DOCUMENTOS DE TRABAJO
ISSN 2174-4912

THE DYNAMICS OF LATIN AMERICAN AGRICULTURAL PRODUCTION GROWTH SINCE 1950

Miguel Martín-Retortillo, Vicente Pinilla, Jackeline Velazco y Henry Willebald [∝]

DT-AEHE N°1610
www.aehe.es

Abril 2016

asociación española de historia económica

DOCUMENTOS DE TRABAJO
ISSN 2174-4912

LAS CAUSAS DEL CRECIMIENTO DE LA PRODUCCIÓN AGRARIA LATINOAMERICANA DESDE 1950.

Miguel Martín-Retortillo[*], Vicente Pinilla[†], Jackeline Velazco[‡] y Henry Willebald[§]

DT-1610, April 2016
JEL: N56, O13, O147, Q11

RESUMEN

Desde 1950 han tenido lugar profundos cambios en la agricultura latinoamericana, como nuevas innovaciones técnicas o cambios en las políticas agrarias y comerciales. Este artículo tiene como objetivo analizar las causas del crecimiento de la producción agraria de Latinoamérica entre 1950 y 2008. Para ello se explora si los incrementos en la producción agraria se han debido a incrementos en el uso de factores productivos o a ganancias en eficiencia.

Nuestros resultados sugieren que la eficiencia hizo una modesta contribución al importante incremento de la producción; este incremento fue principalmente resultado el aumento en el uso del capital. Este fue el factor productivo más importante para explicar los incrementos en la producción, conjuntamente con moderados incrementos en el uso de tierra y trabajo.

Palabras clave: Historia Económica de Latinoamérica, Agricultura latinoamericana, Productividad agraria, Crecimiento agrario.

ABSTRACT

Since 1950 profound changes, such as new technological innovations or changes in agricultural and trade policies took place in the Latin American agriculture. This article aims to analyse the dynamics of the growth of Latin American agricultural production between 1950 and 2008. It explores whether the increases in agricultural production have been due to increases in the use of production factors, or whether production increases have been due to efficiency gains.

Our findings suggest that efficiency gains made a rather modest contribution to the important increase in production; this increase was principally the result of the use of capital. This was the most important productive factor in explaining increases in output, together with more moderate increases in the use of land and labour.

Keywords: Latin American economic history, Latin American agriculture, Agricultural productivity, Agricultural growth.

[*] Universitat Pompeu Fabra, Spain. E-mail: miguel.martinr@upf.edu
[†] Universidad de Zaragoza and Instituto Agroalimentario de Aragón –IA2, Spain. E-mail: vpinilla@unizar.es
[‡] Pontificia Universidad Católica de Perú, Peru. E-mail: jvelazc@pucp.edu.pe
[§] Universidad de la República, Uruguay. Email: hwillebald@iecon.ccee.edu.uy

THE DYNAMICS OF LATIN AMERICAN AGRICULTURAL PRODUCTION GROWTH, 1950-2008[1]

1.- Introduction

The profound worldwide transformations in the agricultural sector in the second half of the twentieth century have generated enormous academic interest. Diverse scientific perspectives have been employed to analyse some of their most notable aspects, such as technological change, including the significance and consequences of the Green Revolution, the increase in production, the changes in social relationships, the evolution of the distribution of property and the attempts at agrarian reform or, in general, the evolution of rural societies.

Today, the Latin American agricultural sector continues to play an influential role in the economic growth of this world region. However, despite the improvements taking place in the second half of the twentieth century, this sector is still far from matching the productivity levels of developed countries.

Given this context, the objective of this article is to attempt to analyse the case of Latin American countries. More precisely, we wish to examine the principal dynamics of the agricultural sector of this world region, and specifically the sources of agricultural production growth in the second half of the twentieth century[2].

To this end, our aim is to observe and explain the growth of agricultural production in Latin America –at an annual rate of 3% in the last 60 years- to determine whether the process has been a response to increases in the use of productive factors, and which of these have been most important, or whether it has been due to efficiency gains and increases in the total factor productivity (TFP henceforth) of the Latin American countries. Therefore, it will be necessary to

[1] This study has received financial support from the Spanish Ministry of Science and Innovation, project ECO 2012-33286 and the Spanish Ministry of Education's FPU Programme, and from the Government of Aragon, through the Research Group 'Agrifood Economic History (19th and 20th Centuries)'. We are grateful for the comments received from the participants in the 11th Conference of the Spanish Economic History Association, the 4th Latin American Economic History Conference (CLADHE IV), the 10th Uruguayan Economic History Association Conference, the 14th Spanish Agricultural History Society Conference, the 3rd Mexican Economic History Association Conference, the 17th World Economic History Congress, the Seminar of Economic History at the Universidad Carlos III of Madrid, and for those made by Pablo Astorga and Leandro Prados de la Escosura.

[2] CEPAL (1975) is a precursor to our study as it also presents a joint vision of the Latin American agricultural sector between 1950 and 1975.

calculate the increase in the use of inputs in the agricultural sector, as well as the gains in TFP.

Other studies have previously calculated TFP in Latin America from 1960 on, or more commonly after 1970. Nevertheless, from the perspective employed in the current study, such research, usually performed by agricultural economists, notably lacks a historical perspective. Their principal objective has been to obtain comparative data on an international scale regarding the rate of growth of productivity, without analysing either the dynamics which have led to such results or the individual contexts of each country which are key to their understanding.

Furthermore, in distinction to ours, few historical perspective studies have paid special attention to the analysis of the evolution of agricultural production in Latin America as a whole, although there are many more of a national character[3]. In particular, for the extended time horizon proposed, such studies are rare. In general, other topics have stimulated greater interest, such as the changes in agricultural ownership, the attempts at agrarian reform or the development policies implemented and their effects on agricultural sectors[4].

We believe that beginning our study in 1950 is particularly interesting, since the majority of analyses of Latin American agriculture commence in the 1960s, thereby ignoring the early years following the Second World War. This is fundamental, as it coincides exactly with the turning point in the model of development of a large part of Latin America, making it possible to analyse the early years of the policies of import substitution industrialization (ISI).

We believe that our approach makes, for all the foregoing, an important contribution to the study of the historical evolution of Latin American agricultural production, during a key period for its transformation, offering a much wider time horizon than any other study, a very extensive sample of countries and a far-reaching historical perspective.

Obviously, as our study has a country-level macroeconomic approach, it has important limitations. Consequently, it cannot explain the extent to which the growth of agricultural production or the strategies of agricultural development led to a reduction of poverty or an improvement in the income of the least favoured rural sectors. However, recent studies approach this perspective very satisfactorily[5].

Due to the difficulty of not having data available for all the variables necessary for the complete period of 1950-2008, we have had to dispense with some countries, normally medium-sized or small. However, the countries included in our study (Argentina, Brazil, Chile, Colombia, Honduras, Mexico, Panama, Peru,

[3] There are clear exceptions, such as Spoor (2002) or Solbrig (2008).
[4] Some studies oriented towards the analysis of agricultural structures in historical perspective have also been with changes in production, as in the synthesis by Long and Roberts (1994).
[5] For example, Kay (2006) or Dirven (2008).

Uruguay and Venezuela) represent a huge majority of Latin American agriculture, given that between 1965 and 2005 they accounted for between 85 and 90 per cent of its gross agricultural production.

To achieve the objectives proposed we have had to construct a quantitative database upon which to found our analyses. It originates largely from the FAO statistics, although especially for the 1950s it has been necessary to perform a series of estimations (see Appendix). In large part we have used this database to calculate the evolution of agricultural production and of the use of inputs. Thus, it has been possible to calculate total TFP, and thereby determine to what extent increases in production are explained by the use of an increase in factors or by an improvement in efficiency.

Following this introduction the next section analyses the principal trends of agricultural production. The third section is devoted to the evolution of the use of productive factors. We then explain how we have calculated the TFP and its main trends throughout the second half of the twentieth century. The paper ends with a conclusions section.

2.- Sixty years of Latin American agricultural production

Firstly, in order to have a complete vision of the second half of the twentieth century, our analysis is centred on the period 1950-2008. With the intention of identifying different sub-periods in agriculture, three periods are distinguished: the implementation phase of the policies of ISI (1950-1973)[6], a second period comprising the years of the oil crisis, the foreign debt payment crisis and the initiation of economic stabilisation programmes (1973-1993) and, finally, the phase of structural reforms and reintegration into international trade until the beginning of the international economic crisis of 2008 (1993-2008)[7].

During the first period, in those countries which implemented ISI policies, the role and functions of the state expanded, as did important changes in the modalities of regulation of productive activities (taxes, subsidies, fees and tariffs). With regard to agriculture for export, it is possible to identify a bias against the

[6] Not all countries adopted from 1950 a clear strategy of an ISI type. The small Central American republics, in our case Honduras and Panama, would not fit within this typology. Of the rest of the countries analysed the principal exception is Peru, which until 1968 attempted to develop by promoting its exports. Venezuela continued to depend essentially on its exports of oil. In the 1960s, even in these countries, a certain industrialist volte-face was generalised (Bulmer-Thomas, 1994).

[7] To establish a criterion which divides the period as a whole, we have empirically and econometrically observed when a structural change occurs in Latin American agricultural production as a whole. We performed the test proposed by Kejriwal and Perron (2010). This approach showed that there was a structural break in 1993. To avoid establishing two sub-periods so unequal in time we performed another break in 1973. We are grateful for the help of Antonio Montañés on this point.

sector[8]. Consequently, export agriculture had negative protection rates, while the opposite was true for that aimed at the domestic market. The change of development strategy meant that export agriculture ceased to be the motor of expansion of agricultural production in the greatest part of Latin America, although for example in the Central American countries the agroexporting model was not modified and brought about an appreciable increase in production (Guerra Borges, 1993). If we take the case of South America as a whole, in 1950 its volume of agricultural exports was already considerably lower than the maximum reached prior to 1929, but it fell still further throughout the 1950s, precisely when world agricultural trade increased more rapidly (Pinilla and Aparicio, 2015). As a result, Latin America lost significant weight among worldwide exporters of agricultural products and food until the beginning of the 1990s (Serrano and Pinilla, 2014). This was not due solely to policy changes and their antiexport agricultural bias, but also to specialisation in products with scarce demand and a low degree of industrial transformation. Further restrictions were caused by protectionist policies with regard to the agricultural products of the developed countries, especially of Europe, given that trade was often undertaken within regional agreements (Serrano and Pinilla, 2016). However, support to agriculture oriented to the production of food or raw materials for the domestic market strongly stimulated this type of production, especially in a context of demographic boom in the Latin American countries.

In the second period, the situation of economic crisis, the exhaustion of ISI and the foreign debt crisis created the conditions for a change to a development model directed at export growth.

