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What explains the intensification and diversification of Brazil´s agricultural production and exports from 1990 to 2012?

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Abstract

The objective of this paper is to provide a comprehensive explanation of the production and export intensification and diversification of the Brazilian agricultural sector in the period 1990-2012. Our hypothesis is that Brazil does not have a predetermined 'model' calibrated for success in international agricultural markets; rather, the country has altered its agricultural policies in a responsive manner reflecting constraints and opportunities arising in both domestic and international markets, and taking advantage of Brazil's agricultural land availability and good climate for agriculture.

We identify four main noteworthy results of the study:

(1) Brazil is no longer an agricultural country, despite the fact that in 2012 agriculture answered for 5.2% of Brazil´s GDP and supports a diversified and fast-growing agribusiness sector which in turn amounted to 22.2% of Brazilian GDP.

(2) Agricultural and agro-industrial production and exports have increased and diversified simultaneously since the 1970s with the farming of new areas.

(3) The location of the fastest-growing farming areas shifted during 1970-1990 from the South and Southeast regions to the Central-West region. Since 2000 a new agricultural frontier has emerged in the Cerrado (savannah) areas bordering the states of Maranhão, Tocantins, Piauí and Bahia (often referred to collectively by the acronyms MATOPIBA or BAMAPITO).

(4) An econometric model of export supply, run using a 1991-2011 dataset, offers a number of insights. In particular, the world's overall GDP growth and Brazilian agricultural and agro-processed production have been the main drivers of Brazilian agricultural and agro-industrial exports, rather than international prices. Simultaneously, in the international market Brazil has taken over a share vacated by the USA and European Union countries.

Keywords: Brazil, agriculture, agricultural policy, agribusiness, exports, production

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1. Introduction

Since its colonial period, Brazil has been a major global supplier of primary goods such as mineral or agricultural products. In the 21st century this has become more the case than ever, despite the fact that Brazil is no longer an essentially agricultural country. While agriculture accounted for 5.2% of Brazil's 2012 GDP, agribusiness – encompassing agriculture-supporting activities, agriculture itself, agro-industries and trading of agricultural and agro-processed products – formed 22.2% of GDP in the same year. Agricultural and agro-industrial products typically make up one-third of Brazilian exports, and a wide range of products have been exported. Brazil continues to be the world's major coffee exporter, but more recently has also been among the top ten exporting countries of products such as soybeans, sugar, pulp, orange juice, and meat.

In the period from 1960 to 2012, three main factors shaped the trajectory of Brazilian agriculture and the country's related agribusiness sector. Firstly, the location of the fastest-growing farming areas has moved, initially from the South and Southeast regions towards the Central-West region in 1970-1990, and since 2000, in the direction of what could be called the new agricultural frontier, namely the Cerrado (savannah) areas bordering the states of Maranhão, Tocantins, Piauí and Bahia (often referred to collectively by the acronyms MATOPIBA or BAMAPITO). (Although it should be clarified that of course agricultural development continues in the former areas.) Secondly, the basic crop basket centring on coffee and sugar during the 1960s has grown to include grains, meat and agro-industrial products (such as orange juice and pulp, for example). Thirdly, Brazil has increased and diversified its agricultural and agro-industrial exports, shifting from traditional crops such as coffee and cocoa to more value-added products, such as orange juice, pulp, and mechanically processed wood.

This evolution is related both to international market changes and to domestic agriculture policy. For instance, from 1990 to 2011 the share of world agricultural and agro-processed exports enjoyed by the USA and European Union countries declined from 60.5% to 51.3%. In the same period, Brazil´s share jumped from 2.4% to 5.6%, while world GDP increased by 217%. Meanwhile, during the 1970s and 1980s, Brazil´s domestic agricultural policy was premised on a division between export-oriented crops and domestic-oriented crops, with the former being produced by medium- and large-sized farmers in the South and Southeast regions, who received the bulk of public policy grants. During the 1990s and 2000s this changed and the important division became that between family and non-family farmers. The former group has

tended to receive more subsidies from public policy, whereas the latter has increasingly been backed by private sector-supporting policies. Nevertheless, both have played a significant role in the growth of Brazil´s agricultural production and exports.

The fast-growing foreign markets purchasing Brazilian goods have also changed, with Brazilian agricultural and agro-industrial exports shifting from the USA and the EU towards Asia (specifically China), Africa and the Middle East. As the USA and the European Union countries' shares of the global food suppliers' market have reduced, Brazil has acquired a higher share into the world market of agricultural and agro-processed products.

Despite increasing productivity, Brazilian agribusiness and specifically agriculture have been hampered by infrastructural bottlenecks, particularly relating to storage, domestic transportation and ports. "[T]he Minister of Agriculture, Livestock and Supply estimates the losses would range from 10% to 15% of total production" (Sou Agro 2011). There does not currently exist Brazilian public policy addressing these important issues specifically as issues for agriculture. Rather, the agriculture sector typically must try to feed off advances in infrastructure created for industrial and urban development.

The above briefly sketches the broad context to this paper, which aims to provide an account of the evolution of Brazilian agriculture and agribusiness in the period from 1990 to 2012, paying particular attention to the growth and diversification of exports and attempting to quantify the main determinants of this. More specifically, this will involve: (a) analysing the changes in Brazilian agriculture during this period, mainly relating to production and farming areas; (b) examining Brazilian agricultural policies to demonstrate the ways in which policy has been market-oriented; (c) running an econometric supply model of agricultural and agro-processed export products, in order to quantify their main determinants.

A large body of literature has addressed these issues separately and over different periods than we consider in this paper. lbuquerque and Nicol (1987), Szmarecsányi (1990), Taglialegna et. Al. (2000) and Barros (2014), for example, have provided an overview of Brazil´s agriculture evolution and its relationship with other sectors but little explain the role of agricultural policies to stimulate that sector. Barros (1979), Goldin and Rezende (1993) and Rezende (2003) have analysed the evolution of Brazil´s agriculture policies, paying special attention to their shifts according to macroeconomic and political restrains but without emphasizing its market-orientation. Almeida and Bacha (1998), Reis and Crespo (1998), Maia (2003) Pimentel et al.

(2005) and Fraga and Bacha (2012) have run equations identifying the main variables that influence Brazil´s agricultural and agro-industrial exports. They have used different econometric methods and have emphasized the importance of world GDP, exchange rate, domestic production, export prices and recently the human capital explaining the Brazilian agricultural exports. However, they have not considered separately agricultural and agro-industrial exports as this paper does. Moreover, this paper integrates the analysis of the three specific objectives mentioned above, what has not been done until now.

Our hypothesis is that Brazil does not have a predetermined 'model' calibrated for success in international agricultural markets. Rather, the country has adopted a responsive and flexible approach. Agricultural policies have been altered in response to constraints in both domestic and international markets, but also in order to seize opportunities arising in these markets. Additionally, Brazilian policy has been tailored to take advantage of available arable land and the country's propitious climate for agriculture. Market-oriented agricultural policies such as rural credit, minimum prices, agricultural insurance, agricultural research and rural extension have been in action since the 1970s (although their functioning has fluctuated according to domestic and international constraints). Their main goal has been to stimulate tradable production, and these policies have allowed farmers to occupy new arable areas in order to produce what both domestic and international markets have demanded.

2. Methodology and dataset

The data is organized into tables and graphs to allow an overview of the evolution in Brazilian agriculture and agribusiness during 1990-2012. An econometric supply model is run to determine the main variables that have influenced exports of agricultural and agro-processed products.

The dataset was collected from the Brazilian Institute of Geography and Statistics (IBGE), the Ministry of Development, Industry and Foreign Trade (MDIC) and from the Food and Agriculture Organization (FAO). These three sources all cover roughly the same variables, but are each stronger in different areas, leading us to use them in different ways:

(a) An IBGE dataset from its Municipal Agricultural Production archive is used to evaluate the evolution of Brazil's main crops and meat production and productivity from 1990 to 2012. Statistical methods are used to analyse the data.

