The dynamism of Brazilian agriculture[1,2]

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Abstract – The Brazilian industrialization process was fundamental to modernize agriculture, creating in cities the demand for food and other inputs. Under this process, three agriculture policy instruments were put in place: subsidized credit, development of science and technology, and rural extension. In the period addressed, from 1975 to 2010, the five most important grains (rice, corn, beans, soybean and wheat) increased production by a yearly rate of 3.66%, and increased productivity by 2.95%. Soybean crops have been the flagship. From 1979 to 2009, beef production increased by 5.42% per year, pork 4.66%, and chicken 8.45%. This dynamic is related to the evolution of the domestic market and exports. Over the last years, sugarcane production increased approximately 9.0% annually. As a global model of agricultural efficiency, Brazilian total factor productivity for the period 1970–2006 increased by 2.27% per year. Agriculture and agribusiness exports generated a trade balance equivalent US$ 403 billion from 1997 to 2009, helping to balance Brazil's foreign trade. Projections show that Brazilian agriculture and agribusiness have a great potential for growth, where the most dynamic products are soybean, chicken, sugar, ethanol, cotton, soybean oil and cellulose.

Keywords: agriculture, agribusiness, production efficiency.

Introduction

The evolution of Brazilian agriculture over the last 35 years – from 1975 to 2010 – shows the efficacy and efficiency of its players. The revolution that took place in production and productivity is due to entrepreneurs, many of which small farmers, the availability of low-price arable land in the Cerrados, despite their low chemical fertility, the development of technologies for tropical edaphoclimatic conditions and for the implementation of agricultural policy instruments, such as credit and minimum price guarantee.

In the mid-1970s, when looking at "potential production supply," the agricultural land of the South, such as in Paraná and Mato Grosso do Sul, had already been taken. What was left was low-fertility farmland in the South and large extensions of savannah in the Central-West, used at that time for extensive livestock production.

On the demand side for that period, industrialization was already gaining momentum in Brazil, leading, in its wake, to accelerated urbanization, as urban salaries were higher than agricultural salaries. The new challenge was to supply the growing population with affordable food and to increase and to diversify agricultural exports and agribusiness processed products, ensuring international reserves to import capital goods, mainly for the emerging industry.

The agricultural sector responded favorably to these new challenges. Supported by sci-

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ence, it was gradually modernized and showed significant land, labor, and capital productivity increase. In addition, soil correction systems and new plant varieties were developed for the Cerrado. As a result, wide unproductive regions were incorporated to production. Thus, the supply for the growing domestic market was guaranteed and exports increased and became diversified.

This paper updates a chapter of a book published by Embrapa in 2008, the *Agricultura Brasileira – Quatro décadas de inovações tecnológicas, institucionais e políticas* [Brazilian Agriculture – Four decades of technological, institutional and political innovations], presenting data up to 2004/2005. It uses data up to 2009 (in some cases up to 2010), reinforces some trends previously identified and assesses current sector performance.

This paper focuses on the evolution of agricultural production and productivity, both partial (land, labor and capital) and total factor productivity (TFP), as well as the use of raw inputs and analyses of exports. It initially identifies the industrialization process as the driving force of the Brazilian agriculture modernization. The period analyzed is from 1975 to 2010. The evolution of the sector is described and fundamental factors that boosted its rapid development are assessed. In the conclusion, production and export projections are presented for main crops and beef, pork and chicken.

This study supports the thesis that the abundance of Brazilian agriculture and agribusiness was not created by chance, but rather a result of political will and intelligent actions that take advantage of foreign and domestic market opportunities.

Industrialization as the driving force of modernization

Over the last decades, Brazilian agriculture was modernized, following the transformation of the global economy and of Brazilian society led by strong industrialization. After World War II, the Brazilian industrialization project was consolidated based on the following ideas:

- According to the thesis of the Economic Commission for Latin America and the Caribbean (Eclac), led by Raul Prebish (1964), the terms of trade were going against countries that exported raw materials. Hence, economic policy should favor the development of the domestic market and the diversification of export goods. The solution was to industrialize.
- The two-sector model, such as the one professed by William Arthur Lewis (1969)[7], was based on the hypothesis of zero marginal productivity of labor in the agricultural sector. As a solution, surplus rural workers should be transferred to industrial and service sectors.
- The war showed that military power was largely dependent on the industrial sector, which had greater ability to diversify and to generate jobs. Those jobs were essential with the increase in birth rates.

In the early 1950s, Brazilian government adopted the draft industrialization economic policy. Until the early 1970s, the industrial sector was granted a series of advantages that discriminated agriculture. The policy was based on the following procedures: supporting an overvalued exchange rate; maintaining multiple exchange rates to favor capital goods imports and to prevent other goods imports; and granting loans with subsidized interest rates to the capital goods industry.

Economic policy also promoted consumer goods imports and investments in energy and transport infrastructure. Finally, low food prices were maintained to avoid pressure over urban

[7] Lewis and Theodore Schultz won the Nobel Prize in 1979 for "pioneering research on economic development [...] where particular considerations were made on the problems of developing countries." Lewis is best known for his concept of "double economy." According to Lewis, the economy of a poor country can be deemed as having two sectors: a small "capitalist" sector and a very large sector than can be called "traditional." This two-sector model became the main theory of the developing process for less developed countries during the 1960s and 1970s. According to this model, the traditional sector is characterized by excessive work because marginal work productivity equals zero (W. ARTHUR..., 2007).

salaries. Government priorities were urban infrastructure, investments in housing and health, and salary safeguarding.

The signs became quite clear in the rural areas: discrimination against agriculture and the promotion of the industrial sector strengthened the population's attraction to cities, and rural migration increased rapidly. Table 1 shows that the urbanization gained momentum from the 1950s and accelerated in the 1970s. This urbanization process is quickly losing momentum because the cycle has been completed in almost every region of Brazil, except for the North and Northeast (ALVES et al., 1999). Table 1 provides projections for 2010 and shows the slowing down of rural migration.

Recent work by Alves and Rocha (2010) shows that rural-urban migrations is still taking place in Brazil, but at a much lower rate than observed some years ago (Table 2). In the period 1991–2000, the rate of migrants from rural to urban areas was 24.7%, and from 2000 to 2007 it fell to 12.5% of the rural population.

Industrialization accomplished its role of creating a diversified and urbanized economy and of increasing the purchasing power of Brazilians. Combined to the population growth in the period 1950–1990, the demand for food increased at rates of up to 6% per year, fostering a very favorable environment for both growth and modernization in agriculture[8]. The opportunity cost of labor increased for farmers in an environment that was conducive to massive rural migration, which made producers intensify and mechanize agriculture.

Hence, industrialization and urbanization set forth the paradigm of agriculture transformation, where the main base was technology and science. Politically, it shifted power from the fields to the cities, transforming Brazil into a sophisticated urban society. Dias and Amaral (2000) provide an excellent assessment of the most important transformation undergone by agriculture until the late 1990s.

Table 1. Urbanization (in %) of the Brazilian population from the 1940s on.

Census year	Rate of urban population
1940	31.2
1950	36.2
1960	44.7
1970	55.9
1980	67.6
1991	75.6
2000	81.2
2010 (forecast)	86.8

Source: original data from IBGE (2010b).

Instruments of modernization

Three policies established the process of agricultural modernization: subsidized credit, especially to buy modern inputs and to finance capital; rural extension; and agricultural research, coordinated by the Brazilian Agricultural Research Corporation (Embrapa).

Given that modern technology largely focuses on modern inputs, rural credit is an agricultural policy instrument that enables its adoption. By the late 1980s, the private sector played a minor role as a lender for rural producers. The Brazilian federal government was the strongest investor, especially through Banco do Brasil and Banco do Nordeste. During the 1970–1985 period, interest rates were more intensely subsidized in Brazil (COELHO, 2001).

Figure 1 shows the amount of money granted as loans to producers and cooperatives in the period 1969–2009, values are in 2009 reais. When compared to other periods, 1975–1982 is outstanding in terms of credit volume, reaching the highest value in 1979, with R$ 132.6 billion. It was during that phase that rural credit drove Brazilian agriculture modernization. Following a strong rural credit reduction in the 1990s, when values were less

[8] Starting in 1980, population growth rates started to decline, a trend which became stronger in 1990.

Table 2. Rural population in Brazil and regions in 1991, 2000 and 2007, and number of migrants for the periods 1991–2000 and 2000–2007.