Finally, the third period was one of a deepening of adjustment policies and structural reforms, undertaken in the late 1980s and early 1990s. As a result of the redefinition of the role of the state and the implementation of policies aimed at favouring the free market, the economy as a whole and agriculture in particular underwent changes in their productive structure, competitiveness, productivity and profitability (David et al., 2000). The new strategy involved mobilising resources in competitive export sectors, including agriculture. 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 with greater expectations from the point of view of demand. New products tended to complete or replace traditional exports, such as fresh fruit and vegetables, vegetable oils or fodder. Consequently, from the 1990s onwards Latin America tended to regain weight in international markets for agricultural products and food (Serrano and Pinilla, 2016). Nevertheless, the prices of traditional agricultural exports from Latin America experienced a sharp fall in real terms from 1976 on, and thus their improvement in terms of volume was

[8] Breaking farm output down into import-competing and exportable products, Anderson and Valenzuela (2010) observe that the former enjoyed significant, positive protection from 1965 (the first year for which estimations were possible) to 2004, despite wide variations in actual support levels, while the latter were unremittingly disadvantaged. The countries considered are Argentina, Brazil, Chile, Colombia, the Dominican Republic, Ecuador, Mexico and Nicaragua.

not reflected in a similar increase in their real value (Serrano and Pinilla, 2011: 233-234). The strong demand from Asia for certain agricultural or food raw materials also strengthened this recovery of and impulse to the agroexporting sector[9].

Latin American agricultural production experienced an unprecedented expansion from the 1950s on, with an average annual growth rate of 3%, which means it multiplied five and a half times in 58 years (see Table 1). Especially notable are the cases of Brazil and Mexico, which grew at an average annual rate of 4% and 3.6% respectively, leading the expansion throughout the whole period, although with different characteristics. While Brazil became one of the world leaders in the production of agricultural and livestock commodities at the start of the twenty-first century, Mexico underwent a sharp expansion during the 1950s and 1960s, to then slow down from the 1980s onwards. By contrast, the lowest increases in agricultural production took place in Argentina and Uruguay, with an average annual growth of merely 1.3% and 1.6% respectively. These are agricultures specialized in production in temperate climates (livestock, cereals), which displayed great dynamism in the final decades of the nineteenth century and the initial years of the twentieth century. This dynamism permitted them to reach very high levels in terms of production and the use of inputs prior to the Second World War (WWII).

Table 1
Agricultural Gross Production

	Mill. US $ 2004-2006 prices				Annual growth rates (%)			
	1950	1973	1993	2008	1950-1973	1973-1993	1993-2008	1950-2008
Argentina	12,186	14,277	19,487	30,370	0.7	1.6	3.0	1.6
Brazil	8,265	20,707	41,708	79,744	4.1	3.6	4.4	4.0
Chile	1,466	1,966	3,935	5,809	1.3	3.5	2.6	2.4
Colombia	2,980	5,260	9,290	12,931	2.5	2.9	2.2	2.6
Honduras	381	852	1,367	2,195	3.6	2.4	3.2	3.1
Mexico	4,461	14,188	23,912	35,271	5.2	2.6	2.6	3.6
Panama	232	493	784	1,293	3.3	2.3	3.4	3.0
Peru	1,312	2,129	2,783	6,301	2.1	1.3	5.6	2.7
Uruguay	1,211	1,313	1,686	2,521	0.4	1.3	2.7	1.3
Venezuela	1,557	4,155	7,381	10,960	4.4	2.9	2.7	3.4
Latin America	34,050	65,338	112,333	187,397	2.9	2.7	3.5	3.0

Triennal averages, except 1950. For more details, see the Appendix.
Source: Authors' elaboration, from FAOSTAT (2012) and FAO (1948-2004).

[9] Due to this strong Asian demand for primary products and the good behaviour of their prices, between 2003 and 2008 the percentage represented by the exports of basic products over the total exported by Latin American countries increased, interrupting the preceding tendency to decrease (Bértola and Ocampo, 2013: 274-275).

Output growth was very high in the case of products for which domestic demand was rising in Latin America (oilseeds, vegetable oils, alcoholic beverages, meat, fruit and vegetables, and dairy products) but very slow for the main agro-export crops[10].

In the subperiod coinciding with ISI (1950-1973) the average annual growth of Latin American agriculture was slightly below that of the entire period, analysed as a whole (2.9%). Most Latin American countries attuned to the interests of urban sectors adopted an import substitution growth strategy in the hope of developing industry. Tariffs, particularly for industrial products, were raised to favour local industries. Yet these industrial products were not internationally competitive for the most part and countries had to return to agriculture to produce the export surplus able to earn the foreign exchange needed to supply industry with capital goods and raw materials. However, the new industries were unable to supply the rural sector, at a reasonable price, with the chemical fertilisers and pesticides or the machinery needed for modernisation. The result was a moderate expansion of the rural sector (Solbrig, 2008). The countries growing most were Mexico, Venezuela and Brazil, with rates of 5.2%, 4.4% and 4.1%, respectively[11]. The three countries have in common an integrationist conception of ISI, in which agriculture serves as a support for the process of industrialisation itself and nurtures itself from it, the state is actively involved in technological development (linked to the Green Revolution) and important institutional changes, such as those related to agrarian reform, take place[12].

From WWII until the 1960s, the ISI became the dominant strategy in Venezuela; it consisted of replacing the import of processed agricultural products. Consequently, wheat, sugar, balanced animal feed, oils, beef cattle and milk, among other food industries, were developed. In order to achieve the modernisation of agriculture, two principal measures were implemented. The first was land reform, which expanded the agricultural frontier by using public and private lands that were allocated to new agribusiness producers of mechanised crops and to peasants, who became part of a modern agricultural process. The second measure was agricultural policy, in which the government financed and supported agricultural expansion through cheap credit and inputs, a pricing policy that ensured low prices for domestic purchases (consumers) and imports (agribusiness). In addition, governments were primarily responsible for technological development (research, extension and technical assistance) (Hernández, 2008 and 2009).

[10] See the production growth rates for each product type in Serrano and Pinilla (2016), Table 2.

[11] For a discussion of the contribution of agriculture to the Mexican process of industrialisation, see Calva (1999).

[12] The transfer of technology from abroad was particularly important in the case of Mexico where, via the Rockefeller Foundation and an agreement with the Ministry of Agriculture, programmes of research and support for the improvement of the performance of various cereals were implemented (Brown, 1970) and the creation of research institutes was encouraged (Fernández-Cornejo & Shumway, 1997).

In Mexico, following the revolutionary process in 1910 and the subsequent implementation of land reforms, including the Cárdenas reforms (1934-1940), the agrarian structure was radically transformed. This meant the consolidation of the "*ejidos*" and the disappearance of traditional landowners. Land reform, by abolishing the monopoly of land, facilitated a rapid expansion of the agricultural frontier. As for the "*ejidos*", they increased their share of arable land (from 13% in 1930 to 47% in 1940), irrigated areas (from 13% to 57%) and total production (from 11% to 53%) (Gomez, 1995). The fastest growth of Mexican agricultural production, between 1950 and 1966, took place as the consequence, on the one hand, of an enormous extension of the irrigated land area, which increased in those years by approximately a million hectares, and the early utilization of high yield seeds, of maize and wheat, developed in Mexico since 1944 by Norman Borlaug through the agricultural research programme established between the Rockefeller Foundation and the Mexican Government. Mexico was therefore the primal nucleus from where the Green Revolution commenced (Brown, 1970; Cerutti, 2015; Fernández-Cornejo and Shumway, 1997).

In turn, the countries with the slowest growth were, as in the period as a whole, Argentina and Uruguay, with weak rates below 1% annually (0.4% and 0.7% respectively). In both cases, the 1950s and 1960s were dominated by a policy of industrial promotion which involved the transfer of resources from the agricultural sector to the manufacturing sector (with profuse rent-seeking activities), and similarly a variety of restrictions on imports of machinery and inputs, producing severe negative effects for the production of agricultural commodities (Lence, 2010). The Argentinean case clearly shows the duality between stagnant agriculture for export, located principally in the Pampas region, and an expansion of the production of industrial and domestic consumption crops. From the mid-1950s on a certain change in agricultural policies favoured a greater increase of agriculture in the Pampas. The low growth exhibited by Argentinean production in the first period is yet further overshadowed if we take into account that the fall in aggregate production in the 1940s and early 1950s was significant, meaning that previous historic maximums were only achieved by the mid-1960s (Barsky and Gelman, 2001).

The growth of Latin American agricultural production between 1973 and 1993 was the lowest in the entire period, although very close to that of the previous stage (2.7%). The generalised adjustment programmes in the region also had an impact upon agriculture. On the one hand there was a fall in the provisions for rural 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 (Morales, 1991). Although exchange rate policies tended to benefit agricultural and livestock exporters, their impact was limited both by the constraints on access to foreign markets and by the sharp deterioration of international agricultural prices in this period (Serrano and Pinilla, 2011).

In this subperiod, Brazil became once more the country with the highest annual growth rate of agricultural production (3.6%), followed this time by Chile (3.5%) and Colombia (2.9%). In the case of Chile, the period coincides with the general takeoff of an economy based, as a political strategy, on the promotion of exports, especially those of a non-traditional character, such as fruit and flowers (Olavarría et al., 2004). In turn, Colombian agriculture underwent its golden age from WWII until 1980 and, as in the Chilean case, a large part of this success depended on the export vocation of production (where the traditional coffee was joined by palm oil) (Kalmanovitz and López Enciso, 2005).

The sharp fall in the rhythm of growth of production was notable in Mexico. Yunes (2010) has attributed this low growth principally to the drastic fall in the production of maize, a basic food in the country, as a consequence of the poor behaviour of its relative prices. Between 1977 and 1981 Mexican agriculture recovered its dynamism as a result of increased public spending (basically irrigation and drainage research and extension, agricultural credit, cheap inputs and profitable prices). However, this expansion ended abruptly in 1982 with the economic crisis, the crisis of the external debt payment and the subsequent implementation of adjustment and stabilisation programmes. All this brought about the end of ISI and interventionism as well as the developmental role of the state, creating the conditions for a new external market-oriented model. In this new scenario, restrictive fiscal policies led to the dismantling of compensatory policies for agriculture and a drastic reduction in investment and public spending (public investment in rural development fell by 92.5% between 1981 and 1998) (Calva, 1999 and Gómez, 1995).

