Analysis of transportation and logistics processes for soybeans in Brazil

A case study of selected production regions

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Thünen Working Paper 4

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Summary

This study examines the relevance of Brazilian domestic transportation and logistics processes for agricultural bulk exports in terms of costs and CO_2 emissions between farm gate and seaport, using the example of soybeans. To estimate the impact of logistics and transportation on the competitiveness of soybeans in a national comparison, export processes starting in four selected regions within the Sorriso-Santos corridor and travelling to the principal seaport for soybean exports in Santos-SP are evaluated. The analysis is based on agricultural statistics and data from field research as well as on information from expert interviews. Experts belong to the transportation and logistics sector, to the sector of agricultural production as well as to relating associations and research institutions. The results provide insight into the development and status quo of the domestic soybean market and infrastructure for transportation and storage of bulk materials. Structure and actors involved in the domestic supply chain are presented in a market analysis. A cost analysis elucidates a clear correlation of the export price (fob Santos) with the producer price (at the local spot market). The prices differ basically by the freight rates for domestic transportation. An impact assessment of CO_2 emissions shows that rail transportation is in the specific cases not more efficient in terms of CO_2 emissions than road transportation. This is due to a low utilization of the transport capacity on the train's return trips. The survey results also show the current bottlenecks and the potential and trends for the future development of the Brazilian logistics and transport sector for agricultural bulk products. The importance of efficient logistics and transportation processes for the competitiveness of soybeans on the international market is increasing with the relocation of the major soybean production areas into remote rural areas with underdeveloped infrastructure. The nationwide deficient network of transportation and storage infrastructure as well as of transshipment terminals leads to increased costs and capacity constraints. Monopoly-like structures and insufficient capacities in the regional rail system also exacerbate the problem of high freight rates. Recent public and private initiatives to improve the national infrastructure, particularly in the ports in northern Brazil, could lead to large improvements in the soybean logistics.

JEL: Q13, Q17, Q50

Keywords: Brazil, soybeans, infrastructure, logistics, transport, logistics costs, transportation costs, CO_2-emissions

Zusammenfassung

In der vorliegenden Studie erfolgt eine Analyse der brasilianischen Logistik und des Inlandstransports für agrarische Schüttgüter am Beispiel von Sojabohnen. Um den Einfluss von Transport und Logistik auf die Wettbewerbsfähigkeit der Sojaproduktion in Brasilien zu ermitteln, wurde eine Markt- und Kostenanalyse für vier Anbaugebiete im Sorriso-Santos-Korridor mit abnehmenden Transportdistanzen zum Hauptexporthafen von Soja in Santos-SP durchgeführt. Hierfür wurden agrarstatistische Daten sowie Ergebnisse von Befragungen unter Experten aus dem Transport- und Logistiksektor, aus der landwirtschaftlichen Produktion sowie aus Verbänden und der Wissenschaft ausgewertet. Die Ergebnisse geben dabei Aufschluss über Entwicklung und Status quo des Sojamarktes und der inländischen Infrastruktur für Transport und Lagerung von Schüttgütern.

In einer Marktanalyse werden Struktur und beteiligte Akteure der inländischen Lieferkette dargestellt. Eine Kostenanalyse verdeutlicht, dass ein klarer Zusammenhang von Hafenpreis (fob Santos) und Produzentenpreis (am lokalen Spotmarkt) besteht. Die Preise unterscheiden sich im Wesentlichen nur durch die Frachtraten. Eine CO_2-Bilanzierung verdeutlicht, dass der Schienentransport aufgrund geringer Auslastungen der Transportkapazitäten auf den Rückfahrten gegenüber dem Straßentransport nicht emissionseffizienter ist. Die Umfrageergebnisse zeigen darüber hinaus die aktuellen Engpässe sowie weitere Potenziale und Tendenzen zur künftigen Entwicklung des brasilianischen Logistik- und Transportsektors für Agrarerzeugnisse auf. Als zweitgrößter Exporteur auf dem Weltmarkt gehört Brasilien zu den Hauptversorgern der weltweiten Sojanachfrage. Der Einfluss von Logistik und Transport auf die Wettbewerbsfähigkeit von Sojabohnen auf dem internationalen Markt nimmt durch die Verlagerung der Hauptanbaugebiete in küstenferne und infrastrukturarme ländliche Räume zu. Die allgemein defizitäre Infrastruktur von Transportnetz, Lager und Verladeterminals führt zu erhöhten Kosten und Kapazitätsengpässen. Monopolähnliche Strukturen und unzureichende Kapazitäten im regionalen Eisenbahnbetrieb verschärfen zudem das Problem hoher Frachtpreise. Investitionen in den Ausbau der Infrastruktur, besonders in den Häfen im nördlichen Brasilien, mit privaten und öffentlichen Mitteln versprechen eine deutliche Optimierung der Logistik.

JEL: Q13, Q17, Q50

Schlüsselwörter: Brasilien, Soja, Infrastruktur, Logistik, Transport, Logistikkosten, Transportkosten, CO_2-Emissionen

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List of Abbreviations

ABIOVE	Brazilian Vegetable Oil Industries Association
ALL	América Latina Logística (Brazilian railway operator)
ALLMN	ALL Malha Norte (railroad MT to SP operated by ALL)
ALLMP	ALL Malha Paulista (railroad SP operated by ALL)
AM	Amazonas (federal state of Brazil)
ANTT	National Transportation Agency
CEPEA	Center for Advanced Studies on Applied Economics of ESALQ
cif	cost insurance freight
CNT	National Confederation of Transportation
CO_{2eq}	CO_2 equivalents
Eq.	Equation
ES	Espirito Santo (federal state of Brazil)
ESALQ	College of the Luiz Queiroz College of Agriculture at the University of São Paulo
ESALQ-LOG	ESALQ Group of Research and Extension in Agroindustrial Logistics
fob	free on board
GDP	gross domestic product
GHG	greenhouse gas(es)
GWP	global warming potential
ha	hectare(s)
IBGE	Brazilian Institute of Geography and Statistics
ICMS	Tax over commercialization and services
IMEA	Institute of Mato Grosso Agricultural Economics
kg	kilogram(s)
l	liter
IPCC	Intergovernmental Panel on Climate Change
LCA	Life Cycle Assessment
mha	million hectares
mm	millimeters
mmt	million metric tons

MS	Mato Grosso do Sul (federal state of Brazil)
MT	Mato Grosso (federal state of Brazil)
MAPA	Ministry of Agriculture, Livestock and Food Supply
MDIC	Ministry of Development, Industry and Foreign Trade
PA	Pará (federal state of Brazil)
PAC	Growth Acceleration Plan
PNLT	National Plan for Logistics and Transportation
PR	Paraná (federal state of Brazil)
PSD	USDA Database Production, Supply and Distribution Online
RO	Rondônia (federal state of Brazil)
RS	Rio Grande do Sul (federal state of Brazil)
Secex	Brazilian Secretariat of Foreign Trade
SP	São Paulo (federal state of Brazil)
t	metric ton(s)
tha	thousand hectares
tkm	tonne kilometer(s)
USA	United States of America
USDA	United States Department of Agriculture

1 Introduction

1.1 Statement of the problem

Brazil is a country with a competitive advantage in agricultural production. Low on-farm production costs and land abundance granted the country this competitive advantage and helped to make Brazil an internationally competitive producer and exporter of soybeans (see appendix 1), as various studies emphasized (CASTILLO/VENCOVSKY/BRAGA, 2011; KUSSANO/BATALHA, 2009; FILARDO et al., 2006; USDA, 2012). But long distances between production sites and domestic destination require a high participation of transportation and logistics services within the process chain of soybean exports. This includes transportation from farm to warehouse and to the seaport as well as storage and transshipments at intermodal transportation[1] terminals and at the seaport.

Because of a low value per unit of agricultural goods, transportation may account for a large share of the total costs of soybean exports (CASTILLO/VENCOVSKY/BRAGA, 2011, p. 21). Increases in transportation costs are directly passed on to the weaker market player, so that rising transportation costs have the effect of decreased prices paid to producers because of their lack of market power (USDA, 2010, p. 3). A well functioning transportation service sector is crucial in order to keep transportation costs at a low level and preserve international competitiveness. A lacking infrastructure, however, may generate high costs for transportation and logistics as well as lead to congestion and consequently longer delivery time in peak harvest seasons. The infrastructure is hence a determinant of the competitive success of the agricultural sector (CAIXETA-FILHO, 2006, p. 1). As soybeans are a low value-added bulk good, the domestic price of which is closely related to the international market price quoted at the CHICAGO BOARD OF TRADE [CBOT] (MAPA, 2007, pp. 45) (see appendix 2), elevated costs of logistics arising from long distance transports consequently reduce the price received by the producers in the remote production areas decisively.

The Brazilian oilseed production expanded in the last decades into rural areas remote from the southern seaports, which cover the major part of the Brazilian soybean exports. It can be inferentially assumed that farm gate prices are strongly affected by transportation costs. Inefficiencies in transportation and logistics systems can hence prejudice the producers and put pressure on prices at all stages of the process chain, counteracting the competitiveness of the Brazilian soybean business (CAIXETA-FILHO/CARVALHO/BRANCO, 2007).

Negative externalities on climate change may also arise when soybeans are transported over long distances owing to large volumes of exhaust emissions that result from high fuel consumption. Due to the rising concern of consumers and policy makers about the climatic impact of product

[1] According to VAHRENKAMP (2007, p. 309), intermodality is the combination of various transportation modes to transport a good to its destination.

chains, the amount of emissions of greenhouse gases [GHG] may become a further factor of influence on competitiveness[2] of soybeans. Few efforts have been made in Brazil to report or reduce the global warming potential [GWP]. There is a great need to raise the environmental awareness of the participants of the soybean business and report exhaust emissions for minimizing the climatic impact.

With the doubling of the export volume between 2001/02 (16.07 mmt) and 2011/12 (32.08 mmt) transportation and logistics processes gained notably weight in Brazil (USDA PSD, 2013). With the increasing volumes that had to be moved, the demand for transportation and logistics services was concurrently boosted. As the world's second biggest producer and exporter of soybeans, the country is an important supplier for the world soybean market. It contributed a share of 28 % (66.50 mmt; cf. USA: 84.19 mmt, 35 %) to the world soybean production (238.73 mmt) and accounted for 35 % (32.08 mmt) of the world export volume in 2011/12, (cf. USA: 37.06 mmt, 41 %) (USDA PSD, 2013). Projections estimated that Brazil would become the globally leading producer and exporter within the next decade (USDA, 2012). In this context, German importers of soybean products emphasized the need for an improvement of the Brazilian infrastructure in order to ensure delivery liability (STRAUSS, 2012; DRESCHER, 2012; HÜNER, 2012). In order to safeguard supply and allow competitive prices for producers, logistics and transportation processes are a key factor for the Brazilian soy sector.

1.2 Research objectives

This thesis aims to analyze the relevance of domestic transportation and logistics processes of soybean exports in terms of costs and CO_2 emissions between farm gate and seaport for selected regions in Brazil. For this purpose, the characteristics of the soybean export process shall be elucidated at first by answering the question:

1. How is the Brazilian market of soybean logistics structured, who are the participants and which are the process stages of the export value chain on national level?

This information provides the basis to evaluate the influence of the logistics processes on the competitiveness of the Brazilian soybeans. To that effect, the further questions that shall be answered within the framework of a market and cost analysis are:

2. How is the logistics cost structure composed and which are the key cost elements?

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[2] DOHLMANN/SCHNEPF/BOLLING (2001, p. 16) define the competitiveness of the soy sector as a composition of various factors, which include relative resource endowments and agro-climatic conditions, as well as the impact of macroeconomic policies, e.g., investment and energy costs and availability, sector-specific policies like tax incentives and credit subsidies, infrastructure for storage and transportation, and of supporting institutions that help markets to work effectively (e.g., credit, regulatory, news and information, etc.).

3. Which is the climatic impact of domestic soybean transports from warehouse to seaport?

4. How can costs and CO_2 emissions of the logistics and transportation processes influence the competitiveness of the soybeans produced in the studied regions?

In order to evaluate future developments of the market, regarding the rising soybean volumes traded and the simultaneously increasing demand for transportation and logistics services, it has to be conclusively considered:

5. What are the challenges and potentials of the Brazilian transport sector for soybean exports?

1.3 Conceptual framework

The influence of the logistics and transportation processes on the competitiveness of the Brazilian soybeans shall be estimated by exemplarily analyzing the soybean export value chains starting in four selected production regions and ending at the seaport of Santos-SP. For that, four case studies, which incorporate the major Brazilian soybean production region Sorriso and the principal soybean export port Santos, are conducted to draw a picture of the current situation of soybean logistics and to analyze the bottlenecks and potentials.

Essential knowledge of the market for soybeans in Brazil is at first provided in chapter two. This chapter presents information on production, consumption and trade, and describes exemplarily the characteristics of four selected soybean production regions, which occupy a central position in the domestic soybean business. It further furnishes information on the status quo of the infrastructural system and agricultural policy measures to increase investments. Subsequently, chapter three explains the performed research approach and defines the applied methods.

The results of the field research and the data analysis are presented in chapter four and five. In chapter four a market and a cost analysis are exemplarily performed for the selected soybean production regions described in chapter two. Within the framework of the market analysis the structure of the soybean logistics and transport market is studied. In the cost analysis, the logistics cost positions of the export process are spotted and described in detail. The reporting of the cost structure is followed by an analysis of the logistics costs. Particular attention is paid to the costs of road transportation, as it is assumed that these represent a major element of total logistics costs. That way, the relevance of the transportation and logistics costs for the farm gate price, i.e., the price that the producer receives is estimated. The importance of single factors of influence on the transport costs shall be evaluated by performing a sensitivity analysis. To assess the impact of domestic transports of soybean exports on climate change, the emissions of greenhouse gases are reported and assessed in a GHG inventory. In order to examine the effects of changes of specific factors on global warming potential a sensitivity analysis is performed subsequently.

In chapter five challenges and potentials of the Brazilian soybean logistics are assessed, considering the bottlenecks within the logistics processes and the projects to improve the infrastructural network. The results are discussed in chapter six. In the final section of chapter seven results are resumed.

2 The Brazilian soybean market

To understand the relevance of the subject and as a basis for the analyses in chapter four, it is necessary to look at the current situation of the global and national soybean production and to elucidate the status quo of the Brazilian infrastructure. The following section provides basic information on soybean production and exports on international, national and regional level. It further addresses logistics issues that refer to the infrastructural conditions, related agricultural policy and climatic impacts of the soybean export process.

2.1 Production development, trade and outlook

With a gross domestic product [GDP] of 4.14 trillion R$ in 2011 (IPEA, 2012), Brazil ranks among the world's eight leading economies (CIA, 2012). Agricultural production valued with 195.60 billion R$ accounted for approximately five percent of the GDP (IBGE, 2011, p. 16; WORLD BANK, 2012). The three products generating the highest value of the national agricultural production are, according to MAPA (2012), soybeans (25 %), sugarcane (18 %) and corn (12 %). Soybeans contributed 50.37 billion R$ to the national GDP of 2011 (IBGE, 2011, p. 17). The agricultural commodity is furthermore a pivotal element of the Brazilian trade balance (MDIC, 2012). With 32.99 mmt being exported in 2011 soybeans represented a value of 16.33 billion US$[1] or six percent of the value of Brazil's total exports (256.04 US$).

The soybean complex

Soybean (Glycine max (L.) Merrill) is an annual crop of the legume (LEGUMINOSAE) family (FRANKE, 1994, p. 271). It is a seasonal crop with a cultivation period of 80 to 200 days, which depends on variety, climate and precipitation. Fertile soils and a temperate to tropical climate with temperatures between 27°C and 32°C as well as steady rainfalls of minimum 500 mm are required for optimum growth and productivity (FRANKE, 1994, p. 273). The soybean cropping regions in south and central west Brazil (see appendix 3-4) meet these climatic conditions. The soils of the South are naturally fertile, whereas soil productivity in the Center West must be enhanced by adding fertilizer, especially lime. Double cropping with soybeans and, e.g., corn is common in this region. No-till production is widely practiced to minimize erosion of the fragile soils and to reduce long-term costs from soil degradation (FLASKERUD, 2003, p. 4; DIAS, 2012; USITC, 2012, pp 2-4, 6-15).

The structure of the soybean complex is represented in figure 2.1. It comprises the production chains of unprocessed soybeans and processed soybeans in form of soybean oil and soybean meal. With an average oil content of 20 % on dry-weight basis, soybeans serve as a source of

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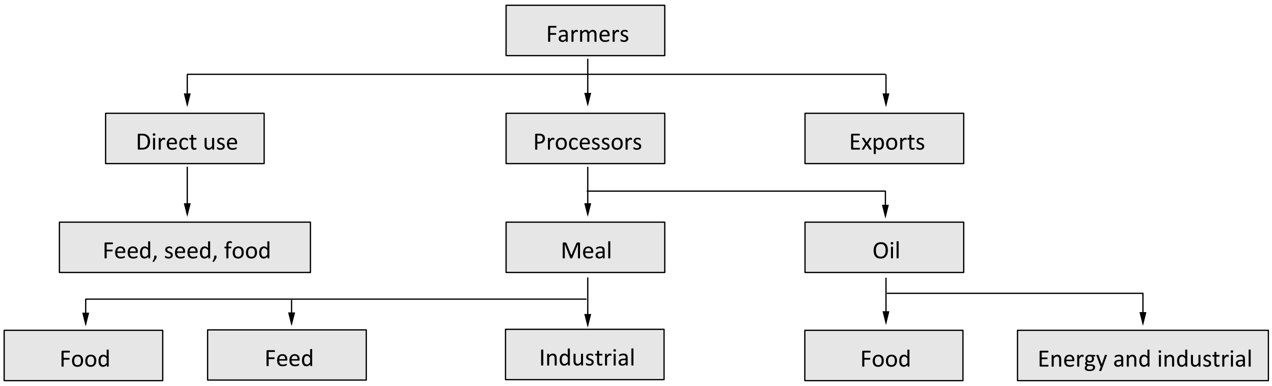
[1] As the value was reported by MDIC (2012) in US$ without citing the applied exchange rate, the value was adopted in US$. This holds good for all values reported in US$ in the text.

vegetable oil. They are used for animal fodder, mostly in form of toasted soy meal[2] that can contain up to 54 % of protein (Endres, 2001, p. 5). The soybean suits industrial purposes like energy and textile production. The principal derived products are meat and - to a rather limited degree - energy in form of, e.g., biodiesel (Goldsmith/Hirsch, 2006, p. 99).

Figure 2.1: Soybean complex - structure of the industry.



Source: Goldsmith (2008, p. 119).

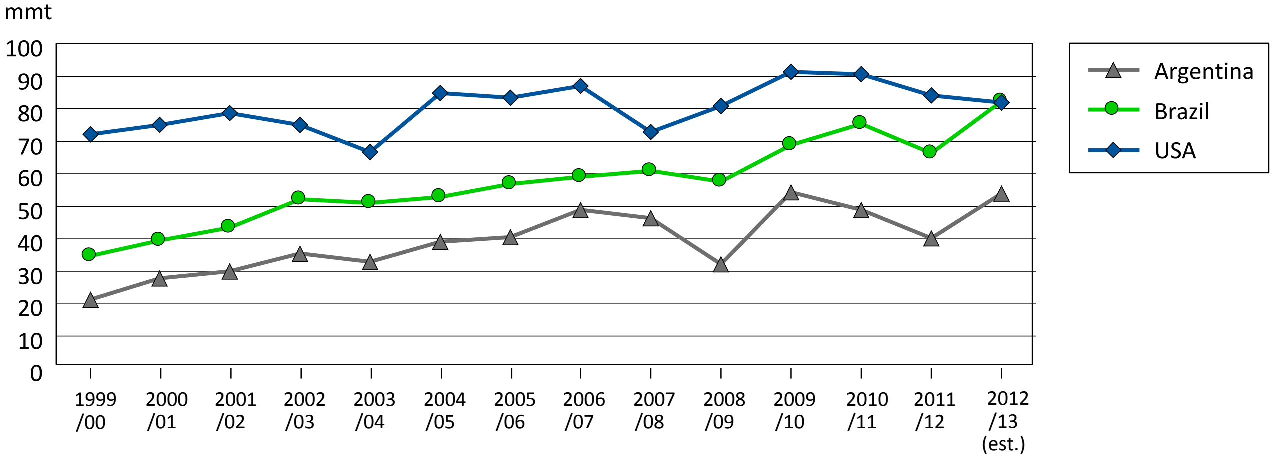
Global soybean production

Brazil belongs to the world's largest soybean producers that include the United States of America [USA], Brazil, Argentina, China and India. Holding a market share of 35 % (2011/12: 84.19 mmt), the USA leads the world soybean production followed by Brazil (28 %; 66.50 mmt) and Argentina (17 %; 41.00 mmt). These three producer countries USA, Brazil and Argentina (presented in figure 2.2) account for 80 % of the volume of the global soybean production. Since 2000/01 the global production increased by 36 % (62.97 mmt), realizing a total output of 238.11 mmt in the 2011/12 season (USDA PSD, 2013).

Imports of soy products are concentrated in Asian and European countries while exports (90.42 mmt) are headed by the USA with a market share of 41 % (2011/12: 37.06 mmt) and Brazil that holds a market share of 35 % (32.08 mmt).

[2] The term is used for soy flours and grits that "are made by grinding and screening soybean flakes either before or after removal of the oil" (Endres, 2001, p. 4).

Figure 2.2: Soybean production of the world's leading soybean producers (1999-2012)



Source: Created by author. Based on data from USDA PSD (2012).

By far the biggest consumer is China with a domestic consumption of 72.07 mmt and imports of 59.23 mmt in 2011/12 (see appendix 5-6). Appendix 7 shows that world consumption and world exports experienced a strong increase since 1996, when China accessed the market (USDA PSD, 2013, custom query).

Development of the soybean production in Brazil

Introduced from China, the first soybean cultivation in Brazil was registered in 1914 in the state Rio Grande do Sul. Natural resource abundance and new technology during the 20th century gave rise to the expansion of the Brazilian soybean industry. Cultivation expanded from the southern regions into the western and northern regions of the country. Governmental incentives for research and development during the 1950s, 1960s and 1970s encouraged the development of new varieties and the adaption of the crop to Brazil's diverse local conditions. The increase of the soybean production area was thereby spurred and large planes of arable land in new cropping areas in the Cerrado, an extensive savannah area in central Brazil encompassing over 200 mha (see appendix 8), were successively covered with soybeans (GOLDSMITH/HIRSCH, 2006, pp. 97).

PARKHOMENKO (2004, p. 143) and GOLDSMITH/HIRSCH (2006, p. 97) underlined the positive effect of a vast demand and favorable world market prices for soybeans in that time on the expansion of soybean production in terms of both area and volume. When Brazil transitioned from military rule to a democratic government, protective policy measures (see appendix 9) were reduced from the late 1980s on and foreign trade increased. Higher import volumes of agricultural inputs like fertilizer, pesticides and machinery boosted agricultural production in the 1990s. This impacted positively on the Brazilian exports of agricultural products so that besides national soybean production exports also accelerated (FLASKERUD, 2003, p. 4; GOLDSMITH/HIRSCH, 2006, p. 98; USITC, 2012, p. 3-24).

Production, consumption and exports

Between 1990 and 2011, the national soybean production grew with a compound annual growth rate [CAGR] of seven percent from 19.90 mmt in 1990 to 32.82 mmt in 2000 and 74.82 mmt in 2011. The area planted with soybeans experienced a slower annual growth rate of four percent from 11.58 mha (1990) to 24.03 mha (2011), 10.34 mha of which were added in the last decade (IBGE, 2012). Productivity per hectare was boosted through the effective use of new technologies, which included artificial soil enrichment and soybean seeds that were engineered for a tropical climate or genetically modified (USITC, 2012, pp. 2-4, 6-15), from 1.72 t/ha in 1990 to 2.40 t/ha in 2000, and to 3.11 t/ha in 2011.

The production of soybeans is concentrated in six Brazilian states (listed in table 2.1), which account for 86 % of the national soybean output. The five principal soybean producing states belong to the South and Center West regions. 38 % (2011: 10.84 mha; 3.12 t/ha) of the total national soybean production area is located in Mato Grosso and Goiás. The area planted with soybeans in the whole Center West region increased by five percent a year from 1990 (3.89 mha) to 2011 (10.84 mha)[3] while in the South the CAGR leveled two percent (1990: 6.16 mha; 2011: 9.09 mha). Due to its naturally fertile soils (Flaskerud, 2003, p. 4), the southern state Paraná has the highest national productivity level (3.39 t/ha). Mato Grosso, on the other hand, holds the leading position in terms of soybean growing area and production volume. It recorded the highest area growth from 1.55 mha in 1990 to 6.46 mha in 2011 (CAGR: 7 %) and the strongest production increase from 3.06 mmt to 20.80 mmt (CAGR: 10 %). In the same period area expansion leveled a CAGR of three percent and six percent in production increase in Paraná state, which led the national soybean production before Mato Grosso overtook the leadership in 2000.