Regions & Brazil	Rural population 1991 (1,000 inhab.)	No. of migrants 1991–2000 (1,000 inhab.)	(%) Base 1991	Rural population 2000 (1,000 inhab.)	No. of migrants 2000–2007 (1,000 inhab.)	(%) Base 2000	Rural population 2007 (1,000 inhab.)
North	4,107.00	771	18.8	3,914.10	673.00	17.2	3,630
Northeast	16,721.30	4,223	25.3	14,759.70	1,659.00	11.2	14,770
Central-West	1,764.50	461	26.1	1,540.60	-25.00	-2.0	1,789
Southeast	7,514.40	1,696	22.6	6,851.60	1,108.20	16.2	6,440
South	5,726.30	1,699	29.7	4,780.90	574.00	12.0	4,739
Brazil	35,834.50	8,850	24.7	31,847.00	3,986.00	12.5	31,368

Source: Alves and Rocha (2010).

than R$ 40 billion, in 1996, the government started to subsidize harvests again, reaching R$ 75 billion[9] in 2009.

Government rural credit and public and private technical assistance together jointly physical and human capital. Until the 1990s, this partnership was compulsory, and producers paid a technical assistance tax through a bank. Nowadays, it is a voluntary partnership and private technical assistance prevails in commercial agriculture.

In the period 1950–1985, the modernization of agriculture as a public policy did not intend to address the majority of producers. The low level of education of most farmers, poor resources available for rural credit and land-related issues, such as land property rights, did not enable the spread of technological development. For that reason, selectivity was chosen, and consequently, rural credit, given that it has an embedded self-selection mechanism resulting in automatic elimination of farmers that do not fulfill the requirements. Hence, the fact that modernization was not inclusive is not in any way surprising. The poorest region of Brazil, the Northeast, was one of the most affected due to its lower rate of education, higher number of irregular land situations and a great number of risk averse farmers.

In the period 1950–1970, the emphasis was on rural extension, research was neglected based on the assumption that there was already a large stock of technologies available. In the early 1970s, it was brought to light that it was a false assumption. Yet it became clear at that time that it was not convenient for Brazil to expand production merely by increasing the area for crops, although over half of the Brazilian territory was still untouched. The best option would be to expand production by increasing land productivity, and to reduce the pressure to conquer the agriculture frontier. For that reason, heavy investments were made on agricultural research with the creation of Embrapa in 1973, and post-graduate courses were created, without reducing rural extension investments made by the federal government. In the mid-1980s, the federal government started to reduce the budget to disseminate technology. In 1991, the responsibility of rural extension was transferred to the Brazilian states, ending a partnership that had started in 1956.

With respect to agricultural research, the creation of Embrapa and of the National Agricultural Research System is a landmark in the modernization process of Brazilian agriculture. In other words: a state-run company under pri-

[9] The figure not include credit resources for familiar agriculture (Pronaf).

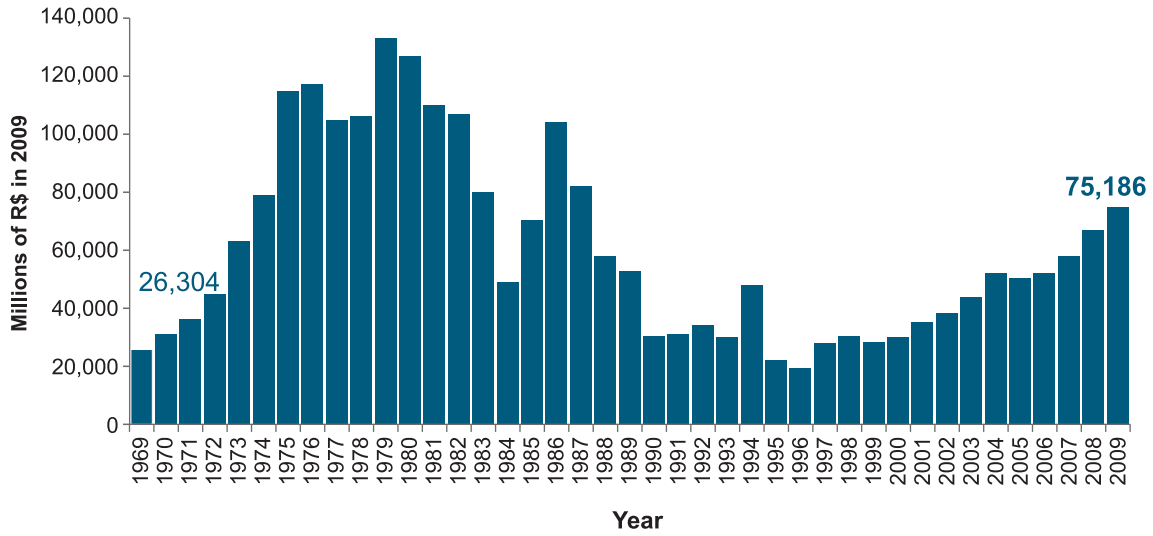

Figure 1. Evolution of rural credit in Brazil – funding to farmers and to cooperatives granted by the National Rural Credit System, in the period 1996–2009.

Note: data deflated by IGP-DI.

Source: Banco Central do Brasil (2010). Data deflated by IGP-DI.

vate Law was created with greater management flexibility and agility, and a research-based model was designed to focus on human resources training and to create centers of excellence in Brazil and abroad, with adequate research infrastructure (such as laboratories) in order to maximize human intelligence time (Figure 2).

Research centers were created according to three criteria: economic significance of products; in little known environments, and in strategic areas. The federal government supported agricultural research mainly through Embrapa, through agricultural research in the Brazilian states and agricultural science universities. Thus the basis was established for a science revolution in Brazilian agriculture.

Applied science unveiled the mystery of acid soils, which were previously considered useless in the Cerrado. New plant varieties turned scientific discoveries into production at growing rates. Inefficient and extensive livestock production was replaced by pioneer and efficient tropical agriculture. Millions of hectares were incorporated into Brazilian agriculture. Brazil became a world model of how to convert unproductive natural resources into productive resources. Currently, over a third of the Brazilian grain production comes from the Cerrado region. Livestock production also improved with animal genetics, where new grazing lands were developed and new nutrition techniques were put in place.

Brazil still has large extensions of arable land that can be incorporated into the production process. There are estimates showing that over 100 million hectares of cerrado area can be incorporated into agriculture to grow annual and permanent crops, maintaining the Amazon Rainforest, which occupies 350 million hectares, intact (IBGE, 2010b; CONAB, 2010). Furthermore, 160 million hectares of pastures (IBGE, 2010b) can be potentially intensified, thus leaving land free to be used for other applications. The environmental issue is safeguarded by the legislation that establishes a percentage of native area to be preserved, and at least 55 million hectares have to be protected, this area is larger than the actual area used for annual crops.

The intensification of agriculture has also required the use of a considerable amount of modern inputs, such as fertilizers (Figure 3).

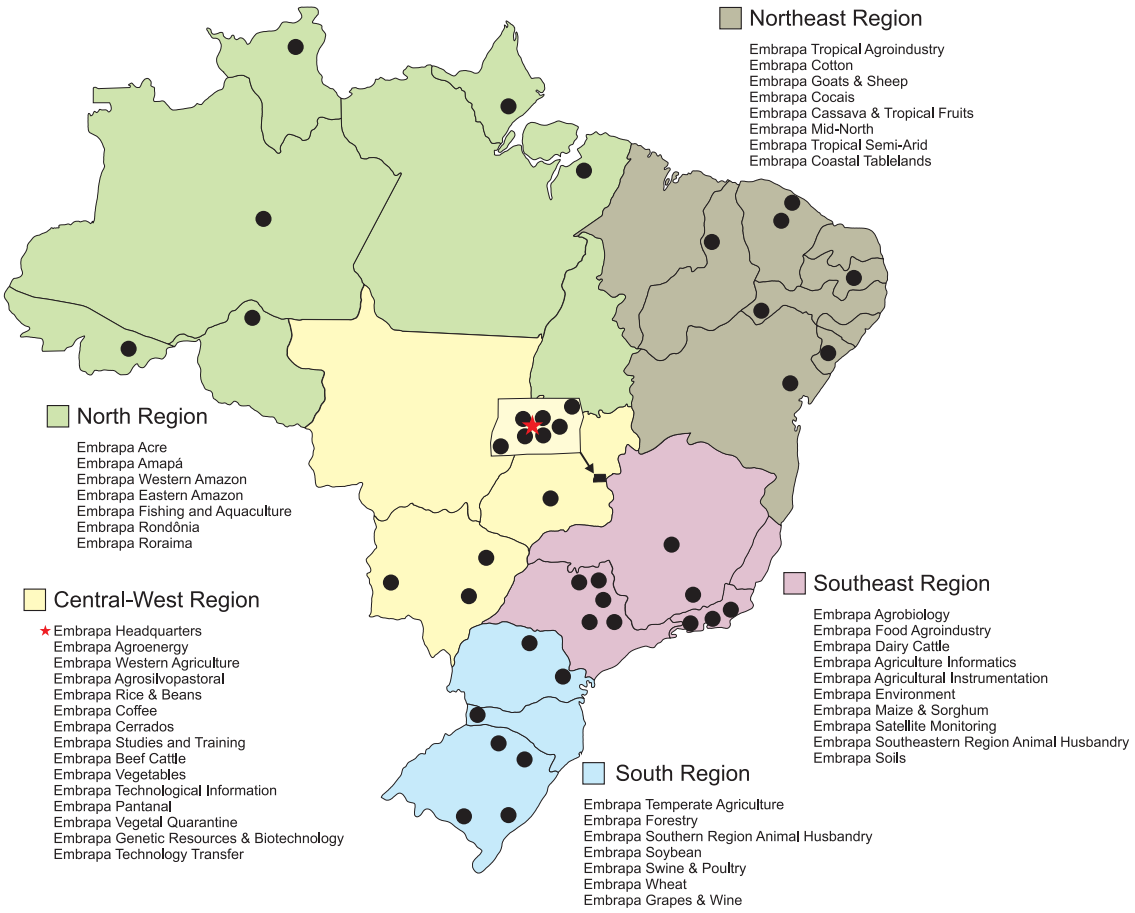

Figure 2. Embrapa's research framework – headquarters and research centers.