As in previous subperiods, Uruguay and Argentina were the countries which least increased their production, with annual growth rates of 1.3% and 1.6%. Both economies underwent, like Chile, rapid and significant processes of economic liberalisation (in a conception with a monetary approach to the balance of payments) with reduced tariffs on imports and fees on exports, but accompanied by rigid exchange rate policies which hindered the competitiveness of agriculture without receiving special programmes of promotion or support in exchange (Notaro, 1984, 2003). Peru also displayed meagre results during a period which included diverse agricultural policies such as price controls to guarantee the low cost of the food basket until 1979 (Álvarez, 1983), and a heterodox programme of expanding demand during the 1980s which resulted in a process of hyperinflation (León, 1994 and Escobal, 1999)

The greatest annual growth in Latin American agricultural production took place between 1993 and 2008, at an average rate of 3.5%, the leaders being Peru (5.6%) and Brazil (4.4%). In the former, it is clear that the implementation of the stabilisation programme and state structural reforms modified the institutional framework and the conditions in which agricultural producers participated in market relations (von Hessen, 2000; Escobal, 1999). In particular, the explicit policy of stimulating investment in the agricultural sector and the liberalisation of the market

for food and agricultural inputs and of the land market were determining aspects. Meanwhile, Brazil consolidated an expansionary trajectory where, progressively, its extensive character of the preceding decades gave rise to a dynamic of increasing intensification in the use of factors (Mendali et al., 2013).

In turn, the lowest increases were produced in Colombia, Mexico and Chile, with rates of 2.2% and of 2.6% for the last two countries. Colombia displayed a contrast with the previous period, since its agricultural sector entered a phase of great difficulties dominated by real revaluations of the currency and sizeable capital movements in a type of "Dutch disease" (Kalmanovitz and López Enciso, 2005). An intensive process of liberalisation took place in Mexico from the beginning of the 1990s, one which also profoundly affected agriculture, and which involved a redefinition of property rights, trade liberalisation with the exterior (reduction of tariffs, the signing of the NAFTA agreement concerning North American integration, the elimination of import permits, etc.), or the elimination of the majority of guaranteed prices to the producer. These policies stimulated on the one hand a sharp increase in exports of fruit and vegetables. Despite this agriculture as a whole did not expand sufficiently. In the opinion of Yunes (2010), this effort was not overly brilliant, with the above-mentioned exception of fruit and vegetable cultivation for export in the north of the country, and can be largely attributed to the incapacity of a liberalising agricultural policy, highly inequitable in its support for farmers, to transform the agriculture of the country.

In the Southern Cone, rising international prices for cereals and soya stimulated a growth in the production of these crops. The adoption of transgenic seeds and other innovations such as direct sowing encouraged Argentinean production from the mid-1990s on; this reached its highest rates in the whole period (Barksy and Gelman, 2003). Foreign demand, as in the 'belle epoque', stimulated this increase in production.

Changes in the leadership of this expansion, in which only Brazil remained in the leading positions throughout the period, are a reflection of Latin American heterogeneity. The dispersion of production levels increased significantly and its variation coefficient moved from a level of 1.15 in 1950 to one of 1.31 in 2008, demonstrating an increasingly disparate evolution among the continent's agriculture.

The composition of production, shared between crops and livestock, experienced moderate changes in the period. Crops had always represented, in Latin America as a whole, and in all its constituent countries, except for Argentina and Uruguay, a majority of production. Until 1990 crop production accounted for approximately 60% of total production; from that date on its importance fell slightly, to 57%. In both Argentina and Uruguay the share of crops rose. In the former, the production of crops became predominant, rising from over 40% at the beginning of the 1960s to 62% of the total in 2008. In Uruguay the importance of crops rose,

although not by the magnitude of Argentina (between the same dates the latter rose from 19.9% to 32.6%) (Cadenazzi, 2009; Oyhantçabal and Narbondo, 2008).

3.- The use of inputs: the incorporation of land and labour and greater capitalisation

Seen from the supply side, the growth of agricultural production may be due to a greater use of inputs. Consequently, we shall proceed to study the incorporation of land, labour and capital into agricultural production. It is important to emphasise that it is only possible to measure those forms of capital for which there are data on an international scale and for a wide chronological horizon[13]. Despite this absence of quantitative data, we shall evaluate their importance when we discuss changes in agricultural productivity.

Table 2 depicts the use of land in Latin American agriculture. The cultivated land area increased throughout the entire period. The Latin American pattern resembles that of the developing world and contrasts with that of the developed countries, where the agricultural land area decreased in general. The increase in the use of land in Latin American agriculture amounted to 1.3% annually, such that it doubled between 1950 and 2008. Only in Chile did agricultural land decline substantially, while the most important process of expansion took place in Brazil, which more than tripled its cultivated land area. The predominant time pattern was that of a progressive deceleration of the process, with decreasing rates in the three subperiods (2.2%, 0.7% and 0.6%, respectively) as the land frontier was progressively reduced.

From a long run perspective, we can divide land use in Latin America into two distinct periods, corresponding to before and after WWII (Solbrig, 2008). During the earlier period, the agricultural cultivation and livestock rearing area expanded primarily in the temperate and subtropical regions (the Southern Cone, southern Brazil and Mexico) and the coastal tropical regions. During the second period, land expanded when agricultural and grazing areas increased principally in tropical and interior regions. This transformation is identified with a movement from extensive to intensive agriculture which was the result of the occupation of most of the best agricultural land together with the availability of new technologies related to the Green Revolution. The general consequence was a slowing down of the incorporation of land to production in the following decades. Once more, the exceptions were Argentina and Uruguay, with strong rates of expansion in 1993-2008. These cases can be related to the increase in their crop production and the previously mentioned

[13]In our case the principal problem we face is the absence of quantitative data regarding the use of the new seeds developed on the basis of the Green Revolution. Buildings are another remarkable type of capital, whose absence is important, but the impossibility of obtaining data for the whole sample leads us to consider this concept only qualitatively.

loss of space destined to livestock production. A part of the increase in the cultivated land area in these three countries is related to the cultivation in new lands of genetically engineered soybeans (Barrows et al., 2014: 102).

Table 2
Arable land and permanent crops

	Thousand of hectares				Annual growth rates (%)			
	1950	1973	1993	2008	1950-1973	1973-1993	1993-2008	1950-2008
Argentina	17,006	26,942	28,020	33,000	2.0	0.2	1.1	1.1
Brazil	20,111	45,614	59,733	68,567	3.6	1.4	0.9	2.1
Chile	3,803	4,283	2,611	1,724	0.5	-2.4	-2.7	-1.4
Colombia	2,440	5,084	4,834	3,462	3.2	-0.3	-2.2	0.6
Honduras	756	1,589	1,953	1,439	3.3	1.0	-2.0	1.1
Mexico	19,928	23,567	26,900	27,643	0.7	0.7	0.2	0.6
Panama	220	544	662	695	4.0	1.0	0.3	2.0
Peru	1,600	3,174	4,051	4,430	3.0	1.2	0.6	1.8
Uruguay	1,448	1,429	1,325	1,660	-0.1	-0.4	1.5	0.2
Venezuela	2,676	3,488	3,365	3,367	1.2	-0.2	0.0	0.4
Latin America	69,986	115,713	133,454	145,986	2.2	0.7	0.6	1.3

Triennial averages, except 1950. For more details, see the Appendix.
Source: Authors' elaboration from FAOSTAT (2012) and FAO (1948-2004).

The active agricultural population (Table 3) grew slightly during the period, although highly diverse behaviours can be appreciated in different countries. In the long term agricultural labour only shrank in absolute terms in Argentina and Uruguay. It grew modestly in Brazil, Chile, Honduras and Venezuela, with notable increases in Colombia, Mexico, Panama and Peru. Of these countries, only in Argentina, Chile and Uruguay was agricultural manpower already a minority of their active population in 1950, with respective percentages of 25.1, 34.2 and 24.3 per cent. In 1980, in all of the above countries except Honduras, agricultural workers already constituted less than 50% of the labour force (Long and Roberts, 1994). It is important to underline that in all those countries which increased their agricultural labour force in absolute terms, in all or part of the period, a significant fall of it in relative terms simultaneously occurred. Thus, the evolution of their active agricultural population was clearly determined by the initial situation in 1950 and the intensity of the processes of industrialisation and urbanisation in the distinct countries.

Practically all the expansion of the agricultural labour force took place between 1950 and 1993, with the above-mentioned exceptions of Argentina and Uruguay. From then on the labour force fell gently, or remained stable, except in Peru. In this country, the number of agricultural workers continued to increase,

although more slowly, due to the improved distribution of land from the end of the 1960s (the agrarian reform) and flexibilisation in the hiring of workers from the 1990s on[14].

Table 3
Active population in agriculture

	Thousands of people				Annual growth rates (%)			
	1950	1973	1993	2008	1950-1973	1973-1993	1993-2008	1950-2008
Argentina	1,623	1,448	1,454	1,421	-0.5	0.0	-0.2	-0.2
Brazil	9,887	14,497	14,037	11,622	1.7	-0.2	-1.3	0.3
Chile	648(1)	709	973	969	0.4	1.6	0.0	0.7
Colombia	1,975	2,759	3,503	3,559	1.5	1.2	0.1	1.0
Honduras	538	557	700	670	0.2	1.1	-0.3	0.4
Mexico	4,824	6,942	8,751	8,098	1.6	1.2	-0.5	0.9
Panama	132	202	256	252	1.9	1.2	-0.1	1.1
Peru	1,361(2)	1,864	2,954	3,648	1.4	2.3	1.4	1.7
Uruguay	216(3)	178	195	187	-0.8	0.4	-0.3	-0.2
Venezuela	705	752	849	745	0.3	0.6	-0.9	0.1
Latin America	21,909	29,908	33,672	31,171	1.4	0.6	-0.5	0.6

(1) Figure calculated for 1950. We have assumed that between 1950 and 1952 the data follow the Argentinian evolution.
(2) Figure calculated for 1950. We have assumed that between 1950 and 1952 the data follow the aggregate of Honduras and Mexico evolution.
(3) Figure calculated for 1950. We have assumed that between 1950 and 1960 the data follows the Argentinian evolution.
Source: Authors' elaboration, from FAOSTAT (2012) and FAO (1948-2004).

To obtain an approximate view of the evolution of the capital employed, we shall use two of its principal components of a fixed nature –livestock head and agricultural machinery- and fertilisers and chemical manure for those of a circulating character.

The increase in livestock was spectacular, since its number of head doubled throughout the period, at an annual rate of over 1.3%. Brazil (2%) and Venezuela (1.8%) were those countries which grew fastest, tripling their stock of live animals in the second half of the twentieth century and the beginning of the twentieth-first. The boom in poultry breeding and the increase in bovine cattle are the main trends explaining this growth. The opposite extreme (0.1% and 0.3% annually) was displayed by Argentina and Uruguay, which by 1950 already had a greater specialisation in livestock. Stagnation in these countries was due to a severe reduction

[14] Considering that the period of analysis is characterised by a continuous growth of GDP, it can be suggested that major changes must have taken place in inter-sectoral labour mobility (World Bank, 2010).

in bovine livestock and draft cattle such as horses and mules, although there were enormous increases in poultry.