Table 2.1: Major soybean producing states in Brazil (2011)

	Area mha	Production mmt	Productivity t/ha
Mato Grosso	6.46	20.80	3.22
Paraná	4.56	15.46	3.39
Rio Grande do Sul	4.08	11.72	2.88
Goiás	2.57	7.70	3.00
Mato Grosso do Sul	1.76	5.08	2.88
Bahia	1.05	3.51	3.36
Brazil	**24.03**	**74.82**	**3.11**

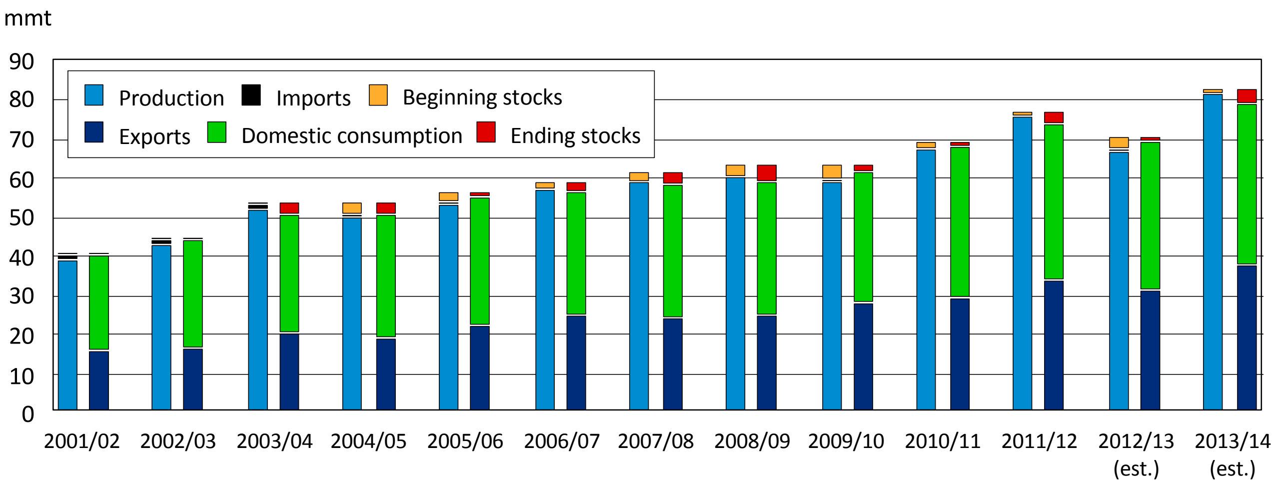
Source: Created by author. Data form IBGE (2012).

[3] The total agricultural production area increased slightly less with a CAGR of 4.5%. The higher increase of area planted with soybeans might be attributed to the adoption of double cropping and GM soybeans.

At the beginning of the 1980s Mato Grosso was still a marginal player within the business (1979/1980[4]: 0.12 mmt; 1.67 t/ha) (CONAB, 2012) but its quantity produced increased by 187 % between 1990 (3.06 mmt; 1.97 t/ha) and 2000 (8.77 mmt; 3.02 t/ha). It developed an above-average productivity (2011: 3.22 t/ha, national average: 3.11 t/ha) and soared to being the state with the biggest production volume (2011: 20.80 mmt). For the time being, Mato Grosso accounts for about 28 % of the national production (IBGE, 2012) and covers a share of approximately 29 % (2011: 9.67 mmt, valued with 4.77 billion US$) of the national soybean exports. 65 % of which (2011: 6.24 mmt) are directed to China (MDIC, 2012).

Brazil's soybean production was growing faster between 2001 and 2011 (CAGR: 7 %) than the domestic consumption level (CAGR: 5 %). Figure 2.3 represents the development of the Brazilian demand and supply over the last decade, which shows that the share of domestic consumption declined from 63 % (24.47 mmt) in 2001/02 to 53 % (40.11 mmt) in 2011/12. In the same period the export volume more than doubled (ABIOVE, 2012).

Figure 2.3: Brazil - demand and supply

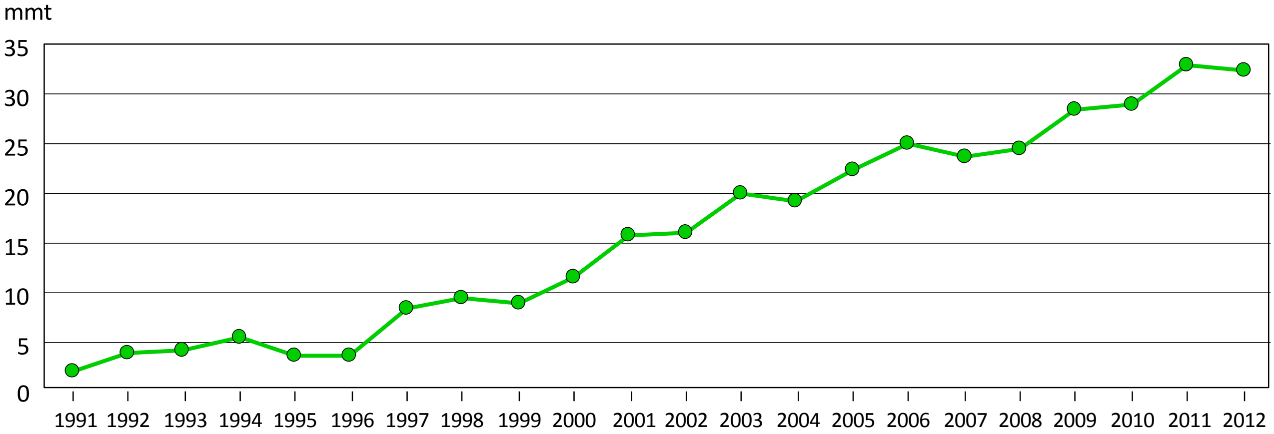


Source: Created by author. Data from ABIOVE (2012).

From 1996 on, when China started to import soybeans, the Brazilian soybean exports increased strikingly (see figure 2.4). In 2011, Brazil exported 32.99 mmt of soybeans with an equivalent value of 16.33 billion US$ (MDIC, 2012). The Brazilian soybeans are distributed to 215 global destinations, of which China is currently the biggest importer whose demanded volumes (22.10 mmt) represented a share of 67 % of the total Brazilian soybean exports. Besides China, the European Union is a principal market for soy products of Brazil, where Spain (2.37 mmt) and the Netherlands (1.52 mmt) are the major importers (MDIC, 2012).

[4] National production volume and productivity in the 1979/80 season: 14.89 mmt, 1.70 t/ha.

Figure 2.4: Brazilian soybean exports (1991-2011)



Source: Created by author. Data from MDIC (2012).

Outlook

According to USDA estimates, Brazil will be the largest soybean grower in the season of 2012/13 (see figure 2.2) and surpass the United States as the world's leading soybean exporter at latest by 2019/20 (USDA, 2012; APROSOJA, 2010). USDA (2012) underlined that, due to very competitive production costs of Brazilian soybean farmers relative to U.S. producers (see appendix 1), Brazil is able to gain enduring export supremacy. The increasing export orientation of the agribusiness firms and cooperatives foments the soybean production volume and area extension (USITC, 2012, pxxi).

Taking into account the natural resource abundance, available technological capacities and rising levels of investment in Brazil, there is according to APROSOJA (2012), GOLDSMITH/HIRSCH (2006, p. 97) and HUERTA/MARTINS (2002) an immense potential for further expanding the soybean production area, e.g., by converting tracts of land in permanent pasture to cropping area (FERREIRA, 2012). In a short term view, the total area planted with soybeans is projected to increase in the 2012/2013 cropping season compared to the previous year by minimum five percent (1.38 mha), of which more than 489 tha will be added to Mato Grosso's planting area (CONAB, 2012a, p. 27).

HIGHQUEST PARTNERS (n.d.) estimated the total production volume cited by APROSOJA (2010) to annually increase by five percent to a volume of 112 mmt in the year 2020 (see appendix 10). The states of Mato Grosso and Paraná are estimated to remain the soybean producing states with the highest yields (CONAB, 2012a, p. 27). The projections are based on expectations of future improvements like eased access to markets via an enhanced infrastructure, boosted domestic consumption by increased per capita income and the adaption of the cultivar to previously unsuitable regions by the development of new seeds (USITC, 2012, pp. 2-4; USSEC, 2011, pp. 17).

Agricultural Policies

Supportive agricultural policies favored the production of raw materials with destination export. An example of such policy measure is the Kandir Law of 1996 that promoted exports of soybeans by exempting exports of raw and semi-elaborated products from the ICMS tax[5]. Prior to the law unprocessed soybeans were taxed more than the processed soy products. This reflected a distorting disadvantage for exporting raw soybeans if its transports had to cross different states to reach the export port, while it favored the domestic crushing in the state of origination or adjoining states (PARKHOMENKO, 2004, p. 143). The expansion of agricultural production to the Central West pushed soybean supply far from traditional consumption regions in the South and Southeast and its well-developed transportation infrastructure (GOLDSMITH/HIRSCH 2006, p. 99). Exporting soybeans from the remote regions became more expensive in terms of fiscal and transportation costs due to long-distance shipping via different states to the seaports and a deficient infrastructure in the Central West (see chapter 2.3). With regard to the national interests of export expansion and foreign exchange inflows, the Kandir Law exempted exports of raw and semi-elaborated products from the ICMS. It aimed to mitigate some of the distortionary effects of the ICMS tax and spur soybean exports. MAPA (2007, pp. 16) reported that after the tax relieve and the consequential diminishment of costs for exporters there was a shift of firms from domestic processing to exporting raw soybeans[6].

2.2 Selected regions relevant for the export

In order to investigate the current situation of soybean logistics in Brazil, four soybean production regions (represented in figure 2.5 by x_1 to x_4) and their export flows to one seaport were analyzed. The county with the major production and export volume, i.e., Sorriso in Mato Grosso, and the seaport with the major share of its soybean exports were selected as principal points of reference for the case study. The export route from Sorriso to Santos (outlined by the arrow in figure 2.5) is henceforth referred to as the Sorriso-Santos corridor. To illustrate the influence of the travel distance from region of origination to port on total logistics costs, further three counties, i.e., Rondonópolis-MT, Rio Verde-GO and Barretos-SP, were selected for detailed analysis according to the following criteria:

- relevance of the production region for the Brazilian soybean exports;
- geographical position close to the Sorriso-Santos export corridor;
- comparable distances from one location to another;

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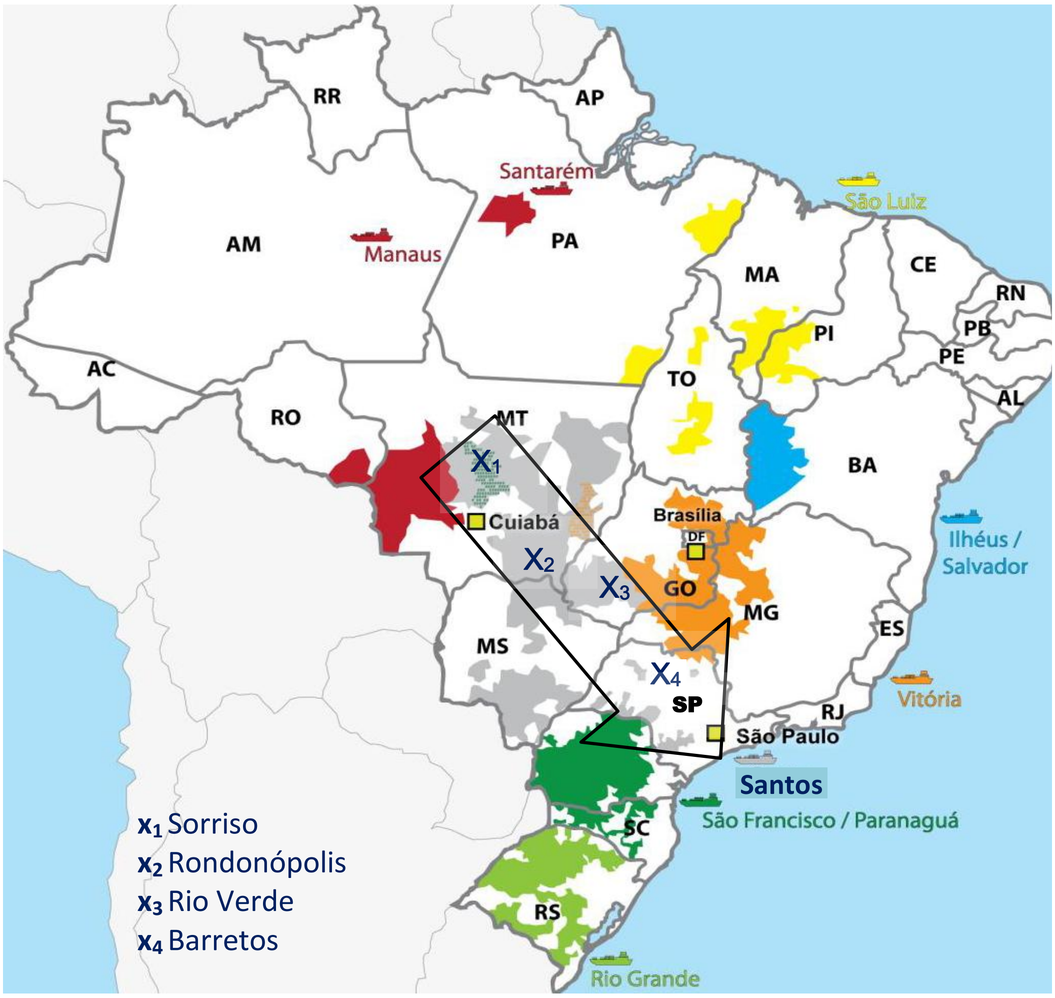
[5] ICMS is a state-run value-added tax on the circulation of goods and on transportation and communication services. It is incurred when production and utilization occur in different states, i.e. discouraging interstate commerce and exports of value-added goods if origination and processing or exportation occur in different states (GOLDSMITH/HIRSCH, 2006, p. 100).

[6] The share of raw soybeans at total exports of the soybean complex increased from 12% at the beginning of the 1990s to 38% at the beginning of the 2000s (MAPA, 2007, pp. 41).

- shaping of a gradient line in terms of kilometers travelled within the Sorriso-Santos corridor, integrating all selected regions.

Figure 2.5: Sorriso-Santos soybean export corridor



Source: APROSOJA (2011). Modified by author.

The principal export port for products of the Brazilian soybean complex is Santos port, where 28 % of the national soybean exports are turned over. In 2011, 90 % (9.23 mmt) of this volume was originated in the states Mato Grosso (6.05 mmt), Goiás (1.41 mmt) and São Paulo (0.86 mmt) (MDIC, 2012). A big part of the Santos soybean exports is originated in the largest production area of Mato Grosso that is centrally located along the highway BR-163 between Cuiabá and Sinop. The region includes the municipalities of Lucas do Rio Verde, Nova Mutum and Sorriso (IBGE, 2012). Part of its agricultural products are shipped towards the northern ports of Santarém and São Luiz, which handle most of the soybean exports originating in north and west Brazil. But the major share of the exported volume, which is 83 % in the case of Sorriso, leaves the country via Santos.

The other selected counties are also important regions for soybean production or trading. Soybean production is in Rondonópolis of marginal importance but the county is a commercial center where large volumes of soybeans and other agricultural inputs and products are traded (OSAKI, 2012). Rio Verde, however, has one of the major cultivation areas of soybeans and corn in Brazil (PARKHOMENKO, 2004, p. 148; IBGE, 2011) and accounted for three percent of the soybeans turned over at Santos port in 2011 (MDIC, 2012). In a national comparison Barretos is a marginal producer of soybeans and accounts only for a small volume of soybean exports. Nevertheless, it is a representative agricultural production area of São Paulo and belongs to the state's principal soybean production regions (FAESP, 2011). It was chosen for being situated close to the seaport and conveniently located on the route Sorriso-Rondonópolis-Rio Verde-Santos. The selected counties are described in detail in the subsequent subchapters.

2.2.1 Sorriso-MT

Sorriso-MT comprises an area of 9,330 km^2 with a population density of 7.13 people/km^2 (IBGE, 2010a)[7]. Sorriso is located in central Mato Grosso about 2,000 km distant from the northern and eastern Brazilian coast (2,100 km to Santos port). Sorriso generates the highest total soybean yields in Brazil (IBGE, 2012). To export the soybeans large distances have to be overcome. As there is no direct access to the railroad network or waterway system, road transportation is inevitable to move the soybeans to the economic centers and transshipment terminals.

The agricultural sector contributed with 32 % (647,021 R$) to the GDP (2.04 million R$). Sorriso's total harvested area encompassed 875,730 ha, producing a value of 1.89 billion R$ in 2011, when Sorriso was generating the highest production value of agricultural products in Brazil (IBGE, 2011, p. 23). Soy is the most important product of the region. With a production of 2.09 mmt in 2011 (see table 2.2), Sorriso accounted for three percent of the Brazilian soybean production volume (74.8 mmt).

[7] Most recent data available by IBGE (2010a) on GDP for the four municipalities are from 2009, data on population are based on the population census conducted in 2007. For reasons of comparability appendix 11 represents most important numbers of 2009 on municipal, state and federal level of the selected regions.

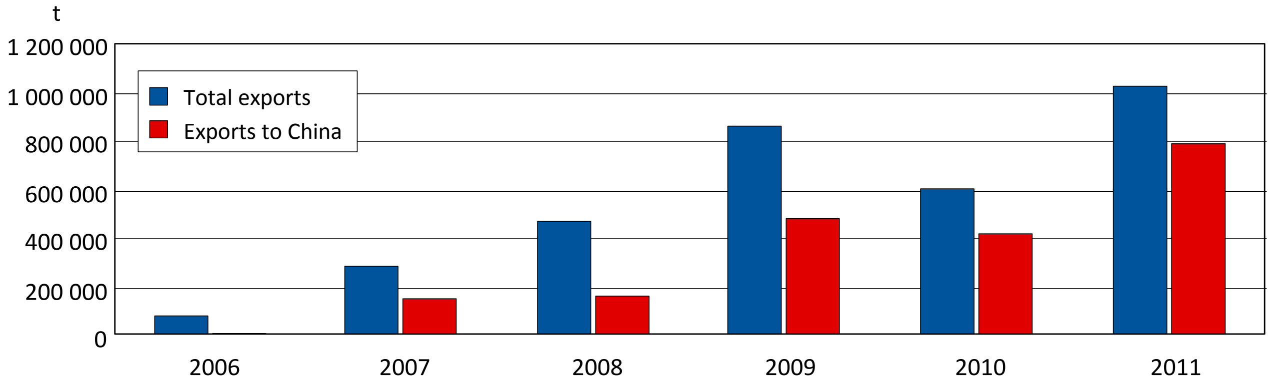
Table 2.2: Sorriso - soybean production and exports (2006-2011)

	Sorriso - MT				
Year	Area ha	Quantity t	Value R$	Exports t	Export share %
2006	597,858	1,789,974	483,293,000	92,016	5
2007	543,000	1,662,666	631,813,000	292,876	18
2008	575,000	1,794,000	1,058,460,000	481,482	27
2009	590,000	1,840,800	1,067,664,000	867,591	47
2010	608,000	1,814,400	725,760,000	605,342	33
2011	600,200	2,088,540	1,420,207,000	1,034,816	50

Source: IBGE (2012), MDIC (2012).

About 50 % of which (1.03 mmt) is exported. This volume represents three percent of the national soybean exports (32.99 mmt). 77 % of Sorriso's soybean exports in 2011 were shipped to China. This share had increased within only five years from 0.01 mmt in 2006 (14 % of Sorriso's soybean exports) to 0.80 mmt in 2011 (MDIC, 2012) (see figure 2.6).

Figure 2.6: Sorriso - soybean exports (2006-2011)



Source: MDIC (2012).

To perform the typical crop rotational system soybeans are produced as summer crop and corn *safrinha*[8] is harvested as winter crop. The area planted with soybeans slightly decreased from 608,000 ha (2010) to 600,200 ha (2011), which KLASENER (2012) justified with a loss of area to corn as summer crop due to a favorable development of world market prices. Nevertheless, medium productivity increased from 2.98 t/ha (2010) to 3.48 t/ha (2011)[9], which notably outlines the national average productivity of 3.12 t/ha (IBGE, 2012).

[8] The cultivation of the second culture is called corn *safrinha*, the 'small harvest' (PARKHOMENKO, 2004, p. 150).

[9] Contributing to this gain might have been a favorable climate as productivity in adjacent production regions also increased, e.g., by 8% in Lucas do Rio Verde-MT. Even though, the increase in Sorriso is strikingly higher by 17%.

2.2.2 Rondonópolis-MT

Rondonópolis encompasses a total area of 4,159 km² with a population density of 47.00 people/km² (IBGE, 2010a). The county is situated in southeast Mato Grosso at the traffic hub, where the two principal soybean export highways BR-163 and BR-364 meet. With all truck transports, which are driving up or down the BR-163 and BR-364, going past Rondonópolis, the city is strategically situated on the Sorriso-Santos corridor.

Agricultural production contributes only a minor share of six percent to the GDP (192 million R$), while 70 % of the GDP are generated by the service sector (2009: 2,345 million R$). The local industries benefit from the inputs carried from the southwestern seaports and agricultural products from Mato Grosso's farms. Plenty of haulers and transportation companies that ship agricultural goods to the intermodal terminals of Alto Araguaia-MT (rail terminal) or São Simão-GO (river port) as well as to the seaports and return with agricultural inputs are settled in the city (ANTUNES, 2012; ANONYMOUS 4, 2012). The trade balance of Rondonópolis reveals a high volume of imports (2011: 2.16 mmt). 98 % of which (2.11 mmt) are agricultural inputs like fertilizer, pesticides and herbicides (COMEX/MDIC, 2011, Rondonópolis PPEXP).

In 2011, soybeans were planted on an area of 73,000 ha. The total yield comprised a volume of 227,760 t (IBGE, 2012). As a large volume of soybeans was purchased from other regions like Sorriso region (OSAKI, 2012), soybean export volumes exceeded production quantities in the past (see table 2.3).

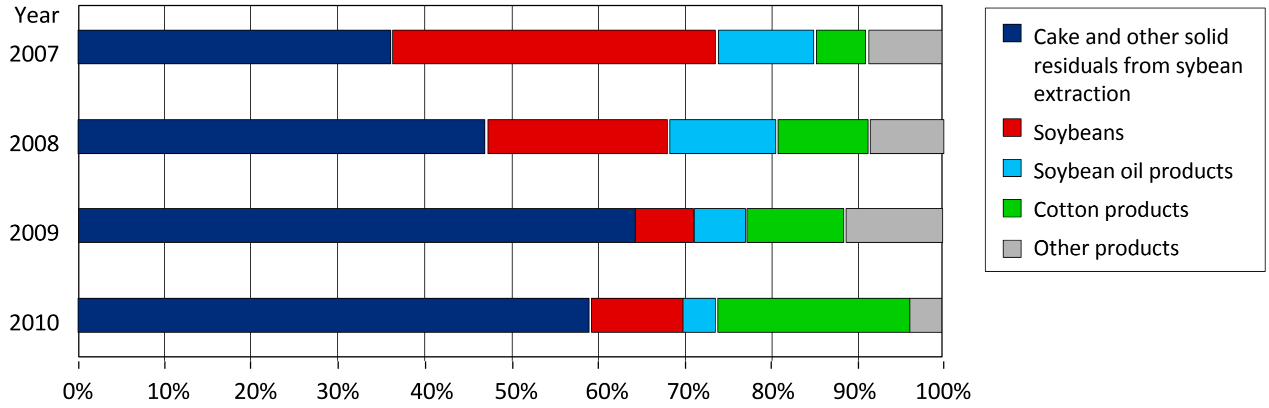
Table 2.3: Rondonópolis - soybean production and exports (2006-2011)

	Rondonópolis - MT				
Year	Area ha	Quantity t	Value R$	Exports t	Export share %
2006	69,000	173,880	50,425,000	1,993,488	1,146
2007	59,000	182,900	72,246,000	1,681,424	919
2008	63,000	195,300	105,657,000	579,442	297
2009	72,000	223,200	133,920,000	159,317	71
2010	75,000	225,000	137,250,000	251,799	112
2011	73,000	227,760	148,044,000	129,757	57

Source: IBGE (2012), MDIC (2012).

A big part of the volumes of soybeans produced or purchased is processed in big soybean crushing plants of trading companies. The processing capacities increased in recent years, which might explain the decline of the soybean export volume with an increase in export products of processed soybeans (see figure 2.7). The still ongoing construction of a new rail terminal in Rondónópolis promises a further growth of trade by simplifying the access to the southern seaports (ANONYMOUS 3, 2012).