(b) The IBGE's 2006 Agricultural Census dataset is employed to analyse the agricultural production structure, particularly to reveal the regional distribution of agricultural production.

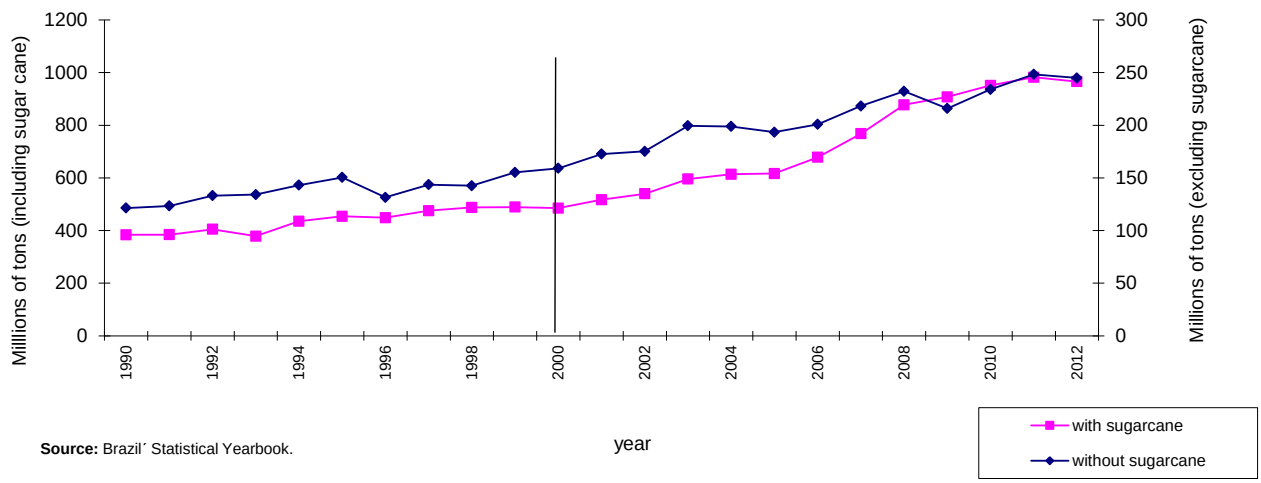
(c) FAO and MIDC datasets on Brazil´s agricultural and agro-processed exports are used to run supply equations in order to find out the main determinants of these exports.

The remainder of this report is organized into four sections. In section 3, we analyse the evolution of Brazilian agriculture, focussing particularly on agricultural and agro-processed production and export, and consider the principle factors that have allowed Brazil to expand its role as a major world supplier of these products. Section 4 considers the role of agricultural policy in this context. Section 5 presents the econometric results from the supply equation run for exports of agricultural and agro-processed products. Finally, section 6 draws together the main conclusions of the report.

3. The evolution of Brazilian agriculture from 1990 to 2012

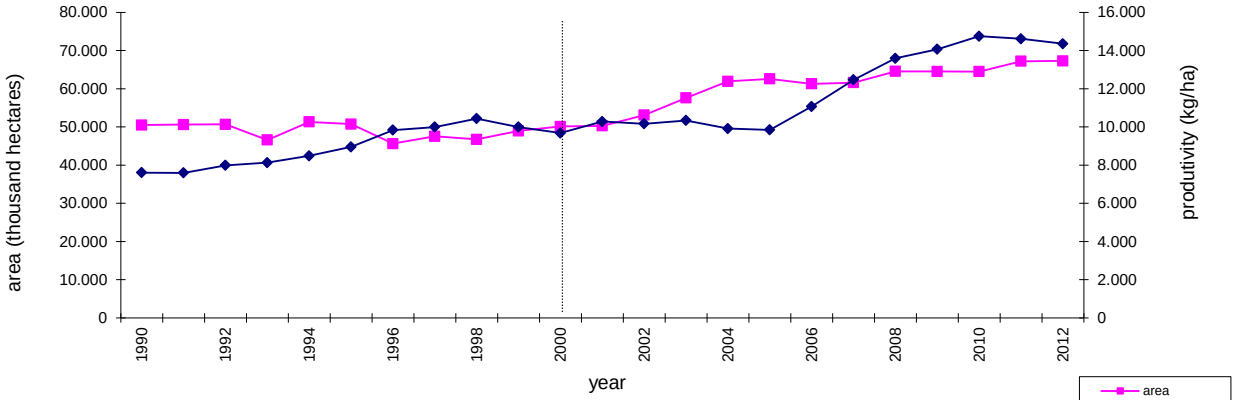
Both agricultural and livestock production have enormously increased in Brazil since the 1990s, with particular intensity since 2000. Looking at the main 63 crops (including sugarcane), agricultural production totalled 384 million tons in 1990, 485 million tons in 2000 and reached 966 million tons in 2012 (Figure 1). The annual geometric rate of growth for crop quantity during the 1990s was 3.2%, and this rose to 6.7% from 2000 through 2012. This growth was achieved with increasing productivity, as shown in Figure 2. Meat production also saw a large increase (Figure 3). Total meat production in 1990 was 5.17 thousand tons, rising to 10.33 thousand tons by 2000 and 22.35 thousand tons by 2012. The annual geometric rate of growth for meat was 7.04% during the 1990s and 6.39% from 2000 through 2012.

Figure 1 - Evolution of crop production in Brazil (including and excluding sugar cane) - from 1990 thru 2012



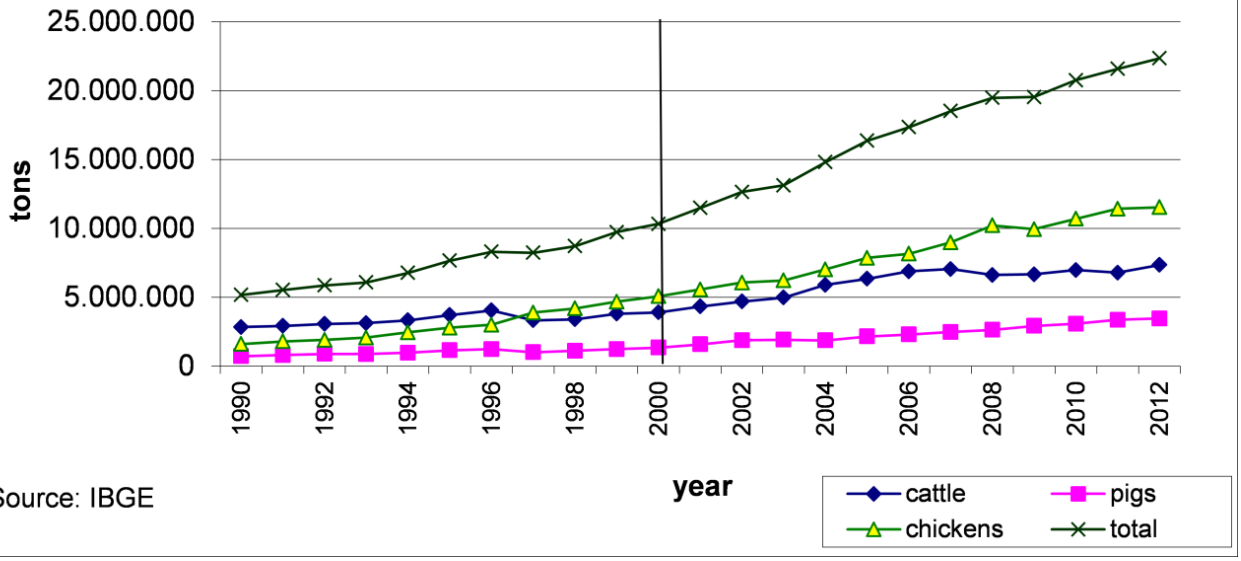
Source: Brazil´ Statistical Yearbook.