Thus, the consumption of fertilizers is one of the indicators of the modernization process that took place in agriculture over the last years. In long-established areas, fertilizers were used to recover soil fertility, and in new areas, such as the Cerrado, to correct soils.

Figure 3 shows the evolution of fertilizer consumption in Brazilian agriculture, according to the Brazilian Institute of Geography and Statistics (IBGE) and the National Association for the Dissemination of Fertilizers (Anda). Considering fertilizer consumption in terms of total nutrients, the average annual rate of consumption of nitrogen, phosphate and potassium fertilizers increased by 4.74%, in the period 1975–2008. This rate was higher than the increase of agricultural production over that period, i.e. 3.68% per year (GASQUES et al., 2008).

The intensification of Brazilian agriculture also occurred with the increased use of agricultural machinery. The factors that helped this expansion were: i) higher demand of agricultural products by the domestic and international markets; ii) strong rural-urban migration; and iii) the creation of the Program to Modernize the Fleet of Farming Tractors and Associated Implements and Harvesters (Moderfrota), in January 2000. The recovery of rural credit resources that started in 1996 was a major help to boost agriculture.

There are some interesting facts in the machinery and equipment market. There was an increase in domestic sales for tractors of all sizes. Small-sized tractors (up to 49 HP) sales increased over the last years but the trend is downward. Average-sized tractors (50–99 HP) sales which were traditionally utilized in Brazilian agricul-

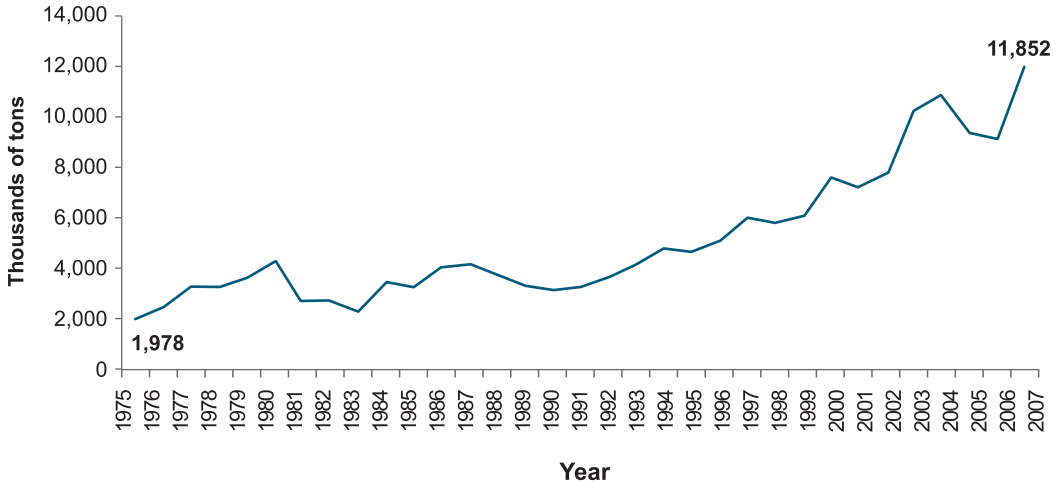

Figure 3. Evolution of the apparent consumption of fertilizers in Brazil, in tons, in the period 1975–2007

Source: IBGE (ANUÁRIO ESTATÍSTICO DO BRASIL, 1975–2008) and Anda (2010).

ture, and 100–199 HP tractors, considered large tractors, are the most sold ones.

The farming machinery market also had an increase in large-sized equipment sales, such as 200+ HP tractors, with over 600 units sold in 2008/2009 (Figure 4). From 1996 to 2009, the domestic sales of tractors were the following:

- Up to 49 HP wheel tractors: sales increased from 655 to 1,322 units annually.
- 50–99 HP wheel tractors: sales increased from 7,008 to 32,230 units.
- 100–199 HP wheel tractors: sales increased from 2,627 to 10,032 units.

When machinery and equipment are considered together, there was also a significant expansion. In 1996, 8,993 units were sold; in 2004, 5,598; and in 2009, 3,683.

Evolution of crop production, area and productivity

Production growth depends on the expansion of planted area and/or increase in productivity. Since the 1970s, yields started to explain production growth rates. It is certain that agricultural prices influence and are influenced by the increase of production. But it is common to agree that modern technology contributes to increasing production, which is reflected in decreasing prices. Thus, there is a precedence relationship.

Depending on the nature of technology, lower prices can interrupt technology dissemination. However, if technology is neutral or if the linear production function is homogeneous, the self-control mechanism will not exist. Hence, technology comes first in order to evolve into price changes. In other words, it is admitted that worldwide technology is the main cause of decreasing prices.

Over the last years, the trend shows a systematic growth of Brazilian crops (Figure 5). The most outstanding fact is that it has been occurring mainly due to productivity gains. That has been the driving force of production increase.

The historical behavior of grain production, area and productivity is shown in Figure 5, which displays the evolution of those crops from 1975 to 2010. While area increased by 45.6% in that period, production increased 268%. Another outstanding aspect is productivity, as the trend shows a significant productivity increase during the period analyzed. There were some

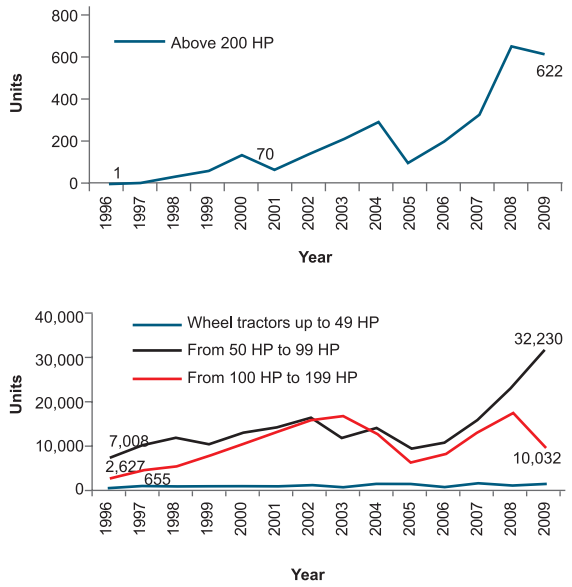

Figure 4. Sales of agricultural equipment in the Brazilian domestic market in the period 1996–2009, as per HP.

Source: Anfavea (2010).

decreasing points, such as in 2004 and 2006, mainly due to draughts. The productivity indicator for the average of grains went from a value of 1,258 kg/ha in 1977, to 3,000 kg/ha, in 2010. This resulted in a 3.2% annual growth average.

Another factor worth mentioning about Brazilian grain production is the second-harvest corn, also called *safrinha* corn, which is planted after the official harvest. Generally, the small harvest is planted in February, although some regions may anticipate or delay the beginning period. The second harvest corn became economically important in Brazil, especially in the Central-West region – mainly in Mato Grosso. Until 2000, It was practically irrelevant but in the 2009/2010 season it was planted in over 5 million hectares, and according to forecasts production will reach approximately 20 million tons and productivity will reach over 4,000 kg/ha.

The increase in agricultural production provided a higher availability of crop products. This is an important factor, as it reflects the positive response of agricultural production in face of a bigger population and it is also a good indicator within the food security context. This observation is ratified by the increased production of staple foods over the last years. Even during the worldwide food crisis of 2008, Brazil's supply was steady, prices increased but returned to historical levels in a short time.

Growth rates of area, production and productivity

Growth rates of production and productivity were estimated for the following periods: 1975–2010, 1980–1989, 1990–1999 and 2000–2010. Production growth in the period 2000–2010 is largely due to yield growth rather than planted area that increased significantly for soybean (3.5%), and little for corn (0.38%). Planted areas with rice, beans and wheat decreased in the period 1975–2010.

All crops in Table 3 increased production at higher rates than the population (1.6%). In the case of soybean, the increase was due to exports and animal protein production. Corn was largely influenced by the advancement of livestock production of beef, chicken and pork.