Figure 2.7: Rondonópolis - Exports by product (2007-2010)



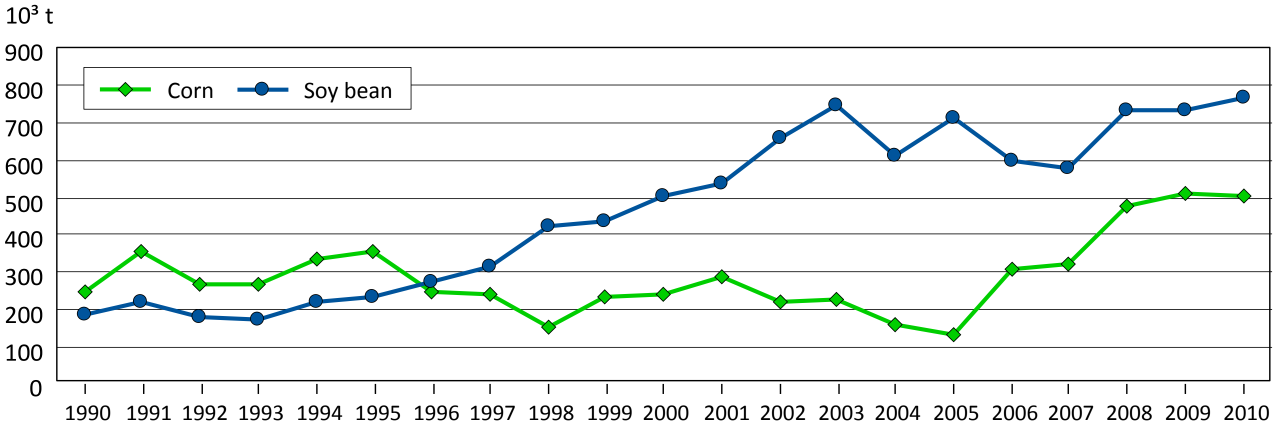
Source: IBGE (2010a).

2.2.3 Rio Verde-GO

Rio Verde comprises an area of 8.380 km^2 with a population density of 21.05 people/km². It is located in centersouth Goiás and belonged in 2011 to the eleven municipalities, which contributed most to the value of national agricultural production (916,419,000 R$; c.f. Brazil: 195,623,606,000 R$). Rio Verde has the largest agricultural production area (440,955 ha) of Brazil, 60 % of which (265,000 ha) were in 2011 used for soybean cultivation (IBGE, 2012; IBGE 2011, p. 23). The principal agricultural products cultivated are soy and corn (PREFECTURE OF RIO VERDE-GO, 2010), which together constitute the typical crop rotation of the region with soybeans planted as summer crop and corn as winter crop (SILVA M., 2012, OSAKI, 2012).

Corn production experienced a strong increase in recent years (see figure 2.8) that might have been due to favorable climatic conditions as well as favorable world market prices, spurring the expansion of corn cultivation (GLOBO NOTÍCIAS, 2012; KLASENER, 2012). With a produced quantity of 1.27 mmt of both corn and soy, Rio Verde participated with one percent in the 2011 national corn and soy production (1.49 mmt) and is the largest grain and legume producer of Goiás (IBGE, 2012). Products from soybeans and corn, either raw or processed, hold a share of 98 % in the total municipal exports (2011: 731 mmt), where raw soybeans represented a share of 36 %. (COMEX/MDIC, 2011, Rio Verde PPEXP).

Figure 2.8: Rio Verde - corn and soybean production (1990-2010)



Source: IBGE (n.d.).

As plenty of industry is settled in the region, the major share of the locally produced soybeans are traded on the domestic market (see table 2.4) and processed in the local factories (ANONYMOUS 3, 2012). Even though, Rio Verde accounts for one percent of Brazil's exports of raw soybeans (MDIC, 2012). In 2011, a soybean volume of 826,800 t valued with 523.36 million R$ was produced, representing one percent of the national soybean production. While planted area remained constant, production volume increased by eight percent compared to the previous year (2010: 768,500 t) and medium productivity leveled the national average of 3.12 t/ha (IBGE, 2012).

Table 2.4: Rio Verde - soybean production and exports (2006-2011)

	Rio Verde - GO				
Year	Area ha	Quantity t	Value R$	Exports t	Export share %
2006	250,000	600,000	199,800,000	50,497	8
2007	230,000	579,600	250,967,000	27,972	5
2008	235,000	733,200	403,260,000	13,884	2
2009	245,000	735,000	514,500,000	181,167	25
2010	265,000	768,500	384,250,000	164,494	21
2011	265,000	826,800	523,364,000	370,163	45

Source: IBGE (2012), MDIC (2012).

2.2.4 Barretos-SP

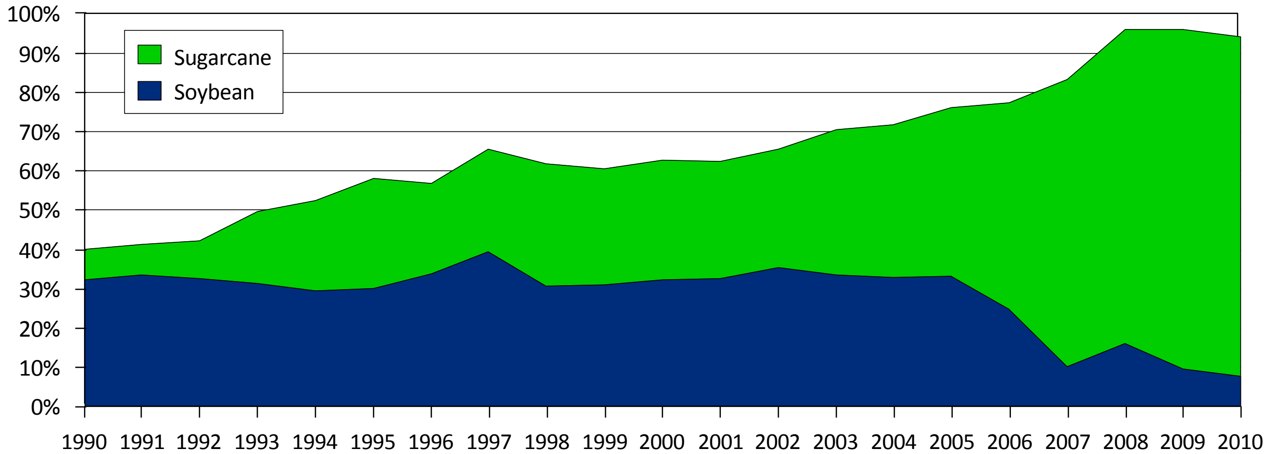
Barretos comprises an area of 1,566 km^2 with 71.58 people/km² (IBGE, 2010a). It is located in close proximity to the border to Minas Gerais state in the North of São Paulo, which is the state that contributed most to the generated value of agricultural production in 2011 (SP: 18 %, cf.

MT: 11 %) (IBGE, 2011, p. 21). However, São Paulo participated slightly with two percent in the 2011 national soybean production (71.82 mmt). With the yield of 1.27 mmt, which was generated on 488,342 ha, its productivity of 2.60 t/ha was below national average (3.11 t/ha) (IBGE, 2012).

Barretos can be described as a marginal area for soybean production, where the oilseed competes with sugarcane and dairy. In 2011, soybeans were cultivated on an area of 6,000 ha (8 % of the total agricultural production area of 73,272 ha) and yielded a production volume of 14,400 t, which represented a below-average productivity of 2.40 t/ha (IBGE, 2012). The legume is commonly used in the crop rotation with the perennial sugarcane culture (DIAS, 2012).

As like in São Paulo state[10], the area planted with soybeans decreased in Barretos since 2005 (see figure 2.9). In the mean time, the planted area with crops that have a high production value, most notably sugarcane, was extended (CONAB, 2012). Nevertheless, Barretos is one of the major soybean production regions of São Paulo state (FAESP, 2011).

Figure 2.9: Area harvested in the county of Barretos (%)



Source: IBGE (n.d.).

Even though, soybeans are of marginal relevance for Barretos' exports, which are dominated by meat products (90 % of local exports). In 2011, a small quantity of 1,723 t of soybeans was exported (see table 2.5), which represented two percent of Barretos' total exports (91.697 t), with all of it leaving the country via Santos (COMEX/MDIC, 2011, Barretos PPEXP).

[10] 75% (5.22 mha) of the agricultural area of the state (6.96 mha) was planted with sugarcane (yield: 427,36 mmt). Soybeans were cultivated on 488,342 ha, which represented only 7% of São Paulo's agricultural area, with a total production quantity of 1.27 mmt (IBGE, 2012).

Table 2.5: Barretos - soybean production and exports (2006-2011)

	Barretos - SP				
Year	Area ha	Quantity t	Value R$	Exports t	Export share %
2006	17,530	42,540	17,654,000	n/d	-
2007	7,330	19,791	9,302,000	n/d	-
2008	12,500	33,750	24,580,000	n/d	-
2009	7,000	17,640	10,584,000	n/d	-
2010	6,000	16,200	10,740,000	n/d	-
2011	6,000	14,400	10,224,000	1,723	12

Source: IBGE (2012), MDIC (2012).

2.2.5 Santos port

Seaports play a critical role that play in the country's access to the international market. About 90 % (700 mmt) of Brazil's total exports of goods is shipped to international destinations via the seaports (SEP, 2012). The principal seaports for soybean exports, which handle 81 % (26.97 mmt) of the soybean exports, are situated in the South and Southeast (see appendix 12).

Santos is the principal trading port for Brazilian soybeans, where 28 % of the Brazilian soybean exports are operated (2011: 9.23 mmt). The total volume of goods exported in 2011 via the port was 62.88 mmt (CODESP, 2011, p. 43). According to the World Bank (2010), more than 70 % of the total volume traded at Santos are agricultural and food products. The main commodities traded include sugar (2011: 16.93 mmt, 27 % of total exports), soybeans in raw or crushed form (9.77 mmt, 16%) and corn (4.57 mmt, 7 %) (CODESP, 2011, p. 48, 49). About 65 % of the soybean volume exported via Santos is transshipped between January and May (2010: 5.49 mmt; 2011: 5.29 mmt), corresponding with the productive months of the harvesting season (see chapter 4.1.3 and appendix 13). 80 % (7.43 mmt) of the volume was in 2011 directed to China (MDIC, 2012). The seaport is particularly for soybeans originated in the Sorriso-Santos corridor an important transshipment point (see figure 2.5). Here, 83 % (0.86 mmt) of Sorriso's total exports (1.03 mmt) and 97 % of the exports of soybeans originated in Rio Verde are handled.

Table 2.6 represents the volumes of the selected production regions exported via Santos port. Soybeans from Rondonópolis are distributed to all of the southern ports. Barretos that plays a marginal role as a soybean producer and exporter is in terms of soybean export volumes of no relevance for Santos, although it exports only via Santos (MDIC, 2012).

Table 2.6: Santos - soybean export volumes of selected regions (mmt)

	2011	2010	2009	2008	2007	2006
			mmt			
Sorriso-MT	0.86	0.50	0.59	0.38	0.07	0.01
Rondonópolis-MT	0.06	0.11	0.05	0.18	0.41	0.64
Rio Verde-GO	0.37	0.16	0.18	0.01	0.03	0.05
Barretos-SP	0.00	0.00	0.00	0.00	0.00	0.00
Total	**9.23**	**8.23**	**8.67**	**7.16**	**4.53**	**6.96**

Source: MDIC (2012).

Centrally located at the coast of the state São Paulo, the port extends along an estuary from the Atlantic Ocean (CODESP, 2012). FIESP (2012) reported a width of 100.00 m and a maximum depth of 13.50 m so that even big vessels like Panamax bulkers that draw up to 12.04 m of water (PANAMA CANAL AUTHORITY, 2005) are able to dock at Santos port. The WORLD BANK (2010, p. 43), however, revealed that the operational draught is limited to 11.80 m and judged the access by water as unsatisfactory.

Access by land was judged as critical. Despite offering extensive road and rail networks, São Paulo State and, hence, Santos lack basic intermodal integration and suffer from continued bias towards road-based transport (USITC, 2012, p. 3-17). Figure 2.10 illustrates Santos' connection to the national road and rail system. The railways of MRS Logística and AMÉRICA LATINA LOGÍSTICA [ALL] are terminating at the port. However, a study performed by the WORLD BANK (2010) found that 57 % of grain cargo and food products is being carried to Santos port by trucks. The limited inland port access and insufficient reception capacity of trucks, especially during peak harvest periods, lead to delays and demurrage costs for ships waiting to be loaded as well as for trucks waiting to be unloaded, respectively (USITC, 2012, p. 3-17).

Figure 2.10: Connection of Santos port to the national transport system

Source: MINISTRY OF TRANSPORT (2012). Modified by author.

Santos port, which is operating 24 hours during seven days per week, is administered by the federal dock company Companhia Docas do Estado de São Paulo (CODESP, 2012). Despite the public ownership, most public ports are run by private terminals. Exports of soybeans are at Santos only handled at private terminals. Since 1995 the port authorities issued concessions of 20 years or more to port operators who handle the port operations and take care of the port's infrastructure. The system is a result of a government regulatory reform and privatization efforts in the 1990s (see appendix 14) that aimed to generate private sector investments in infrastructure like the construction of warehouses (Anonymous 2, 2012; USITC, 2012, pp. 3-14). For the time being, 45 warehouses that are located within the port area, and 39 external warehouses offer a total storing capacity of 416,395 t (FIESP, 2012). But, according to Anonymous 2 (2012) and USITC (2012, p. 3-18), investments are being discouraged by the time limit of the concession. Hence, outdated equipment, labor intensive port processes and inadequate port administration are generating inefficiencies (EIU, 2010, p. 11).

2.3 Characteristics of soybean logistics and transportation in Brazil

The Council of Supply Chain Management Professionals (2012) defined logistics as "process of planning, implementing, and controlling procedures for the efficient and effective transportation and storage of goods including services, and related information from the point of origin to the point of consumption for the purpose of conforming to customer requirements". To ensure efficient and effective transportation and storage the logistics process needs to be well managed.

The USITC (2012, p. 3-1) judged transportation infrastructure as one of the factors that most broadly affect Brazilian agricultural competitiveness. A developed transportation infrastructure can benefit the industries to competitively produce, move, store and market the goods in domestic and export markets. A poor transportation infrastructure, on the other hand, may impact on delivery cost and reliability of supply.

The five principal modes of transportation are road, rail and water transport as well as aviation and pipeline (Mangan/Lalwani/Butcher, 2008, p. 5). Distance and time of delivery are directly influencing transportation costs and reliability of supply. Therefore, driven speed as well as the geographical locations of the transport's origin and domestic destination are key factors for the selection of the transport mode. In order to ensure an efficient logistic process without breakdowns and minimize costs, the choice is determined by the transport medium's costs, speed, flexibility, local access and available capacities. The primary restriction is the existing infrastructure network in the region of activity.

Soybeans in granular form are handled as bulk cargo, which is generally transported in large volumes and shipped via road, railroad or waterway. Transportation by air and pipeline is not relevant for soybean shipping. Due to high flexibility, frequency and speed, trucking is advantageous for short-distance transports of soybeans (see table 2.7 and appendix 15). But soybeans and its domestic movements are characterized by seasonality, long distances, great quantities and low quotients of value to freight. While trains and barge convoys can intake volumes of minimum 6,000 t (GARCIA, 2012; SANTOS/CARDOSO/MOITA, 2012, p. 69), the biggest Brazilian truck model for soybean transports carries 57 t net weight (ANTUNES, 2012). LORETI (2011, pp. 23) considered accordingly rail and waterways as the most suitable options for the transportation of agricultural products and soybeans in Brazil. Both modalities offer efficient shipping of large quantities over long distances at low costs per unit (USDA, 2010, pp. 200) and, due to their lower fuel consumption compared to a truck[11], lower GHG emissions per tkm (see chapter 2.3.6) (APROSOJA, 2011; MANGAN/LALWANI/BUTCHER, 2008, p. 135). Based on data from 2002 to 2004 CAIXETA-FILHO (2006, p. 2) compared average freight costs for soybean transportation in Brazil and confirmed that waterway transportation is the cheapest and road transportation the most expensive mode. He revealed that road freight costs twice as much as waterway freight (see appendix 16). For 2011, MONTEIRO/SEBBEN/GOLIN (2011, p. 3) analyzed that transportation of one ton of cargo via road is about 3.8 times more expensive than transporting the same amount via waterway.[12]

Table 2.7: Comparison of transport modalities relevant for soybean shipping

	Fixed costs	Variable costs	Capacities	Speed	Flexibility	Frequency	Suitable distance
Road	low	high	low	high	high	high	short
Railway	high	low	high	medium	medium	medium	long
Waterway	medium	low	high	low	small	low	long

Source: Loreti (2011). Modified by author.

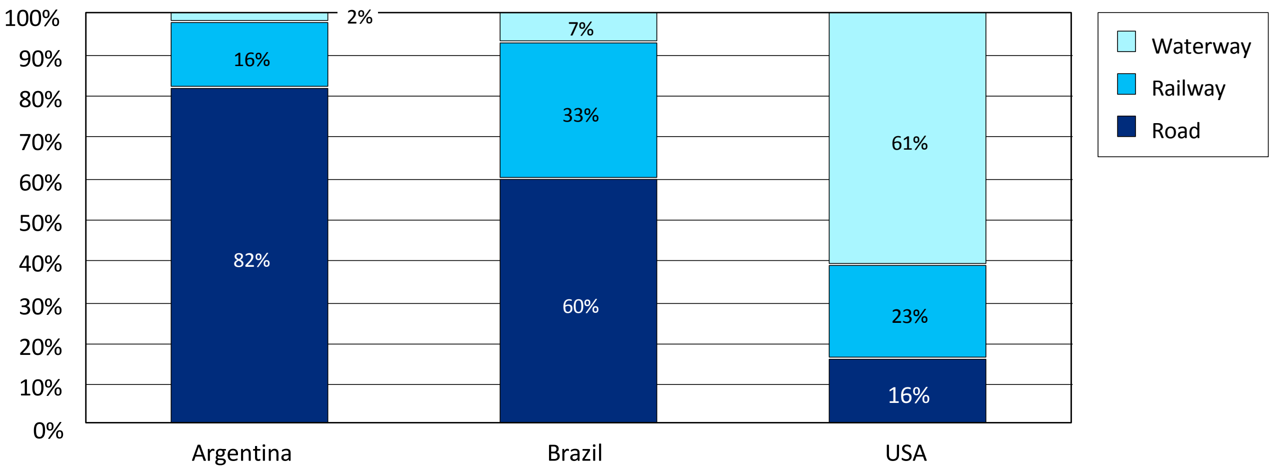
The disposability of trucks in even distant rural areas and its flexibility with respect to route planning and loading or unloading stations is particularly important for the Brazilian agribusiness as the major soybean production regions are distant to the coastal ports without necessarily having direct access to waterways or railways (CAIXETA-FILHO, 2006, p. 2). Inferentially, road transportation is obligatory for transporting soybeans from farm to warehouse and point of transshipment.

Figure 2.11 demonstrates the dependence of the Brazilian soybean transportation matrix on road transportation. Whereas in the USA 61 % of soybeans are shipped via the interior waterway system and 16 % by truck, it is a share of 60 % of Brazilian soybeans (approximately 45.20 mmt) that is moved via the national road network.

[11] According to AFONSO (2006, p. 89) a barge travels a distance of 219 km with one liter of fuel and one ton cargo while a train travels 86 km and a truck 25 km.

[12] Costs per tkm reported by MONTEIRO/SEBBEN/GOLIN (2011, p. 2): 17 US$/tkm (waterway), 65 US$/tkm (road).

Figure 2.11: Transport matrix for soybean shipping



Source: Created by author. Based on ABAG (2005).

NUNES (2010, pp. 53) and CAIXETA-FILHO (2003, p. 2) explained the predominance of the road mode by the larger extension of installed highways[13], due to concentrated governmental investments in the road system during the 1950s and 1960s, as well as by difficulties faced by the other transport modalities to supply the mostly remote production regions. LÍCIO (1995) outlined the relevance of access to infrastructure and the integration of transportation corridors for inter-modal transportation in order to improve competitiveness of the agricultural products and inter-connect production areas with the national and international markets. Accordingly, CAIXETA-FILHO (2003, p. 2) reasoned that the use of the rail and waterway modes, either unimodal or combined with the road mode, reflects competitiveness-related advantages.

2.3.1 Road transportation

The Brazilian road network links producers, manufacturers and service industries to grain elevators, processing plants, markets and ports. Agricultural inputs like fuels and fertilizers are carried to the production sites and agricultural goods shipped to the domestic destination via the roads. However, the quality of the road networks is of great disparity. Despite constituting 60 % of the needs for soybean transports (see figure 2.11), only fourteen percent of the total 1.58 million km of roads and only two percent of the roads under municipal administration are paved (see table 2.8).

[13] Road network: 1,583,331 km; railroad network: 30,051 km; navigable waterways: 29,000 km (CNT, 2012c).

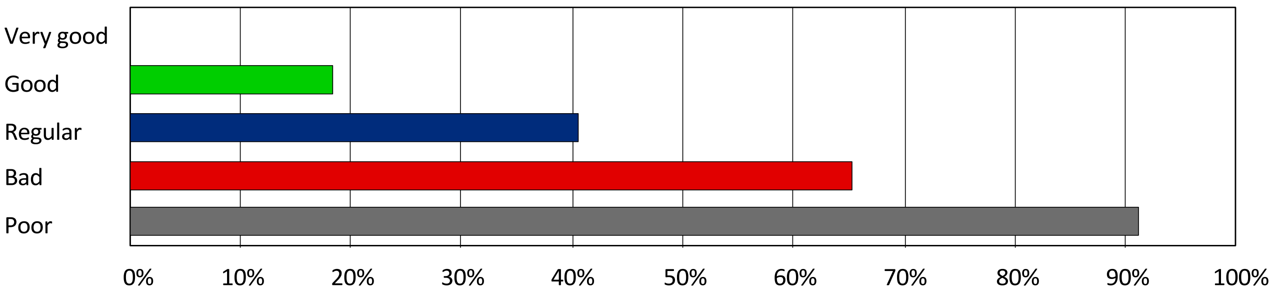
Table 2.8: Brazilian road system extension (km)

		Paved	Non-paved	Total
Federal	km	64,165	12,817	76,982
State	km	110,842	111,334	222,176
Municipal	km	26,827	1,234,918	1,261,745
Total	**km**	**219,089**	**1,364,242**	**1,583,331**
Share	%	13.8	86.2	100.0

Source: Created by author. Based on data of CNT (2012c).

According to a recent survey (CNT, 2012a), 63 % of the paved Brazilian roads (60,053 km) are in regular, bad or poor shape (see appendix 17). Lacking maintenance of the surface reportedly generates infrastructural deficiencies that directly influence operational costs of vehicles (see figure 2.12) and may lead to a lengthening of the travel time (CNT, 2011, p. 25). Critical points are holes in the pavement, erosion of track, damaged bridges and obstacles on the street (CNT, 2012a, p. 6). CNT (2011, p. 285) underlined the corresponding effect of increased exhaust emissions. In order to increase private investments the government issued in the 1990s concessions to private entities for operating roads (Flaskerud, 2003, p. 5; USITC, 2012, p. 3-8). 87 % of the tracks under private administration were rated in the 2012 by CNT as good or very good (CNT, 2012, pp. 78). But these are concentrated in the state of São Paulo and Rio de Janeiro whereas long-distance transports from the Center West are principally travelling on public streets. Most of the federal roads within the Sorriso-Santos export corridor are in regular or good conditions, while state administered roads are mainly rated as bad or poor by CNT (2012, pp. 250).

Figure 2.12: Impact of road condition on operational costs



Source: CNT (2011, p. 277).

Since running an own truck fleet incurs high fixed costs, the majority of the soybean marketers takes advantage from contracting transport service providers. These include haulers with own fleet, self-employed drivers with own trucks and transport agencies without fleet. Fleet owners are equipped with a determined number of trucks, offering their logistics services. They are contracted directly either by grain sellers and traders or by transport agencies. Transport agencies act as intermediaries who subcontract third parties. They are contracted by the grain seller or trader to organize the required capacities of trucks and manpower. Estimated 50 % of all transport services are provided by self-employed drivers (NUNES, 2010, p. 58; IPEA, 2011, p. 127) who are also contracted by freight forwarding companies. Those possess an own fleet but often need to enlarge their capacities for accomplishing individual contracts. Big trading companies with an own truck fleet are rare and are generally organizing the transportation in a subsidiary of the company, which might also offer its services on the market.