Table 4
Livestock units

	Thousands of livestock units				Annual growth rates (%)			
	1950(1)	1973	1993	2008	1950-1973	1973-1993	1993-2008	1950-2008
Argentina	49,196	52,680	49,749	52,943	0.3	-0.3	0.4	0.1
Brazil	60,609	88,936	152,263	192,982	1.7	2.7	1.6	2.0
Chile	3,366	4,105	4,400	4,853	0.9	0.3	0.7	0.6
Colombia	14,582	20,483	25,165	27,035	1.5	1.0	0.5	1.1
Honduras	1,096	1,770	2,273	2,831	2.1	1.3	1.5	1.6
Mexico	22,008	35,309	44,305	47,489	2.1	1.1	0.5	1.3
Panama	643	1,266	1,465	1,689	3.0	0.7	1.0	1.7
Peru	5,422	8,582	8,473	11,461	2.0	-0.1	2.0	1.3
Uruguay	9,649	10,056	11,059	11,569	0.2	0.5	0.3	0.3
Venezuela	5,767	8,636	13,464	16,430	1.8	2.2	1.3	1.8
Latin America	172,338	231,823	312,616	369,282	1.3	1.5	1.1	1.3

(1) Average data calculated by FAO for the period 1948-1952. The rest of the years, triennial averages.
Source: Authors' elaboration, from FAOSTAT (2012) and FAO (1948-2004).

Latin America was not distanced from the process of mechanisation taking place in this period. Table 5 shows the impressive growth in the use of tractors, with annual increases of 4.7% in the region as a whole. The country which most increased the use of machinery was Brazil, with an annual rate of over 7%.

Until 1993 the increase in the use of tractors was very fast, especially until 1973, with an annual rate of increase of 8.2%, coinciding with their widespread diffusion in the world. The number of tractors grew very slowly between 1993 and 2000, and to stagnate from the latter year on. This trajectory could reflect the slower rate of incorporation of tractors into agriculture once they had had a significant diffusion, but it is also undeniable that more recent models were more powerful. This increased horsepower of the new tractors could call into question the apparent decrease noticeable in the process of mechanisation towards the end of the century.

Table 5
Agricultural tractors

	Units				Annual growth rates (%)			
	1950	1973	1993	2008	1950-1973	1973-1993	1993-2008	1950-2008
Argentina	25,000	178,220	259,500	238,825	8.9	1.9	-0.6	4.0
Brazil	15,000	218,500	766,260	788,053	12.4	6.5	0.2	7.1
Chile	5,970	34,150	40,974	53,915	7.9	0.9	1.8	3.9
Colombia	6,500	23,868	27,000	20,413	5.8	0.6	-1.8	2.0
Honduras	244	2,479	4,851	5,055	10.6	3.4	0.3	5.4
Mexico	32,000	95,733	307,503	238,830	4.9	6.0	-1.7	3.5
Panama	399	3,307	5,642	7,797	9.6	2.7	2.2	5.3
Peru	2,400	11,350	12,933	12,822	7.0	0.7	-0.1	2.9
Uruguay	10,500	30,570	33,000	36,465	4.8	0.4	0.7	2.2
Venezuela	3,925	23,302	49,000	47,630	8.1	3.8	-0.2	4.4
Latin America	101,938	621,478	1,506,663	1,449,805	8.2	4.5	-0.3	4.7

Source: Authors' elaboration, from FAOSTAT (2012) and FAO (1948-2004).

The ratio of tractors to each thousand workers (Table 6) also shows the importance of the acquisitions of machinery by farms, with growth of over 4% annually for the region during 58 years. Identifying this indicator with the degree of mechanisation of agriculture, there can be observed, as above, a progressive deceleration of the process, from its most dynamic phase between 1950 and 1973 (6.7%) until a very moderate growth of 0.3% between 1993 and 2008. Particularly notable cases are those of Argentina and Uruguay, which presented levels above even the Mediterranean countries or Eastern Europe until 1950 (with over 15 and 49 tractors per 1,000 workers, respectively) (Martín-Retortillo and Pinilla 2015). All the countries registered increases in their degree of mechanisation in the period and their dispersion fell,[15] although the leaders in the middle of the twentieth century continued to be so at the beginning of the twentieth-first. In 2008, in addition to the traditional leaders, Argentina and Uruguay, Brazil and Venezuela displayed the highest degrees of mechanisation.

In Argentina the adoption of modern machinery was favoured in the 1950s, stimulating its national production and the installation of branches of multinationals for the manufacture of tractors. In addition, the National Institute of Farming Technology (INTA, Instituto Nacional de Tecnología Agropecuaria) channelled from 1957 on the adaptation to Argentinean conditions of the technological supply available, especially seeds and agrochemicals. From the early 1970s in particular, generalised use was made of high yield hybrid seeds in the most important crops,

[15] The variation coefficient fell from 1.52 in 1950 to 1.04 in 2008.

such as maize, wheat, sunflowers or soya, with a strong impact on raising yields (Barsky and Gelman, 2001).

The strategy of successive Venezuelan governments, with the exception of the periods of falling oil income and economic crisis, has been to encourage agricultural production via massive transfers (subsidised loans, price controls, technical transfers, etc.). The result has been the development of a modern agriculture, intensive in the use of fertilisers and agricultural machinery which, nevertheless, displays a model of expansion highly vulnerable insofar as it depends on state support and protectionist policies (Gutiérrez, 1997).

In the case of Brazil agriculture has historically been guided by policies aimed at exports (Mendali et al., 2013). By the 1960s the strategy of import substitution had already been created to settle the bases of capital formation and industrialisation which would give rise to the modernisation of the agricultural sector through fertilisers, chemical products and the manufacture of agricultural machinery. This constituted the first phase in the transformation of Brazilian agriculture (Baer, 2008), and was followed by a second stage, towards the 1960s and 1970s, when the economy continued to expand its exports of processed and semi-processed agricultural products (Mendali et al., 2013) and implement diverse plans for agricultural research and development (Graham et. al, 1987).

Table 6
Mechanization intensity

	Tractors per 1,000 workers				Annual growth rates (%)			
	1950	1973	1993	2008	1950-1973	1973-1993	1993-2008	1950-2008
Argentina	15	123	178	168	9.5	1.9	-0.4	4.2
Brazil	2	15	55	68	10.5	6.6	1.5	6.8
Chile	9	48	42	56	7.5	-0.7	1.9	3.1
Colombia	3	9	8	6	4.3	-0.6	-2.0	1.0
Honduras	0	4	7	8	10.4	2.2	0.6	5.0
Mexico	7	14	35	29	3.2	4.8	-1.2	2.6
Panama	3	16	22	31	7.6	1.5	2.3	4.1
Peru	2	6	4	4	5.5	-1.6	-1.5	1.2
Uruguay	49	171	169	195	5.6	-0.1	0.9	2.4
Venezuela	6	31	58	64	7.8	3.2	0.7	4.3
Latin America	5	21	45	47	6.7	3.9	0.3	4.0

We have used previous data for tractors and active population.
Source: Authors' elaboration, from FAOSTAT (2012) and FAO (1948-2004).

The evolution of the use of chemical fertilisers complements this perspective regarding the use of capital inputs (Table 7). With an average annual rate of growth for the region of 7.9%, generalised growth can be observed around the average.

Growth in the employment of chemical fertilisers, like that of machinery, was concentrated in the initial decades of the second half of the twentieth century, especially between 1950 and 1973 (13.4% annually). The rate of expansion was reduced in the following decades (although annual rates of above 4% were maintained).

Table 7
Chemical fertilizers

	Tonnes				Annual growth rates (%)			
	1950	1973	1993	2008	1950-1973	1973-1993	1993-2008	1950-2008
Argentina	17,119	76,033	334,367	1,308,867	6.7	7.7	9.5	7.8
Brazil	45,559	1,747,633	4,329,133	9,672,333	17.2	4.6	5.5	9.7
Chile	61,192	169,467	370,000	480,000	4.5	4.0	1.8	3.6
Colombia	21,617	251,333	508,033	679,567	11.3	3.6	2.0	6.1
Honduras	1,800 (1)	22,200	41,723	120,048	11.5	3.2	7.3	7.5
Mexico	22,677	782,833	1,618,600	1,605,667	16.6	3.7	-0.1	7.6
Panama	1,400 (1)	25,372	32,542	21,145	13.4	1.3	-2.8	4.8
Peru	7,021	109,633	131,333	313,200	12.7	0.9	6.0	6.8
Uruguay	2,947	59,200	78,400	159,167	13.9	1.4	4.8	7.1
Venezuela	2,026	95,900	283,333	344,567	18.3	5.6	1.3	9.3
Latin America	183,359	3,339,606	7,727,464	14,704,560	13.4	4.3	4.4	7.9

Triennial averages.
(1) Figure for 1950 to nitrogenous fertilizers and for 1952 for potash and phosphorus.
Source: Own elaboration with data from IFA (2014) and FAO (1948-2004). For Honduras and Panama, the data are from FAOSTAT (2012) and FAO (1948-2004). The Peruvian figure for 1950 is from Hopkins (1981). For more details of the sources and for the calculation, see the the Appendix.

The level of fertilisers per hectare (Table 8) also shows a considerable expansion in their use, with increases in this ratio of 6.5% annually for Latin America as a whole. Nevertheless, it should be taken into account that Latin America is highly heterogeneous, in both levels and their variations, in the use of fertilisers. Towards 2008, dispersion was great and, for example, the quantity of fertilisers per hectare in Chile was 10 times that of Argentina. With regard to their variation, in the subperiod 1993-2008, high growth rates –such as those of Argentina (8.3%) and Honduras (9.5%)– alternated with decreases in some countries such as Mexico and Panama. The evolution of this indicator is closely related to the endowment of natural resources (the type and quality of land) and to the productive specialisation of each economy; thus, the deep-rooted differences displayed by Latin America in this field are clearly expressed in this technical coefficient. For example, the low relative level of fertilisation of Argentina was related to its high cost and largely insignificant impact on the predominant crop type. However, the introduction of soya from the early 1980s and its rotation with Mexican wheat varieties of a short cycle meant a strong boost to fertilizers use. While in 1977 less than 100,000 hectares were

fertilised, by 1985 this figure reached almost two million (Barksy and Gelman, 2003).