The effect of the stabilization program that kept exchange rate overestimated, especially for 1990–1999, caused a substantial reduction of harvested area, except for soybean (+2.66% per year). The annual average reduction per grain area was -0.57%, and probably occurred in low-quality soil worked by less efficient farmers.

Certainly, technological innovations helped to increase yields. However, recently (2000–2010), harvested area increased for all crops except for rice (-2.07), where soybean had an outstanding increase (5.0%). Looking at the period 1975–2010, the annual expansion of harvested area was only 0.70%. For grains, soybeans were outstanding (3.58%), and rice, wheat and beans presented an area reduction of -2.38%, -1.63%, and -0.64%, respectively.

There was a 3.32% per year increase for all crops during the period 1975–2010. In all periods, soybean was the major product, with 5.55% annual variations for the whole period

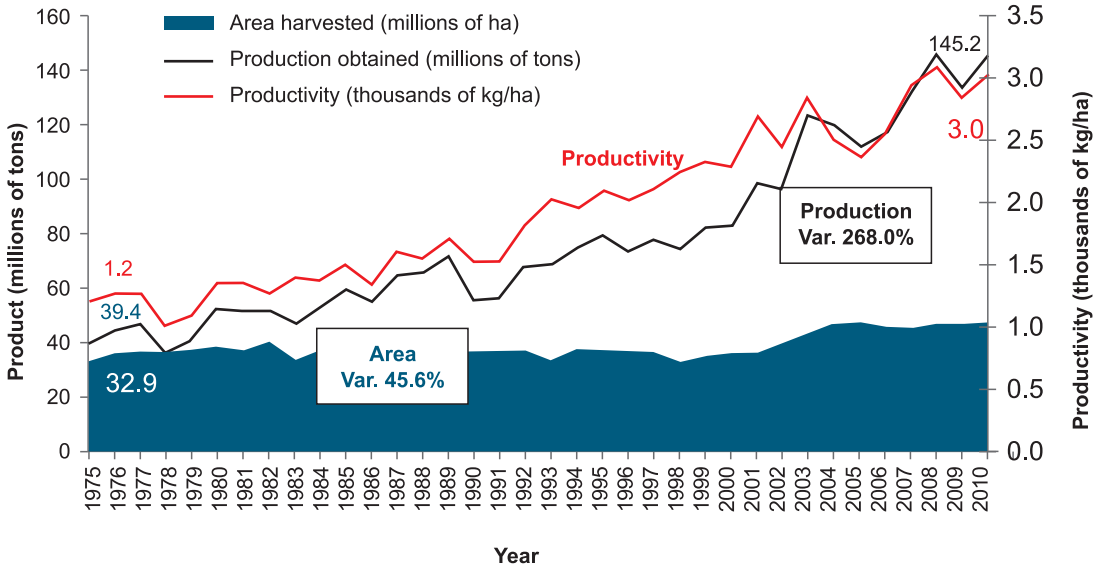

Figure 5. Evolution of harvested area in millions of hectares of grain production and productivity, in millions of tons, in 1975–2010.

Source: created by the authors for this study, based on data from the National Food Supply Company (CONAB, 2010).

and 6.06% more recently. Corn came in second place with 4.38% annual growth (2000–2010). In the 1990s, wheat production decreased (-2,09% per year); but that crop had increased 14.76% between 1980 and 1989, showing significant variations between both periods due to a change in the agricultural policy for that product. In January 1999 there was a change in the exchange rate regime and a floating exchange rate was put in place. As a result, imported agricultural products were no longer capable of replacing domestic production.

The evolution of land productivity largely shows the incorporation of technology, particularly biological technologies, to the production process. Crop productivity in the period 1975–2010 increased by 2.59% per year, with a positive evolution for all crops, where rice (3.51%), wheat (2.92%) and corn (3.04%) were outstanding. Soybean productivity grew 1.90% annually. More recently (2000–2010), soybean productivity increased only 0.96% per year, which can be explained by strong draughts during the 2004–2005 and 2005–2006 harvests, especially in the South of Brazil.

As a conclusion, the data show the substantial increase of production efficiency for all crops during all periods at hand, when growth rates were higher than those for the Brazilian population. Rural producers have added technology to the production process, which resulted in a surplus that was sent to the international market, which was fundamental to prevent domestic prices from decreasing and to balance Brazilian trade.

In the past, an overvalued exchange rate caused an increase in imports and this disturbed domestic production. However, with exchange rate fluctuation, this effect ceased and production continued to grow due to growing yield.

Evolution of livestock production and productivity

Evolution of production

A revolution has taken place in Brazilian meat production (Figures 6 and 7). Considering the three main types of livestock (beef, pork and chicken), production jumped from 2,659,000 tons

Table 3. Annual growth rates.

Harvested area					
Period	**Rice**	**Corn**	**Beans**	**Soybean**	**Wheat**
1975–2010	-2.38	0.38	-0.64	3.58	-1.63
1980–1989	-0.97	1.72	1.35	3.35	5.08
1990–1999	-3.25	-0.95	-3.04	2.66	-6.15
2000–2010	-2.07	1.53	0.13	5.05	3.09
Quantity produced					
Period	**Rice**	**Corn**	**Beans**	**Soybean**	**Wheat**
1975–2010	1.05	3.43	1.52	5.55	1.35
1980–1989	2.98	2.98	1.13	4.16	14.76
1990–1999	0.82	3.54	0.28	6.80	-2.09
2000–2010	1.31	4.38	2.63	6.06	5.96
Productivity					
Period	**Rice**	**Corn**	**Beans**	**Soybean**	**Wheat**
1975–2010	3.51	3.04	2.18	1.90	2.92
1980–1989	3.99	1.24	-0.22	0.79	9.21
1990–1999	4.20	4.53	3.43	4.04	4.32
2000–2010	3.45	2.80	2.50	0.96	1.79

Source: IBGE (2010a).

in 1975 to 19,503,000 tons in 2009, i.e. a seven-fold increase. The production of chicken went from 373,000 tons to 9,940,000 tons (27 times); pork from 496,000 tons to 2,924,000 tons (6 times); and beef from 1,791,000 tons to 6,640,000 tons (4 times). There was production growth during the entire period for all types of meat.

The above-mentioned data shows the competitive advantage of Brazilian livestock production given the availability of low cost inputs, such as pasture for cattle and corn and soymeal as feeding for pork and chicken. Besides the resources advantages, the improvement of macroeconomic conditions, such as controlled inflation (1994) and the exchange rate correction (1999) stimulated the sustained growth of meat production. The growth of Brazilian domestic income and higher international demand created a market for increasing production. For Brazilian exports, livestock production adds value to primary products, such as soybean and corn.

In terms of animal production, it is important to point out the evolution of milk. Even though in the past milk imports were subsidized in the origin, domestic policy for milk was disrupted and the exchange rate was over valuated, production has been growing more steadily than the population. In 1975, milk production was 7.9 billion liters, reaching 11.2 billion liters in 1980,

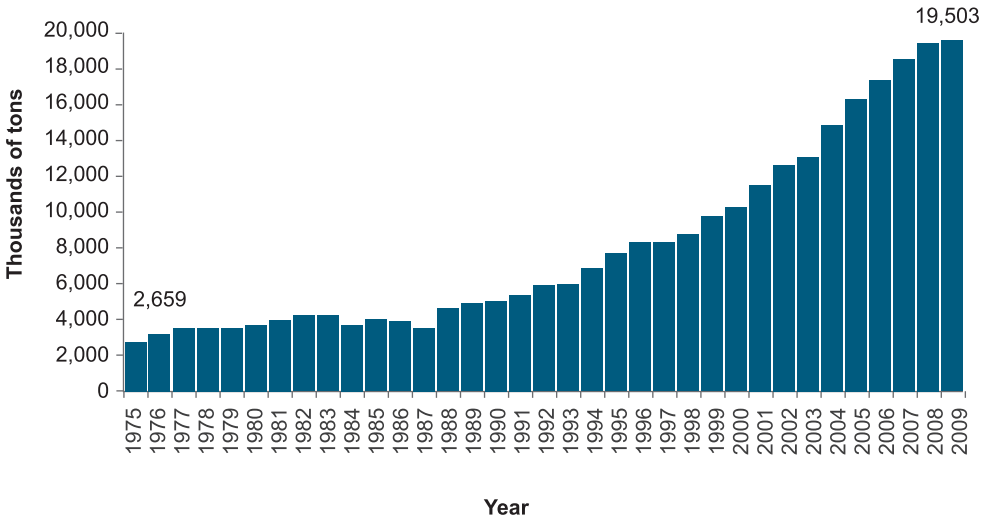

Figure 6. Evolution of total production, in tons, of cattle, swine and poultry carcasses in Brazil in 1975–2009.

Source: IBGE (2010a).