Transport companies aim to use the vehicle at maximum capacity so that backhauling trucks are in most cases loaded with other products than soybeans (PARREIRA, 2012). The Brazilian fleet consists of 2.33 million trucks (CNT, 2012c) with 32 % of it being heavy-duty trucks (MMA, 2011, p. 27). It is unevenly distributed all over Brazil with a concentration in the South and Southeast. While Mato Grosso is the largest soybean-producing state, only three percent of the national fleet is registered here (USITC, 2012, p. 3-6). During peak harvest season the insufficient local trucking capacities is revealed. The excessive demand has thus to be satisfied by trucks sent from other states. The USITC (2012, p. 3-6) declared this as a driving factor of freight prices and a reason for congestion on deficient roads within the export corridors.

2.3.2 Rail transportation

The Brazilian rail network extends 30,051 km[14] (CNT, 2012c), on which in 2011 a volume of 470 mmt was transported (CNT, 2011a, p. 22). Approximately 50 % of the rail network is concentrated in the South and Southeast of Brazil (see appendix 18), where areas are rich in mineral deposits and agricultural production is strong. The principal goods transported are iron ore and coal (2011: 77 %; 364 mmt) as well as agricultural products (12 %; 55 mmt). Soybeans cover five percent of the total cargo transported on Brazil's railroads with the major part being originated in Mato Grosso (ANTF, 2012). The Brazilian rolling stock, comprising the equipment to form rail compositions, totaled 101,983 cargo wagons and 3,093 train engines in 2011 (ANTT, 2012a, p. 8).

In 1957 the national rail system still extended 37,000 km. A market regulating policy as from the 1960s inhibited private participation while governmental investments were mainly directed to the developing automotive industry and the national road network (ANTT, n.d.). Maintenance of the railroads was widely neglected so that the network deteriorated and diminished in extension (RODRIGUES, 2005 cited by SANTOS, 2007, p. 22). Investments recovered when the state railroad companies were privatized. From 1996 to 1998 the government issued concessions for a period of 30 years in order to spur the productivity of the sector (CASTILLO/VENCOVSKY/BRAGA, 2011, pp. 20; USITC, 2012, p. 3-9). The long-term agreements made investments attractive as the conces-

[14] According to USITC (2012), this represents one seventh the size of the rail network in the USA which extends 225,000 km. Other countries with similar dimensions are Russia with a rail network of 87,000 km, China with a rail network of 86,000 km and India with a rail network of 64,000 km.

sionaires can benefit from the return on profitable investments. As a result, private concessionaires (see appendix 19) currently operate 95 % of the national rail system (28,614 km).

The development of the rail system in the early 20th century was due to the expansion of the Brazilian agribusiness supported by a high participation of private investors. While the individual regional rail networks were extended, they were not linked at a supraregional level. This led to the problem that until today track gauges differ from region to region, which creates difficulties in further integrating the system. Prevailing types of gauge are the metric gauge (1 m), the broad gauge (1.6 m) and mixed gauges (1.0 m to 1.6 m). According to ANTT (2012a, p. 4) the metric gauge accounts for nearly 80 % of the total Brazilian rail kilometers, and predominates in the southern region. The broad gauge accounts for 19 % of total railroads and prevails in the Southeast and Center West region, leaving about two percent mixed. New rail tracks shall use a broad gauge of 1.6 m as it provides better stability to trains (USDA, 2011). The deficient connections of the networks under concession and their different track gauges inhibit the employment of equipment in different regions for maximizing the loading factor and limit the competitiveness of the transportation modality (USITC, 2012, p. 3-9). According to GREGOIRE (2011, p. 7) only ten percent of the rail network is fully utilized. These inefficiencies influence the competitiveness of the soybean business, e.g., by elevated freight rates.

Another effect of this concession model was the emergence of local monopolistic market structures in the rail transport sector as only one concessionaire was appointed per track. The limited competition led to an untransparent monopoly pricing system and increased freight prices, getting close to the price level of truck transport (see also chapter 4.2.1). MONTEIRO/SEBBEN/GOLIN (2011) compared rail freight prices of Brazil and the USA and revealed that rail transport is in Brazil almost three times as expensive per tkm as in the USA over similar distances.[15]

The Center West region is covered by the rail networks ALL - MALHA NORTE [ALLMN] and ALL - MALHA PAULISTA [ALLMP], which together constitute the Santos corridor (CNT, 2011a, p. 79). Both are run by the private company ALL and have the broad gauge (1.6 m), which enables trains to travel from Mato Grosso directly to Santos port (ANTT, 2012a, pp. 4). The ALLMN railroad extends 512 km from Alto Araguaia-MT to Aparecida do Taboado-MS, where it connects to the ALLMP railroad that ends in Santos (ANTT, 2010, p. 11). 250 km of railroad, linking Alto Araguaia and Rondonópolis, are currently under construction (VENCOVSKY, 2011, p. 52).

Soybeans (2010: 3.65 mmt), soy meal (1.82 mmt) and corn (4.84 mmt) account for 98 % of the total volume transported (10.50 mmt) on the ALLMN railroad in direction Santos (ANTT, 2010, appendix). Between 50 % (SILVA, 2010, p. 8) and 80 % (ALL, n.d.a) of the soybean exports from Mato Grosso are transported via this railroad. The area of influence extends principally over southern and central Mato Grosso, including Sorriso, northeastern Mato Grosso do Sul and

[15] Road: 0,051 US$/t/km; Rail: 0,0186 US$/t/km (MONTEIRO/SEBBEN/GOLIN (2011).

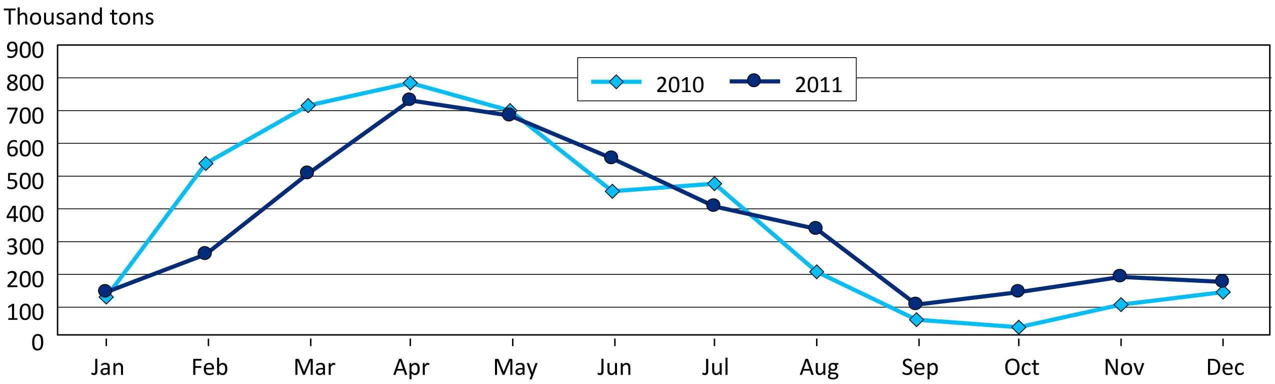
southwestern Goiás, including Rio Verde. The most important intermodal terminal for soybean and corn transshipments is located in Alto Araguaia where about 10 mmt of grains, oilseeds and byproducts are turned over per year (ALL, n.d.a). Returning trains carry principally fertilizers to the Center West (CNT, 2011a, p. 30) but most of the wagons return empty (about 70 %) (GARCIA, 2012). That way, being linked to the rail network of São Paulo state, the ALLMN railroad connects major soybean production regions to the port of Santos.

2.3.3 Water transportation

Even though, as pointed out before, waterway transportation has the lowest costs for bulk transports over large distances the use of this modality is still modest in Brazil (see figure 2.11). The country has a waterway system of 44,000 km and 29,000 km of navigable rivers, of which only 13,000 km (45 %) are used for commercial navigation (CNT, 2012c). In 2011, a total volume of 25.14 mmt has been moved on the inland waterways.

The primary commodity moved on the waterway is iron ore, accounting for 21 % of the total cargo transported (5.32 mmt). Soybeans are the second largest commodity group with 17 % (4.24 mmt) (ANTAQ, 2012a, pp. 26-30). Figure 2.13 illustrates the characteristic of the seasonal output of transportation services. This corresponds with the period of soybean exports from February to September (see chapter 4.1.3). An advantage, as the months of high demand for waterway transports (February-April) coincide with the rainy season whereas a low water level during dry season including August to December can paralyze transportation activities like in 2010 (ANTAQ, 2011, p. 5).

Figure 2.13: Demand for soybean transportation via the waterway (2010-2011)



Source: ANTAQ (2012a).

The NATIONAL AGENCY FOR WATERWAY TRANSPORTATION [ANTAQ] divided Brazil into 12 hydrographical regions, which are illustrated in appendix 20. Only five areas are relevant for cargo transportation, namely the Amazonas region, Tocantins/Araguaia region, Paraná region, Paraguay region and Atlântico Sul region. SANTOS/CARDOSO/MOITA (2012, p. 67) asserted that 90 % of the transported volume is concentrated in the northern region, particularly in the Amazonas region including the waterways Solimões-Amazonas, Madeira and Tapajos.

The waterways of relevance for the selected regions (see chapter 2.2) are the Madeira, Tapajós and Paraná-Tietê waterways. Soybeans produced in western and northern Mato Grosso (2011: 9.67 mmt; MDIC, 2012) leave the state by truck mostly in direction Porto Velho-RO (access to Madeira river) or Itaituba-PA (access to Tapajos river), where the bulk is transshipped to barges and carried over a distance of approximately 1,675 km to the seaport of Santarém-PA (ANTAQ, 2011, p. 5). In 2011, 2.24 mmt of soybeans have been shipped on the Madeira waterway (ANTAQ, 2012, p. 11), where barge convoys of approximately 24,000 t are moving. The Tapajos river (extending 345 km) enables barge convoys with about 7,500 t loading capacities to travel to Santarém. But due to lacking infrastructure in northern Mato Grosso access is limited, wherefore it accounts for a small share of soybean exports yet (no data on volumes available) (RIBEIRO, n.d.; ANTAQ, 2012, p. 16).

The PARANÁ-TIETÊ shipping corridor is the most developed waterway of the country in terms of infrastructure and equipment (ANTAQ, 2012a, p. 23). It extends 1,653 km from São Simão-GO in southeastern direction (ANTAQ, 2012a, p. 24) and transports soybeans from the regions of southern Mato Grosso, northern Mato Grosso do Sul and south Goiás. Barge convoys with capacities up to 4,800 t (RIBEIRO, n.d.) carry the cargo from São Simão-GO to Pederneiras-SP (about 680 km), where exported soybeans are transshipped to trucks or train and transported to Santos. In 2011, 1.17 mmt of soybeans and 0.48 mmt of corn have been shipped that way, accounting together for 53 % of total volume transported (3.11 mmt) on the waterway (ANTAQ, 2012, p. 11).

Due to the large volumes that have to be transported in order to make transportation by barges a profitable option, waterway transport is principally utilized by traders with large handling capacities, offering a low-cost transportation alternative for goods originated in production areas in the proximity of the inland waterways. As Brazil's inland waterways, except of the Tietê-Paraná, do not connect the remote soybean production areas with economic centers, intermodality including trucking is necessary to ship soybeans to the seaports (USITC, 2012, p. 3-14).

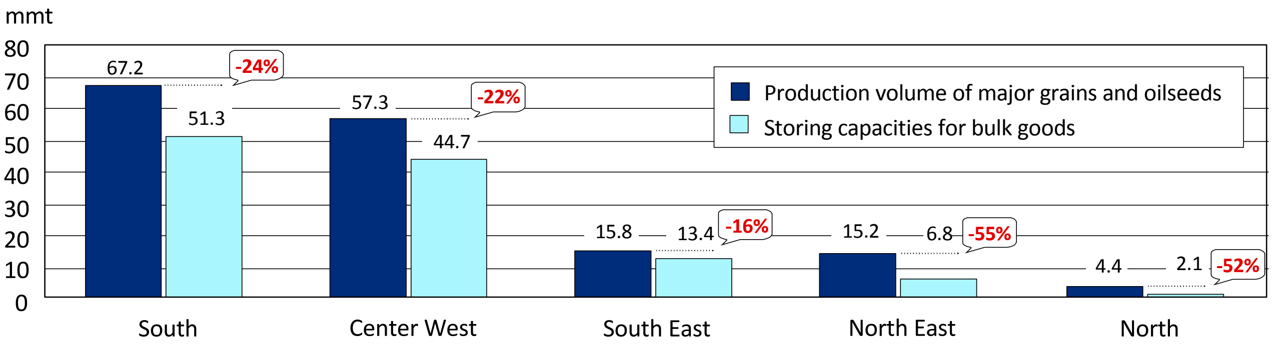
2.3.4 Storage

MATTHÄUS/MÜNCH (2009, p. 113) define storing as a way of keeping goods available over a period of time in order to satisfy demand at a later date and maintaining the goods at a high quality level with minimal loss of substance. Soybeans are stored in silos or flat storage systems (MATTHÄUS/MÜNCH, 2009, p. 126). Elevators realize the transport between tipping gutter of the transshipment station, where the truck is loaded and unloaded, and storehouse. To achieve maximum economic efficiency high intake and discharge capacities as well as low labor requirements are necessary (MATTHÄUS/MÜNCH, 2009, p. 125). According to SEIBEL (2005, pp. 192), those should be between 70 t/h and 120 t/h to avoid long waiting times during harvesting season.

As oilseeds are living organisms whose chemical composition changes with their development (PANIZZI/MANDARINO, 1994, p. 242), soybeans are sensitive to humidity and temperature during storage (MATTHÄUS/MÜNCH, 2009, pp. 94, 104). Post harvest management helps to protect soybeans from deterioration and achieve stabilization on a high quality level with optimum moisture level for handling (SEIBEL, 2005, pp. 228). The moisture level of the seed averages twelve to fourteen percent at harvesting (KLASENER, 2012) and is the major determinant on storability of soybeans (see appendix 21). If the moisture level exceeds thirteen percent drying is necessary to reduce the risks of decreased seed quality and spoilage from, e.g., seed respiration and mold attack (ACASIO, n.d., p. 5). Cooling and ventilation can diminish or inhibit respiration and metabolic processes. These are stimulated by warehouse temperatures higher than the optimum and favor the development of microorganisms like fungi and insects (MATTHÄUS/MÜNCH, 2009, p. 114). The release of toxic gases in small doses into the air is an additional measure to prevent pest infestation (GARCIA, 2012). That way, losses can minimized and the availability of good quality products when needed for marketing at a later point of time ensured (ACASIO, n.d., p. 5). The post harvest management enables to meet the values of the export standard represented in appendix 22, which have to be met for liberating the product for export.

The Brazilian warehousing capacities for grains and oilseeds did not keep pace with the rapid growth of the agricultural production. The country currently suffers a shortage of storage capacities for agricultural bulk goods. For the time being a total volume of 143.22 mmt of static storage capacities is available, 118.22 mmt of which are covered by warehouses specialized on bulk goods (CONAB, 2012b). These warehouses only have the ability to gather 89 % (118.22 mmt) of the volume of the major agricultural bulk goods produced in 2011 (160.17 mmt) (see appendix 23) (IBGE, 2012). Considering that international recommendations suggest a warehousing capacity of at least 1.2 times of the average production volume (GALLARDO et al., n.d., p. 2) the need for further investments is clearly reflected. Distribution difficulties, which arise due to an uneven geographical scattering of warehouses within the country (see figure 2.14), and local deficits in storage capacities make matters even worse (USITC, 2012, p. 3-14).

Figure 2.14: Storage capacities vs. production per macro region (2011/12)



Source: Created by author. Based on data from CONAB (2012) and IBGE (2012), listed in appendix 23.

On-farm storing is in Brazil not very common yet. According to CONAB (2011), only 14 % of rural producers in Brazil[16] have warehouses located on their farms (see appendix 24). The major part of the producers depends on the off-farm storage infrastructure. With the principal share of off-farm warehouses being situated in urban areas (44 %), traffic volume of trucks is locally immense during harvest. 36 % of the warehouse capacities are located in rural areas whereas the Brazilian ports account for six percent of the total storage capacities (MORCELI, 2012).

Warehouses are important to ensure a smooth flow of the supply chain by preventing distribution problems through congestion at transshipment stations and ports during harvest season (GALLARDO ET AL., n.d.). Scarce capacities impede the producer to benefit from higher market prices or lower freight rates at a later point of time. For a limited time seasonality of the crops can hold the balance between supply and demand. But with the beginning of the next harvest, producers are forced to take out the stored soybeans in order to take in the freshly harvested crop (FERREIRA, 2012). Hence, the limited storage capacities lead during harvesting time to a high supply of soybeans and a great demand for transportation services. As a result the commodity price tends to lower while the freight price increases in comparison to the interim periods, impacting negatively on local producer prices (KUSSANO/BATALHA, 2012, p. 625).

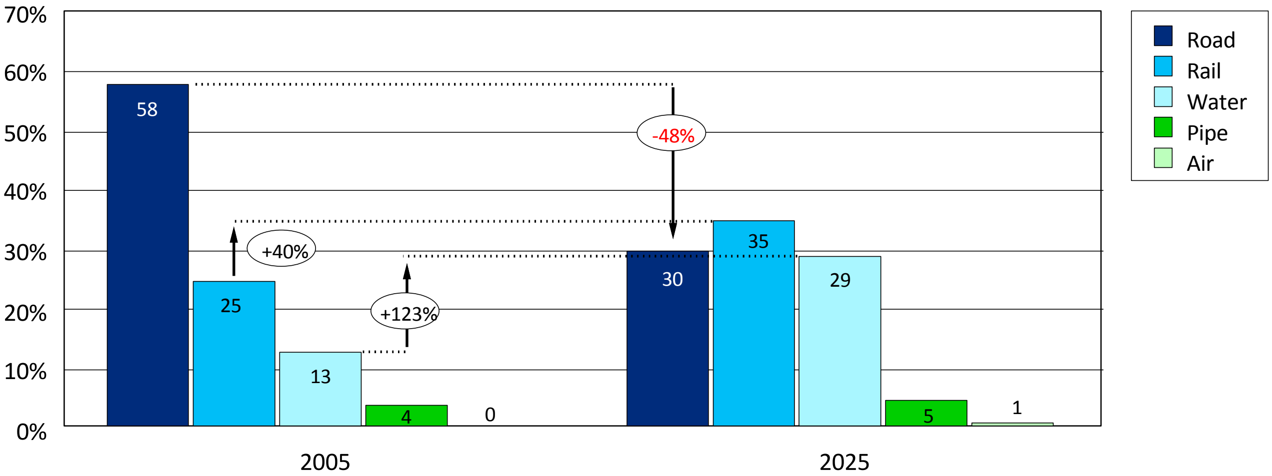
2.3.5 Policy and investments

A lack of incentive policies and investments in infrastructure during the last decades had led to underdeveloped and generally sub-standard waterways and overland rail transportation infrastructure (HUERTA/MARTINS, 2002, p. 4). Over the past 40 years the percentage of GDP for infrastructure investments has been declining from averaged five percent in the 1970s to two percent in the 1990s and 2000s (see appendix 25) (MORGAN STANLEY, 2010, p. 3).

This trend was reversed only with the implementation of the governmental GROWTH ACCELERATION PLAN [PAC] (2007-2011). When exports increased during the 1990s and 2000s, it became apparent that the country's infrastructure was not capable to satisfy the additional demand for transportation and logistics services (FILARDO ET AL., 2006, p. 37) and the government recognized the need for investments in infrastructure. In 2007, it launched the PAC program with the goal to change the general cargo transportation matrix, by increasing the participation of rail and water transportation, and develop an integrated intermodal system (see figure 2.15). The PAC is part of the NATIONAL PLAN OF LOGISTIC AND TRANSPORTATION [PNLT], which provides funds in three phases from 2008 to 2023 for strategic investments in infrastructure with the focus set on rail and port infrastructure (see appendix 26). The infrastructure investment rate leveled in 2011 36 % of the GDP (CNT, 2012, p. 328).

[16] Share of on-farm storing: USA 65%, European Union 50% (MORCELI, 2012).

Figure 2.15: Transport matrix - 2005 and 2025 (%)



Source: Created by author. Based on Ministry of Transport/Ministry of Defense (2007).

2.3.6 Climatic impact of soybean transportation

According to the IPCC (2007a, p. 330) and ECMT (2007, pp. 21), the transportation sector including transportation of cargo and persons is a considerable continuously growing source of greenhouse gas emissions. Its contribution to overall emissions is thirteen percent (see appendix 27), with the majority of the transported cargo being industrial goods (EPA, 2012). However, the increasing awareness of policy makers and consumers of the climatic impact of purchased goods in recent years made it relevant to marketers to analyze and optimize the global warming potential of the respective products (ECMT, 2007, pp. 17).

Greenhouse gases trap heat and absorb infrared radiation in the atmosphere. This leads to the effect of global warming because the average temperature gradually rises in correlation with the increase in concentration of the gases (EPA, 2012). GHGs include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorinated gases (see table 2.9), of which CO_2 accounts for the largest share of emissions (82 % in 2008; UNFCC, 2010, p. 10). Burning of fossil fuels, which are major inputs for powering engines of transportation vehicles, is the principal reason for CO_2 emissions (EPA, 2012).

Table 2.9: Greenhouse gases and sources of exhaust emissions

GHG	GWP	Principal emitter (economic sector)	Sources of emission
CO_2 (Carbon dioxide)	1	**Transportation**	Burning fossil fuels (coal, natural gas and oil), solid waste, trees and wood products
CH_4 (Methane)	21	**Industry and Transportation**	Production and transport of coal, natural gas and oil, livestock, other agricultural practices, decay of organic waste
N_2O (Nitrous oxide)	310	**Agriculture**	Agricultural practice, industrial activities, combustion of fossil fuels and solid waste

Source: Created by author. Based on information of EPA (2012).

Freight transport occurs between nearly all succeeding process steps of a product system and is necessary for delivering the product from producer to consumer. Hence, it is of major interest to know the GWP of the transportation processes in order to be able to optimize the exhaust emissions of the soybean export process. The GWP is a relative measure of the total energy that a given mass of GHG is estimated to contribute to global warming, compared to the same mass of CO_2 (EPA, 2012). The GWP is measured in CO_2 equivalents (see table 2.9), which are based on the calculations of IPCC (2007) over a time horizon of 100 years. Inferentially, the presented gases directly influence the climate. The international KYOTO PROTOCOL of 1997 called for a 60 % reduction in total carbon emissions[17] by 2050 (relative to the 1990 level), in order to stabilize the emission of GHGs in the atmosphere and curb global warming (ECMT, 2007, p. 20).

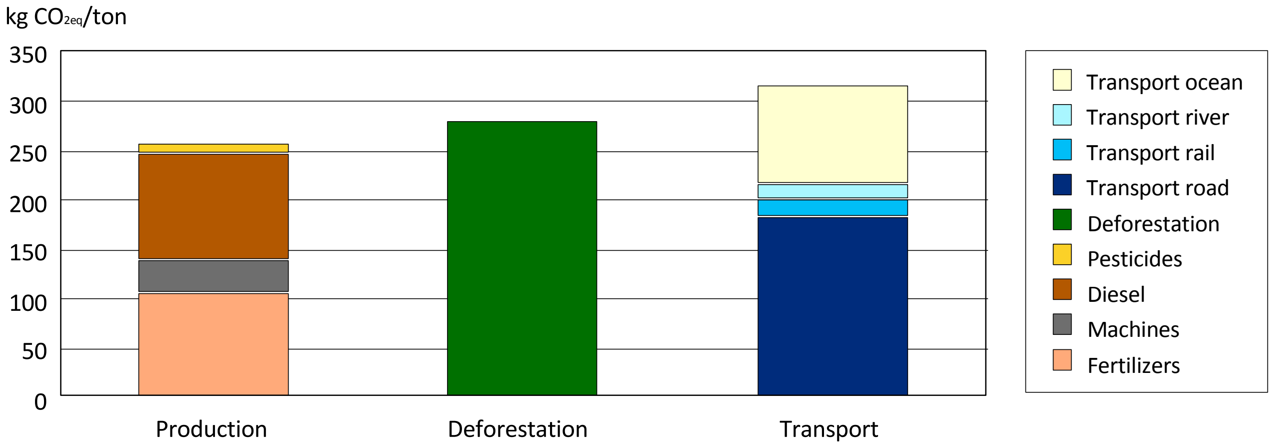
In Brazil, road transportation accounted in 2011 for 97 % (36.38 billion l) of the domestic diesel oil consumption (37.70 billion l) and contributed nine percent (136.15 billion tCO_2/year) to the country's total GHG emissions (1,574.54 tCO_2/year) (CNT, 2012e). According to CNT (2012, p. 358), the share of road transports of general cargo and simultaneously its emissions are steadily increasing. The current fleet of Brazil consists of 2.33 million trucks (CNT, 2012c), 32 % of which are older than 20 years and about 17 % are even older than 30 years (CNT, 2012d). According to IPEA (2011, p. 126), more than 50 % of the truck fleet run on engines that predate the 'Euro 0' phase (see appendix 28). Furthermore, approximately 63 % of the paved Brazilian roads are in regular, bad or poor condition (see chapter 2.3.1). The characteristics of the truck fleet and deficient road qualities can lead to increased fuel consumption and result in increased exhaust emissions (IPEA, 2011, p. 127).