Figure 2 - Evolution of area and productivity for the main 63 crops in Brazil - 1990 thru 2012



Source: Brazil´s Statistical Yearbook.

Figure 3: Brazilian meat production from 1990 through 2012



Source: IBGE

According to Schlesinger and Noronha (2006), Bacha (2011, 2012), and Campos (2010), Brazil´s increasing agricultural production is due to: (a) good availability of arable land, especially with the development of new agricultural frontiers in the Centre-West and MATOPIBA regions in the 1970s-1990s and post-2000 respectively; (b) modern technology generated by a network that encompasses Brazilian Enterprise for Agricultural Research (EMBRAPA), public universities, state-funded agricultural research institutes and private-funded organizations; (c) state-funded agricultural policies; (d) the availability of international markets for Brazilian production and the role of large multinational agribusiness companies; and (e) the presence of market-oriented farmers in the categories of both family and non-family farming.

Brazil has eco-climatic features favourable to the raising of cattle and cultivation of crops. In some areas (such as in the state of Paraná and other Cerrado areas) it is possible to plant three crops in the same area during the same farming year without needing to fallow the land. For example, in the state of Paraná it is possible to plant and harvest soybean from September to March, beans from March to April and corn from later April to August, restarting the same sequence in the next farming year. Different crop combinations are also possible in other areas, such as planting and harvesting soybeans from September to March and corn from later March to August. These procedures are viable due to factors including the availability technology and extensive use of agricultural inputs such as fertilizers, improved seeds and irrigation. Moreover, Brazil still has considerable arable land available (excluding conservation areas). In 2010, there were 85.3 million hectares of arable land available for new plantation, an expanse that if planted would double the currently-farmed area (Table 1), without encroaching on legally established conservation areas.

Most of the currently available arable land is located inside the Cerrado areas and in the last four decades the advancing agricultural frontier has inaugurated major shifts in Brazilian agriculture. Table 2 shows the regional distribution of Brazilian agricultural production in selected years. Although the South and Southeast regions have been and remain the main agricultural producers, these areas' share of overall agricultural production is falling, while the Central-West has increased its share, largely due to the good availability of arable lands covered with Cerrado vegetation. In 1970, the South and Southeast regions accounted for 71.1% of the gross value produced by the country's agriculture, which decreased to 62.2% by 2006. In this period, the Central-West region's share rose from 7.5% to 13.8% respectively. The Central-West held 8.7% of Brazil's temporary cropland in 1970, rising to 18.5% by 1985 and 23.8% by 2006.

The Central-West held 6% of the poultry population on December 31st 1996, and 12% on December 31st 2006. Percentages for swine on these dates were, respectively, 8.1% and 11.8%. MATOPIBA states held 7.3% of gross value of agricultural production, 11.2% of total temporary cropland and 21.2% of total permanent cropland in 1996; these rates rose to 9.1%, 12% and 23% respectively by 2006.

Table 1: Use of land in Brazil, year of 2010

Land use	Area (million hectares)	Share of Brazil´s territory
Arable land	157.2	18.5%
With permanent crops[(a)]	6.3	0.74%
With temporary crops[(a)]	59.1	6.94%
With planted forests[(b)]	6.5	0.76%
Available to plant	85.3	10.02%
Pastures[(c)]	158.8	18.7%
Area occupied with native forests and conservation units [(d)]	509.0	59.8%
Conservation units	133.0	15.6%
Indigenous land	108.0	12.7%
legal reserve and permanent preservation areas inside the farms	268.0	31.5%
Urban areas, roads, power plants and other construction[(d)]	26.0	3.1%
BRAZILIAN TERRITORY (total)	851	100%

Source: (a) IBGE´s 2010 Municipal Agricultural Production Research; (b) ABRAF´s 2010 report, (c) Brazil´s 2006 Agricultural Census, (d) EMBRAPA. The latter was presented by José Garcia Gasques in his speech at the 50th Congress of Sober, in Vitória, state of Espírito Santo, from July 22 to 26 2012.

Authors such as Portugal and Contini (1997), Bonneli and Pessôa (1998), and Beintema, Avila and Fachini (2010) have emphasized the role of EMBRAPA, public universities, state-funded research agencies and privately-funded research centres in generating technology for Brazilian agriculture. EMBRAPA, for instance, has had an important role in developing new soybean seeds tailored for planting in the Brazilian Cerrado areas. The sugar and ethanol company Copersucar, the São Paulo state-funded public universities, and the former Federal Government-funded Sugar and Alcohol Institute (IAA) have all contributed to generating technology to enlarge sugarcane plantations in the state of São Paulo. The Campinas Agronomy Institute (IAC, a 125-year-old São Paulo state-funded research institute) was the main agency responsible until the 1970s for crucial innovations in the plantation of crops such as coffee and cotton. During the 1970s and 1980s, the Federal Government-supported Brazilian Institute of Coffee (IBC) conducted research into coffee plantation and Rio Grande do Sul´s Rice Institute (IRGA) developed important research about the rice crop. During the 1990s, and especially during the 2000s, EMBRAPA has focused on practical research and has expended much energy

disseminating this widely. This perhaps explains the tendency of some commentators to assume that the spread of agriculture through the Cerrado area is entirely due to EMBRAPA research (e.g. The Economist 2010, 3). As mentioned above, however, while EMBRAPA performs an important role coordinating a large range of crop and livestock research, it is only one among a huge network of agencies undertaking agricultural research in Brazil. According to data presented by Beintema, Avila and Fachini (2010, 2) EMBRAPA accounted for 57% of the total investment and expenditure on agricultural research in 2006, while state-funded institutes comprised 21% and universities 16%. Shares for personnel involved meanwhile were 41%, 38% and 16% respectively.

Table 2: Regional concentration indicators for agriculture (values are % of Brazil totals)