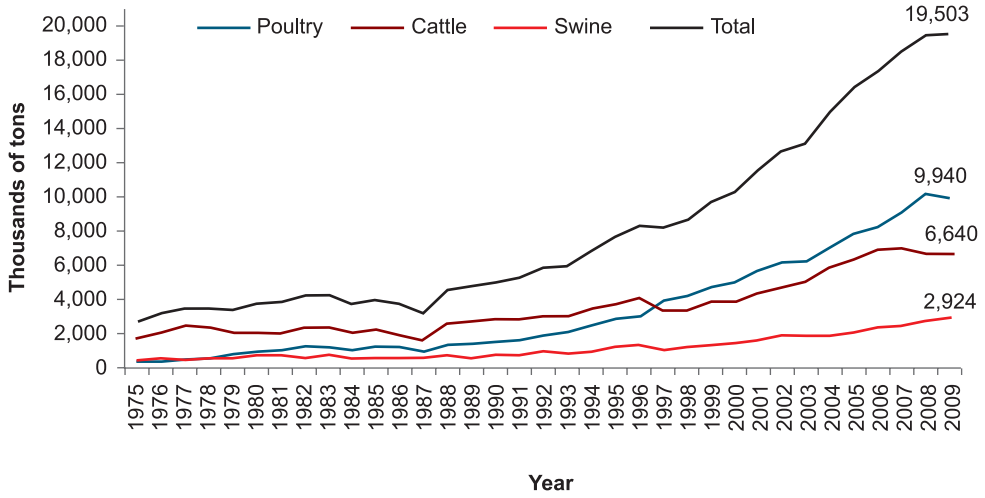

Figure 7. Evolution of production, in tons, of cattle, swine and poultry carcasses in Brazil in 1975–2009.

Source: IBGE (2010a).

and 14.5 billion liters in 1990; 19.8 billion liters in 2000; and 30.3 billion liters in 2009.

The annual milk production growth rate in the period 1980–2009, was 3.47%, a much higher growth rate than the population growth rate, which shows that milk has high income elasticity. The positive milk production reaction is strengthening as prices are no longer regulated and because the exchange rate is fluctuating. Milk production in Brazil is becoming more modern as production efficiency improves. Hence, new opportunities are being created with recent exports of powdered milk.

The growth rate of meat production

Table 4 shows the geometric growth rate of beef, pork and chicken production. For the period 1979–2009, the production of all types of meat increased: 8.45% per year for chicken;

5.42% for beef and 4.66% for pork. Chicken and beef had a vigorous increase over the three decades analyzed. Pork increase was less than 2% per year in two decades (1980–1989 and 2000–2006), but it still exceeds the growth rate of the Brazilian population.

Evolution of fruit production and productivity

The evolution of fruit production over the last decades is shown in Table 5. Given that products are presented in different units it is not possible to compare them. All products showed a significant increase in production in the period. The most significant increases occurred with lemon, apple and papaya production. Especially in the case of apple and papaya, there was a significant technological improvement over time, which allowed Brazil to become an important producer of both fruits.

Table 5 shows annual production and productivity growth rates for some of the most important Brazilian fruits for the period 1975–2008. Apple production showed an impressive 11.50% per year increase in that period, which was mainly caused by its introduction as a commercial crop. Other high growth products were lemon (5.13%), papaya (9.50%) and orange (3.80%).

Also in terms of productivity, the best performance studied was shown by apples, papayas, lemons and grapes that increased 5.86%, 3.44%, 2.19%, and 1.89% per year, respectively.

The recent boom of agroenergy

The expansion of agroenergy in Brazil over the last years is one of the most relevant points in the dynamics of domestic agribusiness. Total ethanol production (anhydrous and hydrated) went from 14.43 million cubic meters

Table 4. Annual growth rates of meat production (in %).

Meat	1979–2009	1980–1989	1990–1999	2000–2009
Beef	5.42	8.51	4.50	3.11
Pork	4.66	0.18	5.63	1.97
Chicken	8.45	4.72	9.58	7.25

Source: Conab gross data (2010).

Table 5. Production growth rate of the area and yield of selected fruit and produce, in the period 1975–2008 (in %).

Product	Quantity produced	Area	Productivity
Banana	1.68	1.47	0.21
Orange	3.77	2.17	1.57
Lemon	5.13	2.88	2.19
Apple	11.51	5.34	5.86
Papaya	9.53	5.89	3.44
Mango	2.14	2.54	-0.40
Grapes	2.61	0.70	1.89

Source: IBGE (2010c).

in the 1996/1997 harvest to 27.58 million cubic meters in 2008/2009 (Figure 8). Sugar production increased 130.5% during that period, from 13.63 million tons to 31.3 million tons. Sugarcane production also increased between 1997 and 2009, from 289.52 million tons to 563.64 million tons.

The growing demand for hydrated ethanol, mainly in the domestic market, and higher sugar prices in international markets are the main factors explaining production expansion. However, government policies also played a role. The government has two instruments to intervene in the ethanol fuel market. The first one is the mandate to blend anhydrous ethanol and gasoline. This blend can vary from 20% to 25% depending on production availability. The second instrument has a more structural nature and is a lower IPI tax (IPI is an industrialized goods tax) applied in cars fueled with ethanol, with the exception of cars with up to 1000 cc.

Another important institutional incentive for the sector is the National Program to Foster Alternative Electric Energy Sources (Proinfa). The main goal of this program is to give incentives to diversify the energy matrix by increasing the use of alternative sources of energy. Through Proinfa there are incentives for cogeneration of energy from biomass residues in small power plants and aeolic energy plants.

The sugar and ethanol industry is experiencing optimistic times due to some favorable facts. Not only is the domestic economy starting to recover, which is reflected in higher sugar and fuel consumption, but also foreign markets became more attractive due to production crises in other sugar supply countries, such as India, in 2009/2010.

In 2002, when consumers started to renew their interest in cars fuelled by ethanol, the launch of flex-fuel cars and higher oil prices abroad caused the production of hydrated ethanolto become a great business, especially in cities near producing regions. After only 2 years of existence, flex-fuel technology already accounted for 50% of new cars sales, in 2005, and 90%, in 2009.

It is estimated that over the next years at least 1 million vehicles will be put into market annually, which require 1.5 billion liters of hydrated ethanol for annual consumption. These vehicles are expected to consume an average

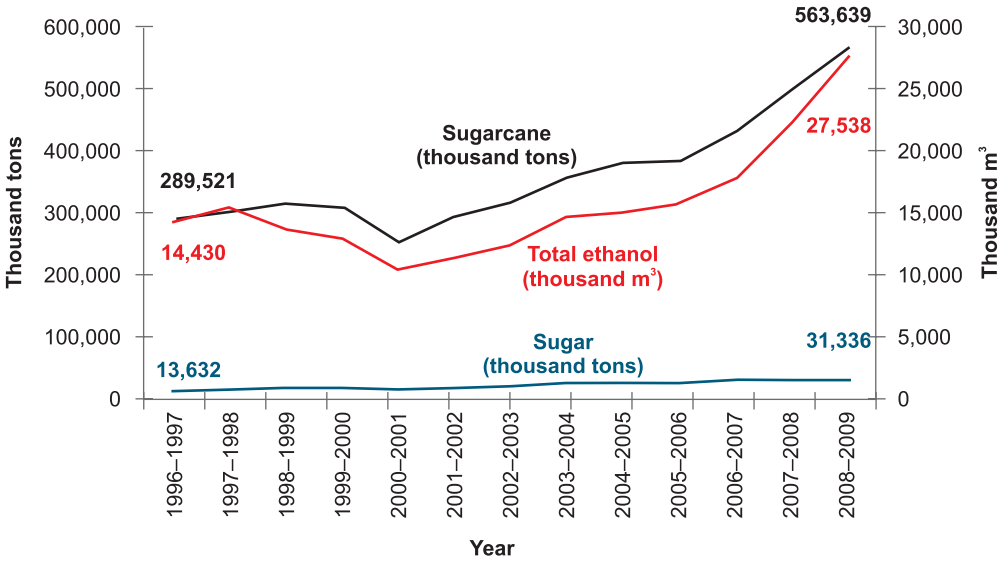

Figure 8. Evolution of sugarcane, sugar and alcohol production in Brazil, in the period 1996–2009.
Source: Brasil (2009a).

of 2,000 liters/year; however, 500,000 liters/year should be discounted, as it will not be consumed by the old fleet that is deteriorating.

Total Factor Productivity[10]

When IBGE disclosed the 2006 Agricultural Census data, it was possible to update and to improve the Total factor Productivity (TFP) previous work for the 1970 to 1995 period by Gasques and Conceição (2001). With new information it is possible to study the behavior of Brazilian agricultural productivity in greater detail and for a longer period of time. The database provided by the Agricultural Census gives a better coverage for products that are included in the productivity calculation, as well as presents a comprehensive information about agricultural inputs. Furthermore, it helps to obtain state productivity estimates instead of only aggregated indexes for Brazil. The main purpose of this section is to estimate Brazilian total factor productivity indexes, for the period 1970–2006, using as reference the 1970, 1975, 1980, 1985, 1995/1996 and 2006 Censuses.