As described in chapter two, about 60 % of the domestic transports of Brazilian soybeans is realized with trucks. In the 2010/11 cropping season, a volume of 45.15 mmt, of which 33.79 mmt

[17] UNFCC (2010) explained that the term carbon emissions includes total aggregate GHG emissions, which implies that GHG emissions are calculated as a weighted sum of CO2, CH4, N2O and the fluorinated gases HFCs, PFCs and SF6; the sum is made using the GWP.

were destined for export, was transported by trucks. Due to their remote geographic location, the Brazilian soybean exports from the major production regions in the Center West require a high participation of road transportation over large distances (see chapter 2.3). SILVA ET AL. (2010) concluded that improvements in the logistics of transportation, e.g., by relocation of transport services from road to rail, can contribute to significantly reducing GHG emissions. Performing a life cycle assessment [LCA] (see chapter 3.6) for soybeans produced in the Center West, they were able to show that domestic road transport from remote production regions to the seaport contributes even more (19 %) than ocean transport from Brazil to Europe (11 %) to the total GHG emissions (see figure 2.16).[18] The major factors of influence on global warming within the soybean life cycle revealed by SILVA et al. (2010) are deforestation (29 %) and crop production (38 %), including the production process and inputs used, e.g., fertilizers (11 %) and diesel (11 %). The study demonstrated that road transport and deforestation represent the major determinants for differences in overall emissions for soybeans produced in south Brazil and the Center West. There were no comparable studies in order to validate the results.

Figure 2.16: Amount of $kgCO_{2eq}$ emitted during the life cycle of soybeans produced in the Center West



Source: SILVA ET AL. (2010). Modified by author.

In contrast to the South, deforestation is in the Center West still in progress (NIEDERMEIER, 2012). This factor was neglected in the calculation in the LCA for soybeans from the southern region. Furthermore, the distance travelled is much lower, which leads to lower emissions of road transportation. As a result, a noticeably larger part of emissions was accredited to the crop production process (62 %) while road transportation accounted for only 12 %. For both cases, road transportation held a larger stake on total CO_2 emissions than rail and water transportation modalities that account only for a small share.

[18] The presented values of the specific transport modalities are weighted means, which were calculated by assessing the percentage of soybeans transported by road, rail and waterway[18] to the studied distances. Numbers of reference in SILVA et al. (2010): 58% soybeans transported by road, 25% by rail, 13% by waterway.

3 Methodology

For understanding the theoretical approach of the study, this chapter at first explains in brief the own research approach for determining the relevance of domestic transportation and logistics processes of soybean exports in terms of costs and CO_2 emissions between farm gate and seaport for selected regions in Brazil. Subsequently the sources of data and information as well as the selection of assumptions for the market and cost analysis are discussed.

3.1 Own research approach

The study was realized in three phases. The first phase included a thorough literature review and the posing of the research objectives. In this period prior to the field research an interview guideline was created and the organizational framework for the research trip set up. In a second phase, primary data was collected in the field in Brazil by interviewing researchers and experts, which belonged to transportation and trading companies. Visits to the logistics facilities of the ALLMN rail terminal in Alto Araguaia-MT and to the private port terminal of a trading company (volume of soybeans traded ≥ 2 mmt/year) in Santos-SP as well as visits to two farms in the county Rio Verde-GO provided insights into the operational processes and enabled a panoramic view over various stages of the process chain. In a third step data was worked up and a market and cost analysis performed. The applied methods are explained in detail in the following subchapters.

3.2 Market analysis

The market analysis was based on the approach of AAKER (2005, pp. 78). The purpose of a market analysis is to determine the structure and attractiveness of a market as well as to understand its processes and dynamics. As its scope depends on the available data, this study was limited to the observable factors. These comprised trade flows, prices, infrastructural conditions and market trends. The analysis included structure and size of the market, distribution systems, cost structure and market trends, using the examples of the case study regions (AAKER, 2005, pp. 79).

Information for the determination of the market size and on trade flows was sourced from government data and associations. The data on Brazilian supply and demand were achieved from ABIOVE while for world market development of soybean production, consumption and trade, the USDA database PSD ONLINE was consulted. The data refer to the individual local marketing years of the respective countries[1]. Data on Brazil differed between PSD ONLINE and ABIOVE, which AMARAL (2012) explained by different approaches for data collection. USDA PSD ONLINE data have been used for international comparisons. The data from ABIOVE were used for the national market

[1] Argentina - April to March; Brazil - February to January; USA - September to August.

analysis because these, according to AMARAL (2012) and OSAKI (2012), represent the reference for national research institutes like CEPEA. For detailed information on national, state, macro regional and municipal levels data were sourced from IBGE, which provides detailed data of agricultural production in its web systems SIDRA, ESTADOS and CIDADES as well as in annual reports on municipal agricultural production. Data on exports were obtained from the governmental web system ALICEWEB2 provided by SECEX and MDIC. The NCM 4-digit code 1201 (category: 'Soya beans, whether or not broken') was used. Further features (port: 'Santos', detail filter: county; periods) were selected for detailed queries. The COMEX trade balances of MDIC were consulted for supplementary data verification.

3.3 Case studies

A case study is a quantitative or qualitative method that "investigates a contemporary phenomenon in depth and within its real-life context" (YIN, 2009, p. 18). This flexible research approach compares or contrasts individuals, groups, actual situations, or cases. It is integrative to historical and political issues or regional characteristics, by considering more variables of interest than only data points, and relies on multiple sources of evidence. It is therefore useful for explorative studies (YIN, 2009, pp. 2). This method was assumed appropriate for accomplishing the objectives of this study (see chapter 1) and a multiple-case design with four cases applied.

For the case studies one seaport and four production regions were chosen, as explained in chapter 2.2. Based on data from IBGE (2012), the county with the greatest national soybean production volume and a high contribution to the Brazilian soybean exports, Sorriso-MT, was identified as major reference of the study. Using the database ALICEWEB2 (MDIC, 2012), the trading port Santos that covers most of the soybean exports of Brazil (28 %) and of Sorriso (83 %), the major Brazilian production region (see chapter 2.2), was determined as national destination of the export process. In order to estimate the impact of transportation costs on total costs of soybean exports, three further locations within the corridor of Sorriso-Santos, which display different distances to Santos, were defined according to the criteria explained in chapter 2.2.

Comparing the selected regions shall enable an estimation of the impact of transportation costs on total export costs of soybeans. As road transport represents the most important transport modality (see chapter 2.3) for all of the selected regions, the focus of this study was set on this transport mode. Rail transport via the Santos railroad plays an important role for the regions Sorriso and Rondonópolis and was therefore considered in the analysis, where data were available. Waterway transportation, which only plays a marginal role for the case studies, was widely neglected and only mentioned in order to draw an integral picture of the whole process chain.

3.4 Semi-structured interview

As an approach to do qualitative research, the form of the semi-structured expert interview was chosen to be the method applied. It ensures flexibility and openness during the interviews as the questions can be adjusted to the interview context and situation as well as to the interviewed person (UN FAO, 1990). This high flexibility allows probing for details within the interview, to discuss new issues arising as a result of preceding statements and to reshuffle topics to pursue new ideas. The discussions were typically initiated by giving background information about the project and a short presentation of the company by the interviewed partner. The further proceeding was designed as an open interview. As recommended by LINDLOF (1995, p. 185), an interview guideline was created prior to the interview, which served as a thematic framework for a fluid structure of the interview by organizing the menu of topics to be covered. That way, a flexible handling of the interview was possible while keeping the focus on the thematically important subjects. It further enabled the comparison of the different interviews for analysis after the field research (MEUSER/NAGEL, 2009, pp. 52, 56).

The main items discussed concerned structure of the process of soybean exports, major problems within these processes, essential cost positions, projections of the future development of the Brazilian infrastructural system. The semi-structured interview enabled to gather new information and data during the field research as well as to verify, validate and adjust data and information obtained in prior literature research.

The face-to-face interviewed persons were chosen according to their function as within the process chain and their accredited market expertise (see table 3.1). As experts, researchers or agents who are involved in the transportation and logistics processes were identified. Managers of commercialization and managers of transport and logistics in the big trading companies and transport companies composed the focus group. They should have an extensive general and exclusive knowledge of the soybean sector and be able to offer solutions and projections, relying on a wealth of experience. Due to thematic misconduct or lacking expertise of the interviewee, about 20 % of the interviews was not valid for this study and neglected.

Table 3.1: Expert interviews by category

Discussion partner	Type	Objective	Main items of discussion
Research institute Association	Explorative	Introduction and overview of the market and process chain	General information, structure and characteristics of the Brazilian soybean market and logistics
Producer Trading company Transportation company	Systematizing	Profound information on specific process chain stages	Specific information on operational processes, freight prices, modalities of transportation

Source: Created by author.

The aim of the interviews was to obtain comparable results by interviewing agents of the same type in each region. The focus was set on the trading companies that organize the overall processes of origination, commercialization and transportation for obtaining information about market structure and behavior. Transport service providers were consulted for information about specific transportation characteristics. Due to organizational constraints, like limited time, and the broad range of agents that had to be interviewed and, it was not possible to interview experts from each category of table 3.1 in every region. For each selected county at least one expert related to a transport company and one expert related to a trading company was interviewed.

3.5 Cost reporting

Horngren (2009, p. 53) defined cost "as a resource sacrificed or forgone to achieve a specific objective[, which] (...) is usually measured as the monetary amount that must be paid to acquire goods or services". A cost accounting gathers any information relating to the costs of acquiring or using resources in an organization or market and ensures transparency through documentation (Horngren, 2009, p. 30). By understanding the cost structure of a market, information on key success factors can be identified (Horngren, 2009, p. 73).

To identify each cost position within the logistic processes a cost report from the point of view of the seller was elaborated (see table 3.2), based on the information from the market report of Safras&Mercado (2012) and the expert discussion with Alves (2012).

Table 3.2: Calculation method

1. FOB Santos	**US$/t**
2. Exchange rate	R$/US$
3. Turnover (FOB Santos)	**R$/t**
4. Export expenses	R$/t
4.1 Port fee	R$/t
4.2 Comissions, brokerage	R$/t
4.3 Taxes	R$/t
4.4 Damage	R$/t
5. Price at port gate	**R$/t**
6. Freight rate	R$/t
7. Total logistics costs	**R$/t**
8. Theoretical price at local warehouse	**R$/t**
9. Price quoted at local spot market	R$/t
Difference [9]-[8]	R$/t, %
Share [6]/[7]	%

Source: Created by author. Based on data from Safras&Mercado (2012) and Alves (2012).

The free on board (fob) price (position 1) represents, according to INCOTERMS rules, the price, which implies that the seller accounts for the costs of shipment to the port and loading onto the ship. Until loading of the good, any risks of loss and damage to the goods are borne by the seller.

The applied exchange rate (position 2) corresponds to the monthly average data published by IPEA (2012). Any further logistics costs and risks linked to the export process are charged from the purchaser (ICC, n.d.).

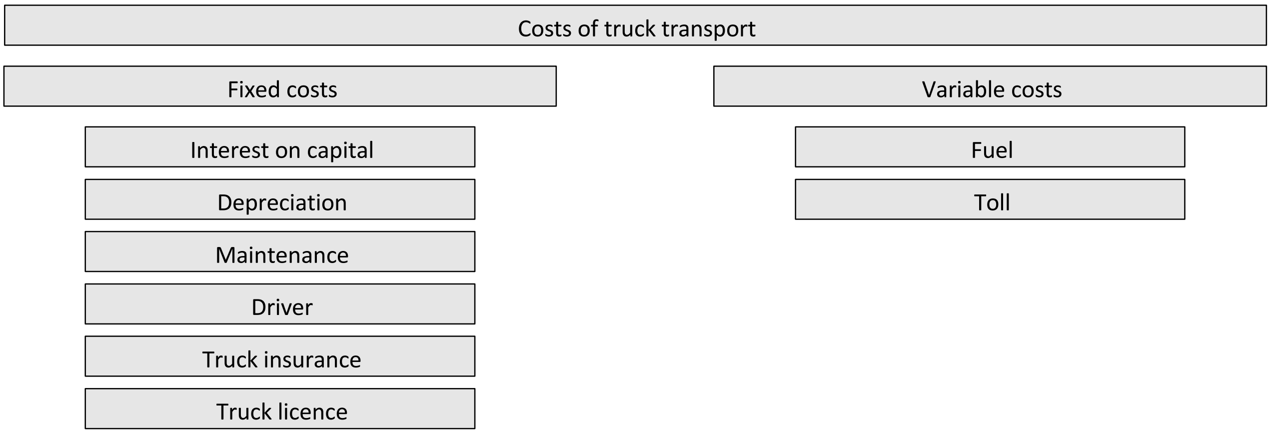
Logistics costs include transport costs, warehousing costs, transshipment costs, fiscal cost and port operations costs (KUSSANO/BATALHA, 2009, p. 31). The logistics costs (position 7) of the soybean export process were analyzed for each selected region based on the report. It was assumed that the seller is user of transportation and storage services, the cost of which are represented by the freight price (position 6) and the storage fee, respectively. Costs for storage were assumed to be 0.00 R$/t because for soybean storage there is typically no fee charged in Brazil (see chapter 4.2.1). The position was therefore neglected in table 3.2. Transshipment costs were assumed to be included in the costs for freight.

A theoretical price at the local warehouse of the selected region (position 8) was calculated by subtracting the export expenses (position 4) from the turnover (position 3). The theoretical price was used as a benchmark, with which the current price quoted on the local spot market (position 9) was compared. To evaluate the deviation of the calculated price from the real price, the difference was calculated. For understanding the impact of freight costs on total logistics costs, position 6 and 7 were set into relation.

Information about producer prices, commissions and brokerage and fob prices at Santos port were sourced from CEPEA, while data on the port fee were primary data from the survey.

Freight (position 4.2) represents the costs for shipping a specific volume of freight from a specific origin to the determined destination. Corresponding to data availability, monthly average freight prices for road transportation on the routes Rio Verde-Santos and Barretos-Santos were sourced from ESALQ-LOG, while data for the routes starting in Mato Grosso state were provided by IMEA. Small differences in the data of these two institutions, where overlapping, were observed, which might be attributed to different approaches of data collection. For reasons of comparison the functional unit tonne-kilometer (tkm) was taken as the basis of the price calculations and applied to the distances. Losses due to damage (position 4.5) were calculated with 0.5 % of the turnover at Santos (position 3), based on the market report of SAFRAS&MERCADO (2012) and on the experts' statements (ANONYMOUS 4, 2012; JESUS, 2012; GARCIA DA SILVA, 2012).

Figure 3.1: Transportation costs



Source: Created by author. Based on GÖTZE (2004, p. 157) and expert interviews.

Subsequently, the costs of the road transportation were analyzed from the point of view of the transport service provider to evaluate the major cost positions. The cost data were gathered in the field research and aggregated into one exemplary transport cost report. As the interviewed transport service providers employ their trucks all over the country, collected data have not been distinguishable for each case study, except costs for fuels and tolls, which were accordingly classified as variable costs.

Following the approach of SCHMALENBACH cited in GÖTZE (2004, p. 157) the transport costs were separated into their fixed- and variable-cost components (see Eq. I), as shown in figure 17. HORNGREN (2009, p. 57) distinguished variable costs from fixed costs by their relation to a given activity or volume over a determined time span. Variable costs change in total proportion to changes in the level of activity or volume while fixed costs remain unchanged for the respective time.

Fixed costs, which are not directly tied to the transport operation, include depreciation, interest

Eq. I $$C = C_f + C_v$$ *where* *C = total costs (R$/tkm)*
C_f = total fixed costs (R$/tkm)
C_v = total variable costs (R$/tkm)

on average fixed capital and - to a limited degree - labor costs. The average fixed capital is determined by the purchase price and the salvage value (GÖTZE, 2004, p. 58) (see Eq. II).

Eq. II $$\mathrm{Cap} = \frac{\left(\frac{P - S_n}{2} + S_n\right)}{x} = \frac{\left(\frac{P + S_n}{2}\right)}{x}$$ *where* *Cap = average fixed capital (R$/tkm)*
P = purchase price of vehicle (R$)
S_n = expected salvage value after n periods (R$)
n = asset depreciation range (years)
x = average annually distance travelled year [km]

The used price refers to the purchase price of a Bitrem truck and trailer composition with 37t loading capacity, which is the typically used truck type for soybean shipping (see chapter 4.1.2.3) (ANTUNES, 2012). The annual values were scaled to the functional unit of one tonne-kilometer. Costs for maintenance and repair may be directly tied to the transport operation but were assigned to fixed costs because a fixed monthly rate per truck was reported and attribution to a specific transport process was not possible. Any observable differences between regions were elucidated. For the cost positions of labor, truck insurance and license, annual or monthly values were utilized according to experts' statements.

Capital costs arise with the purchase of the vehicle and depend on the purchase price and the annual interest rate. They include interest and depreciation of the acquired resources (see Eq. III and Eq. IV).

Eq. III $$\mathrm{I} = \mathrm{Cap} \times \mathrm{i}$$ *where I = interest costs (R$/tkm)*
i = interest rate (%)

Depreciation of the vehicle is based on the purchase price of the new vehicle including truck and trailers, on its asset depreciation range and its salvage value. Using the linear depreciation method, depreciation rates per period are constant.

Eq. IV $$\mathrm{d_t} = \frac{\mathrm{P} - \mathrm{S_n}}{\mathrm{n}}$$ *where d_t = depreciation rate in period t (R$/tkm)*

Variable costs were calculated for each selected region by multiplying the specific costs of fuel (R$/km) with the distance travelled and adding the arising toll costs (see Eq. V).

Eq. V $$\mathrm{C_v} = \text{fuel costs}_\mathrm{a} \times \text{distance}_\mathrm{x} + \sum \text{toll cost}_\mathrm{x}$$ *where a = selected production region*
x = route

Local average monthly fuel prices (R$/l) by the Brazilian NATIONAL AGENCY OF PETROLEUM, NATURAL GAS AND BIOFUELS were provided by BEDOYA (2012). Toll costs were calculated with data from ARTESP (2012). Total transport costs were finally calculated according to equation I (Eq. I). Data was not sufficient to provide a similar estimate for rail transportation.

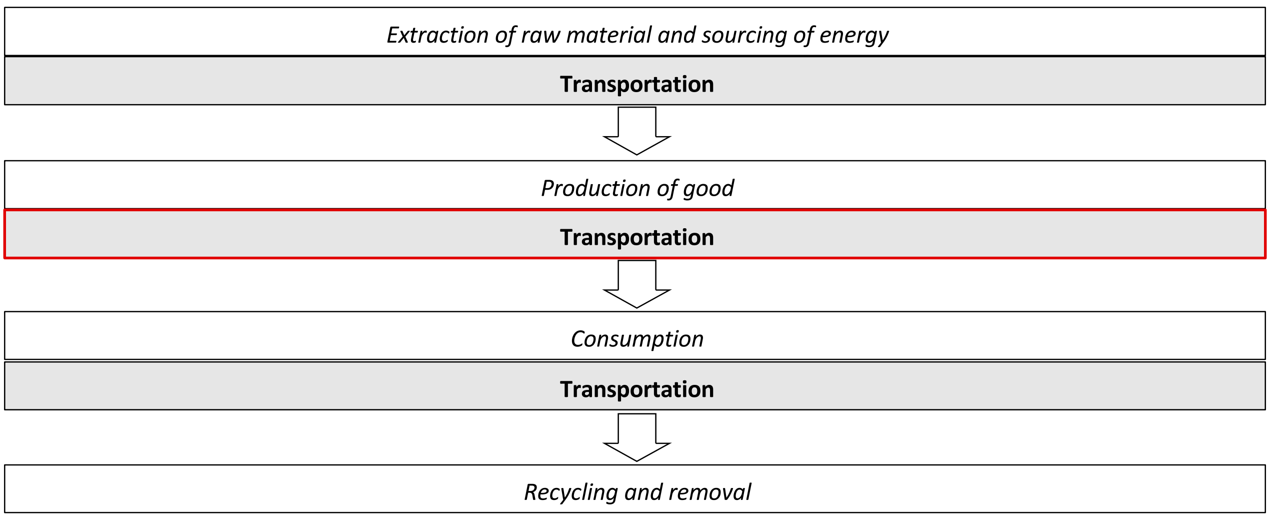
3.6 Greenhouse gas inventory

For the calculation of the greenhouse gas emissions of domestic soybean transports from farm gate to seaport, a GHG inventory was set up, which is based on the 1996 and 2006 guidelines of the IPCC. The approach of the GHG inventory is part of the LCA methodology, which is an international standardized approach (ISO 14040, ISO 14044) for estimating the environmental impact of a product over its complete life span. It is composed of goal and scope definition, life cycle inventory analysis, life cycle impact assessment and life cycle interpretation (Klöpffer/Grahl, 2009, pp. 2, 12) and is used as a framework for this analysis.

Goal and scope definition

The GHG inventory addresses emissions due to domestic transportation processes for export necessary to move the soybeans to the seaport. The study aimed to identify the GWP and potential savings of domestic transports embedded in the soybean export process chain (see figure 3.2). Identified optimization potentials can be used to contribute to the climate goals of the Kyoto Protocol and to increase the attractiveness of the product for consumers by active marketing of the climatic improvement.

Figure 3.2: Product life cycle



Source: Created by author. Based on Klöpffer/Grahl (2009).

The analysis singled out the distances between Santos port and the selected production regions Sorriso-MT, Rondonópolis-MT, Rio Verde-GO and Barretos-SP. As described in chapter 2.3 the transport modalities of interest for these regions are road and railroad. As grease and lubricant consumption is less than one per cent of the fuel consumption (Biaggioni/Bovolenta, 2010, p. 592), these factors are neglected in the analysis. For reasons of comparison and to estimate the climatic effect of soybeans the analysis is based on the functional unit of one ton of soybeans to which all estimates are related.

The field data provided first-hand information for the GHG inventory and were utilized for the calculation of the GHGs emissions. The values used were obtained in the field research and, if lacking, complemented by data published by CNT and ANTT. To date, only few studies (Silva et al., 2010; Biaggioni/Bovolenta, 2010) exist, which address the environmental impact of soybean transportation and logistics processes and use the LCA approach.

Life cycle inventory analysis

With regard to the available limited data quantity the Tier 1 method of IPCC (2006) was chosen as an appropriate approach for the GHG inventory and applied to the selected process. The calculation is based on quantity and the type of fuel combusted as well as average emission factors. Tier 1 focuses on the GHGs CO_2, CH_4, N_2O (see table 2.9). The indirect GHG NO_x and the acidification factor SO_2 are included, but not described in detail. Applying the Tier 1 approach, emissions are calculated in terms of CO_2 equivalents (see Eq. VI). The estimated fuel consumption was multiplied with a default factor, which is equal to the total carbon content (see footnote 19) of the fuel multiplied with the ratio of molecular weight of CO_2 (44) to the molecular weight of Carbon, which is 12 g/mol (IPCC, 1996, p. 3.12). The CO_2 equivalent used for calculation includes CH_4, N_2O and CO_2, the latter of which constitutes more than 95 % of the emissions from fuel combustion (SILVA et al., 2010, p. 1836).

Eq. VI

$$\mathrm{E} = \sum \mathrm{Fuel} \times \mathrm{EF}$$

where *E = GHG emissions ($kgCO_{2eq}$)*
Fuel = fuel consumed (l)
EF = emission factor ($kgCO_{2eq}$/l)

According to BARTHOLOMEU (2006, p. 54) a 100 % oxidation, which is required for this method (IPCC, 2006, p. 3.35), can be assumed because only a small fraction (≤ 1 %) of the fuel entering the combustion chamber escapes from oxidation. The emission factor determination is based on a number of assumptions concerning input data like vehicle technology mix, driving conditions, including travelling speeds, and climatic conditions. The default value for diesel of 2.67 CO_{2eq}/l suggested by IPCC (1996) is a value for European heavy-duty diesel trucks. Because fuel qualities and transport conditions differ between countries, local emission factors and energy data have to be considered to ensure comparability. Appendix 29 presents the values, which were taken as reference. In this study the emission factor 2.80 CO_{2eq}/l, suggested by BARTHOLOMEU (2006, pp. 51), was applied. BARTHOLOMEU (2006, pp. 51) argued that low quality diesel is used in Brazil and adjusted emission factors to a higher value compared to IPCC default value.