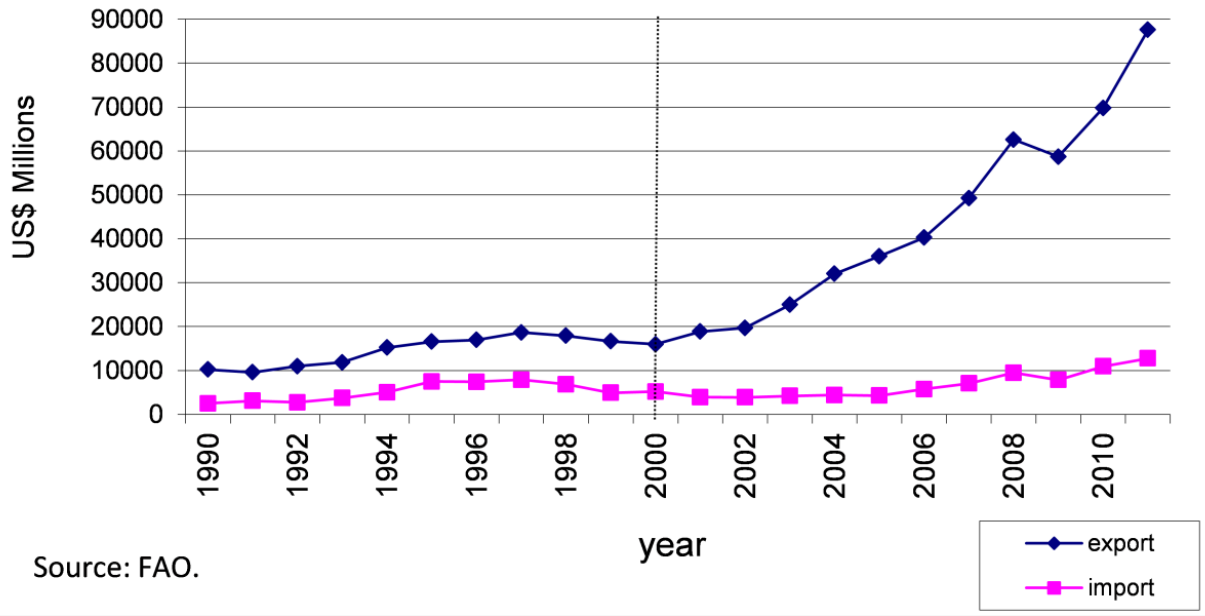
Region	Year	Gross value of production	Total farming area	Temporary cropland	Permanent cropland	Herd size			Tractors
						cows	pork	poultry	
	1970	3.1	7.9	1.9	1.7	2.2	2.9	3.6	0.7
North	1985	4	12	3.2	6.9	4.2	7.1	3.8	1
	1995/96	4.1	11.8	2.9	9.4	7.9	7.2	3.6	1.3
	2006	3.7	12.3	3.8	15.2	14.7	4.3	1.8	2.1
	1985	0.7	4.6	1.4	0.6	2.8	1.3	0.5	0.8
Tocantins	1995/96	0.8	4.7	0.7	0.3	3.4	0.8	0.3	1
	2006	0.5	4.3	1.1	0.9	3.5	0.8	0.3	1.2
	1970	18.3	25.3	24.4	49.8	17.6	22.5	17	4.4
Northeast	1985	24.6	17	23.9	43	17.5	25.8	18	6.3
	1995/96	14.7	14.1	22.5	35.1	14.9	22.9	14.4	6.9
	2006	19.8	22.9	24.2	30.2	14.8	12.6	8.6	7.6
	1970	7.5	27.8	8.7	1.8	22	8	5.7	6.2
Central-West	1985	9.8	26.4	16.1	2.4	28.2	8.4	4.6	13
	1995/96	14.4	30.7	18.5	3.3	33.2	8.1	5.9	14.3
	2006	13.8	31.5	23.8	6.1	33.5	11.8	12.1	15.5
	1970	37.3	23.6	28.6	27.2	34.2	18.4	41.5	49.8
Southeast	1985	38.5	19.5	23.2	38.1	27.9	18.4	33.5	35.9
	1995/96	34.6	18.1	21.4	43.4	23.5	16.2	36.5	34.8
	2006	33.3	16.4	19	34.8	19.9	16.8	31.2	31.3
	1970	33.8	15.5	36.4	19.5	24.1	48.3	32.3	39
South	1985	30	12.8	32.2	9.1	19.4	39	39.6	43
	1995/96	31.4	12.5	34.0	8.6	17.1	45	39.3	41.7
	2006	28.8	12.6	28.2	12.8	13.6	53.7	46	42.3

Source: Agricultural Censuses of Brazil – multiple years.

Since the second half of the 1960s, in spite of changes in endowments and priority groups, the Federal Government has maintained traditional agricultural policies such as rural credit, minimum prices, insurance, research and extension. However, on the whole these policies have stimulated market-oriented production rather than self-consumed production.

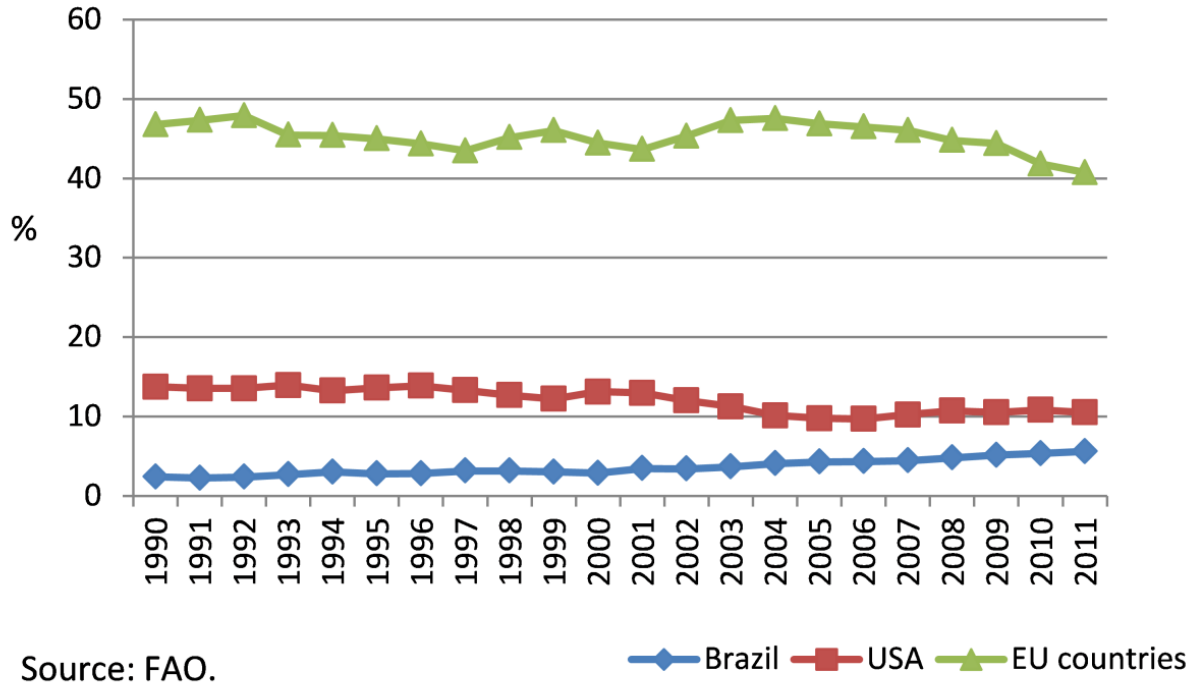
Large multinational agribusiness companies have backed medium- and large-sized farmers in Brazil, encouraging them to produce exportable agricultural products. During the 1970s and 1980s, these companies funded farmers to plant grains in Cerrado areas using the so-called Green soybeans contract, a forward sale not established by law, in which agribusiness companies lent money and/or agricultural inputs to the farmers and later received reimbursements in the form of agricultural products (soybeans). In the 1990s, this kind of contract became regulated as a Note of Agricultural Product ('Cédula de Produto Rural'), and has been widely used by these companies since then. Furthermore, these companies have consistently bought a large share of Brazilian agricultural production and exports; foreign markets have been an important destination for a sizeable proportion of Brazil´s agricultural production. Figure 4 shows the evolution of Brazil´s exports and imports of agricultural and agro-processed goods from 1990 through 2011. Brazil´s exports of agricultural and agro-processed products rose from US$ 10.2 billion in 1990 to almost US$ 87.5 billion in 2011, i.e. they multiplied eightfold in twenty-two years. A particularly large increase has taken place since 2000, in contrary motion with the decrease of the USA's and European countries' shares of the world agricultural and agro-processed product markets (as seen in Figure 5). In 1990, EU countries accounted for 46.8% of world exports of agricultural and agro-processed products, which fell to 40.7% by 2011. US exports of the same products comprised 13.8% of the world total in 1990 and 10.5% by 2011. Meanwhile, Brazil´s exports rose from 2.4% to 5.6% respectively in this period.

Figure 4: Brazil's exports and imports of agricultural and agro-processed products from 1990 through 2012



Source: FAO.

Figure 5: EU, USA and Brazil shares of world agricultural and agro-processed goods exports



Source: FAO.

Brazil is the world´s largest producer and exporter of coffee, sugar and orange juice; the second largest exporter of soybeans, and holds the third and the fourth rank respectively as exporter of corn and cotton. Also, Brazil is the largest exporter of beef and poultry, holding the largest commercial cattle herd.