Brazilian total factor productivity shows a growing trajectory during these 36 years of agricultural development analysis. There was no decrease in any of the periods considered, which leads to the conclusion that agriculture has been steadily growing. TFP starts in 1970 from a 100 index and in 2006 this index was equivalent to 224, representing a 124% increase in the period. Looking at the product index there was a change from 100, in 1970, to 343, in 2006. The input index evolved from 100 to 153 between the two points of comparison (Table 6). However, while agricultural production, which is a combination of vegetal and livestock production as well as rural agroindustry products, increased 243%, input use increased by only 53%, for the period 1970–2006. This result shows that Brazilian agricultural growth was mainly based on productivity.

Figure 9 shows these results more clearly. It presents product, input and productivity indexes. The different lines show that, until 1955, Brazilian agricultural production was mainly driven by higher input use. This can be observed because the red line, which corresponds to inputs, is above the green line, which corresponds to total factor productivity. In fact this was a period with strong land growth because land was occupied in new regions, such as the Central-West. It also reflects the large subsidies granted to rural credit and a pattern of growth characterized by the introduction of technology in the agricultural sector.

Based on growth rate results it can be seen that product index increased on average 3.48% annually during the period 1970–2006 (Table 7). Looking at 1995–2006, product growth was equivalent to 3.14% per year The states of Mato Grosso and Rondônia showed the highest growth rates for both periods. In Rondônia, the index increased 10.24% per year from 1970 to 2006, and 7.15% from 1995 to 2006. In Mato Grosso, it increased over 6% per year in the entire period, and 8.68% from 1995 to 2006.

TFP average annual growth rates in the 1970–2006 historical period was 2.27%, and 2.13% in the period 1995–2006.

Table 6. Product index, input index and TFP in Brazil.

Year	Product index	Input index	TFP (100)
1970	100	100	100
1975	139	122	114
1980	173	142	122
1985	211	149	142
1995	244	137	178
2006	343	153	224

Source: data obtained from Gasques et al. (2010).

[10] This section is based on the article by Gasques et al. (2010).

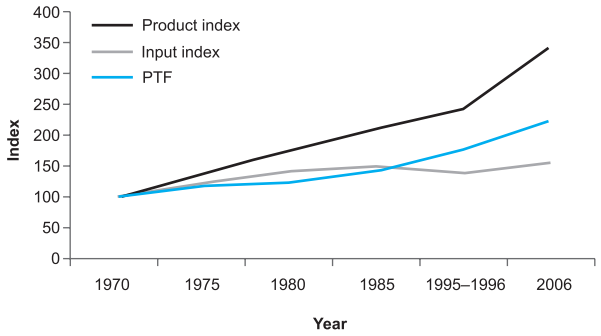

Figure 9. Product index, input index and TFP in Brazil.
Source: Gasques et al. (2010).

Table 7. Growth rate of product index, input index, TFP, land productivity and work productivity in Brazil.

Specification	2006–1970	2006–1995
Product index	3.48	3.14
Input index	1.19	0.99
TFP	2.27	2.13
Land productivity	3.32	3.16
Work productivity	3.53	3.40

Source: Gasques et al. (2010).

When investigating the main causes for product growth, one sees that between 1970 and 2006, total factor productivity explained 65% of agricultural product growth, and higher quantity of input use explained 35%. During the 1995–2006 period, the increase in total factor productivity explained 68% of agricultural product growth, while higher input quantity use explained 32%. Hence, productivity has been the main driver for the growth of Brazilian agriculture.

Table 7 shows land and labor productivity growth rates, which allow the calculation of the land area growth rate that each producer can farm. This rate is equivalent to the difference between labor and land productivity. During the period 2006/1970, the annual rate for the area each producer farmed was equivalent to 0.21% per year, and for the period 2006/1995 it was equivalent to 0.24% per year These apparently low growth rates for labor productivity, when considering the area each producer farms, is greatly due to the fact that Brazilian agriculture is not sufficiently mechanized, with the exception of grains production in the Central-West, and parts of the Southeast and South regions of Brazil.

According to some studies, the agricultural labor force is now better trained (DEL GROSSI; SILVA, 2006; BALSADI, 2006; DE NEGRI, 2006), which is in fact one of the causes of higher productivity. The improved management of rural units is also part of the better training of workers, as shown in a piece of research carried out by the Confederation of Agriculture and Livestock Production of Brazil (CNA).

Another critical factor for the higher agriculture productivity was the improvement in machinery and equipment over the last years. A study carried out by Embrapa (ALBUQUERQUE; SILVA, 2008) shows the increased operational capacity of farm machinery and equipment and their effect on sugarcane yields. The trend for the last years shows greater use of medium and large size tractors, which also explained the increase in labor productivity (ANFAVEA, 2010).

The increase in land productivity was due to greater research investments, especially by Embrapa, and also due to the use of new areas, which occurred during this 30-year period. Over the last years technological innovations for rice, corn, coffee, sugarcane and livestock were enormous (ALBUQUERQUE; SILVA, 2008). In addition to the innovations introduced by research to improve quality and productivity, other innovations production processes, such as no-till farming, bacteria inoculation, integrated pest management and the development of varieties and species with enough flexibility to adapt to different environmental conditions.

Greater investments in research have a direct effect on productivity. The 1% increase of investment in research made by Embrapa has

increased the index of total factor productivity by 0.2% (GASQUES et al., 2008).

Looking at TFP growth in the 1995–2006 period, Figure 10 shows that there was diversified growth in the Brazilian states. Two states located in the Northern region (Pará and Tocantins) presented productivity growth below the Brazilian TFP growth. In the Northeast, only Paraíba and Rio Grande do Norte presented a TFP growth below the Brazilian average. In the Southeast, only in Espírito Santo and Minas Gerais productivity growth was above the Brazilian TFP growth. In the South, Rio Grande do Sul and Paraná productivity growth was below the Brazilian average, and in the Central-West only Mato Grosso presented a TFP growth above the Brazilian average (Figure 10).

Agricultural and agribusiness exports

Brazilian exports experienced major changes over the last 11 years (Table 8). The most visible ones occurred in the ranking of products and scope of countries of destination. In terms of ranking of products, the main change is related to the new position meat occupies. In 1997, beef, pork and chicken accounted for 6.8% of the value of Brazilian agribusiness exports. In 2009, the figure for beef export (US$ 11.78 billion) corresponded to 18.4% of the amount exported by Brazilian agribusiness (BRASIL, 2009a). Another change was the opening of new markets and the reduction of exports to countries that were traditionally partners of Brazil. For over 10 years, trading with China, Russia, the Middle-East, and also African countries has increased; there was a relative reduction of exports to Japan, Germany and the United States.

In the period 2000–2009, production and exports of beef, pork and chicken had an impressive growth. Those sectors showed a better performance than crops, except for soybean and corn, which are directly affected by livestock production. Despite exports growth, domestic per capita consumption also grew at higher annual rates, of which chicken presented the highest rate.

Both export growth and per capita consumption show how relevant livestock production was for the welfare of the Brazilian population. Table 8 shows exports growth rates for different periods; notice that there was a small reduction of beef and chicken in the 1980s. However, in other periods, exports for both types of meat were impressive. Pork exports increased rapidly in all periods.

Another performance measure of the domestic agribusiness is the degree of openness expressed in the relationship between the value of agribusiness exports and agribusiness GDP.

Figure 10. TFP growth rates in the states, in the period 1995/1996–2006.
Source: Gasques et al. (2010).

Table 8. Growth rate of Brazilian meat exports, in the period 1979–2009 (in %).

Meat	1979–2009	1980–1989	1990–1999	2000–2009
Beef	7.92	-0.91	13.59	14.16
Pork	24.28	28.62	23.91	12.37
Chicken	11.38	0.51	10.71	15.82

Source: gross data by Conab, created by AGE/Mapa (BRASIL, 2010a).

As shown in Table 9, in 1994, the degree of agribusiness openness was 2.67%, whereby the sector exported a smaller percentage of its GDP. In that same year, the degree of openness of the economy in general was 8.02%. In 2008, the degree of agribusiness openness was 17.2%, while the degree of economic openness was 12.1%. That change in agribusiness was fundamental to expand the sector and to modernize it.

Table 9. Degree of openness of the economy and of agribusiness.