Corresponding to the major export routes of the four case study regions, the analyzed routes are Sorriso-Santos (2,200 km), Rondonópolis-Santos (1,400 km), Rio Verde-Santos (1,050 km) and Barretos-Santos (500 km). For calculating the emissions of one tkm of soybeans equation Eq. VII was used (IPCC, 1996). The results of the carbon emission inventory are presented as absolute values of total carbon dioxide-equivalents measured in kilograms per ton ($kgCO_{2eq}$/t).

Eq. VII

$$\mathrm{E} = \frac{\mathrm{EF} \times \mathrm{Fuel} \times \mathrm{Distance}}{\mathrm{Volume\ transported}}$$

where *E = GHG emissions of CO_{2eq} per route ($kgCO_{2eq}$/t)*
Distance = kilometers travelled (km)
EF = emission factor ($kgCO_{2eq}$/l)
Fuel = fuel consumed (l/km)
Volume transported = volume of cargo (tkm)

A heavy-duty truck, model Bitrem with 37 t net weight, which operates with diesel and consumes 0.5 l/km, i.e., 0.0135 l/tkm, was assumed for road transportation (ANTUNES, 2012). As road transport is typically operated by haulers who employ their trucks using almost 100 % of the capacities, a one-way travel between origin and destination with 100 % loading factor was assumed. GHG emissions emitted during return transports, where trucks are loaded with different products, were accordingly not assigned to the exported soybeans.

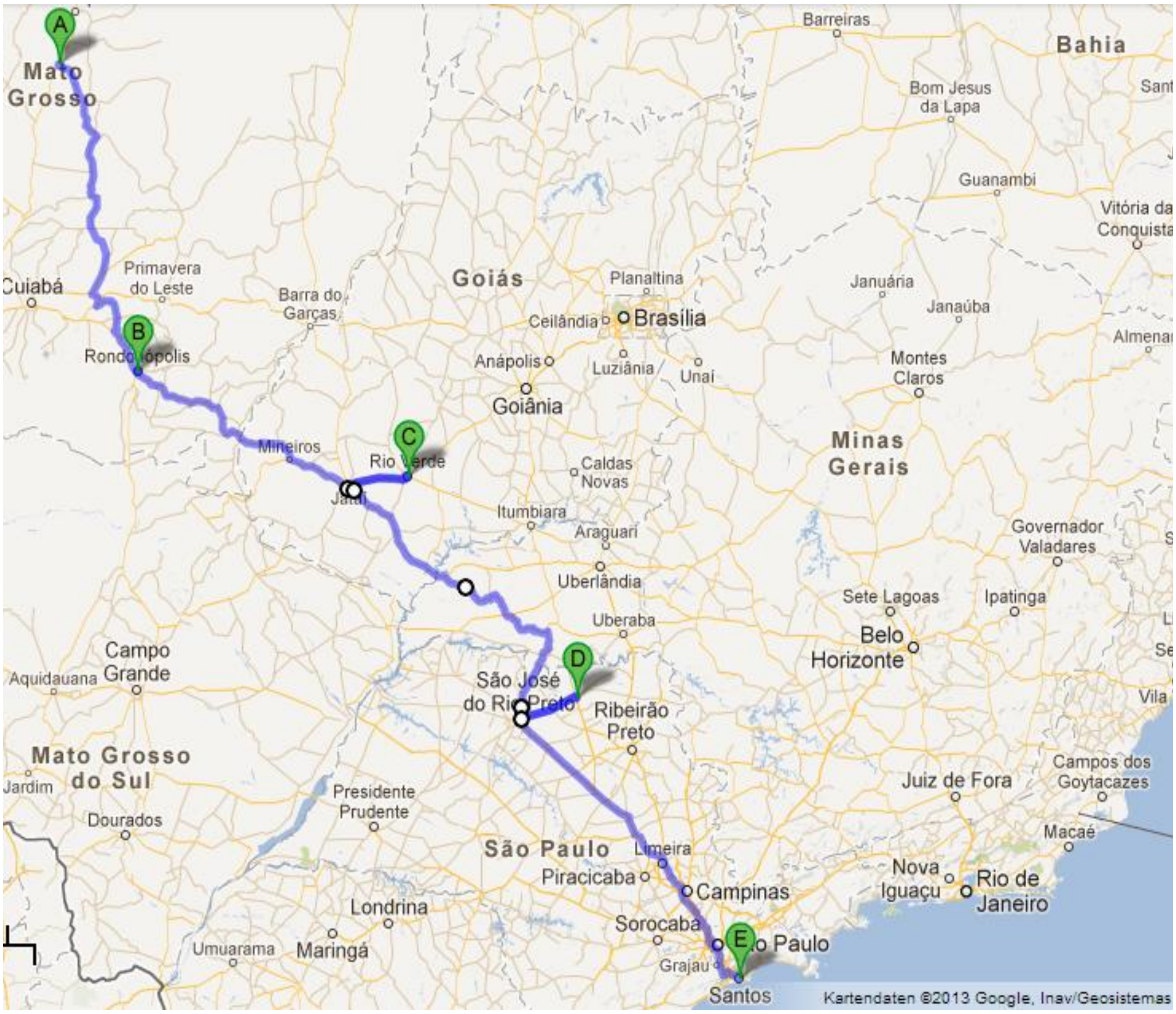
For rail transportation, a train composition with a diesel engine locomotive and 70 wagons with a total net weight of 7,000 t was considered for soybean shipping on the Alto Araguaia-Santos railroad as suggested by GARCIA (2012). Due to varying gauges and restricted access to railroads that are operated by other concessionaires (see chapter 2.3.2) the rail equipment is not employed on other railroads than the ALLMN and ALLMP. Because only about 30 % of the capacities of the returning train composition is utilized for the transportation of other products (GARCIA, 2012), 70 % of the emissions emitted during the return travel have to be attributed to the soybean transport.

To calculate the emissions from rail transports a fully-loaded train transporting soybeans from Alto Araguaia to Santos with a diesel consumption of 0.007 l/tkm was considered in a first step (ANTT, 2010, p. 21; GARCIA, 2012). In a second step assumptions for the return transport from Santos to Alto Araguaia were changed. Due to a small loading factor (30 %) with other goods like fertilizers, lower fuel combustion of 0.005 l/tkm was considered and 70 % of the gases emitted during the travel were attributed to the soybean export process.

4 Analysis of the Brazilian soybean export value chain

This chapter shall elucidate the pattern of the logistics market by reporting the market structure, based on the data achieved during the field research. In order to estimate the importance of logistics and transportation processes for the soybean exports and its impact on competitiveness in terms of costs and CO_2 emissions, the logistic costs in general and the costs of road transportation specifically as well as the emission exhaust are analyzed using the examples of four selected regions (see figure 4.1) and their export routes to Santos port (see appendix 30).

Figure 4.1: Exemplary route integrating selected production regions



Source: Google Maps (2013).

4.1 Market analysis

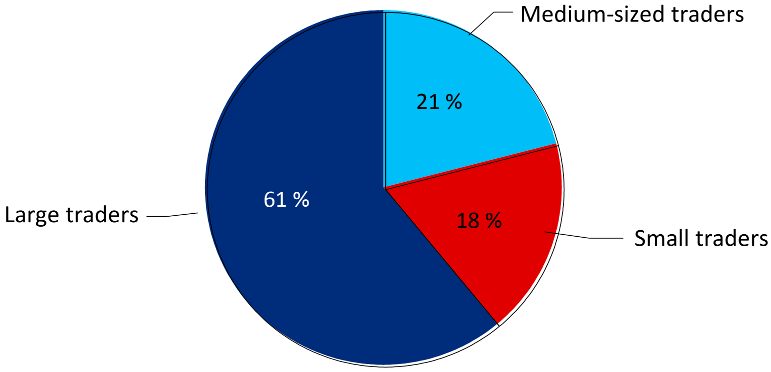
Soy is a seasonal crop, which is in Brazil produced between September and May. The soybean marketing year, however, begins in February and lasts until January of the following year (AMARAL, 2012). Transportation services for soybean shipping are principally demanded during harvest (January to May), as a large part of the harvest is immediately shipped to the export ports or warehouses of the industries (see chapter 2.3.4). Few large international companies dominate the soybean trading whereas the market structure of the transport service sector is fragmented. The road transport service sector is highly competitive. Road freights are therefore determined by the company's costs and the market behavior. By contrast, the railroad of the Sorriso-Santos corridor is operated by a monopolistic operator. Rail freight prices are individually negotiated and often more expensive than shipping by truck.

4.1.1 Agents

The Brazilian soybean business is dominated by a limited number of trading companies, which account for approximately 80 % of the soybean commercialization. Cooperatives are covering 20 % of the traded volume (AMARAL, 2012).

The top four players on the Brazilian market are the international companies ADM, BUNGE, CARGILL and LOUIS DREYFUSS COMMODITIES. Besides other agricultural products and inputs, these large companies handle large volumes of soybeans (≥ 2 mmt/year) and account for a market share of 61 % (see figure 4.2). Four medium-sized companies that rank within an annual trading volume between one and two million tons of soybeans per year hold a market stake of 21 %, while about thirteen small companies (≤ 1 mmt/year) cover the residual 18 % (AMARAL, 2012). Many of the large and medium-sized trading companies, like the Brazilian ANDRÉ MAGGI GROUP, integrate back in the value chain. The group incorporates a medium-sized trading companies and one of the world's largest soybean producing companies. Besides, it maintains an own freight company (FERREIRA, 2012). ADM, CARGILL and BUNGE own large warehouses and crushing factories. They further operate port terminals in Brazil. As a result these companies possess a strong market position, which according to PEETERS (2012) enables them to force prices down or demand more services.

Figure 4.2: Market share by company size



Source: Created by author. Based on AMARAL (2012).

Producers negotiate independently with their clients or take advantage of cooperatives or farmer unions. In the Cerrado region, including Rio Verde, Rondonópolis, and Sorriso, the typical farm size is 1,000 ha with 65 % of the farms being even larger (DOHLMANN/SCHNEPF/BOLLING, 2001, p. 20; USITC, 2012, p. 2-4). A number of farms have more than 10,000 ha (DRESCHER, 2012). These large producers are often organized in small farmer unions, forming powerful lobbies and negotiation parties. Particularly in the case of Sorriso, where large farm sizes are common, trading companies often directly negotiate with the local producers or farmer unions. About 15 trading companies are active in Sorriso while in Rondonópolis it is only about half of it (ALVES, 2012).

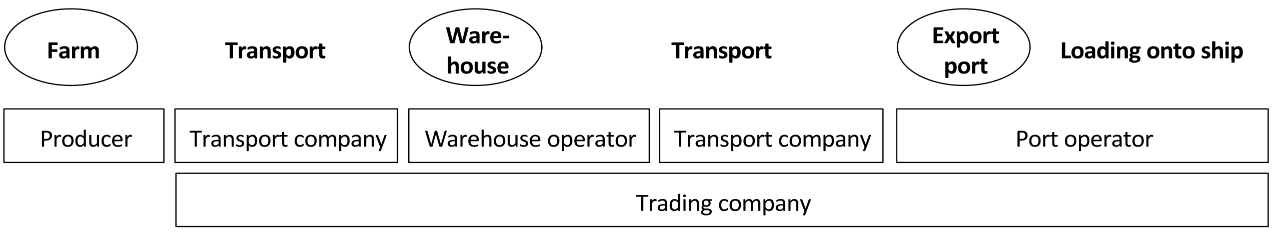
Only few cooperatives are settled in Mato Grosso (AMARAL, 2012), whereas in Rio Verde a major competitor on the soybean market is the large cooperative COMIGO. COMIGO is active as trader, processor and supplier of agricultural inputs. Due to its large crushing capacities and further infrastructure for processing of soybeans in the region, the cooperative principally focuses on the domestic market and directs the soybeans to the factories. The soybean volumes that are destined to export, however, are mainly traded by private trading companies (SILVA, 2012). The number of cooperatives increases when going southeast (ALVES, 2012). In the South and Southeast, including Barretos-SP, farms are generally small with an average size of 40 ha due to higher population densities (see chapter 2.2) and more expensive land prices. The small-scale producers are closely related to the local cooperatives that buy and market the agricultural products (DRESCHER, 2012; USITC, 2012, pp. 2-4, 6-9).

On the market of road transportation services acts a plethora of small companies while the market for rail services on the Sorriso-Santos corridor tends to have a monopolistic structure. Rail transportation services are contracted annually with fixed freight rates (ANONYMOUS 5, 2012). This occurs in the case of road transportation rarely, e.g. in the case of the small trading company for which ANONYMOUS 6 (2012) worked. In the majority of cases hauling services are contracted just in time with a weekly frequency (ANONYMOUS 4, 2012). Confirming CAIXETA-FILHO (2008, p. 8), PARREIRA (2012) stressed that the market is highly competitive where companies are under pressure to keep costs at a minimum. Big companies with large handling volumes often cooperate with transportation agencies, which manage the transport process and aggregate the needed capacities of trucks and drivers. While Nunes (2010, p. 58) and IPEA (2011, p. 127) reported equal market shares of the market participants, Anonymous 4 (2012) estimated that on national level about 70 % of the road transports are operated by self-employed drivers and 30 % by transportation companies with own fleet. In Mato Grosso the proportion is reverse. Anonymous 4 (2012) instanced that 50 % of the transportation processes of the trading company for which he worked (volume of soybeans traded ≥ 2 mmt/year) are realized with self-employed drivers and another 50 % with trucking companies.

4.1.2 Logistics processes

The logistic process of procurement, storage and distribution of soybeans includes various stages, in which either one or several agents are involved. The shipping process starts at the farm gate from where the product is transported via road to its next destination. Most of the harvested volume is carried to a regional warehouse, where post harvest management measures are applied and classification takes place. Only small volumes (no detailed data available) are directly shipped to the seaport. Figure 4.3 illustrates an exemplary structure of the export process including the involved participants, assuming that the soybeans are stored off-farm and sold to a trading company that organizes the handling of the product from farm gate until ship loading.

Figure 4.3: Exemplary export process from farm to seaport.



Source: Created by author.

4.1.2.1 Grain origination

The soybean producers of the Center West sell their grains mainly to trading companies. In the southern soybean production regions producers frequently sell to cooperatives that also act as traders. In some cases, intermediaries like local elevators or commodity brokers participate in the grain origination process. In other cases soybeans are directly sold from the production site to soybean processors or exporters (MAPA, 2007, p. 66). Together, the national process chain involves private service providers such as trading companies, brokers and warehouse operators, as well as freight forwarders, transporters, and bankers on the one hand, but also public agencies like customs, port authorities and transport regulators on the other hand.

Generally, producers market their soybeans at harvest on the local spot market or earlier through forward contracts (ALVES, 2012). These contracts imply an agreement between producer and purchaser, which defines price and quality considerations of the commodity to be fulfilled at a fixed delivery date. NIEDERMEIER (2012) confirmed the statement of MANGAN/LALWANI/ BUTCHER (2008, p. 92) that a forward contract works as a buffer against uncertainties such as volatile demand levels or price fluctuations. The originator purchases the soybeans either *fob warehouse farm* or *cif* (i.e., cost insurance freight) *warehouse purchaser* (FRANÇA, 2012; ANONYMOUS 3, 2012). Both manners are differentiated by the liability for transportation to the warehouse, classification, drying and storage. In the case of *fob warehouse farm* it is the purchaser who is liable, while in the other case (*cif*) it is the producer's liability. The other option is to sell the soybeans on the spot market. A farmer's decision to sell the soybeans immediately at harvesting or at a later point of time is determined by the availability of sufficient capacities of storage and of capital (ANONYMOUS 1, 2012; FRANÇA, 2012). Per unit costs of financing and insuring inventories are high over time (USITC, 2012, p. 3-14), which makes the expectation of the increase of prices by more than the cost of storing the decisive factor. If the future price is lower than the current cash price, the producer has the incentive to sell immediately to minimize his loss. At least, the decision to store is based on the expected returns from storage and financial power of the seller.

4.1.2.2 Warehousing

Grains are stored in warehouses, which are located in close proximity to the production areas and belong to private companies, cooperatives, producers or governmental institutions. Large trading companies provide additional transshipment points, which are located within an average radius of 50 km to the farms. These serve for the collection of the agricultural products from the farms nearby in order to take advantage from aggregated shipment to the trader's warehouse. The system is particularly beneficial to farms distant to warehousing infrastructure (GARCIA DA SILVA, 2012; ANONYMOUS 5, 2012).

Basically, warehouses in Brazil are operated by private companies (76 %) and cooperatives (20 %), who offer their services to the producers (CONAB, 2011). Warehouses under governmental administration account only for a small part and are not relevant for this study. The majority of the privatized warehouses are owned by big trading companies, which handle large volumes and are therefore able to utilize the warehouses to capacity in order to keep the fixed costs at a minimum. Access to the private warehouses is often restricted to the company's clients. In contrast, cooperatives work as service providers in general, offering public access to storage for money (FREITAS, 2012). The share of on-farm storage capacities levels approximately fourteen percent of the total storage capacities (see appendix 24). Large funds are required for investing in storage capacities and operating an on-farm warehouse, so that only a slight percentage (no detailed data available) of farmers operates an own warehouse in the South and Southeast, where most farms are small (see chapter 4.1.1) (DRESCHER, 2012). This percentage is much higher in Mato Grosso. ANONYMOUS 1 (2012) guessed that one third of the storage capacities in Mato Grosso is located on farms (see appendix 31). KLASENER (2012) estimated that in the region of Sorriso 60 % of the farms have warehouses, typically with storage capacities for 50 % of the farm's production volume. In contrast, in Goiás the share of farmers who are operating an own warehouse is small but the medium size of on-farm capacities is large (90,000 t). SILVA M. (2012) stated that only ten out of 1,060 farmers in the region of Rio Verde store on-farm, assuming that a share of less than two percent of the producers in the whole state Goiás own a warehouse. There were no data available for Barretos and Rondonópolis. Table 4.1 represents the storage capacities in the selected regions.

Table 4.1: Storage capacities in selected regions vs. production output of soybeans and corn (2011)

Warehouse type	Conventional		Specialized on bulk goods		Total		Soybean and corn output
	N° of warehouses	Capacity t	N° of warehouses	Capacity t	N° of warehouses	Capacity t	2011 t
Sorriso	23	135,911	188	3,382,626	211	3,518,537	2,978,346
Rondonópolis	31	219,679	54	975,639	85	1,195,318	293,760
Rio Verde	20	87,222	65	1,423,699	85	1,510,921	1,494,050
Barretos	4	6,322	6	139,715	10	146,037	22,500

(Status 12/20/12)

Source: Conab (2012b).

4.1.2.3 Transportation

With farms normally having no direct access to rail terminals or inland ports, short distance transports from farm to warehouse have to be performed by truck. Only a small part goes directly to a factory for processing or to the export port. Long-distance transports from warehouse to port are either realized by trucks or by intermodal transportation, which includes road and rail or road and waterway transport. The cargo is shipped to the export port where it is first stored or directly loaded onto the cargo ship. Operations within the port area are conducted either by the port operator or by the concessionaire, which is in most cases a trading company (ANONYMOUS 2, 2012).

Road transportation

For shipping agricultural bulk goods, transport service providers commonly use a double trailer truck with either seven or nine axles. ANTUNES (2012) asserted the use of the seven axle model *Bitrem* (see figure 4.4). It has a net weight cargo of 37 t and a maximum gross weight of 57 tons. Medium fuel efficiency was estimated at 0.5 l/km. The truck model with nine axles *Rodotrem* has a maximum gross weight of 74 tons with net weight cargo of 50 t. Even though the capacity is greater, it is less used because reception infrastructure in intermodal terminals is lacking and working hours during the day are legally restricted. Furthermore, complicated licensing procedures for new registrations hinder the fleet owners to take advantage of the *Rodotrem* model (JESUS, 2012; ANTUNES, 2012; ANONYMOUS 4, 2012).

Figure 4.4: Truck model *Bitrem*

Source: ANTUNES (2012).

The principal route, which can be travelled by truckers from any of the regions and which was cited by most of the experts, is the route Sorriso-MT - Cuiabá-MT - Jataí-GO - São José do Rio Preto-SP - Araraquara-SP - Santos-SP (illustrated in figure 4.1). The route includes the highways BR-163, BR-364, BR-153, SP-310, SP-330, SP-348 and SP-160. These are classified by CNT (2012) to be in regular, good or very good conditions. As reported in chapter 2.3, the highways of São Paulo, which are operated by concessionaires, have the best conditions (CNT, 2012a, p. 8) but are tolled (see appendix 32). In contrast, the state governed highways and roads to the farms in Goiás and Mato Grosso are in clearly worse conditions. Examples are documented in appendix 33. But GARCIA DA SILVA (2012) stated that large tracks are already being improved.

The export routes from Sorriso to Santos coincide with the Rondonópolis-Santos routes from Rondonópolis on. An attractive alternative route for truckers to the one cited above is going from Rondonópolis through Mato Grosso do Sul (Campo Grande-MS) to São Paulo (see appendix 30). This route offers improved road conditions compared to the former (ANONYMOUS 4, 2012) but more kilometers have to be travelled. Soybeans shipments from Rio Verde to Santos follow mainly the principal route cited or are alternatively guided via Uberlândia-MG and Ribeirão Preto-SP to Santos. Transports from Barretos join the principal route in Araraquara-SP or drive past Ribeirão Preto to Santos (GARCIA DA SILVA, 2012). Table 4.2 represents for each region the average transit time, i.e., the time spent on the road, and averaged speed driven of a travel to Santos. For loading of the truck most experts suggested a time of one day including waiting times at the warehouse. Unloading at Santos was calculated with one day. ROGÉRIO (2012) and others added that waiting time at the port often takes up to 48 hours during peak harvest season or even longer.

Table 4.2: Transit time from selected regions and average speed driven.

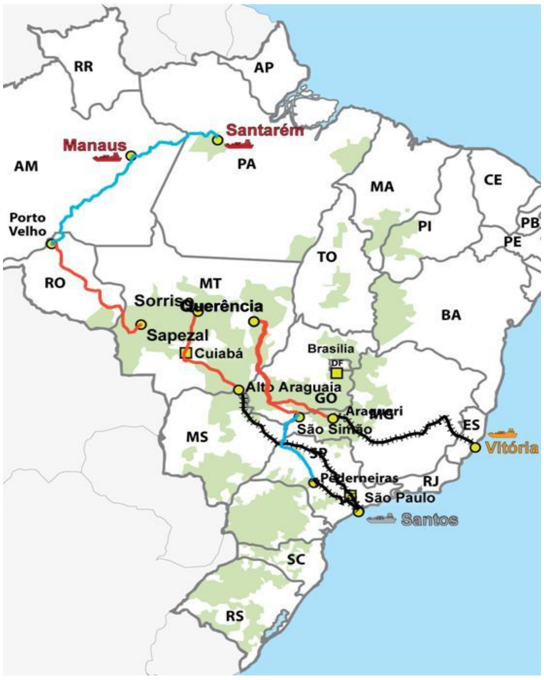
Origin	Distance to Santos km	Transit time days	Average speed km/h
Sorriso-MT	2,200	6	40
Rondonópolis-MT	1,400	5	40
Rio Verde-GO	1,050	3	45
Barretos-SP	500	0.75	n/d

Source: Created by author. Based on expert interviews.

Intermodal transportation

The combination of two or more transport modes is an alternative option for soybeans originated in the Center West. Referring to the conclusions drawn in chapter 2.3 that rail transportation is more efficient for long distance transports than road transportation, intermodality is a considerable option for shipping the soybeans from the remote Center West regions to Santos port. The ALLMN railroad and the Tietê-Paraná waterway offer the option of intermodal transportation of agricultural products to Santos via road and rail or road and waterway, respectively. Trucks carry the soybeans to the terminals in Alto Araguaia-MT (rail) or São Simão-GO (waterway), where it is transshipped and carried towards Santos (see figure 4.5).

Figure 4.5: Intermodal export corridors



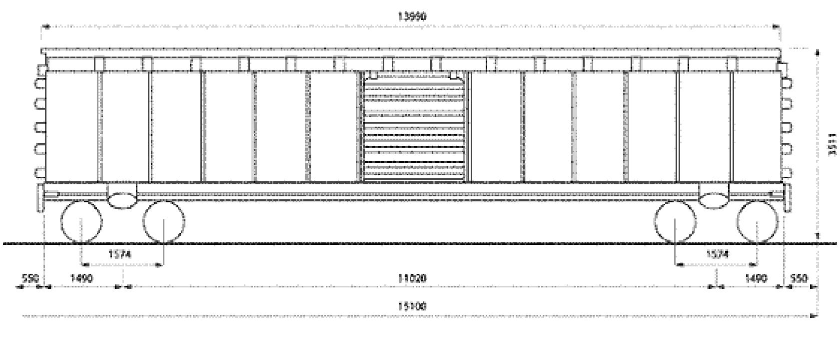
Source: Aprosoja (2012).