Table 8
Chemical fertilization intensity

	Tonnes per 1,000 hectares				Annual growth rates (%)			
	1950	1973	1993	2008	1950-1973	1973-1993	1993-2008	1950-2008
Argentina	1	3	12	40	4.6	7.5	8.3	6.5
Brazil	2	38	72	141	13.1	3.2	4.5	7.4
Chile	16	40	142	278	4.0	6.6	4.6	5.0
Colombia	9	49	105	196	7.8	3.8	4.3	5.5
Honduras	2	14	21	83	8.0	2.1	9.5	6.3
Mexico	1	33	60	58	15.8	3.0	-0.2	7.0
Panama	6	47	49	30	9.0	0.3	-3.2	2.7
Peru	4	35	32	71	9.4	-0.3	5.3	4.9
Uruguay	2	41	59	96	14.0	1.8	3.3	6.9
Venezuela	1	27	84	102	16.9	5.8	1.3	8.8
Latin America	3	29	58	101	11.0	3.5	3.8	6.5

Triennial averages, except for the data of the land in 1950 and the fertilizers in 1950 for Honduras and Panama.
Source: the same than the tables 2 and 7.

Although the only types of capital whose quantification has been possible are those examined above, we cannot ignore the crucial role played by others, and in particular the new high yield seeds (HYS), principally the result of the efforts of public agronomic research centres which led to the so-called Green Revolution. We have already underlined the leading role which Mexico played from the 1940s onwards with wheat. Subsequently, although in Latin America the employment of HYS was delayed somewhat with regard to the speed acquired in their adoption by the Asian countries, their contribution to the increase in agricultural yields and productivity was marked (Evenson and Gollin, 2002)[16]. Thus, for example, it has been estimated that in Brazil the use of HYS raised by 50%, on average, the yields of those crops to which they had been introduced between 1991 and 1998 (Avila et al., 2002). In addition, a third of the increase in the productivity of Brazilian agriculture between 1970 and 1985 was also due to the increase in the use of HYV (Evenson and Rosegrant, 2002).

[16] In 1970, 1980, 1990 and 1998 the averages of the utilisation in Latin America of modern varieties in crops as a whole were 8%, 23%, 39% and 52% respectively, as opposed to 13%, 43%, 62% and 82% in Asia (Evenson, 2002: 450).

4.- Total Factor Productivity in Latin American agriculture

4. 1 Calculation methodology

Total factor productivity (TFP) is a good indicator to approach the measurement of the efficiency of the agricultural sector and, in this case, to evaluate its comparative evolution among Latin American countries. The measurement proposed follows the methodology of growth accounting. This productivity is based on the primary definition of the Solow residual, that is to say, it is calculated as the difference between the growth of output and of a combination of production factors. In the present analysis, this combination is formed by the land factor, comprised of an aggregation of rainfed and irrigated land (arable hectares of land and permanent crops) (Fuglie, 2010, 2012), labour and capital, which comprises chemical fertilisers, self-propelled machinery and livestock units[17]. The data that we have used are from FAOSTAT (2012), FAO (1948-2004) and IFA (2014)[18].

This combination is a weighted average in which the weightings used are those appearing in Tables A3.1, A3.2 and A3.3 of the Appendix and are the remunerations each factor receives in percentage terms over total production (Del Gatto et al., 2011). We have applied to Argentina and Uruguay the weightings of Argentina, to Mexico, Honduras and Peru those of Mexico, and to the rest those of Brazil.

The formula employed to obtain the growth of TFP is that used by Fuglie (2010, 2012):

$$\ln\left(\frac{TFP_{i,t}}{TFP_{i,t-1}}\right) = \ln\left(\frac{Y_{i,t}}{Y_{i,t-1}}\right) - \sum_{i}\left(s_{i,j,t}\right)\cdot \ln\left(\frac{x_{i,j,t}}{x_{i,j,t-1}}\right)$$

where:

Y and *X* are vectors*; s*: weightings; *i*, countries; *j*, inputs. i=1,…, 10; j=1,…,5

4.2 Decomposing the growth of production: the evolution of TFP.

Table 9 shows the rates of growth of production, inputs and agricultural productivity of Latin America and of the countries analysed[19].

[17] The estimation of the growth of capital is performed on the basis of the rates of capital for which we have data (tractors, fertilisers, livestock units), which involves assuming that the growth in the rates of capital not considered (principally buildings, new seeds or insecticides) was produced at the same rate as for those for which we do have information.

[18] For more details, see the Appendix.

[19]We have included a short survey and two tables (Tables A.4 and A.5) in the Appendix analysing the previous studies of TFP in the Latin American region.

Table 9
Annual average logarithmic rates between 1950 and 2008

	Production	Labour	Land	Capital	TFP
Argentina	1.68	-0.23	1.13	3.66	-0.04
Brazil	3.97	0.28	2.23	4.57	1.90
Chile	2.46	0.69	-0.55	2.34	1.51
Colombia	2.55	1.01	0.98	2.01	1.19
Honduras	3.04	0.38	1.15	3.69	0.98
Mexico	3.67	0.89	0.77	3.22	1.99
Panama	2.99	1.11	2.03	2.78	1.26
Peru	2.70	1.70	1.17	2.49	1.13
Uruguay	1.13	-0.25	0.48	2.31	0.23
Venezuela	3.46	0.10	0.68	3.58	2.22
AL BRA	3.01	0.61	1.33	3.26	1.43
AL MEX	3.01	0.61	1.33	3.41	1.04
AL ARG	3.01	0.61	1.33	3.87	0.93

AL BRA, Latin America with the Bazilian shares in the capital and TFP calculation; AL MEX, Latin America with the Mexican shares in the capital and TFP calculation; AL ARG, Latin America with the Argentinian shares in the capital and TFP calculation. The capital growth rate for this and subsequent tables is a weighted average of the growth rates of fertilizers, machinery and livestock. We have used as shares the same than for the calculation of the TFP, but for these tables these three weights sum to 1.
Source: Authors' elaboration, from FAOSTAT (2012), FAO (1948-2004) and IFA (2014).

The impressive rate of growth (3 % annually) was principally driven by the incorporation of inputs into the production process; the most notable role was that of capital, which expanded by over 3%. The strong capitalisation of Latin American agriculture was a feature which extended throughout the region. The contribution of TFP was modest, although very significant differences are to be found. Thus, the leading economies in the increase of productive efficiency were Venezuela, Mexico and Brazil, with increases of 2.2%, 2% and 1.9%. The only countries to distance themselves significantly from the Latin American average were Uruguay and Argentina, where the rates of variation of TFP were very low for the former country and negative for the latter. The remaining countries had values very close to the regional average. To better visualize the evolution of these indicators we shall analyse them separately for the three subperiods into which we have divided the years 1950-2008.

The growth in the use of capital registered its highest rate during the stage identified with the ISI and the contribution of TFP was the lowest throughout the period analysed. That is to say, the period of industrialisation induced by the state showed, in the agricultural sector, an "extensive" growth[20] which barely supported itself by efficiency improvements (Table 10). Furthermore, these were very different among countries throughout the entire period, alternating very high rates –such as Mexico (3.0%) and Venezuela (2.6%)–with others which were almost non-existent –such as Honduras or Colombia– or negative –as in Peru, Uruguay, Panama and

[20]Growth was based on increasing inputs, as Federico has suggested (Federico 2005: 221).

Argentina. This period coincides with the highest growth of production and TFP in Mexican agriculture. The panorama changed sharply in the following stage.

The high rate of growth of Mexican agricultural productivity in the period 1950-1973 was associated with the use of improved seeds introduced in the 1950s and the increased use of modern inputs, especially irrigated land, fertilisers, pesticides and animal feed (Fernandez-Cornejo and Shumway, 1997). That is to say, land reform, infrastructure and favourable relative prices generated a significant process of the capitalisation of Mexican agriculture which permitted a boom to take place. In this scenario, government involvement was essential, through massive investment and public subsidies, to finance the expansion of the sector. For example, between 1957 and 1981, public investment in agriculture grew at an annual rate of over 10% (Gómez, 1995). A substantial part of this investment was channelled into the expansion of irrigation in Northern Mexico, which encouraged the expansion of the cotton export sector and boosted wheat production for the domestic market (Cerutti, 2015). These years further coincide with the takeoff of the Green Revolution, precisely on Mexican territory and initially applied to the cultivation of wheat.

The Argentinean case, surely the most advanced agriculture in the region in 1950, is significant. The low incorporation of technological innovations in the country in this period had already been underlined by early analysts of those years such as Díaz Alejandro (1970: 145). The volte-face in the strategy of development discouraged the adoption of such innovations in an agriculture which had until then been strongly oriented towards exports.

Table 10
Annual average logarithmic rates between 1950 and 1973

	Production	Labour	Land	Capital	TFP
Argentina	1.21	-0.49	1.97	4.17	-0.71
Brazil	4.24	1.66	3.59	6.52	0.83
Chile	1.69	0.39	0.34	3.54	0.61
Colombia	2.73	1.45	3.31	3.84	0.11
Honduras	3.49	0.15	3.30	6.55	0.04
Mexico	5.35	1.58	1.02	5.49	3.01
Panama	3.43	1.84	3.94	5.88	-0.04
Peru	2.16	1.37	1.79	5.23	-0.36
Uruguay	0.21	-0.83	0.06	3.70	-0.84
Venezuela	4.46	0.28	1.50	5.65	2.56
AL BRA	3.14	1.35	2.17	4.76	0.74
AL MEX	3.14	1.35	2.17	5.57	0.26
AL ARG	3.14	1.35	2.17	5.65	-0.01

Source: Same sources as table 9.

Between 1973 and 1993, and in contrast to the foregoing subperiod, despite agricultural output increasing at a slightly lower rate, the contribution of productivity was greater. In this subperiod no negative variations in productivity were recorded and Chile (1.9%), Brazil (1.9%) and Venezuela (1.7%) stood out, with above average increases. Exports of Chilean temperate fruit grew quickly from 1974 to the beginning of the 1990s. An important aspect of this unusual success was the rapidity with which Chileans were able to transfer, adapt and extend fruit technologies, initially developed for California and other fruit growing regions, to their home country. Moreover, although the public sector was responsible during the 1960s for developing the scientific expertise and technological base that initiated the expansion of the fruit sector, the private sector was the motivating force for the substantial, varied and broadly diffused technological advances which occurred after 1974 and which have been directly associated with Chile's expansion into international markets (Jarvis, 1994). In 1973, a military coup imposed an authoritarian government that quickly moved to liberalize markets, reduce government intervention and end the land reform (Olavarría et al, 1994). Rural labour unions were banned and workers could be fired at will. Real wages fell significantly, reducing labour costs and increasing producers' profits.

