural activities, but also the development of an internationally competitive agriculture.

One of the examples of this process is Brazil[24]. Until the end of the 1980s, agricultural production had been fundamentally stimulated by the greater use of inputs and, especially, by the occupation of new regions in the centre and west of the country (Garcia *et al*. 2010; Wesz Junior 2017). In fact, in the mid-1980s, public policy shifted towards reform movements in land ownership, with the aim of alleviating the problems of rural poverty, including subsidised loans, research and extension services. However, this type of extensive growth gave rise to another more intensive growth with a predominance of productivity gains which involved improvements in the qualification of the labour force, increases in the operational capacity of machinery and greater expenditure on research and development applied to the land (Mueller and Mueller 2018). Nevertheless, and despite substantial improvements in agricultural productivity (even when compared with countries on the technological frontier, such as the United States), serious problems of structural

[23] Despite factors of production per worker being more important, TFP produced almost 30 per cent of agricultural labour productivity growth in Argentina.

[24] The contribution of TFP to agricultural labour productivity growth in Brazil was 32 per cent in the period 1950-1973, 52 per cent in the intermediate subperiod and 64 per cent between 1993 and 2008.

heterogeneity persisted (Fornazier and Ribeiro 2013) and the consequences in environmental terms have been severe[25].

In this period, Peru was the country with the greatest increase in the TFP, which has been explained by the increasing openness to international markets—favoured by the growing international demand for healthy, high-quality food—, domestic higher quality food demand, and the expansion of private investment in agriculture (Velazco and Pinilla, 2018, pp. 431-432).

The increasing importance of TFP growth in the Latin American agriculture of the second half of the 20th century is a noteworthy result. Recent Latin American literature on economic growth agrees with a stylised fact: the gradual increase of TFP from 1960 to the present day (Daude and Fernández-Arias 2010; Pages 2010). According to evidence, it is only after the late seventies that a fast increase in the relative TFP in Latin America can be confirmed (Cavalcanti *et al*. 2010), which would indicate that the widespread government intervention and import-substitution industrialisation did not harm overall economic growth. In sectoral terms, the emphasis on this weak evolution has been placed on services (Arias-Ortiz *et al*. 2014) contrasting with manufacturing. In this context, the role of agriculture has been moved into the background of the analysis. In this respect, our results would show the importance of agriculture as the successful sector in the TFP trajectory of the region and the conceptual and empirical relevance of primary production in terms of economic policy[26].

6. CONCLUSIONS

It is important to recognise, as already stated in section 2, that the empirical approach used has some caveats, which is why we are required to take careful precautions when considering the conclusions that may arise from the analysis carried out.

[25] In fact, the inadequate management of the environmental conditions in Brazil has frequently resulted in economically inefficient, socially inequitable and environmentally devastating outcomes (Mueller 2009). Pollution and deforestation rates have been high and ill-defined and insecure property rights have led to diverse difficulties for investment (Alston *et al*. 1999). In addition, there has been a massive invasion of public and private land properties. Regulations and laws have been repeatedly violated. In the Amazon, the two most important drivers of deforestation have been cattle ranching and soybean cultivation; both increasingly export-driven (McAllister 2008). Forest reserve requirements (80 per cent in the Amazon) have rarely been taken into account, and the question has emerged as to whether the Amazon basin constitutes a natural barrier to agricultural expansion. «Economic activity in the form of agriculture, ranching, mining, fishing, and extraction is often wasteful, destructive, and unsustainable, resulting in pollution, erosion, extinction, conflict, and violence» (Mueller 2009, p. 109).

[26] This statement must be taken with caution. As the calculation of TFP in other sectors could be measured with other methodologies, comparisons are not always feasible. Although TFP depends directly on how the factors evolve, the inclusion of more or fewer inputs, the quality of the information used, as well as the relative weights used can significantly affect the results.

The transformations of the agricultural sector in the second half of the 20th century were deep-rooted and essential for understanding the evolution of this sector and the development processes of many countries. The differences in these transformations can be observed through the evolution of agricultural production and labour productivity.

In our analysis of agricultural growth in the second half of the 20th century we have observed two different models in the world: developed and developing regions. Developed countries, with a moderate increase in production, displayed a strong increase in agricultural labour productivity, owing to increases in the land–labour ratios. Meanwhile, developing regions increased their labour productivity to a lesser extent than developed countries but their production expanded more quickly. In addition, developing regions augmented their labour productivity, due to increases in land productivity.