During the first twelve years of the 21st century, Brazil exported an increasing amount of agricultural and agro-processed goods, both to established and, particularly, emerging markets (see Table 3). From 2000 to 2011, Brazil´s exports of agricultural and agro-processed products to European Union countries increased almost 200%, despite the fact that the share of overall Brazilian agricultural/agro-processed exports represented by these countries actually decreased from 50% to 27%. African, Asian and Middle Eastern countries, especially China, have increased their imports of agricultural and agro-processed products from Brazil. In 2000, countries from these regions bought 27% of Brazil´s agricultural and agro-processed exports; by 2011 this percentage was 53%. China alone accounted for 18% of Brazil´s exports of agricultural and agro-processed goods in 2011.

Table 3: Destination for Brazilian agricultural and agro-processed exports – selected years

	Exported value (agricultural and agro-processed products) – US$ millions								**2000 thru 2011 Growth rate [1]**
Region or country	**1997**		**2000**		**2007**		**2011**		
European Union	9,510	**0.51**	7,925	**0.50**	20,047	**0.41**	23,361	**0.27**	294.77%
Latin America	1,964	**0.11**	1,990	**0.12**	4,073	**0.08**	7,259	**0.08**	364.76%
Mercosur	1,447	**0.08**	1,220	**0.08**	1,350	**0.03**	2,131	**0.02**	174.69%
Africa	880	**0.05**	602	**0.04**	3,711	**0.08**	8,622	**0.10**	1,431.39%
Asia	3,520	**0.19**	2,739	**0.17**	10,754	**0.22**	29,104	**0.33**	1,062.54%
Middle East	1,067	**0.06**	939	**0.06**	4,652	**0.09**	8,558	**0.10**	911.81%
EUA	2,212	**0.12**	2,334	**0.15**	5,234	**0.11**	6,378	**0.07**	273.20%
Japan	1,182	**0.06**	920	**0.06**	1,680	**0.03**	3,426	**0.04**	372.20%
China	704	**0.04**	560	**0.04**	4,606	**0.09**	15,893	**0.18**	2,837.73%
Russia	686	**0.04**	411	**0.03**	10	**0.0002**	4,023	**0.05**	978.04%
India	55	**0.003**	86	**0.01**	22	**0.0004**	391	**0.004**	454.48%
Total exported [2]	**18,649**		**15,966**		**49,269**		**87,650**		**548.97%**

Source: Secex/MDIC e FAO

(1) Growth rate = (VF - VI) /VI where VF 2011´s value and VI is 2000´s value.

(2) Total exported value of agricultural and agro-processed products made in Brazil.

4. Agricultural policy in Brazil

Writers such as Mueller (1982, 1983, 2010), Helfand (2000), and Lamounier (1994) have shown that important variables shaping Brazil´s agricultural policies have been: (a) the political and institutional organization of the nation (for instance, whether the government is authoritarian or democratic); (b) the view of the good society advocated by the dominant elements within government; (c) political alliances established inside the government; (d) domestic and international political and economic circumstances; (e) macroeconomic targets in place at a given time (such as increasing the GDP growth rate, reducing inflation, reducing unemployment, etc.).

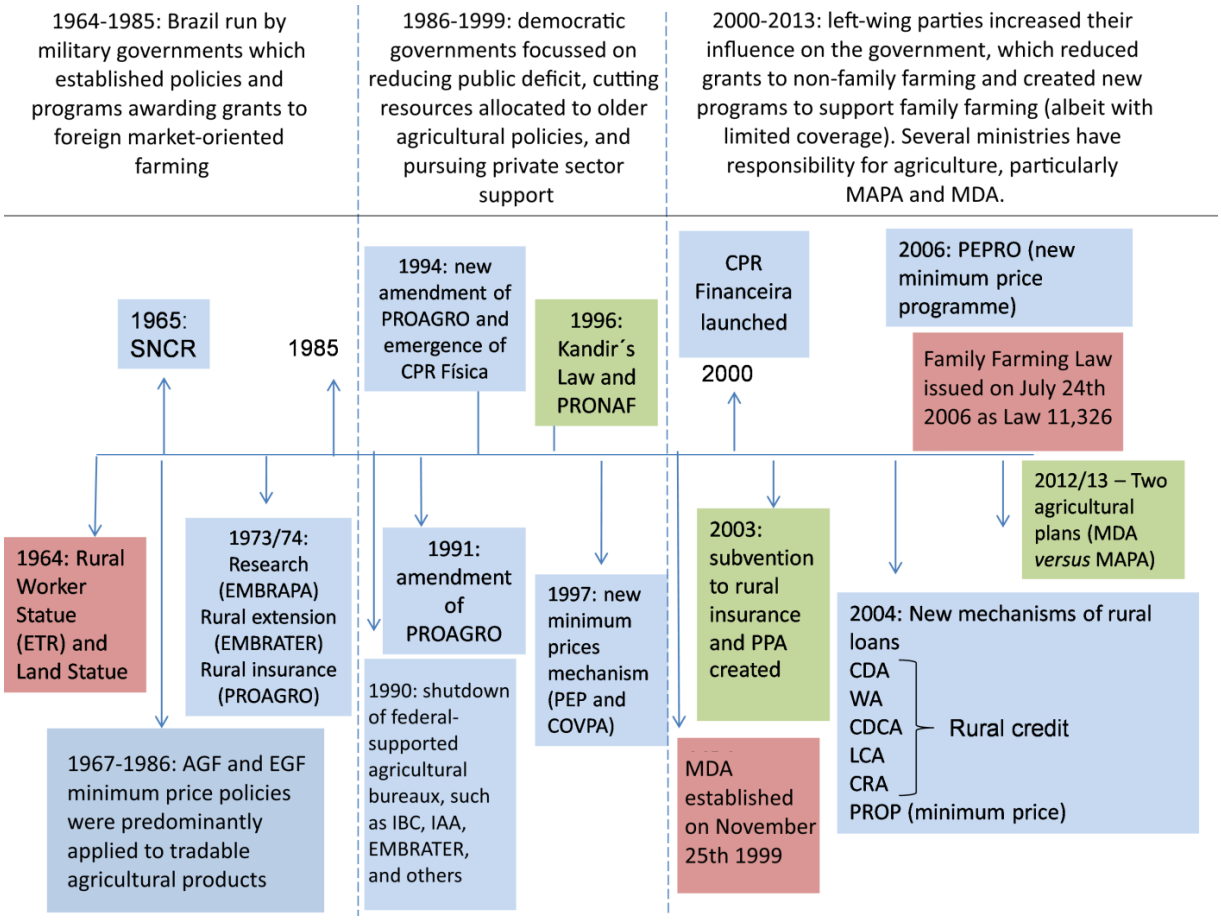
Considering the last five decades overall, agricultural policy in Brazil has been backed by the same economic instruments such as rural credits, minimum prices, federal and state-funded agricultural research, rural extension and subsidized insurance. In other words, policy has been predominantly market-oriented, aiming to encourage farmers to produce tradable goods rather than producing only for self-consumption. However, the specific endowments for each of these policies and their programs have changed according to the five variables mentioned above. Additionally, some programs have been created in order to address specific groups of farmers (e.g. family farmers).

Figure 6, below, gives an overview of the evolution of Brazil´s agricultural policy from 1964 through 2013. Three broad periods can be identified.