Table 11
Annual average logarithmic rates between 1974 and 1993

	Production	Labour	Land	Capital	TFP
Argentina	1.44	0.02	0.21	3.03	0.07
Brazil	3.44	-0.16	1.54	4.10	1.89
Chile	3.11	1.58	-1.15	1.94	1.87
Colombia	2.62	1.19	0.28	1.56	1.54
Honduras	2.43	1.14	1.16	2.18	0.70
Mexico	2.63	1.16	0.90	3.40	0.19
Panama	2.32	1.20	1.04	1.63	1.11
Peru	1.76	2.30	0.97	0.18	0.97
Uruguay	1.17	0.44	0.01	1.36	0.43
Venezuela	2.95	0.61	0.14	3.19	1.67
AL BRA	2.65	0.59	0.88	2.92	1.26
AL MEX	2.65	0.59	0.88	2.91	0.69
AL ARG	2.65	0.59	0.88	3.35	0.83

Source: Same sources as table 9.

A second phase of agricultural transformation took place in the 1970s and early 1980s in Brazil, when the economy continued to open up, due to the expansion of processed and semi-processed agricultural exports (Graham et al., 1987). The establishment of EMBRAPA, a Brazilian agricultural research agency in 1973, led to an even greater transformation of production. EMBRAPA was formed to increase human capital investment, to provide research and development to improve small farmers' productivity, and increase yields (Mendali et al., 2013). In the late 1980s,

Brazil began to move towards a more laissez-faire and free market oriented policy which significantly affected the agricultural sector. Agricultural policy became focused on the elimination of export taxes and price controls, the deregulation and liberalization of commodity markets and unilateral trade reduction (Gibson, 2009).

TFP results were higher than average growth in Latin America until the 1990s and then the growth rate fell below the overall average. The irregular performance of agricultural production, coupled with the potential increase in demand for food, became a clear problem. Venezuela represents the case of a country which is a victim of the "curse" of natural resources (based on oil exports), which prevents the creation of the conditions for sustainable agriculture and steady growth.

Whatever the case, the period of greatest productivity increases was that of the two last decades of the period under study (1994-2008); this coincides, on the other hand, with the greatest increase in production. In this latter subperiod the contribution of TFP was notable, exceeding even the expansion of capital for the Latin American average, with the sole exception of Argentina. As in the period as a whole, the countries with the worst performance in terms of efficiency improvements in agriculture were Uruguay (1.6%) and Argentina (0.8%).

This significant increase of TFP coincided with the reduction in the use of labour, which fell by 0.5% in Latin America on average, in a trend which was also followed by Argentina, Brazil, Chile, Honduras, Mexico, Panama, Uruguay and Venezuela. Finally, the contribution of the land factor was highly varied. It moderated its contribution in Latin America as a whole and underwent a decrease in three countries.

Kay (1994) maintains that as part of the process of the globalisation of the economy, transnational agricultural corporations and local investors appear preponderantly on the Latin American scenario. With the use of new technology which permitted improvements in the systems of storage, agro-industrial processing, preservation, transport, communications and industrial organisation, these companies had achieved advantages in the production of fruit, vegetables and flowers. The cases of Chile and Peru (and, partially, Brazil and Colombia) are representative of these trends. The structural reforms of the 1990s and, in particular, the policies aimed at promoting the development of the agrifood industry –together with the advent of free trade treaties- created favourable conditions for non-traditional agricultural exports to expand and become consolidated. Thus, in the period 1990-2008 notable changes were produced in TFP, which were accompanied by the greater trade opening to international markets, the increasing worldwide demand for healthy, quality foodstuffs, the incorporation of new lands into agricultural activity, the increasing interest in biofuels, the increase in the income of a population which demanded a more varied supply of high quality foodstuffs, and the expansion of private investment in agriculture. In the temperate zones –such as the Southern Cone- from the 1990s on, the economy embarked upon a stage of

marked liberalisation, with a reduction of tariffs and rigid exchange rates which affected the competitiveness of agriculture without receiving special programmes of promotion or support. The challenge was met by important advances in agricultural modernisation, the results of which gave clear indications of structural change, including the expansion of the agricultural frontier in Argentina (Campi, 2008) and various states of Brazil, a greater intensity in the use of land in the Pampas, new forms of production (the "sowing pools", whose star product was soya) and the explosive growth of feedlots.

Table 12
Annual average logarithmic rates between 1994 and 2008

	Production	Labour	Land	Capital	TFP
Argentina	2.70	-0.15	1.06	3.74	0.84
Brazil	4.28	-1.26	1.04	2.21	3.56
Chile	2.77	-0.03	-1.11	1.05	2.41
Colombia	2.18	0.11	-1.65	-0.20	2.39
Honduras	3.16	-0.29	-2.16	1.33	2.80
Mexico	2.50	-0.52	0.23	-0.50	2.84
Panama	3.20	-0.10	0.44	-0.43	3.46
Peru	4.78	1.41	0.46	1.36	3.61
Uruguay	2.49	-0.28	1.74	1.46	1.61
Venezuela	2.58	-0.87	0.12	0.93	2.42
AL BRA	3.31	-0.51	0.65	1.44	2.72
AL MEX	3.31	-0.51	0.65	0.76	2.72
AL ARG	3.31	-0.51	0.65	1.84	2.50

Source: Same sources as table 9.

4.- Conclusions

The analysis of the diverse Latin American countries offers very important contrasts among them. It is difficult to talk of a common model, but instead of strong variations among the diverse national experiences. If we take into account the contribution to the increase in production of the inputs employed and of TFP, several conclusions may be reached.

Firstly, an increase in production took place in the period as a whole. This was remarkable, at 3% annually for 58 years, which meant an increase in production truly notable in absolute terms (production in 2008 was over five times higher than in 1950). However, the differences among countries were important. The countries which were most successful in basing their model of growth on the first globalisation of agricultural exports, Argentina and Uruguay, were those which grew least, due especially to their poor performance until 1990. Brazil, Mexico and Venezuela were the leaders in growth.

Secondly, this increase was very similar during the stage of ISI and the crisis of the 1970s and 1980s, to then accelerate during the subsequent liberalisation. Once more, there is a sharp contrast with the developed countries and Europe, where production increased significantly until 1985 and then decelerated. The acceleration of growth in Latin America after 1990 is clearly apparent in those countries which had grown least and around the decade of the 1990s returned strongly to the world market for agricultural products, Argentina and Uruguay. Brazil maintained very high rates throughout the period, while some countries, such as Colombia, Mexico or Venezuela, reduced their speed of growth from those dates onwards.

Efficiency gains made a rather modest contribution to this strong increase in production. Above all, capital was the productive factor which best explains the increase in output. The remaining factors, in contrast to the developed countries and Europe, displayed positive growth. All the above suggests a model of agricultural development very different to that of the developed countries and even to that of the centrally planned European economies.

The differences among the Latin American economies are very significant. Paradoxically, in the countries with a more modern agriculture in 1950, Argentina and Uruguay, the contribution of TFP was lower. Countries such as Mexico, Venezuela or Brazil, which in 1950 continued to have a fairly traditional sector, were those in which the contribution of TFP was greatest.

From a time perspective, efficiency gains have made an increasing contribution to the growth of production. In the last subperiod the abandonment of ISI policies and the introduction of a greater liberalisation into agriculture were especially significant.

References

ÁLVAREZ, E. (1983): *Política Económica y Agricultura en el Perú, 1969-1979*. Lima: IEP

ANDERSON, K., VALENZUELA, E. (2010): América Latina: ¿cómo repercuten en los mercados y el bienestar la reformas de la política agraria y del comercio? *Revista de la CEPAL*, pp. 147-168.

ARNADE, C. (1998):"Using a Programming Approach to Measure International Agricultural Efficiency and Productivity." *Journal of Agricultural Economics* 49: 67-84.

AVILA, A. F., EVENSON, R. E., (2010): Total Factor Productivity Growth in Agriculture: The Role of Technological Capital. In: Pinghali, P. and Evenson, R., *Handbook of Agricultural Economics, vol. 4*. North Holland, Amsterdam.

AVILA, A.F.D., EVENSON, R.E., DE SILVA, S. and DE ALMEIDA, F.A. (2002): "Brazil", in R.E. Evenson and D. Gollin (eds.) , *Crop Variety Improvement and its Effect on Productivity. The Impact of International Agricultural Research*, CABI Publishing, Wallingford, pp. 409-426.

BAER, W. (2008): The Brazilian Economy.London: Lynne Rienner Publishers.

BARROWS, G., SEXTON, S. and ZILBERMAN, D. (2014): "Agricultural Biotechnology: The Promise and Prospects of Genetically Modified Crops." *Journal of Economic Perspectives*, 28(1): 99-120.

BARSKY, O. and GELMAN, J. (2001): *Historia del agro argentino. Desde la Conquista hasta fines del siglo XX*, Buenos Aires, Grijalbo.

BERTOLA, L. and OCAMPO, J.A. (2013): *El desarrollo de América Latina desde la independencia*, Fondo de Cultura Económica, Mexico.

BHARATI, P. and FULGINITI, L. (2007): "Institutions and Agricultural Productivity in Mercosur." In: Teixeira, E. and Braga, M. (editores). *Institutions and Economic Development*.Vicosa, Brazil: OsEditores

BRAVO-ORTEGA, C. and LEDERMAN,D. (2004): "Agricultural Productivity and Its Determinants: Revisiting International Experiences". *Estudios de Economia* 31, No. 2:133- 163.

BROWN,L. (1970): Seeds of Change: The Green Revolution and Development in the 1970s. Praeger, New York.

BULMER-THOMAS, V. (1994): *The Economic History of Latin America Since Independence*, Cambridge University Press, Cambridge.

CADENAZZI, G. (2009). "La historia de la soja en Argentina. De los inicios al boom de los ´90". XXVII Congreso de la Asociación Latinoamericana de Sociología. Asociación Latinoamericana de Sociología, Buenos Aires.

CALVA, J. (1999): El Papel de la Agricultura en el Desarrollo Económico de México: Retrospección y Perspectiva. En *Problemas del Desarrollo*, Vol. 30, No.18, pp. 35-56.

CAMPI, M. (2008): Cambios históricos en la frontera agraria pampeana La tecnología y el uso de la tierra. Maestría en Investigación Histórica, Universidad de San Andrés.

CEPAL (1978): *25 años en la agricultura de América Latina: rasgos principales (1950-1975)*, Cepal, Santiago de Chile.

CERUTTI, M. (2015): "La agriculturización del desierto. Estado, riego y agricultura en el norte de México (1925-1970)", *Apuntes*, 77, pp. 91-127.

COELLI, T. and RAO, D. (2005): "Total Factor Productivity Growth in Agriculture: A Malmquist Index Analysis of 93 Countries, 1980-2000". *AgriculturalEconomics*,32(1s), pp. 115-134.

DE A. DAVID, M., MORALES, C. y RODRIGUEZ, M. (2000): Modernidad y Heterogeneidad: Estilo de Desarrollo Agrícola y Rural en América Latina y el Caribe. Pontificia Universidad Javeriana. Seminario Internacional, Bogotá, Agosto de 2000.