The selected regions, which are able to take advantage of the railroad, are Sorriso and Rondonópolis, while soybean shipping from Rio Verde can be accomplished by integrating water transportation. The ALLMN railroad is principally utilized by the big trading companies, which ship up to 80 % of their handled volumes by train (ANONYMOUS 1, 2012; ANONYMOUS 3, 2012). BIRKHAN (2012) explained that great shipping volumes are required to make rail transportation a profitable option for traders. Contracts with determined volumes to be transported are fixed for one year. After that period contracts are renegotiated. Freight prices and volumes are then adjusted (ANONYMOUS 3, 2012; ANONYMOUS 6, 2012).

Basically, the company ALL owns the rail equipment and provides transportation services to its clients. But according to ANONYMOUS 1 (2012) and GARCIA (2012) big traders often provide the rolling stock themselves or rent private rail terminals. ANONYMOUS 3 (2012) confirmed that the trading company for which he worked (volume of soybeans traded ≥ 2 mmt/year) owns wagons, which are operated by the transport service provider. According to WORLD BANK (2010, p. 39), this lowers the risks to the concessionaires and thereby allows lower tariffs. That implies that these companies have privileges to use the railroad while smaller traders with minor trade volumes and insufficient funds end up not using the railroad.

For soybean transports ALLMN utilizes wagons with a loading capacity of 60 to 120 t. The type of rail wagon used for bulk is shown in figure 4.6. GARCIA (2012) asserted that a typical train composition transports during peak of the soybean export season a volume of approximately 7,000 t. It is, according to ANONYMOUS 2 (2012), transported in about 70 wagons with intake capacities ranging between 60 t to 120 t, which are pulled by diesel-electric driven engine machines. The travel ends in the port area of Santos, where the cargo can be directed to the different terminals (ANONYMOUS 2, 2012).

Figure 4.6: Wagon for bulk transports.



Source: ANTF (2012).

Until arriving at the border of São Paulo trains travel at maximum with a driving speed of 80 km/h. Due to urban areas and a less resilient antique railroad infrastructure, the speed has to be slowed down to maximum 40 km/h. Often, maximum speed cannot be driven because of limiting factors like civil works on the railroad, bad signposting or people on the track. SILVA (2010, p.

10) reported a slowdown to 14 km/h, when getting closer to Santos. Medium fuel efficiency was estimated at 0.007 l/tkm (ANTT, 2010, p. 21; GARCIA, 2012). While GARCIA (2012) outlined the fast time of travel, ANONYMOUS 4 (2012) guessed that moving soybeans by train from Alto Araguaia to Santos takes about seven days because of infrastructural deficiencies while a truck starting in Rondonópolis can perform a transit time of five days (see table 4.2).

The TIETÊ-PARANÁ waterway export corridor to Santos starts in São Simão-GO and ends in Pederneiras-SP, from where soybeans are shipped by truck or train to the seaport. Besides for soybeans originated in Rio Verde and adjacent regions, according to APROSOJA (2011) the waterway is also frequently used for soybean exports from the eastern region of Mato Grosso including, e.g., Querência. Even though this is the cheapest way of shipping, efficiency is according to ANONYMOUS 1 (2012) little because further transshipments to rail or truck at Pederneiras are necessary. Thus, only a small portion of the soybean harvest in the respective regions is shipped that way. The option is furthermore limited in use to the big trading companies due to high fixed costs (GARCIA DA SILVA, 2012). A large trading company (volume of soybeans traded ≥ 2 mmt/year), who operates a private terminal in São Simon, sends only five percent of its Mato Grosso soybean exports that way (ANONYMOUS 4, 2012). ANONYMOUS 5 (2012) reported that, due to high rail freight prices (see chapter 4.2.1), large trading companies, tend to shift from transporting the major volumes via rail to water and road transportation.

4.1.2.4 Port

At the port the bulk good is classified and sent to the warehouse, where it is stored for a short period of time until loading onto the ship, or directly loaded onto the ship. ANONYMOUS 1 (2012) guessed that in the gutters of the terminal of the trading company for which he worked (volume of soybeans traded ≥ 2 mmt/year), where data were exemplarily collected, every hour about 30 trucks discharge their loading volume, which equals a capacity of circa 1,000 t/h, in peak harvest time. Three rail reception channels enable a maximum intake of 1,650 t/h from trains (channel one: 700 t/h or 160 wagons/day; channel two: 600 t/h or 140 wagons/day; channel three: 350 t/h or 80 wagons/day). About 250 wagons/day are on average unloaded during harvest time. The turnaround time of a wagon at the company's port terminal is on average eight hours. Storage capacities are utilized only for aggregating the cargo volume until ship loading. Medium storage time is six days. The three warehouses at the terminal offer storage capacities of 50,000 t, 72,000 t and 50,000 t. The large bulk carriers, like PANAMAX, have loading capacities of 60,000 t to 80,000 t. Smaller handy size vessels have loading capacities of more than 10,000 t. Capacities of 48 t/day or 2,000 t/h for shipment enable to load a PANAMAX vessel in about 1.5 days (ANONYMOUS 2, 2012).

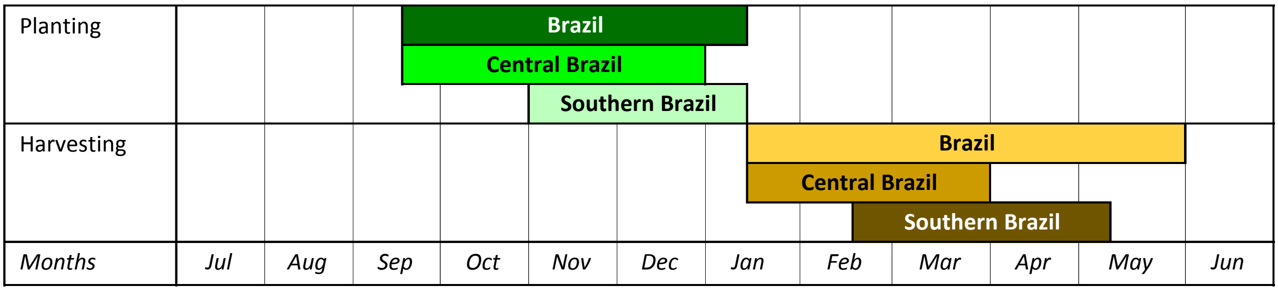
4.1.3 Soybean season

The Brazilian soybean cropping cycle starts in late September and lasts until May (see table 4.3). In the Center West, a typical crop rotation system includes the production of soybeans as summer crop (September - February) and corn as winter crop (February - August) (SILVA, 2012). The exact dates of planting and harvesting soybeans vary from region to region from September to November, depending on the day of the first rainfall after the drought period, which initiates the planting process. Generally, first planting occurs in Mato Grosso in late September with harvest season starting in January (GARCIA DA SILVA, 2012; OSAKI 2012; CONAB, 2012a, p. 26). Due to rain falls at a later date, planting in the southern states typically starts in late October. In these regions harvesting lasts from February (Paraná) until early May (Rio Grande do Sul) (DRESCHER, 2012; CONAB, 2012a, p. 26). Some regions in Goiás and Mato Grosso, like Montividíu-GO, are characterized by such a favorable climate that production of up to three different crops per year is possible, as far as irrigation is provided. Additionally, the second crop needs to be harvested until early July. OSAKI (2012) suggested sorghum and millet as third crops.

From an agronomical point of view it is also possible to plant precocious soybean but it is widely avoided and even restricted by law to grow soybeans as winter crop to prevent rust and fungi.

PEETERS (2012) reported oats and beans with harvest in September to be planted in Rio Verde.

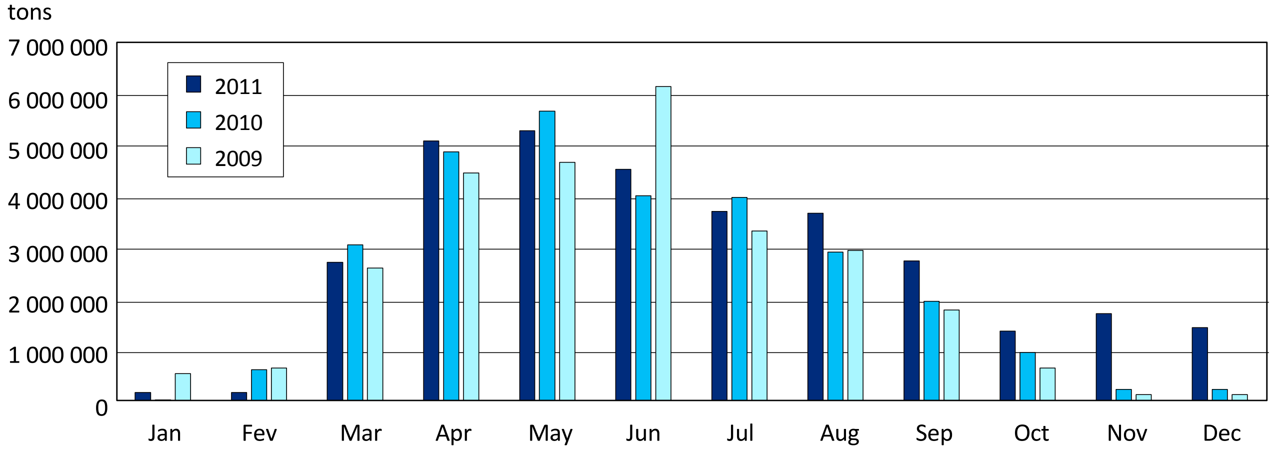
Table 4.3: Soybean crop calendar



Source: Created by author. Based on Conab (2012a, p26) and Nunes (2012).

The demand for transportation and logistics services corresponds to the seasonality of the soybean crop cycle. The total export season extends over the period of February until September (NUNES, 2012). According to ANONYMOUS 3 (2012) the peak of global demand for Brazilian soybeans is in late February and March when soybeans have gotten scarce in the importing countries. The more intensive period for soybean exports and transports is from March to June (see figure 4.7 and appendix 34) when the harvested soybeans have already passed through post harvest management and classification and are sent to the seaports. From September on, when major part of the Brazilian exports is already sold and U.S. soybean harvest begins (USDA FAS, 2012), export volumes shrink.

Figure 4.7: Brazil - monthly soybean exports (2009-2011)



Source: MDIC (2012).

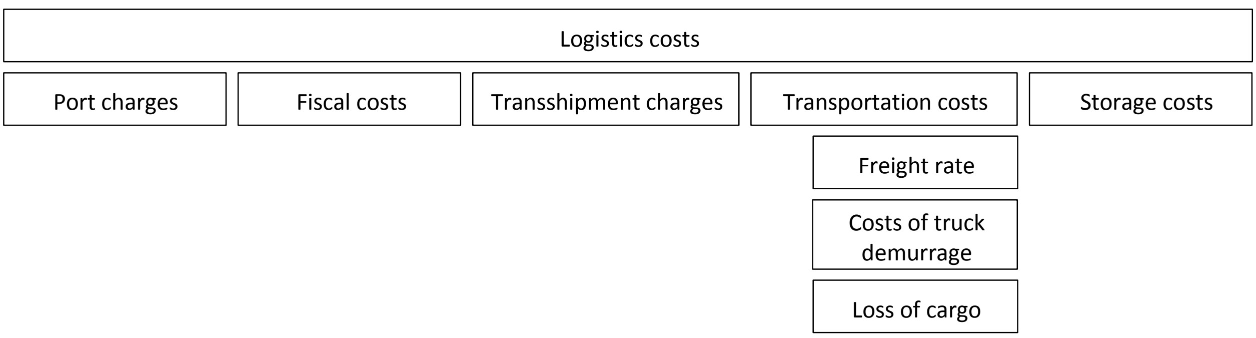
4.2 Cost analysis for four production regions

Starting the analysis at the port with the fob price, each cost position was documented to finally calculate a theoretical price received by the producer in the local warehouse of the respective production region.

4.2.1 Cost positions and cost structure

The logistics costs of the soybean export are presented in figure 4.8 with the major cost centers being port charges, transportation and storage costs. Generally, fiscal costs have to be considered but as explained in chapter 2.1 soybeans that are exported are exempted by the Kandir Law from taxes, so that fiscal costs equal to 0.00 R$/t in the analysis. Transshipment costs may arise at various stages of the transport process but are generally included in the port fee and in the freight rate, which represents the transport costs.

Figure 4.8: Logistics cost structure



Source: Created by author.

Port charges

In Santos, soybeans are handled at private terminals, which are operated by concessionaires. Prices for port operations are formed through negotiation and depend on various factors, including volume and cadence of the cargo to be handled (ANONYMOUS 1, 2012). KUSSANO/BATALHA (2012, p. 622) stated that the port fee comprises all costs relating to the use of the port infrastructure, including the costs for transshipments and warehousing. The estimated values of the port costs gathered in the field research varied from 15 R$/t to 25 R$/t[1]. The difference in values may be due to different volumes handled or a privileged access to the port terminal for an agent, e.g., a trading company who runs an own terminal. The cost position, which impacts most on the total costs for running a terminal, is the lease cost (approximately 70 %). Major operational costs are energy and personnel costs (ANONYMOUS 1, 2012; ANONYMOUS 2, 2012). Based on the information given by the experts (FRANÇA, 2012; ANONYMOUS 1, 2012) and congruently with CEPEA (OSAKI, 2012), the port fee for the calculation was determined at 11 US$/t (22 R$/t).

Experts complained the strong position of the port syndicate. The port operator is obliged to contract a large part of the required stevedores from the syndicate's pool (NUNES, 2012). AMARAL (2012) asserted that these regulations inhibit the tertiarization of services and mechanization of processes. It further causes elevated operational costs as, e.g., the tariff regulations for syndicate personnel represent high costs for the terminal operator. Lacking commitment to work, frequent strikes of the syndicate personnel and high rates of absence result in inefficiencies and trouble port processes. Especially strikes may lead to high extra costs. ANONYMOUS 1 (2012) exemplified that as from a waiting time of 18 hours a demurrage cost of 50 R$/h is charged per unloaded rail wagon by the rail operator with 150 to 250 wagons being unloaded during harvest time.

Restricted inland port access (see chapter 2.2.5) and limited reception capacities at the port lead during peak harvest season to long line-ups of trucks both at the port gates and at intermodal terminals. A demurrage fee for overtime costs of a waiting truck has to be paid by the trader or exporter after 24 hours and levels 0.40 R$/t/h, or 14.80 R$/truck/h (PARREIRA, 2012; ANONYMOUS 6, 2012; GARCIA DA SILVA, 2012; ROGÉRIO, 2012). According to OSAKI (2012), the elevated costs are passed on to the producer who will receive a lower price for his products.

Experts estimated that the average time of a truck waiting to unload the soybeans at the terminal is approximately two days in peak harvest season if there are no further distortions, e.g., rain, of the process (ANONYMOUS 6, 2012; GARCIA DA SILVA, 2012). ANONYMOUS 1 (2012) and ANONYMOUS 2 (2012) reported truck line-ups of 10 to 30 days. Rainy weather induces a loading stop because the terminals are not protected against rain (GARCIA DA SILVA, 2012; ANONYMOUS 2, 2012). ANONYMOUS 2 (2012) underlined the effect of a stoppage of ship loading by elucidating that during harvest season an estimated volume of 30,000 t/day of soybeans is moving by train or truck to the port. A

[1] In some cases, experts reported values in US$. These values were accordingly recorded. For reasons of comparison approximated values in R$ are recorded in brackets [applied exchange rate: 2.03 R$/US$ (August 2012; IPEA, 2012); applied exchange rate in calculations: according to month and year of reference of the calculation].

delay at the port of ship loading would bring 60,000 t of cargo volume and of trucking capacities to a standstill at the port gates and lead to high opportunity costs.

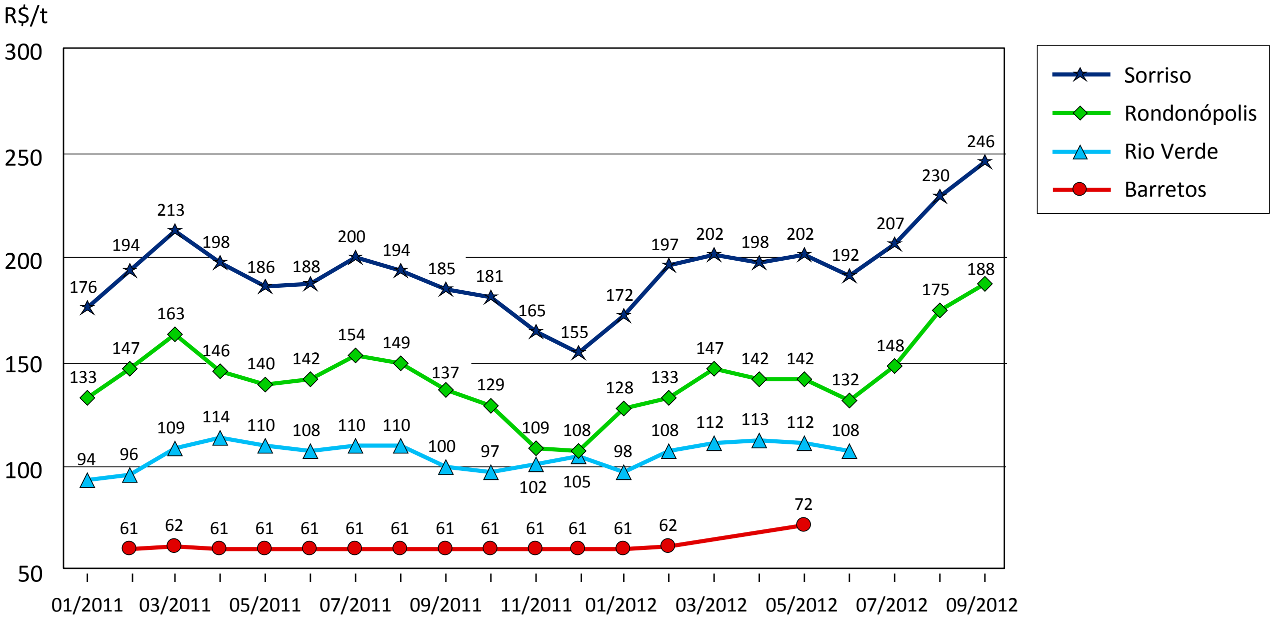
Freight

The transport service market is a demand-driven market. Freight rates are volatile and subject to seasonality. According to CAIXETA-FILHO (2003, p. 1) "freight prices are formed through free negotiation determined by supply and demand for the transport service". The rates are composed by the transport costs and a profit margin of the service provider. The seasonal supply/demand relation may increase or decrease the profit of the transportation company (JESUS, 2012).

Road transport

The formation of the road freight price which the buyer, i.e., the trader or exporter is willing to pay was described by ANONYMOUS 4 (2012). On the basis of historical data the buyer estimates the freight costs for the planning period, which usually corresponds to the calendar year. The historical freight rates at peak harvest time are evaluated and the market analyzed. It is common to exchange ideas with other market participants in order to optimize the estimates. Based on this information the freight rate, which the buyer is willing to pay, is calculated. As the transport market is a volatile market (see figure 4.9), buyers and suppliers both have to steadily adjust their positions to the market. They have to stay current on changes in every shipping cost variable and in market behavior to negotiate efficiently with the counterpart. ANONYMOUS 4 (2012) asserted that the few big trading companies (see chapter 4.1.1) have as large buyers the negotiation power to exert pressure on transport haulers to obtain freight transport discounts. Thus, freight rates are influenced by the customers' willingness to pay as well as by the demand and supply relation.

Figure 4.9: Freight rates for selected regions (2011-2012)



Source: Created by author. Based on data from ESALQ-LOG and IMEA.

On this highly competitive market transportation companies are price takers who have to at least cover their costs. The composition of the transport costs is illustrated in table 4.4. JESUS (2012) stated that in his company 70 % of the costs of the truck are determined by the gross driver labor rates, costs of fuel, maintenance and tires. PARREIRA (2012) confirmed that the major cost positions are fuel and personnel costs. But experts emphasized that the biggest freight price drivers, which e.g. in 2011 and 2012 led to high freight rates, are market demand and opportunity costs. The opportunity costs refer to the loss of benefits, which would have been received by choosing the next best alternative. Lacking capacities for transportation frequently result during harvest peak in excess demand, leading to inefficiencies and driving prices. The experts exemplified that the price surge during 2012 was no result of changes in transport costs, but was caused by shortages in capacities of trucks and labor due to very large harvest volumes of soybeans and corn *safrinha*, and due to a new truck drivers law (see chapter 5.6) (ROGÉRIO, 2012; ANTUNES, 2012). Moreover, waiting times at the port gates of 48 hours up to five days are common during harvest season and (see chapter 4.1.2.3) (PARREIRA, 2012). Any waiting time less than 24 hours is paid by the transport service provider who can include these costs in the charged freight rate (ROGÉRIO, 2012).

Table 4.4: Composition of road freight rate

1. Costs of truck	2. Operational costs of company	3. Fiscal payments
1.1. Capital costs	2.1 Energy	3.1 Taxes on company's profit
1.2 Maintenance costs including tires	2.2 Personnel	3.2 ICMS, PIS/CONFINS
1.3 Fuel costs	2.3 Administrative costs	3.3 Social contribution payments
1.4 Labor costs	2.4 Experience	
1.5 Costs of licence	2.5 Financing of delayed payments of clients	
1.6 Opportunity costs	2.5 Other costs	

Source: Created by author. Based on expert interviews.

Rail transport

The competitiveness of rail transportation is restricted by elevated rail freight prices in Brazil. According to ANONYMOUS 5 (2012) the rail freight rate increased significantly within the last years. The ALLMN railroad is owned by the investment company GP INVESTIMENTOS and operated by ALL. Because the company holds a monopoly, prices are adjusted accordingly (ANONYMOUS 5, 2012). The monopolistic market position enables to settle the freight price above marginal cost without losing all customers.

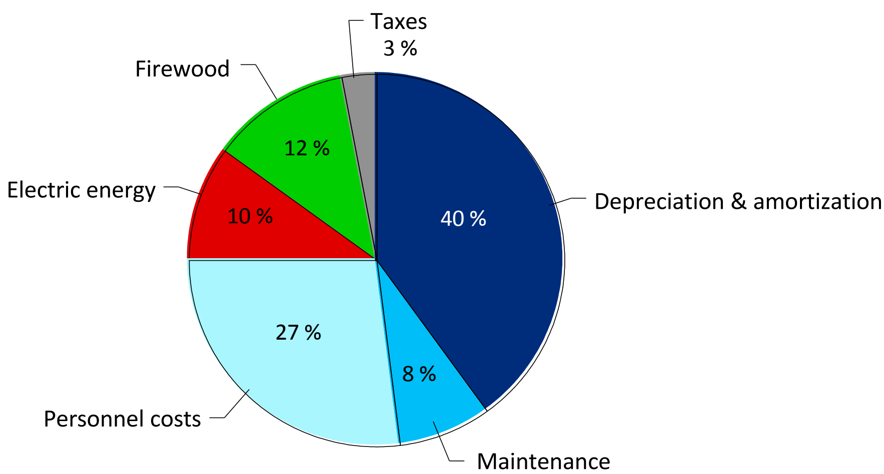
Because the rail market is rather closed, no exact data were revealed in the interviews. Experts explained that the freight price is calculated by using the projected road freight as reference value to which some amount is added (SPERANDIO ET AL., 2012). BIRKHAN (2012) estimated a 20% premium of the rail freight rate relating to the truck freight price. FRANÇA (2012) and SPERANDIO ET AL. (2012) instanced margins of four to seven percent. A different picture was drawn by ROGÉRIO (2012). He stated that rail transportation within the state of São Paulo is decisively cheaper than transportation by truck. Various rail networks converge in this state, i.e., the market and the rail freight prices are more competitive. ROGÉRIO exemplified that rail freight would level approximately 40 % of the road freight price (e.g.: 38 R$/t railroad vs. 98 R$/t road).

Warehousing costs

In the soybean business it is not common to charge a warehousing fee. JUNQUEIRA (2012) explained that the value from farm gate to finishing the soy product is aggregated in the value chain. Warehousing costs are absorbed by the industry or exporter. Even if a fee is charged, this value does not cover the real costs of warehousing. OSAKI (2012) suggested that a charged fee ranges between 3 % and 3.5 % of the value of the stored volume. To give an impression of the price level warehousing fees published by SIARMA (2010) are listed in appendix 35. If the good is stored on-farm for removing it at a later date, a specific date of latest removal by the purchaser is defined and the selling price adjusted by the warehousing costs (ANONYMOUS 4, 2012).

The major cost positions of maintaining a warehouse are depreciation as well as amortization on warehouse and maintenance facilities and other equipments (JUNQEIRA, 2012) (see figure 4.10). The principal limitation to investments in on-farm warehouses is the high financial requirement. KLASENER (2012) instanced a project to build a new warehouse in Nova Mutum-MT, close to Sorriso. With planned capacities of approximately 9,000 t in silo storing systems and elevators with a performance of 100 t/h[2], investment costs come by four million R$.