In this study, we have shown, first, that the growth model of Latin American agricultural production possesses some typical characteristics which hinder its insertion into the more general pattern of not only developed countries but also developing countries. The rapid growth of production fits well within that of developing countries, while its increase in labour productivity places it at an intermediate level between the lowest of developing countries and the highest of developed countries. Furthermore, it has been the only region of the developing world in which the improvement of labour productivity has been based not only on improvements in land productivity, but also on the land–labour ratio.

Subsequently, we have analysed the main components of agricultural production and labour productivity in Latin American countries. Furthermore, we have discussed the existence of a Latin American pattern in order to understand the components of these variables. We can observe that the differences in Latin American agriculture are strong enough to explain the behaviour of these variables and to indicate the existence of a Latin American pattern. However, we can identify several general trends in this region. The first is related to the explanation of agricultural production growth. The components of this variable have tended to depict a growing importance of labour productivity and a diminishing importance of the workforce from the first subperiod (1950-1973) to the last (1993-2008).

The second general trend is related to the components of agricultural labour productivity growth, when these components are divided into land productivity and the land–labour ratio. Diversity is the most observable trend. Throughout the period, land productivity has been crucial in labour productivity growth in Latin America, as in other developing world regions, but this role has changed over the period or between countries. This analysis shows the different patterns among Latin American countries, as we have seen in Table 4 and Figure A.3. On the one hand, several countries increased their labour productivity thanks to increases in land–labour ratios, for

example Argentina and Uruguay. On the other hand, there are others in which land productivity growth has been fundamental to help us understand labour productivity growth, such as Colombia or Chile.

Finally, we have tried to understand the sources of agricultural labour productivity growth, decomposing this between TFP (efficiency) and factors of production per worker (intensity). We have found a greater importance of TFP throughout the second half of the 20th century, while the factors of production per worker declined in importance. The latter was the most important source of labour productivity growth between 1950 and 1973, while TFP was the most relevant in the last subperiod.

The changes in the innovations and new techniques adopted, the institutional framework and also the geographical conditions in each country are very important in order to understand these trends in the Latin American agricultural sector. These trends are essential to identify the sources of the differences between them. Furthermore, these differences between Latin American agricultural sectors are fundamental to clarify the differences in income in these countries.

Although we cannot identify a single agricultural growth model in Latin America, we can outline two basic trajectories, while with some reservations due to the many national nuances that exist.

A first group of countries, initially formed only by Argentina and Uruguay, already had an advanced agricultural sector in 1950 with high levels of productivity per worker that were considerably higher than the average for Latin America. Until the beginning of the 21st century, the absolute gap in labour productivity with respect to the Latin American average widened. Its growth model was based mostly on a slight increase in this productivity and modest rises in land productivity. The growth in labour productivity was based more on a greater endowment of production factors per worker, particularly capital, than on efficiency. Other countries, starting with much more backward agricultures, tended to converge towards this model, such as Brazil or Venezuela, which increased their production much more than Argentina or Uruguay. These countries have increased their labour productivity at a very fast pace. This increase was based on an increase in the land–labour ratio and land productivity. A differential feature of the growth experience of Brazil and Venezuela, with respect to the other two countries, is the enormous contribution made by efficiency, with high TFP growth rates.

The rest of the countries have tended to base the increase in production more on the improvement in their productivity than on the expansion of their workforce, but unlike the former countries the growth of this latter group has also been considerable. In 2008, in all of these countries, such as Colombia, Mexico or Peru, contrary to the first group, the labour productivity was lower than the average for Latin America. Even so, the improvement in labour productivity has been noteworthy and, in many

cases, exceeded that of the first group. The improvement in labour productivity has been largely based on strong increases in land productivity with smaller increases in the land–labour ratio. In all of them, TFP has contributed to improving labour productivity to a greater extent than factor endowment per worker.

It is no surprise that a single model for agricultural growth in Latin America cannot be found. The region has diverse climates, its institutional change was also varied and although the economic policies developed share common traits, they also had significant differences. Finally, its insertion in the first wave of globalisation and its economic development during this period also varied widely between nations (Bulmer-Thomas 1994; Martín-Retortillo *et al*. 2018). The individual characteristics of different countries have also been highlighted in the study of other regions in the world. Europe is a good example of the lack of a single agricultural growth pattern in the same period, with three clearly different patterns being identified (Martín-Retortillo and Pinilla 2015b). The same is the case in Asia, where the common characteristics of its agricultural development do not hide the diversity of experiences (Pinilla and Willebald 2018).

SUPPLEMENTARY MATERIAL

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