(1) During the military dictatorship of 1964-1985, the dominant view of the good society centred around increasing the GDP growth rate, reducing inflation, and generating a surplus of trade balance. These targets were aimed at by modernizing the labour market in rural areas and offering economic stimulus to market-oriented farmers, rather than the agrarian reform advocated by some groups in the late 1950s to early 1960s. Supported by medium- and large-sized farmers as well as by industrial tycoons, the Federal Government issued in 1964 the Statute of Rural Labour and the Land Statute, extending to rural workers rights that had been established for urban labour in 1942. In 1965, the Federal Government created the National System of Rural Credit (SNCR); this became a crucial source of low-interest loans for farmers looking to purchase industrial inputs and machinery, and was therefore a key step in increasing agricultural productivity. During the 20 years of military dominance, the SNCR benefitted medium- and large-sized market-oriented farmers and these farmers used rural credits to buy

products from domestic industry, which predominantly explains the industrial sector´s support for rural credit (Kageyama and Silva 1983; Goldin and Rezende 1993). Also from 1965-1985, the Federal Government improved the effectiveness of minimum price programs such as the Federal Government´s Purchases (AGF) and Federal Government´s Loans (EGF). Both AGF and EGF were more effective for the market-oriented crops normally planted by medium and large-sized farmers. Completing the range of agricultural policies, the Federal Government created EMBRAPA (Brazilian Enterprise for Agricultural Research) in 1973 and, one year later, EMBRATER (Brazilian Enterprise for Rural Extension) was created to oversee rural extension. During the military period, both EMBRAPA and EMBRATER gave most of their attention to market-oriented farming. The government´s agricultural insurance policy, meanwhile, was reinvigorated in 1974 with the inauguration of the Guarantee Program for Agricultural Activity (PROAGRO). This was initially linked with rural credits and benefitted medium and large-sized farmers, who were the main borrowers of rural credit (Bacha 2012).

Figure 6: evolution of Brazil's agricultural policy from 1964-2013



Source: based on Goldin and Rezende (1983) and Bacha (2012)

(2) From 1987 to 1999, as the newly-democratic governments struggled to stabilize the Brazilian currency by reducing the public deficit, government endowments to the earlier-established agricultural policies were drastically reduced, and, simultaneously, new programs were created to involve the private sector in financing agriculture. In 1990 several Federal Government-run agriculture bureaux, chambers and institutes were shut down (such as the Brazilian Institute of Coffee (IBC), the Sugar and Alcohol Institute (IAA) and EMBRATER), and some sectors were deregulated (such as coffee and sugar). The official insurance program (PROAGRO) was twice revised in order to reduce its deficit, and the revision also reduced its scope (Souza 2000). In 1994, forward sales of agricultural products were regulated in law as Rural Product Notes with product delivery (CPR-física), allowing the private sector to lend money to farmers without penalties for charging interest. In 1996 'Kandir's Law' exempted Brazilian exports of agricultural and agro-processed products from value-added tax, boosting these exports. In the same year, in light of the reduction of rural loans from SNCR, the Federal Government created the National Programme for the Strengthening of Family Agriculture (PRONAF), offering low-rate loans to family farmers and giving them priority over non-family farmers for government-provided rural loans. One year later, new minimum price programs – the Premium for Product Flow (PEP, Prêmio para Escoamento do Produto) and the Selling Option Contract of Agricultural Products (COVPA, Contrato de Opção de Venda de Produto Agropecuário) – were created in order to limit the number of farmers who could access these programs, and to involve the private sector in their running (Rezende, 2001; Verde, 2001; and Bacha 2012).

(3) From 2000, left-wing parties strengthened both inside and outside the Federal Government, and pressured for more grants to family farmers. At the end of 1999, the Ministry of Agrarian Development (MDA) was created to support family farming, while the Ministry of Agriculture, Livestock and Food Supply (MAPA) continues to support non-family farming. Since then, MDA and MAPA have shared the responsibility for supporting Brazilian agriculture by using the same policies (rural credit, minimum prices, rural extension and subsidized insurance) but with programs tailored for their respective sectors (family and non-family). For example, in 2003 MAPA created a new insurance program, the Subsidy for Rural Insurance (necessary because PROAGRO was dedicated exclusively to family farming). In the same year, MDA created the Food Acquisition Program (PAA), a new version of AGF. (Farmers of either sector can apply to AGF whereas PAA serves only family farmers.) In 2004, MAPA expanded the private-supporting

rural credit loan programs by creating CDA, WA, CDCA, LCA, CRA[1], financial securities that allow the enlargement of privately-supplied rural credit. Additionally, further new minimum price programs run by the private sector were created, such as PROP (Risk Premium to Purchase Agricultural Products Derived from a Private Selling Option Contract) in 2004 and PEPRO (Equalizing Premium Paid to Growers) in 2006.

The Family Farming Law of 2006 defined the category of 'family farmer',[2] and since 2012 MDA and MAPA have independently outlined separate annual agricultural plans. These follow the same established agricultural policies overall, but employ different programs customised for family and non-family farmers. Family farmers can apply for both MDA and MAPA programs, but non-family farmers can only apply to MAPA's programmes. However, the bifurcated structure of agricultural policymaking (between MDA and MAPA) has not constrained agricultural expansion, and on occasion has actually proved helpful in settling seeming divergences within central government.

5. Econometric equations to explain changes in Brazilian agricultural exports

Based on Almeida and Bacha (1998), Reis and Crespo (1998), Maia (2003), Pimentel et al. (2005) and Fraga and Bacha (2012), this paper evaluates the importance of world GDP, exchange rate, domestic production and export prices on agricultural exports, agro-industrial exports and both added. The following equation has been run for the period 1991-2011 (for which data is available for all variables listed in equation 1):

$$EXP_t = f(TP_t, e_t, PI_t, WGDP_t) \qquad (1)$$

Where:

EXPt: value of Brazil´s agricultural and agro-industrial exports;

TP_t: Brazil´s total agricultural production (*quantum*);

[1] CDA = Certificate of Agricultural Deposit; WA = Agricultural Warrant; CDCA = Certificate of Agricultural Credit Rights; LCA = Notes of Agribusiness Credit; CRA = Certificate of Agribusiness´s Receivable Assets.

[2] The categories of family farming and non-family farming were established for the purposes of agricultural policy by Law 11,326, issued on July 24th 2006. A 'family farming' property meets the following criteria: (1) the total farming area is at most four fiscal modes (a fiscal mode represents the minimum area for a farm to be considered economically viable and ranges from 5 to 110 hectares, depending on the municipality); (2) the farm preferentially employs family members; (3) the farmer's income is solely derived from farming. It is worth noting that these conditions don't imply that the designation of 'family farmer' necessarily means a poor or low-income person; those covered by it range from poor peasants to highly capitalized farmers. According to Brazil´s 2006 Agricultural Census, family farming accounted for 33.2% of Brazilian agriculture´s gross production value in that year. Almost one quarter of family farmers rank in the highest band of agricultural income in Brazil (R$ 500 thousand or more per year). However, the family farming sector does also contain the vast majority of the lowest-income farmers.

e_t: Real exchange rate;

PI_t: international price index for agricultural and forest products;

$WGDP_t$: world gross domestic product.

Equation (1) will be linearized and each explanatory variable will be taken by its neperian logarithm. Then, the following equation will be run:

$$logEXP_t = \alpha + \beta_1 logTP_t + \beta_2 e_t + \beta_3 logPI_t + \beta_4 logWGDP_t + \epsilon_t \quad (1)$$

All expected signals for betas are positive.

The ordinary least squares method (MQO) will be used to run Equation (1). Chart 2 provides information about the explanatory variables.