Year	Total exports (R$ million)	Total GDP (R$ million)	Agribusiness exports(R$ million)	Degree of openness Total (%)	Degree of agribusiness openness (%)	Agribusiness GDP(R$ million)
1989	0.04	0.43	0.0	9.65	-	-
1990	0.86	12	0.4	7.46	-	-
1991	5.02	60	2	8.33	-	-
1992	70	641	26	10.87	-	-
1993	1,424	14,097	589	10.10	-	-
1994	29,412	349,205	12,904	8.42	2.67	99,240
1995	42,911	705,641	19,258	6.08	4.06	171,040
1996	48,129	843,966	21,314	5.70	4.58	186,933
1997	57,278	939,147	25,255	6.10	5.49	199,941
1998	59,545	979,276	25,087	6.08	5.41	208,917
1999	88,886	1,065,000	37,942	8.35	7.90	236,849
2000	101,071	1,179,482	37,785	8.57	8.00	269,732
2001	137,011	1,302,136	56,140	10.52	11.69	302,880
2002	180,981	1,477,822	74,477	12.25	13.90	374,061
2003	223,635	1,699,948	93,774	13.16	16.96	489,355
2004	281,432	1,941,498	113,853	14.50	19.96	549,039
2005	285,417	2,147,239	105,226	13.29	19.75	554,694
2006	298,597	2,369,484	107,235	12.60	18.92	566,816
2007	310,049	2,661,344	112,750	11.65	17.55	642,628
2008	362,923	3,004,881	131,657	12.08	17.22	764,494
2009	304,502	3,143,015	128,893	9.69	-	-

Note: total degree of openness is the relationship between exports and GDP; and degree of agribusiness openness is the relationship between agribusiness exports and agribusiness GDP.

Source: data from Mapa (BRASIL, 2010b), Cepea (2010) and Ipeadata (IPEA, 2010). Created by AGE/Mapa.

Figure 11 presents the importance of agribusiness exports to balance Brazil's trade accounts. Every year, the sector presented a significant surplus, while other sectors presented a deficit. From 1997 to 2009, the accumulated trade balance for the agribusiness was equivalent to US$ 405 billion. As of 2003, performance improved, and in the last 2 years (2008 and 2009), the annual value was higher than US$ 55 billion.

Agribusiness projections for Brazil in the period 2009/2010–2019/2020

Brazilian agribusiness has a large potential for growth. The domestic market for all products analyzed is expressive, and the international market has shown a strong growth. Overpopulated countries will find difficult to meet food demand due to the depletion of their farming areas. Difficulties to replenish worldwide stocks, increased consumption, especially of grains (like corn, soybean and wheat), and the ongoing urbanization process in the world create favorable conditions for countries like Brazil that have a huge production potential and technology available. Brazil's availability of natural resources and the style of domestic agriculture growth based on continuous and increasing productivity gains are also competitiveness factors.

The most dynamic products of Brazilian agribusiness in the future should be chicken, sugar, ethanol, cotton, soybean oil and cellulose. These products point to a high growth potential for production and exports in the next few years.

It is estimated that the production of the five most important grains (soybean, corn, wheat, rice and beans) should exceed 129.8 million tons in 2008/2009 and 177.5 million tons in 2019/2020. This indicates an increase of 47.7 million tons to the current production in Brazil, and a 36.7% increase in relative values. Meat production (beef, pork and chicken) should increase by 8.4 million tons. This represents a 37.8% increase in beef production in 2009. Three other products with estimated high increase are: sugar with over 15.2 million tons; ethanol with 35.2 billion liters; and milk with 7.4 billion liters (Table 10).

Agricultural production growth in Brazil should be productivity-based. Recent studies estimated that total factor productivity will continue to increase. Results attest for higher increase in agricultural production than for area increase. Projections indicate that from 2010 to 2020, average crop production growth rate should increase by 2.67% annually, while area should increase by 0.45%.

Although Brazilian exports will increase over the next years, the domestic market will absorb most of the production. Projections for soy-

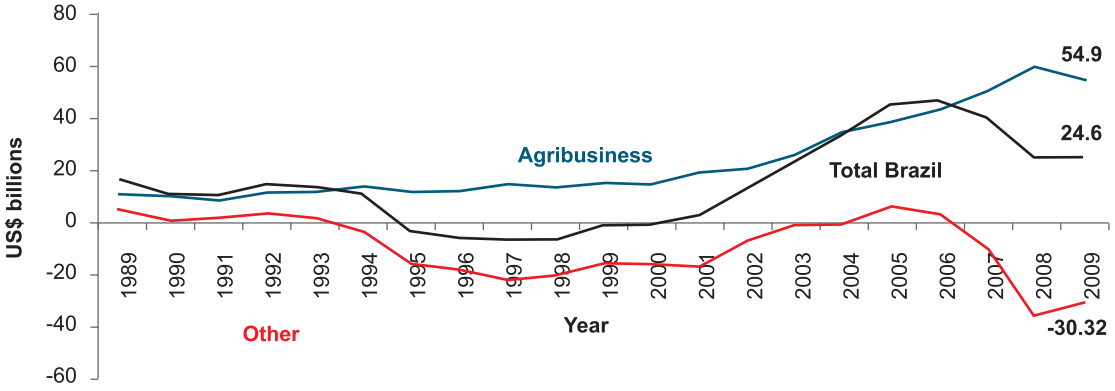

Figure 11. Balance of agribusiness trade in the period 1989–2009.
Source: Brasil (2010b).

Table 10. Main trends of production of grains, cereals, meats, and others[1] for the period 2019–2020.

Grain	Millions of tons		Meat	Millions of tons	
	2008–2009	2019–2020		2008–2009	2019–2020
Corn	50.97	70.12	Chicken	11.13	16.63
Soybean	57.09	81.95			
Wheat	5.67	7.07	Beef	7.83	9.92
Rice	12.63	14.12	Pork	3.19	3.95
Beans	3.48	4.27			
Total	129.84	177.52[2]	Total	22.14	30.5[3]

[1] Sugar – more 15.2 million tons; ethanol – more 35.2 billion liters; milk – more 7.4 billion liters.

[2] More 47.7 million tons (36.7%).

[3] More 8.4 million tons (37.75%).

Source: Brasil (2010a).

bean and corn production increases indicate that 52.0% and 80.0%, respectively, of this increase will be absorbed by the domestic market. As a result, there will be domestic production pressure from exports and from the domestic market.

There will also be an increase in the domestic demand for meat. Projections for chicken, beef and pork indicate that 65.3%, 77.0% and 80.0% of this increase, respectively, will be absorbed by the domestic market. Hence, although Brazil is the most, or one of the most important exporters of many of those agribusiness products, domestic consumption will be the main final destination of production.

Projections show that there will be a significant change in Brazil's worldwide market ranking. The relationship between Brazilian exports and world trade shows that in 2018/2019 the Brazilian beef exports will account for 30% of worldwide trade; pork, 14.0% of trade; and chicken, 48%. These results show that Brazil will maintain its rank as first worldwide exporter of beef and chicken (Table 11).

Table 11. Brazil's share in worldwide food trade (in %)[1].

Product	2009–2010	2013–2014	2014–2015	2019–2020
Sugar	46.5	46.5	46.5	46.5
Green coffee beans	27.2	27.2	27.2	27.2
Soybean	30.2	31.9	32.5	35.8
Soybean meal	22.1	20.7	20.5	19.5
Soybean oil	21.1	16.2	16.4	17.8
Corn	10.1	10.9	11.2	12.7
Beef	25.0	30.9	30.7	30.3
Pork	12.4	14.0	13.9	14.2
Chicken	41.4	47.7	48.0	48.1

[1] Obtained from the relationship between Brazilian exports and worldwide exports. For coffee, we maintained the same position as in 2009–2010, as there are no projections for that product.

Source: Usda (2010) and AGE/Mapa (BRASIL, 2010a).

Final considerations

This article gives rise to the following considerations:

- The Brazilian industrialization policy played a fundamental role in the modernization of agriculture, creating in the cities a demand for food and inputs. The cost of labor in rural areas increased with the rural-urban migration, forcing farmers to intensify production and to mechanize their plantations. Over the last years, improved macroeconomic fundamentals, i.e. inflation control and fluctuating exchange rates, boosted the sector's production growth and enabled greater opening for foreign trade.
- In the agricultural policy area, three instruments were used to modernize agriculture: i) subsidized credit to buy modern inputs and to finance capital; ii) investments in science and technology made by Embrapa, by state research systems and by post-graduate courses; and iii) public rural extension, and more recently private rural extension. Besides government policies, additional factors that helped boost agriculture efficiency: abundant availability of production factors, such as low-cost and arable land, greater availability of modern raw materials and entrepreneurs, which were especially small-size producers.
- The analysis of data for the five major grains (rice, corn, beans, soybean and wheat) shows that in the period 1975–2010, farmed area increased 0.88% annually, while production 3.66%, and productivity 2.95%. Soybean crops are the key-product with annual area expansion of 3.58%, 5.55% production increase and 1.90% productivity increase. Unlike rice – which is the first crop grown in the Cerrado before other crops or pasture are planted – soybean was introduced in Brazil as a modern crop with efficient production systems.
- Meat production had an extraordinary growth over the last three decades. From 1979 to 2009, beef production increased 5.42% annually; pork 4.66%, and chicken 8.45%. From 2002 to 2009, beef, chicken and pork increased 3.1%, 7.25% and 1.97% annually, respectively. This dynamics is related to the evolution of exports, and could have had a better performance if it were not for the international economic crisis that started in 2008, which had a considerable impact on Brazilian exports.
- Traditional sugarcane crops showed incomparable competitiveness for the production of sugar and hydrated ethanol. Sugar exports benefitted from the gradual opening of foreign trade, where beet sugar production in the European Union was granted less subsidies. Hydrated ethanol gained force with the launch of flex-fuel cars in the domestic market. Over the last years, sugarcane production increased approximately 9.0% annually.
- Furthermore, in addition to the positive performance of crops and meat, this study also presented estimates on the evolution of Brazilian total factor productivity, which is a global model of higher agricultural efficiency. For the period 1970–2006, product's growth rate was 3.48%, and inputs 1.19% annually. More recently (1995–2006), growth rates were 3.14% for product and 0.99% for inputs. For the period in general, total factor productivity reached 2.27% annually, and more recently 2.13% annually.
- Brazilian exports experienced strong changes over the last 11 years. The most visible one occurred in product ranking and products destination. Another important aspect in terms of the foreign market was the greater opening of agribusiness.