DEL GATTO, M., DI LIBERTO, A., PETRAGLIA, C., (2011): Measuring Productivity. *Journal of Economic Surveys*, vol. 25, No. 5, pp. 952-1008.

DÍAZ ALEJANDRO, C. (1970): *Essays on the Economic History of the Argentine Republic*, Yale University Press, New Haven.

DIRVEN, M. (2008): "Principales tendencias del desarrollo agrícola: tensión entre las variables macro y micro", *Revista de Estudios Agrosociales y Pesqueros*, 218, pp. 45-70.

EBATA, A. (2011): Agricultural Productivity Growth in Central America and the Caribbean, Tesis de Maestría en Economía Agrícola presentada en la University of Nebraska-Lincoln.

ESCOBAL, J. (1999): El Gran Ausente: El Agro. Serie Estudios. Instituto Peruano de Economía, Lima.

EVENSON, R.E. (2002): "Production Impacts of Crop Genetic Improvement", in R.E. Evenson and D. Gollin (eds.) , *Crop Variety Improvement and its Effect on Productivity. The Impact of International Agricultural Research*, CABI Publishing, Wallingford, pp. 447-472.

EVENSON, R.E. and GOLLIN, D. (eds.) (2002): *Crop Variety Improvement and its Effect on Productivity. The Impact of International Agricultural Research*, CABI Publishing, Wallingford.

EVENSON, R.E. and ROSEGRANT, M. (2002): "The Economic Consequences of Crop Genetic Improvement Programmes", in R.E. Evenson and D. Gollin (eds.) , *Crop Variety Improvement and its Effect on Productivity. The Impact of International Agricultural Research*, CABI Publishing, Wallingford, pp. 473-498.

FAO (1948-2004): FAO Production Yearbook. Rome, Food and Agriculture Organization of the United Nations

FAOSTAT (2012): FAO database (*faostat.org*) Net production, fertilizers, machinery, labour, land, livestock, irrigation. Accessed on November 2012.

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

FERNANDEZ-CORNEJO, J. y SHUMWAY, R. (1997): Research and Productivity in Mexican Agriculture. *American Journal of Agricultural Economics*, Vol. 79, pp. 738-753.

FUGLIE, K. O. (2012) Productivity Growth and Technology Capital in the Global Agricultural Economy. In: FUGLIE, K. O., WANG, S. L., BALL, V. E., *Productivity Growth in Agriculture: An International Perspective.* CAB International, Oxfordshire.

FUGLIE, K. (2010). Total Factor Productivity in the Global Agricultural Economy: Evidence from FAO data. In J.M. Alston, B. Babcock, P.G. Pardey, *The Shifting Patterns of Agricultural Production and Productivity Worldwide*. Ames, Iowa: Midwest Agribusiness Trade and Research Information Center, pp 63-95.

FULGINITI, L. and PERRIN, R. (1998): "Agricultural productivity in developing countries". *Agricultural Economics*19 (1-2):45-51.

GIBSON, D. (2009). Brazil v. Argentina: Different Responses to the Rising Food Commodities Market, The Law & Business Review of the Americas, Volume 15, Number 4.

GOMEZ, L. (1995). El Papel de la Agricultura en el Desarrollo de México. Serie Rlac / 95 / 09 - Plan - 27. Oficina Regional de la FAO para América Latina y el Caribe, Santiago de Chile.

GRAHAM, D.H., GAUTHIER, H., and BARROS, J.R. (1987). "Thirty Years of Agricultural Growth in Brazil: Crop Performance, Regional Profile, and Recent Policy Review." *Economic Development and Cultural Change:* 1-34.

GUERRA-BORGES, A. (1993). "El desarrollo económico", in H. Pérez Brignoli (ed.), *Historia General de Centroamérica. Vol. V De la posguerra a la crisis*, Sociedad Estatal Quinto Centenario/FLACSO, Madrid, pp. 13-84.

GUTIERREZ, A. (1997). Venezuela: Crisis, Reformas Económicas y Reestructuración del Sector Agrícola. *Agroalimentaria*, No. 4. pp. 11-30.

HEADEY, D., ALAUDDIN, M. and RAO, P. (2010): Explaining agricultural productivity growth: An international perspective. *Agricultural Economics* 41: 1-14.

HERNANDEZ, J. (2008). Elementos Claves para la Discusión sobre la Problemática Agraria Venezolana. Facultad de Ciencias Políticas y Jurídicas. Ediciones del Rectorado, Mérida.

HERNANDEZ, J. (2009). Evolución y resultados del sector agroalimentario en la V República. Cuaderno de CENDES, Año 28, No. 72. Tercera Epoca, pp. 67-100.

HOPKINS, R. (1981). *Desarrollo desigual y crisis en la agricultura peruana 1944-1969*. IEP, Lima.

IFA (2014) International Fertilizer Industry Association. Chemical Fertilizers. *http://ifadata.fertilizer.org/ucSearch.aspx* .Downloaded September 2014.

JARVIS, L. (1994) "Changing private and public roles in technological development: lessons from the Chilean fruit sector". In Anderson, J. (ed.) Agricultural Technology: Current Policy Issues for the International Community, Wallingford: CAB International., Ch. 4, pp. 243-266.

Kalmanovitz, Salomón y López Enciso, Enrique (2005*) La agricultura colombiana en el siglo XX*, Fondo de Cultura Económica, Bogotá.

KAY, C. (1994) Rural Development and Agrarian Issues in Contemporary Latin America Working Paper No. 173. *Institute of Social Studies*, The Hague.

KAY, C. (2006): "Rural Poverty and Development Strategies in Latin America", *Journal of Agrarian Change*, 6, 4, pp. 455–508.

KEJRIWAL, M. and PERRON, P. (2010) A sequential procedure to determine the number of breaks in trend with an integrated or stationary noise component. *Journal of Time Series Analysis*, Apr., 301, 305-328.

LENCE S. H. (2010). "The agricultural sector in Argentina: major trends and recent developments." In Alston, J., Babcock, B., and Pardey, P. (eds.) (2010). *The Shifting Patterns of Agricultural Production and Productivity Worldwide*. Midwest Agribusiness Trade and Research Information Center (MATRIC).

LEON, J. (1994). Política de Estabilización y Crisis Agraria. En Dancourt, O. Mayer, E. y C. Monge (editores), *Perú: El problema agrario en debate*. Sepia V. Sepia, Lima

LONG, N. AND ROBERTS, B. (1994): "The agrarian structures of Latin America, 1930–1990", in L. Bethell (ed.), *The Cambridge History of Latin America. VI. 1930 to the Present. Part I. Economy and Society,* Cambridge University Press, Cambridge, pp. 325-390.

LUDENA, C. (2010): Agricultural productivity growth, efficiency change and technical progress in Latin America and the Caribbean. IDB Working Paper Series No. IDB-WP-186.

MARTÍN-RETORTILLO, M. and PINILLA, V. (2015) Patterns and causes of the growth of European agricultural production, 1950-2005, *Agricultural History Review*, 63.

MENDALI, R., AMES, G. and GUNTER, L. (2013): Total Factor Productivity in Brazil's and Argentina's Agriculture: A Comparative Analysis. Paper prepared for presentation at the *Southern Agricultural Economics Association (SAEA) Annual Meeting,* Orlando, Florida, 3-5 February.

MORALES, C. (1991): "La agricultura latinoamericana: crisis y planificación", en P. Talavera (ed.), *La crisis económica en América Latina*, Sendai Ediciones, Hospitalet de Llobregat, pp. 69-86.

NIN. A, ARNDT, C., HERTEL, T. and PRECKEL, P. (2003): "Bridging the Gap between Partial and Total Factor Productivity Measures using Directional Distance Functions". *American Journal of Agricultural Economics* 85, No. 4:928-942.

NIN, A. and YU, B. (2009): Getting implicit shadow prices right for the estimation of the Malmquist index: The case of agricultural total factor productivity in developing countries. Document presented to the International Association of Agricultural Economists Conference, Beijing, China, August 16-22, 2009.

NOTARO, J. (1984) La política económica en el Uruguay 1968 – 1984. Ediciones de la Banda Oriental, Montevideo.

NOTARO, J. (2003). "La batalla que ganó la Economía. 1972 -1984". En Instituto de Economía (Ed.) *El Uruguay del siglo XX*. La Economía. Vol. 1, Ediciones de la Banda Oriental, Montevideo, pp. 95-121,

OLAVARRÍA, J., BRAVO-URETA, B. y COCCHI, H.(2004): "Productividad Total de los Factores en la Agricultura Chilena: 1961-1996." *Economía Agraria y Recursos Naturales* 4 (8): 121-132.

OYHANTÇABAL, G. and NARBONDO, I. (2008). *Radiografía del Agronegocio sojero. Descripción de los principales actores y los impactos socio-económicos en Uruguay*. Redes AT, Montevideo.-

PFEIFFER, L. (2003): "Agricultural Productivity Growth in the Andean Community". *American Journal of Agricultural Economics* 85, No. 5:1335-41.

SERRANO, R. and PINILLA, V. (2011): "Terms of Trade for Agricultural and Food Products, 1951-2000", *Revista de Historia Económica-Journal of Iberian and Latin American Economic History*, 29, 2, pp. 213-243.

SERRANO, R. and PINILLA, V. (2014): "New Directions of Trade for the Agri-food Industry: A Disaggregated Approach for Different Income Countries, 1963-2000", *Latin American Economic Review*, 23:10, pp. 1-22.

SERRANO, R. and PINILLA, V. (2016): "The Declining Role of Latin America in Global Agricultural Trade, 1963-2000", *Journal of Latin American Studies*, 48, 1.

SOLBRING, O (2008): "Structure, Performance, and Policy in Agriculture". In BULMER-THOMAS, V., COATSWORTH, J. and CORTÉS CONDE, R. (Eds.) *The Cambridge Economic History of Latin America*. Volume II, The Long Twentieth Century, Cambridge University Press, US, Ch. 12, pp. 483-536.

SPOOR, M. (2002): "Policy Regimes and Performance of the Agricultural Sector in Latin America and the Caribbean During the Last Three Decades", *Journal of Agrarian Change*, 2, 3, pp. 381–400.

TRUEBLOOD, M. and COGGINS, J.(2003): "*Intercountry Agricultural Efficiency and Productivity: A Malmquist Index Approach*". World Bank, Washington DC.

VON HESSE, M. (2000) Aspectos Macroeconómicos. En Von Hesse, M., Trivelli, C. Diez, A. y Castillo, L., *Desafíos del Desarrollo Rural en el Perú*. Consorcio de Investigación Económica y Social, Lima.

WORLD BANK (2010) *El Mercado Laboral Peruano Durante el Auge y Caída*. Washington DC: Banco Mundial.