Chart 2: explanatory variables used in Equation (3)

Explanatory variable		**Description**	**Source**
Brazil´s agricultural and agro-processed exports	EXP_t	Agricultural, forest, agro-processed exports have been added (US$ million)	FAO
Total agricultural production	TP_t	Index of Brazil´s agricultural production, 2002 = 100	IBGE
Exchange rate	e_t	Purchasing power of Real in relation to the 16 major Brazilian partners´ currencies. An index with 2005 = 100	IPEA
International Price Index	PI_t	Index of agricultural and agro-processed product prices. Calculated by dividing value of exports over quantity exported	FAO
World GDP	$WGDP_t$	Sum of all countries' GDP (US$ million).	World Bank

5.1 Econometric results

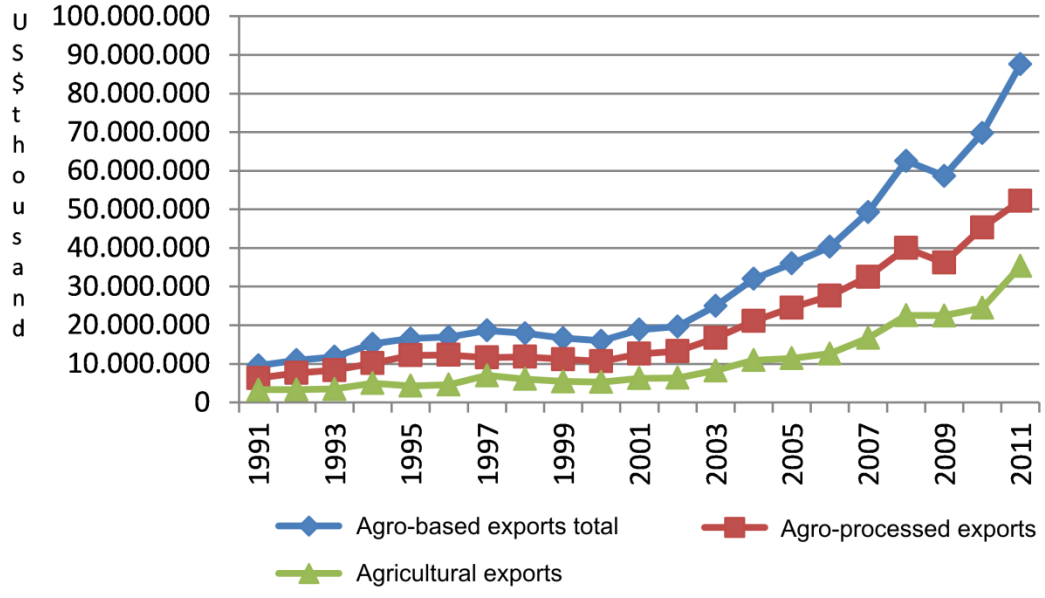
Figure 7 shows the growth of Brazil´s agricultural and agro-processed product exports since 1991, as well as the total agro-based product exports. The latter has increased from US$ 9.6 billion in 1991 to US$ 87.6 billion in 2011. Agro-processed products have been responsible for almost two thirds of total agro-based exports. At first glance, the evolution of agro-processed exports is similar to that of agricultural exports. However, some differences appear, particularly

in 1997, 2009 and 2011 when for instance agricultural product exports increased more than agro-processed product exports, or when the former was stable despite the later decreasing.

Although certain products have remained predominant among Brazil´s agro-based exports, an examination of the Herfindal-Hirschman index (HHI) for the sector shows that diversification is nevertheless high, particularly for agro-processed exports. As seen in Figure 8, the HHI index for agro-processed exports decreased from 0.44 in 1991 to 0.26 in 2011, while for agricultural exports in the same period the index increased from 0.41 to 0.46. Notably, the diversification is higher for agro-processed product exports than for agricultural product exports.

In order to assess the differences between agricultural and agro-processed exports, three equations will be run in this section: one for all agro-based product exports, one for only agricultural product exports, and one for only agro-processed product exports. Table 4 displays the dataset used in the regressions presented in this section, while Table 5 shows the results of equation (1). EViews and Stata were used to conduct the analysis.