The relationship between agribusiness exports and the their share of the GDP jumped from 2.67% in 1994 to 17.22% in 2009.

- Projections made by international institutes and the Strategic Management Advisory Office of the Ministry of Agriculture show that Brazilian agribusiness has a strong potential for growth, both in the domestic and in foreign markets. The availability of natural resources, tropical technology and entrepreneurial people are competitiveness factors. The most dynamic products of the Brazilian agribusiness in the future should be soybean, chicken, sugar, ethanol, cotton, soybean oil and cellulose. These products show high potential for growth both in terms of production and exports over the next years.
- Finally, the benefit that the growth of agriculture and agribusiness has brought to Brazil is notable, increasing the availability of food, especially animal protein shich had a decisive role for exports, and more recently, for renewable energy.

References

ALBUQUERQUE, A. C. S.; SILVA, A. G. da. (Ed.). **Embrapa Agricultura Tropical**: quatro décadas de inovações tecnológicas, institucionais e políticas. Brasília, DF: Embrapa Informação Tecnológica, 2008. v. 1.

ALVES, E.; LOPES, M.; CONTINI, E. O empobrecimento da agricultura brasileira. **Revista de Política Agrícola**, Brasília, DF, v. 8, n. 3, p. 5-19, 1999.

ALVES, E.; ROCHA, D. P. **Ganhar tempo é possível?** CI Florestas. Documentos e Artigos. <http://www.ciflorestas.com.br/arquivos/doc_ganhar_possivel_13249.pdf>. Disponível em: Acesso em: 10 mar. 2010.

ANDA. Associação Nacional parta Difusão de Adubos. **Principais indicadores do setor de fertilizantes.** Disponível em: <http://www.anda.org.br/estatisticas.aspx>. Acesso em: 10 mar. 2010.

ANFAVEA. **Estatística** [1972-2008]. Disponível em: <http://www.anfavea.com.br/tabelas.html>. Acesso em: 20 abril 2010.

ANUÁRIO ESTATÍSTICO DO BRASIL. Rio de Janeiro: IBGE, 1975-2008.

BALSADI, O. V. **O mercado de trabalho assalariado na agricultura brasileira no período 1992-2004 e suas diferenciações regionais**. 2006. Tese (Doutorado)– Instituto de Economia, Universidade de Campinas, Campinas, 2006.

BANCO CENTRAL DO BRASIL (Bacen). **Anuário do crédito rural**: evolução do crédito rural. Disponível em: <http://www.bcb.gov.br/htms/CreditoRural/2009/evolucao.pdf>. Acesso em: 3 maio 2010.

BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. **Anuário estatístico da agroenergia**. Brasília, DF, 2009a. 160 p.

BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. Assessoria de Gestão Estratégica. **Projeções do agronegócio**: Brasil 2009/10 a 2019/20. Brasília, DF, 2010. 48 p. Disponível em: <www.agricultura.gov.br/images/MAPA/arquivos_portal/proj_agro2010.pdf>. Acesso em: maio, 2010a.

BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. Secretaria de Relações Internacionais. **Agrostat**. Disponível em: <www.agricultura.gov.br/portal/page?_pageid=33,1537717&_dad=portal&_schema=PORTAL> Acesso em: maio, 2010b.

BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. Secretaria de Relações Internacionais do Agronegócio. **Intercâmbio comercial do agronegócio**: principais mercados de destino. Brasília, DF, 2009b. 469 p.

CEPEA. Centro de Estudos Avançados em Economia Aplicada. **Índices exportação agro**. Disponível em: <http://www.cepea.esalq.usp.br/macro/>. Acesso em: 15 abril 2010.

COELHO, C. N. 70 anos de política agrícola no Brasil: (1931-2001). **Revista de Política Agrícola**, Brasília, DF, v. 10, n. 3, p. 3-58, 2001. Edição especial de aniversário de 15 anos.

CONAB. **Levantamento de Safras**. Disponível em: <http://www.conab.gov.br/conabweb/download/safra/BrasilProdutoSerieHist.xls>. Acesso em: mar. 2010.

DE NEGRI, F.; DE NEGRI, J. A.; COELHO, D.; TURCHI, L. Tecnologia Exportação e Emprego. In: DE NEGRI, J. A.; DE NEGRI F.; COELHO, D. (Org.). **Tecnologia, Exportação e Emprego**. Brasília, DF: IPEA, 2006. Cap. 1, p. 17-50.

DEL GROSSI, M.; SILVA, J. Mudanças recentes no mercado de trabalho rural. **Parcerias estratégicas**, Brasília, DF, n. 22, jun. 2006. Edição Especial.

DIAS, G. L.; AMARAL, C. M. Mudanças estruturais na agricultura brasileira, 1980-1998. In: BAUMANN, R. (Org.). **Brasil**: uma década em transição. Rio de Janeiro: Cepal: Campus, 2000.

GASQUES, J. G.; BASTOS, E. T.; BACCHI, M. R. P. Produtividade e fontes de crescimento da agricultura brasileira. In: DE NEGRI, J. A.; KUBOTA, L. C. (Ed.). **Políticas de incentivo à inovação tecnológica no Brasil**. Brasília, DF: Ipea, 2008. Cap. 11, p. 435-459.

GASQUES, J. G.; BASTOS, E. T.; BACCHI, M. R. P.; VALDES, C. **Produtividade total dos fatores e transformações da agricultura brasileira**: análise dos dados dos censos agropecuários. Março de 2010. Versão preliminar. Não publicado.

GASQUES, J. G.; CONCEIÇÃO, J. C. Transformações da agricultura e produção total dos fatores. In: GASQUES, J. G.; CONCEIÇÃO, J. C. **Transformações da agricultura e políticas públicas**. Brasília, DF: Ipea, 2001. 539 p.

IBGE. **Censo Agropecuário**. Banco de Dados Agregados. Disponível em: <http://www.sidra.ibge.gov.br/bda/agric/default.asp?z=t&o=11&i=P>. Acesso em: 15 abril 2010b.

IBGE. **Levantamento Sistemático da Produção Agrícola**. Disponível em: <http://www.ibge.gov.br/home/estatistica/indicadores/agropecuaria/lspa/default.shtm>. Acesso em: 15 abril 2010a.

IBGE. **Produção Agrícola Municipal**. Disponível em: <http://www.sidra.ibge.gov.br/bda/pesquisas/pam/default.asp?o=23&i=P>. Acesso em: 15 abril 2010c.

IPEA. Instituto de Pesquisa Econômica Aplicada. **Ipeadata**. Disponível em: <http://www.ipeadata.gov.br/ipeaweb.dll/ipeadata?1413239359>. Acesso em: 20 abril 2010.

LEWIS, W. Arthur. O desenvolvimento econômico com oferta ilimitada de mão-de-obra. In: AGARWALA, A. N.; SINGH, S. P. **A economia do subdesenvolvimento**. Rio de Janeiro: Forense, 1969. p. 406-456.

PREBISH, R. **Dinâmica do desenvolvimento latino americano**. Rio de Janeiro: Fundo de Cultura, 1964. 206 p.

SILVA, J. G. da. **A Nova Dinâmica da Agricultura Brasileira**. 2. ed. Campinas: Unicamp-IE, 1998. 211 p.

USDA. **Usda Agricultural Projections to 2019**. Disponível em: <http://www.ers.usda.gov/publications/waob011/waob2001fm.pdf>. Acesso em: 5 fev. 2010.

W. ARTHUR Lewis. Disponível em: <http://grupohead.tripod.com/economistas/lewis.htm>. Acesso em: 2 set. 2007.