YUNES, A. (2010: "Las transformaciones del campo y el papel de las políticas públicas: 1929-2008", in S. Kuntz (ed.), *Historia Económica General de México. De la Colonia a nuestros días*, El Colegio de Mexico/Secretaría de Economía, México, pp. 729-755.

Appendix

1. Antecedents

Table 1.1.
Summary of studies: Percentage of growth of agricultural total factor productivity in selected Latin American countries

Author/s	Ebata	Ludena	Coelli and Rao	Nin and Yu	Nin et al.	Trueblood and Coggins
Date	2011	2010	2005	2009	2003	2003
Nº. countries	14	120	93	72	20	115
Period	1977-2006	1961-2007	1980-2000	1964-2003	1961-94	1961-91
Methodology	Malmquist	DEA	DEA	DEA	DEA	DEA
Argentina	n.a.	2.4	-2.7	2.9	2.5	-2.6
Brazil	n.a.	1.8	2.0	1.4	-0.3	-0.6
Chile	n.a.	2.1	1.0	1.9	0.6	1.4
Colombia	n.a.	2.1	1.4	2.7	1.5	1.6
Honduras	3.5	1.3	0.3	1.7	n.a.	-1.3
Mexico	n.a.	2.1	1.5	1.2	n.a.	0.5
Panama	1.7	1.1	n.a.	0.2	n.a.	0.4
Peru	n.a.	1.2	1.5	1.2	n.a.	-0.1
Uruguay	n.a.	0.9	0.0	0.8	1.5	-0.1
Venezuela	n.a.	2.1	0.6	1.5	n.a.	0.7

Author	Fulginiti and Perrin	Arnade	Bravo-Ortega and Lederman	Avila and Evenson	Bharati and Fulginiti
Date	1998	1998	2004	2010	2007
Nº. countries	18	70	77	82	10
Period	1961-85	1961-93	1960-2000	1961-2001	1972-2002
Methodology	DEA	DEA	Translog	Accounting relationship[1]	Translog
Argentina	-4.8	-1.9	1.8	2.1	2.2
Brazil	-0.5	-2.1	1.9	1.9	2.6
Chile	1.1	1.3	1.2	1.4	2.2
Colombia	0.0	1.8	1.4	1.6	1.1
Honduras	n.a.	-0.4	0.8	1.6	n.a.
Mexico	n.a.	1.2	1.9	1.9	n.a.
Panama	n.a.	n.a.	n.a.	1.0	n.a.
Peru	n.a.	0.6	1.4	1.2	1.1
Uruguay	n.a.	-1.3	n.a.	0.5	1.9
Venezuela	n.a.	0.2	1.4	2.0	2.4

Table 1.1. Summary of studies (cont.)

Author	Pfeiffer	Headey et al.	Fuglie
Date	2003	2010	2012
Nº. countries	5	88	155
Period	1972-2000	1970-2001	1961-2009
Methodology	DEA/ Translog	Stochastic Frontier Analysis	Growth accounting: Cobb-Douglas
Argentina	n.a.	n.a.	1.0
Brazil	n.a.	1.1	2.0
Chile	n.a.	1.9	1.8
Colombia	1.9/1.4	n.a.	2.0
Honduras	n.a.	n.a.	1.1
Mexico	n.a.	n.a.	1.6
Panama	n.a.	n.a.	0.8
Peru	1.4/1.9	2.2	1.2
Uruguay	n.a.	n.a.	1.4
Venezuela	1.5/1.1	1.4	2.1

Source: Authors' elaboration, on the basis of Ludena (2010: Appendix, Table 1, pp. 30), Ebata (2011), Nin et al. (2003), Nin and Yu (2009), Bharati and Fulginiti (2007), Avila and Evenson (2010), Headey et al. (2010) and Fuglie (2012).

n.a.: Not available. 1/ The accounting relationship assumes that the value of the product is equal to the value of the inputs required to generate the product.

2. Construction of the statistical series

For the variables for which there were no continuous series during the 1950s, we have calculated the data which were lacking through linear interpolation among the data which appear in the FAO production yearbooks (1948-2004) and the data for 1961 from FAOSTAT. In this way we have obtained an annual series since 1950, which we have linked with those of FAOSTAT, which began in 1961. We comment below on the concrete estimations which require more detail.

Gross agricultural production:

For the calculation of an annual series between 1950 and 2008 we have had to make certain calculations. On the one hand, the FAOSTAT database only offers data from 1961, in $US from 2004-2006. To obtain a homogenous series for our entire sample, we take the series of agricultural production indexes which appear in the FAO production yearbooks. As a first step, we take the 1963 yearbook, obtaining from it the index which goes from 1952 to 1962. Assuming that the agricultural production of Latin American countries followed the same trend as these indexes, we can obtain a homogenous series between 1952 and 2008. For the years prior to 1952, we undertook the same operation with the indexes from 1948 on which appear in the 1952 yearbook. Linking these series of indexes with those offered by FAOSTAT, we managed to obtain a series which covers almost 60 years of Latin American agricultural production.

Land:

The data from the FAO Production Yearbook for 1950 are not consistent with those available in the literature for Argentina, Chile and Uruguay.

Argentina: we have calculated the arable land area for the 1950s assuming that this variable followed the same trend as the aggregate land area sown with the 15 principal crops of Argentinean agriculture (Ferreres, 2005).

Chile: faced with the absence in the census of comparable values between 1950 and 1961, we have utilized the datum which appears in FAO (1948-2004) for 1949. Finally, we calculated the annual series through a linear interpolation between this datum from 1949 and that from 1961 from FAOSTAT. The coefficient of correlation between the series of the data interpolated between 1949 and 1961 and the data for cultivated land of the principal crops of Mitchell in those years is 0.81.

Uruguay: To obtain an annual data series of arable land in Uruguay between 1951 and 1961 we have assumed that it followed the same trend as the number of hectares of tillage, orchards, vineyards, and fruit trees which appear in the censuses of 1951 and 1956. With these two data from 1951 and 1956, we can estimate an annual series from 1951 to 1961 through a linear interpolation between 1951 and 1956 and between 1956 and 1961. For the calculation of the year 1950, we have assumed that this variable grew in that year at the same annual rate as between 1951 and 1955.

Livestock:

Argentina: In the FAO yearbooks there are no data for ducks, geese, rabbits and turkeys for the 1950s. To calculate an annual series for this decade we have assumed that they evolved equally as between 1961 and 1971.

Brazil: In the FAO yearbooks there are no data for ducks, geese and buffalo for the 1950s. To calculate an annual series for this decade we have assumed that they evolved equally as between 1961 and 1971.

Chile: In the FAO yearbooks there are no data for asses and mules for the 1950s. To calculate an annual series for this decade we have assumed that they evolved equally as between 1961 and 1971.

Mexico: In the FAO yearbooks there are no data for ducks and geese for the 1950s. To calculate an annual series for this decade we have assumed that they evolved equally as between 1961 and 1971.

Panama: There are no data in the FAO yearbooks for ducks and turkeys for 1950 and nor for previous years. To calculate these poultry animals for that year we have assumed that they evolved equally to chickens. Neither for goats are there data for the year 1950. For their calculation, we have assumed that during this year they increased at the same rate as between 1951 and 1955.

Uruguay: In the absence of data for ducks, geese and turkeys for the year 1950, we have assumed that during this year the number of these poultry animals followed the same trend as chickens.

Venezuela: In the absence of data for all animals for the year 1950, we have assumed that during this year the aggregate data for livestock increased equally as between 1951 and 1955.

Tractors:

For the countries for which from 2002 on FAOSTAT did not offer data regarding tractors (Argentina, Colombia, Honduras, Panama, Peru and Venezuela), we have assumed that they followed the same trend between 2002 and 2006 as the aggregate of countries formed by Brazil, Chile, Mexico and Uruguay. We have assumed that from 2006 until 2008 the evolution of tractors remained constant.

Fertilisers:

The data for fertilisers have been taken from the database of the IFA (International Fertilizer Industry Association, 2014) which have been available in this database since 1961, while for Honduras and Panama the data come from FAOSTAT (2012). For the 1950s we have assumed that the trend of these series is the same as that given by the FAO data (1948-2004). The case of Peru is an exception, as the evolution for the 1950s displayed an evolution similar to organic and inorganic fertilisers. To correct this conflictive datum, we have assumed that the data for Peru followed the same trend as the chemical fertilisers calculated by Hopkins (1981, 104).

3. Calculation of Total Factor Productivity

The data employed for the calculation of the TFP come from the FAO database, from both its electronic version and its yearbooks (FAO 1948-2004 and FAOSTAT 2012). The production data correspond to gross production valued in constant US dollars from 2004-2006. The land data are an aggregate between the hectares of arable land and permanent crops and hectares equipped for irrigation. Agricultural labour is measured through the active population in agriculture.[21] Machinery is measured through the number of tractors. Chemical fertilisers are the sum of the consumption of nitrogenous, potassium-based and phosphoric fertilisers. Livestock units have been calculated by aggregating the number of live animals with the weightings of Hayami & Ruttan (1989).

For this calculation, it is necessary to weight the variables described previously. For our calculation we have taken into account three types of weightings which come from studies concerning Mexico, Brazil and Argentina. We have applied to Argentina and Uruguay the weightings of Argentina; to Mexico, Honduras and Peru that of Mexico; and to the rest that of Brazil.

Table A3.1
Weightings corresponding to Mexico

	Work	Land	Cattle	Fixed capital	Chemicals
1950	0.256	0.489	0.118	0.089	0.048
1973	0.242	0.373	0.200	0.147	0.038
1990	0.117	0.202	0.362	0.289	0.031
2008	0.115	0.225	0.353	0.263	0.045

Source: Authors' elaboration using data from Fuglie (2012)

Table A3.2
Weightings corresponding to Brazil

	Work	Land	Cattle	Fixed capital	Chemicals
1950	0.434	0.342	0.126	0.071	0.027
1973	0.434	0.342	0.126	0.071	0.027
1990	0.429	0.137	0.1745	0.144	0.116
2008	0.373	0.083	0.129	0.161	0.255

Source: Authors' elaboration using data from Fuglie (2012)

[21] The correct measurement of labour would have to be considered hours worked. The time and spatial amplitude of the sample make measurement necessary via a proxy such as the active agricultural population.

Table A3.3
Weightings corresponding to Argentina

	Work	Land	Cattle	Fixed capital	Chemicals
1950	0.333	0.333	0.188	0.106	0.040
1973	0.340	0.261	0.160	0.122	0.117
1990	0.345	0.207	0.140	0.135	0.174
2008	0.350	0.150	0.118	0.148	0.234

Source: Díaz Alejandro (1975) and Elías (1992)