Figure 7: Evolution of Brazil's agricultural and agro-processed exports



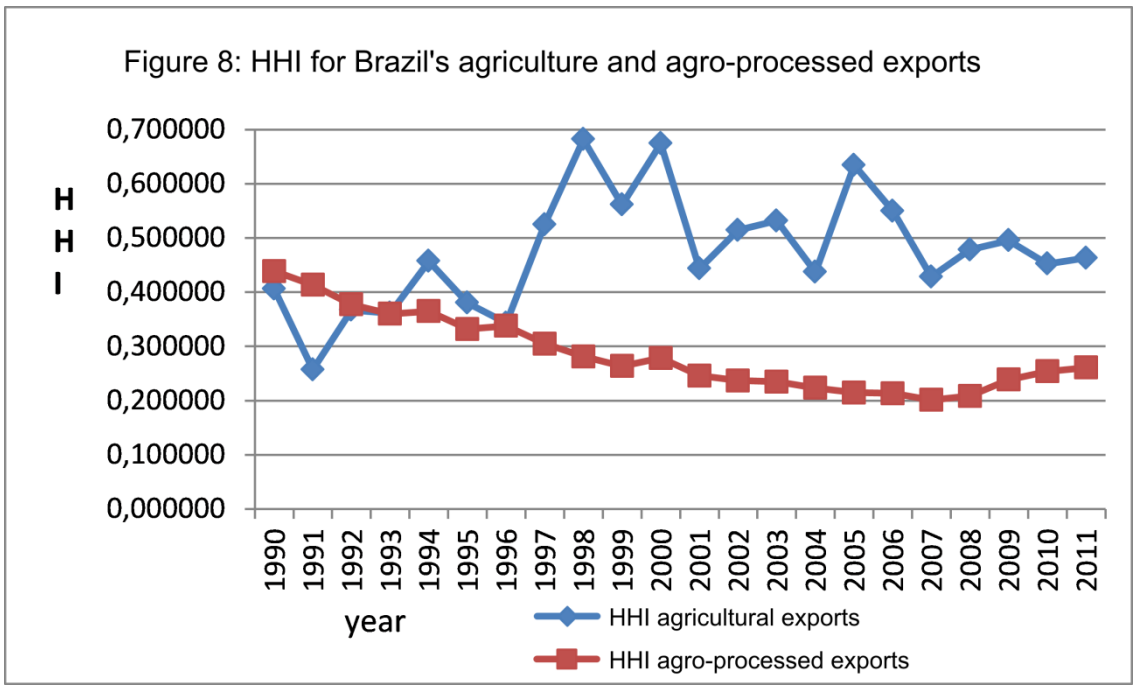


Table 4 – Dataset used in regression

	Agro-based exports (US$ Thousand)			Total production index (2002 = 100)	Exchange rate (index 2005 = 100)	Export price (index 1990 = 100)			World GDP (US$ thousand)
	EXPtot	EXPagroind	EXPagric	TP	e	PItot	PIagroind	PIagric	WGDP
1991	9.603.586	6.301.524	3.302.062	90,52	83,632858	102,35126	95,02227	124,99110	23,083,060,874
1992	10.969.313	7.643.878	3.325.435	90,20	94,492938	94,98367	94,21650	100,28754	24,680,057,182
1993	11.843.030	8.367.739	3.475.291	93,07	90,724586	87,98711	88,09325	91,24881	25,019,085,816
1994	15.206.796	10.192.867	5.013.929	98,84	85,608219	99,43504	93,11410	121,53153	26,868,046,895
1995	16.556.274	12.244.871	4.311.403	95,80	77,117592	102,56043	97,36722	142,79954	29,810,265,371
1996	16.967.944	12.339.936	4.628.008	98,74	73,521996	109,94797	105,88581	137,38682	30,414,072,001
1997	18.649.278	11.626.932	7.022.346	104,29	73,396764	106,37301	99,52915	119,75555	30,332,640,624
1998	17.905.380	11.811.714	6.093.666	100,09	74,870395	92,46631	87,21015	108,08094	30,218,686,284
1999	16.637.110	11.194.695	5.442.415	97,94	110,732406	76,38116	72,33604	90,30791	31,336,888,285
2000	15.966.235	10.653.802	5.312.433	93,14	105,102868	79,44200	80,97072	75,58511	32,346,737,845
2001	18.868.800	12.594.199	6.274.601	96,50	124,480712	66,35842	75,69203	50,07890	32,158,035,465
2002	19.702.595	13.312.446	6.390.149	100,00	121,512935	65,86386	70,38562	56,36005	33,408,324,796
2003	24.987.559	16.719.430	8.268.129	103,69	120,767475	72,24875	78,70658	59,37476	37,589,241,167
2004	32.033.170	21.070.344	10.962.826	108,42	117,926323	83,18346	88,07120	72,36243	42,301,833,545
2005	36.008.929	24.546.110	11.462.819	104,05	100	85,57167	88,14020	80,02874	45,740,739,371
2006	40.280.679	27.627.375	12.653.304	107,55	91,146961	92,36719	102,75737	72,60815	49,563,116,493
2007	49.269.996	32.546.692	16.723.304	112,80	86,182465	105,33228	116,80972	83,75103	55,906,626,293
2008	62.589.995	40.027.658	22.562.337	113,62	90,3800867	138,78091	145,10537	123,22449	61,377,990,448
2009	58.696.987	36.194.755	22.502.232	107,79	90,5966957	120,54960	125,55327	107,07506	58,132,091,128
2010	69.806.037	45.300.895	24.505.142	112,86	81,100564	131,87206	145,27370	106,29948	63,508,421,305
2011	87.583.591	52.252.396	35.331.195	111,08	88,310064	163,07736	172,94290	139,91298	70,441,599,068

Source: FAO, IBGE and World Bank.

Initially, equation (1) was run by using the ordinary least squares method, and both Durbin-Watson and Breusch-Godfrey statistics do not suggest the presence of residual autocorrelation. The values of the Variance Inflation Factor (VIF) also do not suggest the presence of multicolinearity among the explanatory variables. However, a White test suggests the presence of heteroskedascity in the agricultural export equation. This equation was then rerun by using the Generalized Least Squares (GLS) method. Both results are presented in Table 5. Their coefficients are similar, but their significant levels are different.

Table 5 – results from equation (1) run by using the ordinary least squares method (OLS) and the generalized least squares method (GLS)

		constant	**lnTP**	**lne**	**lnPI**	**lnWGDP**
Agricultural exports (using OLS)	Coefficients	**-35.83536**	**1.802589*** **	**0.272786** ^{ns}	**0.207186** ^{ns}	**1.694405** *
	Standard deviation	2.726899	0.937143	0.313899	0.168377	0.199155
	t-statistic	-13.14144	1.923494	0.869021	1.230487	8.507962
	F-statistic = 177.3856*		Durbin-Watson = 1.719434		VIF = 5.29^{ns}	
	Breusch-Godfrey (chi2) = 0.130 ^{ns}		R^2 = 0.972434		White test (F) = 3.961930**	
Agricultural exports (using GLS)	Coefficients	**-35.83536**	**1.802590*** **	**0.272786** ^{ns}	**0.207186** ^{ns}	**1.694405** *
	Standard deviation	3.012747	0.860401	0.285142	0.169827	0.205233
	t-statistic	-11.89458	2.095058	0.956667	1.219984	8.256024
	F-statistic = 177.3856*		Durbin-Watson = 1.719434		VIF = 5.29^{ns}	
	Breusch-Godfrey (chi2) = 0.130 ^{ns}		R^2 = 0.972434			
Agroprocessed exports	Coefficients	**-26.41764** *	**0.945757****	**-0.082116** *	**0.050732** ^{ns}	**1.594243***
	Standard deviation	1.193903	0.505315	0.144928	0.144232	0,147778
	t-statistic	-22.12713	1.871618	-0,566601	0.351735	10.78811
	F-statistic	509.2316*	Durbin-Watson = 1.381537		VIF = 7.58^{ns}	
	Breusch-Godfrey (chi2) = 1.344^{ns}		R^2 = 0.990258		White test (F) = 1.751888 ^{ns}	
Total agro-based exports	Coefficients	**-28.22800** *	**1.285355***	**0.080861**^{ns}	**0.191643**^{ns}	**1.564041***
	Standard deviation	0.901602	0.433108	0.139098	0.116260	0.112789
	t-statistic	-31.30873	2.967749	0.581326	1.648408	13.86698
	F-statistic	735.9119*	Durbin-Watson = 1.679515		VIF = 6.64^{ns}	
	Breusch-Godfrey (chi2) = 0.229^{ns}		R^2 = 0.993242		White test (F) = 0.3961^{ns}	

Source: results from the research.

Note: * 1% significant, ** 5% significant, *** 10% significant.

According to Table 5, total production (TP), international prices (PI) and World GDP (WGDP) display the expected signals even though only TP and WGDP coefficients are statistically significant. The exchange rate coefficient has the expected signal for agricultural and total agro-based product exports, but the coefficients were not statistically significant in any equation. The F-statistic proved to be significant at 1% level, and R^2 is over 0.97, showing that all coefficients are statistically different from zero. World GDP (WGDP) has the highest impact on Brazil´s agricultural and agro-processed product exports. Its coefficient (1.56) indicates that a 1% increase in world GDP leads to an increase of 1.56% in Brazil´s agricultural and agro-

industrial exports. The second highest impact comes from Brazil´s agricultural production with an elasticity of 1.29. International price (PI) had the expected signal, but was not statistically significant. By considering separately agricultural and agro-processed product exports, some differences among their main determinants are revealed. The impact of total production on agricultural product exports (elasticity of 1.8) is larger than that of world GDP (elasticity 1.69), while the opposite is the case for agro-processed product exports (elasticity of 0.95 and 1.59 respectively).

As such, we can conclude that the huge growth of Brazil´s agricultural and agro-industrial exports since 1990 has been driven by world economic growth and the increase in Brazil´s own production, which has predominantly been oriented towards the international market. This market-oriented production has been conducted by both family and non-family farms; both sectors have increased their productivity and have also been supported by market-oriented agricultural policy.

6. Conclusions

Since 1990, and particularly during the 2000s, Brazil has experienced very high growth in agricultural and agro-industrial exports, which rose from US$ 10 billion in 1990 to US$ 16 billion in 2000 and had shot up to US$ 88 billion by 2011. Simultaneously, Brazil´s share of the worldwide food supply market increased from 2.4% in 1990 to 2.9 % by 2000, and to 5.6% by 2011.

Several factors can explain this growth; in particular, increasing domestic production, the growth of world consumption, and changes in the exchange rate have been key. Also relevant, although not of the same importance, are changes in international prices. According to the econometric model run in this study, the main determinant of Brazil´s agricultural and agro-industrial export growth has been the increase in world GDP (with an elasticity of 1.56, meaning that each 1% increase in world GDP implied a 1.56% increase in Brazilian exports of agricultural and agro-industrial products). The second most important determinant was the increase in domestic production, with an elasticity of 1.29.

From 1990-2012, a huge increase in both crop and livestock production took place. In 1990, the quantity produced of the 63 major crops was 384 million tonnes, rising to 485 million tonnes by 2000 and reaching 966 million tons by 2012. In the same years, meat production was 5.17, 10.3

and 22.3 thousand tons respectively. This increase in production is due to several primary factors: (1) market-oriented agricultural policies, but with higher subsidies to family farms; (2) the presence of agricultural frontiers and business farmers, especially the soybean farmers who have migrated within Brazil; (3) the presence of large domestic and foreign companies who have guaranteed the purchase of Brazilian agricultural products, thereby financing a large share of business farmers as well as agricultural exports; and (4) an agricultural technology network encompassing federal and state-funded bureaux, universities, private organizations and companies.

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