Figure 4.10: Exemplary cost structure for operating a warehouse



Source: Created by author. Based on JUNQUEIRA (2012).

[2] Antique elevators of the referred warehouses had a performance of 60 h/t (KLASENER, 2012).

ANONYMOUS 5 (2012) estimated that the storage cost in the warehouses of the trading company for which he worked (volume of soybeans traded ≥ 2 mmt/year) average 16 R$/t. The value includes costs of classification, cleaning and drying. Information given by FREITAS (2012) revealed that warehousing costs at COMIGO in Rio Verde are at a higher cost level of approximately 20 R$/t with 60 % of it being attributed to drying. All experts concordantly reported it as the major cost position within the operational processes. Intensity of drying and hence the costs of drying are determined by the humidity level of the soybeans at harvesting.

Farm gate prices

The price, which the Brazilian producer receives at the local warehouse, is represented by the locally quoted spot market price. Brazilian soybean prices are closely related to the CBOT quotation (see appendix 2) and accompany world market developments (illustrated in appendix 36). Reportedly, any price movement in Chicago is transferred to the Brazilian producer prices (see chapter 1). The local spot market prices tend to be lowest during peak harvest time (February to April) and to increase afterwards (July to October) (see appendix 37). When stocks get smaller and supply on the global market is scarce in the interim period of Brazilian and U.S. soybean harvest, world market prices tend to increase until the U.S. soybean harvest season begins in late September (see appendix 36). USDA FAS (2012) asserted that soybean world market prices are trending lower when the new U.S. crop enters the market, which is encouraging the liquidation of Brazilian stocks until that date.

Other costs

Brokers and other intermediaries participating in the export process generally charge a fee for their services. CEPEA indicated a default value of 7.50 US$/t, which aggregates all related costs in the position commissions and brokerage.

Experts often mentioned a unquantifiable cost, called *custo Brazil*. It describes the costs arising by inefficiencies in the system, which diminish the international competitiveness of Brazilian goods (KUSSANO/BATALHA, 2009, p. 29). AMARAL (2012) instanced long and complicated decision paths in institutional processes that inhibit process flows and progress of projects. ANONYMOUS 4 (2012) added that the complex fiscal process also plays an important role for the *custo Brazil.*

4.2.2 Cost reporting

The costs are analyzed in two steps. In a first step total logistics costs of the soybean export process until the domestic seaport and their impact on the local producer price are studied in detail. In a second step a closer look is taken on the transport costs and its composition. To examine the effects of changes in the underlying assumption, a sensitivity analysis was conducted.

4.2.2.1 Total logistics costs

The logistics costs analysis considered the costs, which arise between farm gate and loading the soybeans onto the ship. It was assumed that the producer delivers the soybeans to the warehouse and bears the costs of short distance transportation, for which DIAS (2012) reported costs between 0.02 R$/tkm and 0.04 R$/tkm. However, no other data was available to validate the values. Due to the insufficient basis of data, the analysis starts at the local warehouse. The local spot market quotation served as benchmark for the comparison with the theoretical price. As elucidated in chapter 4.2.1, storage costs were neglected. The related taxes ICMS and COFINS/PIS[3] equal 0.00 R$/t (position 4.3 in table 4.5) (see chapter 4.2.1).

Table 4.5: Logistics cost calculation for selected regions (April 2011)

APRIL 2011						
Origin			Sorriso-MT	Rondonópolis-MT	Rio Verde-GO	Barretos-SP
Distance to Santos			2,200 km	1,400 km	1,050 km	500 km
1. FOB Santos	**US$/t**	**515.95**				
2. Exchange rate	R$/US$	1.59				
3. Turnover (FOB Santos)	**R$/t**	**818.53**				
4. Export expenses	R$/t	31.86				
4.1 Port fee	R$/t	15.86				
4.2 Comissions, brokerage	R$/t	11.90				
4.3 Taxes	R$/t	0.00				
4.4 Damage	R$/t	4.09				
5. Price at port gate	**R$/t**	**786.67**				
6. Freight rate	R$/t		198.22	145.60	120.75	60.75
7. Total logistics costs	**R$/t**		**230.08**	**177.46**	**152.61**	**92.61**
8. Price at warehouse	**R$/t**		**588.45**	**641.07**	**665.92**	**725.92**
9. Price quoted at local spot market	R$/t		599.17	655.17	669.67	730.50
Difference [9]-[8]	R$/t		10.71	14.09	3.74	4.58
	%		*1.82*	*2.20*	*0.56*	*0.63*
Share [6]/[7]	*%*		*86*	*82*	*79*	*66*

Source: Created by author.

In the exemplary calculation for April 2011 (see table 4.5), it is 28 % of the turnover in Santos (position 5) that has to be spent on logistics for soybean exports from Sorriso. This percentage value decreased the shorter the distance travelled (Rondonópolis: 22 %; Rio Verde: 19 %, Barretos: 11 %), or if freight prices tend to be lower (see exemplary calculation September 2011 in appendix 38). This might result in reduced competitiveness of the remote regions of Mato Grosso in terms of prices received. When considering that agricultural input prices like the fuel prices (see appendix 39) are higher in these regions, it becomes clear that the previously stated competitive

[3] COFINS/PIS is a social contribution tax, charged by the federal government based on the gross revenue.

advantage of the Center West farming from low production costs (see appendix 1), can be largely offset by the high prices for logistics services and its impact on local soybean producer prices and agricultural input prices.

The major cost position of the total logistics costs is the cost for transportation, represented by the freight rate (position 6). It is strongly related to the distance travelled, i.e., it increases proportionally while total logistics costs per tkm decrease (see table 4.6). While in the case of Barretos, which is situated closest to Santos port, transport costs accounted for 66 % of the total logistics costs in April 2011 and represented 0.19 R$/tkm, this share leveled 86 % in the case of Sorriso but only 0.10 R$/tkm. Export expenses (position 6) constitute the difference value.

Table 4.6: Total logistics costs - comparison of selected regions (R$/tkm)

	Sorriso-MT 2,200 km	Rondonópolis-MT 1,400 km	Rio Verde-GO 1,050 km	Barretos-SP 500 km
	R$/tkm			
April 2011	0.1046	0.1268	0.1453	0.1852
September 2011	0.1000	0.1128	0.1345	0.1916

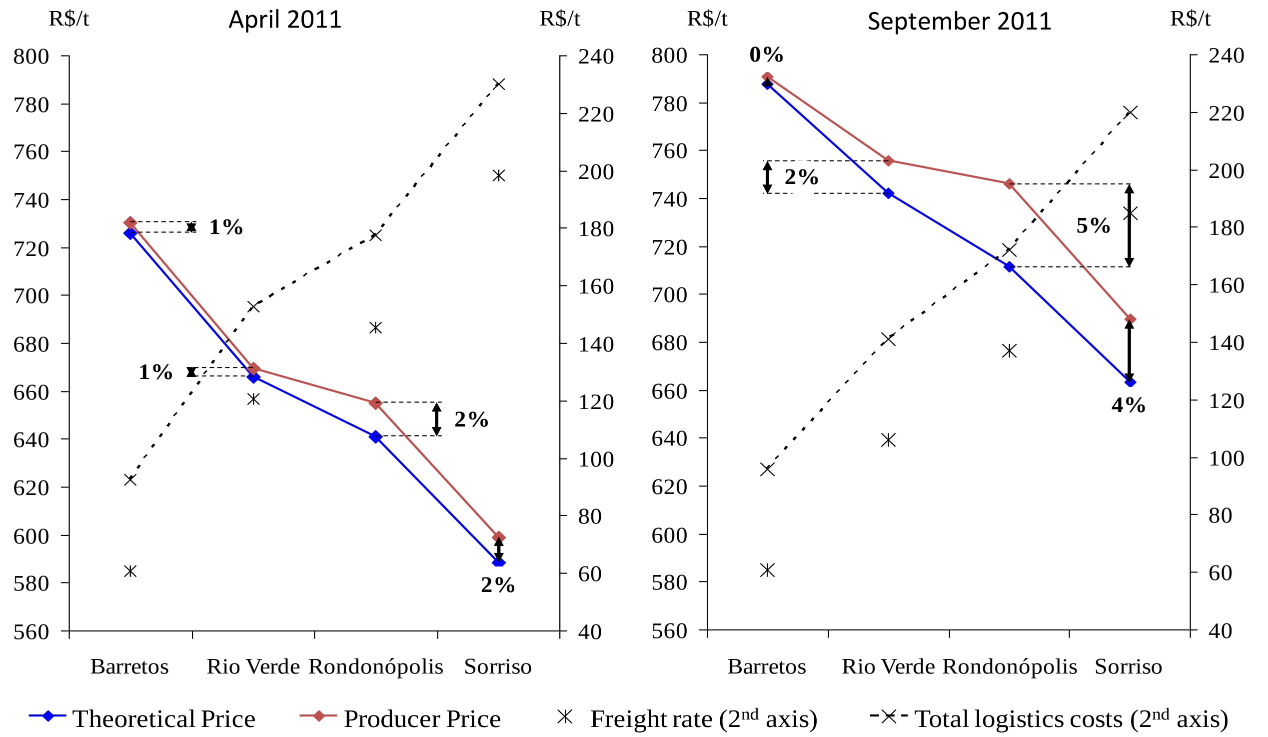
Source: Created by author.

Various factors might be influencing the spot market prices and cause differences between the local spot market price and the calculated theoretical price, as shown in figure 4.11. On the one hand, market power could be a reason for differing values. The theoretical price includes only visible cost factors. However, the power of demand and supply may act as a price driver for local spot market prices. It may increase local spot market prices in periods of low supply or high world market prices, or lower the prices in a contrasting market situation, respectively. A further factor of influence might be time. To move the soybeans from the local warehouse to the ship it takes one day or more (see table 4.2). The transit time represents a time shift. The local spot market price is quoted at trading day *x* while the fob price received may refer to a later date, at which the product is loaded onto the ship (fob price quotation at day *x+n*, where *n* = the transit time in days). As the market is volatile, changes might have occurred within this period, so that calculated prices may vary from the local spot market prices. Besides, it has to be considered that the used values are monthly averaged values, which might lack precision and congruence.

The observed differences were highest in Rondonópolis. As its travel distance to the seaport is not the largest of all selected regions but Rondonópolis is a major trading place, it could be assumed that market behavior is the major determinant in this case. The calculation performed for the month of September in 2011 revealed that the differences in prices increased between April 2011 and September 2011 for the Center West regions of Sorriso, Rondonópolis and Rio Verde. Freight prices were lower (Sorriso and Rondonópolis: 7 % decrease; Rio Verde: 12 % decrease) in September 2011 and producer prices higher (Sorriso: 15 % increase; Rondonópolis and Rio Verde:

13 % increase) so that the share of transportation costs on overall logistics costs slightly decreased. In Barretos freight prices remained on an equal level (0 % change) and the relation of transport costs to total costs did not change significantly. This could be reasoned by the low importance of the soybean crop for that region and a probably continuous demand for transportation of agricultural products over the observed period. As a result, freight prices do not vary much before, during and after the soybean harvest season as it is the case in the other regions. The local spot market price increased less (8 % increase) than in the other selected regions. The higher increases could be attributed to the decreased freight rates. A relation between freight price decrease and producer price increase could be assumed.

Figure 4.11: Comparison of theoretical and real producer price (April 2011, September 2011)



Source: Created by author.

4.2.2.2 Cost of truck transport

Based on the information given by the transport service providers a purchase price of 400,000 R$/truck and an asset depreciation range of five years for the truck were assumed (Anonymous 4, 2012; Parreira, 2012; Antunes, 2012) (see table 4.7). An annual travel distance of 80,000 km was taken as reference value for the calculation of fixed costs. The period of effective use of the truck in the company depends on its maintenance costs. It is replaced at latest, when maintenance costs begin to increase or manufacturer's warranty expires. The applied interest rate on capital was 2.5 % and might be attributed to subsidies. The low interest is an incentive for high annual depreciation rates (PARREIRA, 2012). The monthly paid gross driver labor rate varied from 2,640 R$/month to 4,600 R$/month. It was reasoned that self-employed truck drivers, who are largely unregulated (USITC, 2012, p. 3-5), might calculate a lower labor rate than the transportation companies that may pay higher salaries. Hence, a medium value of 3,500 R$/month, as indicated by ANTUNES (2012), was adopted. Maintenance costs were reported with a fixed monthly amount of 5,000 R$, which includes costs relating to tires.

Table 4.7: Fixed costs of model

Average fixed capital	R$/year	300,000
Interest on capital	R$/year	7,500
Depreciation	R$/year	40,000
Maintenance costs (incl. tires)	R$/year	60,000
Gross driver labor rate	R$/year	42,000
Truck insurance	R$/year	8,000
Truck licence	R$/year	1,300
Total fixed costs per truck and year	R$	158,800
Total fixed costs per km	R$/km	1.99
Total fixed costs per tkm	**R$/tkm**	**0.0536**

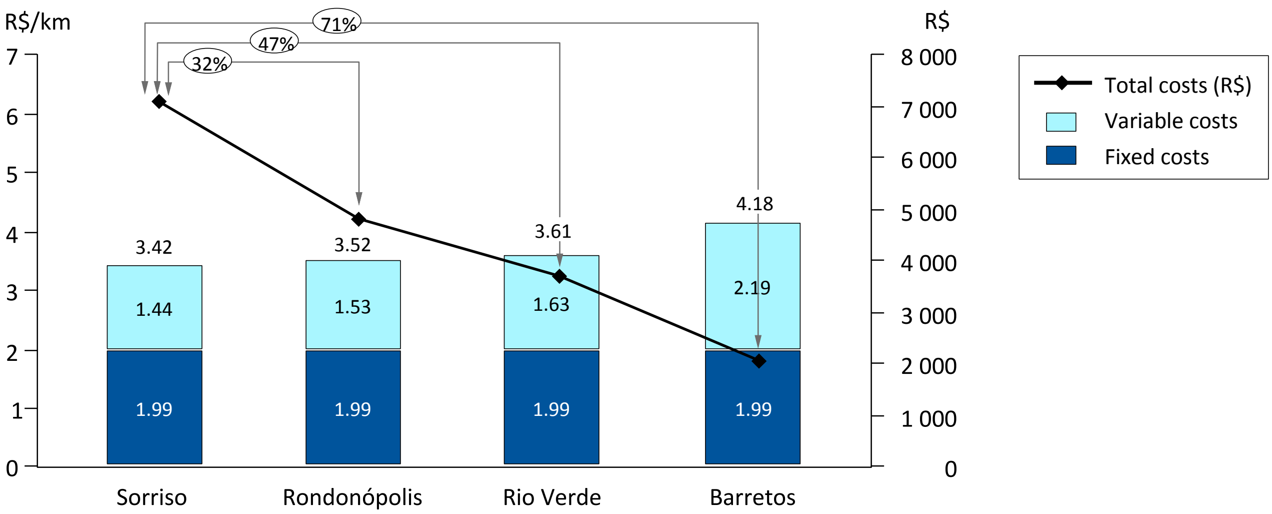
Source: Created by author.

The analysis revealed fixed costs C_f of 1.99 R$/km or 5.36 Brazilian centavos/tkm. The two major cost elements of fixed costs were identified to be the costs for maintenance (38 % of C_f) and the gross driver labor rate (26 % of C_f) (see table 4.7).

Total transportation costs C were strongly differing between the case study regions. A large difference in transportation costs of 71 % was observed when comparing the production area closest to Santos port (Barretos, 500 km: 4.18 R$/km and 0.11 R$/tkm) and the most distant production area (Sorriso, 2,100 km[4]: 3.42 R$/km and 0.09 R$/tkm) with the data of March 2011. Figure 4.12 illustrates the disparities of transport costs between the analyzed soybean production areas in Brazil. It further shows the allocation of variable costs c_v and fixed costs c_f as well as the total transportation costs depending on the travelled distance.

4 In this figure the Sorriso-Santos route via Goiás (2,100 km) was considered, while other routes from Sorriso to Santos have averaged distances of 2,200 km.

Figure 4.12: Costs of road transportation (March 2011)



Source: Created by author.

The variable costs per km decreased the larger the distance travelled. In contrast, total costs per route increased decisively with the distance travelled, which might heavily affect the competitiveness of soybeans from more distant regions. Except for Barretos (500 km), c_f exceeded c_v per truck transport due to the long distances travelled in any other case. The share of C_f over C varied from 48 % (Barretos) to 55 % (Rio Verde) and 57 % (Rondonópolis, Sorriso). Variable costs per km c_v/km impacted most in the case of Barretos, where c_v/km were 35 % above those of Rio Verde. In the other cases, c_v/km differed more slightly by six percent one from another.

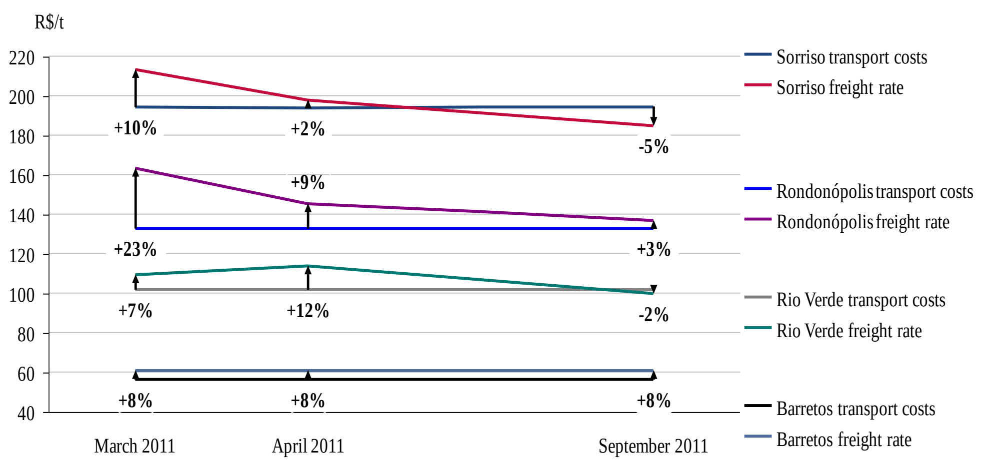
The costs of truck transport were analyzed for the year 2011 at the starting of harvest (March), at peak harvest time (April) and at the ending of the export season (September). As toll costs remained constant over the year 2011, variations in fuel prices determined the changes in total transport costs. As the Brazilian fuel industry is located close to the eastern coastline, the diesel has to be shipped to the production regions. The local fuel price increases in consequence according to the distance due to elevated acquisition costs (see appendix 39). Within the time scope of the analysis (export season 2011), fuel prices were at Sorriso highest in September 2011. The total costs for truck transport from Sorriso to Santos differed between March and April 14.70 R$/km (0.40 R$/tkm), and between March and September by 11.55 R$/km (0.31 R$/tkm). In the other regions fuel prices remained constant or slightly decreased. The absolute cost difference equaled at Barretos 1.00 R$/km (0.03 R$/tkm; March/April) and 1.50 R$/km (0.04 R$/km; March/September) with a change of 0.4 % in the local diesel price. A 1.1 % (March/April) and a 1.5 % (March/September) change in diesel prices at Rio Verde reduced costs by 12.08 R$/km (0.33 R$/tkm) and 16.28 R$/km (0.44 R$/tkm), respectively. In Rondonópolis the diesel prices continued on the same level from March to May 2011 so there was a zero effect in transport costs in this period but a slight effect of 4.50 R$/km (0.12 R$/tkm) between September to March.

In the cases under consideration, toll costs were charged on privatized highways in São Paulo. The impact of this cost position increased the shorter the distance. While toll costs accounted in the case of Sorriso for eight percent and in Rondonópolis for twelve percent of the total transport costs, the share was with 16 % decisively larger for Rio Verde. For transports from Barretos toll costs were a major cost positions, which held in the exemplary calculation a share of 29 %. The drivers often cut tolled streets in order to save expenses (PARREIRA, 2012). This might imply the use of roads in worse conditions and result in elevated costs of fuel or losses (see chapter 5.1).

To elucidate the cost impact of toll costs on total costs a supplementary calculation was performed for the alternative route Sorriso-MS-Santos (route I in appendix 30). The choice of this route implies a 21 % increase in toll costs compared to route two (Sorriso-GO-Santos). The higher costs for tolls combined with an increase in travel distance of 100 km lead to a six percent increase in total transport costs relating to route two. There was no detailed data available on the saving potential by choosing route one with respect to maintenance and fuel costs.

A comparison of the transport costs and the freight rate (represented in figure 4.13) revealed differences, which most experts attributed to the relation of demand and supply at the different points of time in the soybean export season. The demand for transport services increases decisively at beginning of the export season (see chapter 4.1.3), driving freight rates up. Figure 4.13 illustrates that freight prices were highest in March whereas the freight rate earned in September did not cover transport costs in most cases. According to PARREIRA (2012), transport costs often exceed the freight rate received on the market. The freight rates used in this analysis are averaged market values. The costs of truck transportation are averaged costs of transportation companies, which do not include self-employed drivers. However, the market freight price integrates the freight prices of the self-employed drivers. As vehicles of self-employed truck drivers are often older (see chapter 2.3.6) costs for depreciation and maintenance might vary, costs of labor might be calculated differently and fixed costs are lower. It should be therefore considered that costs might differ distinctly between the different market participants. According to USITC (2012, p. 3-5), fierce competition among the self-employed truckers, hence, often drives down the price of road transport services below the total transport cost of the transportation companies.

Figure 4.13: Comparison of transport costs and freight rates



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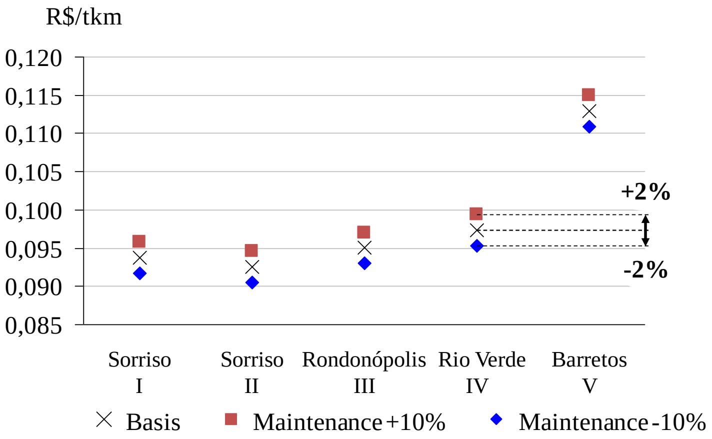
4.2.2.3 Sensitivity analysis

A sensitivity analysis based on the data of March 2011 was conducted in order to examine the effects on transportation costs if an underlying assumption changes.

As explained before, fixed costs may vary according to the age of the truck. First, it was examined a ten percent variation of maintenance costs(see figure 4.14). Maintenance costs generally increase with the age of the vehicle or with a more frequent driving on roads in worse condition (assumed cost increase: +10 %). In the opposite case, a newer truck or driving on better roads might reduce cost compared to the reference case of chapter 4.2.2.2 (-10 %). The ten percent variation of maintenance costs resulted in a variation of four percent of fixed costs and two percent of total transport costs. The ten percent cost reduction represented saving potentials of 0.08 R$/km (0.002 R$/tkm) in fixed costs. As fixed costs are not tight to the distance travelled, any change will result in the variation of total costs at the same percentage in each studied region. In this analysis, the change leveled two percent (minimum$_{\text{Barretos V}}$: 1.80 %; maximum$_{\text{Sorriso I}}$: 2.24 %), which represented an absolute variation in total transport costs of maximum 165.00 R$ for route one and of minimum 37.50 R$ for route five.

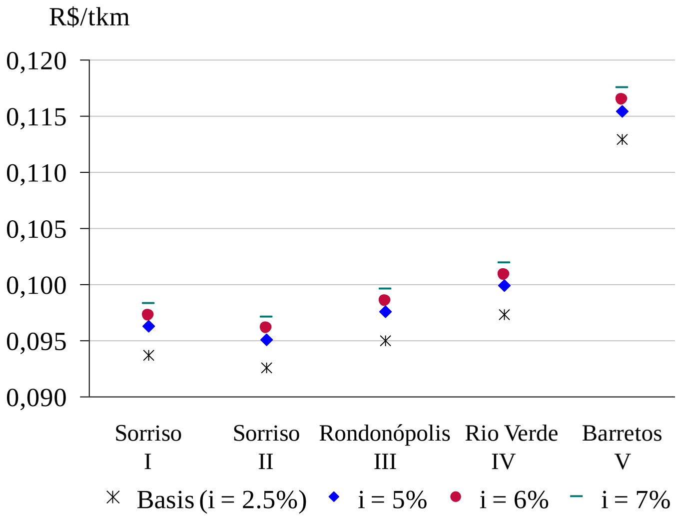
Figure 4.14: Sensitivity analysis - maintenance costs



Source: Created by author

Figure 4.15 represents the factor variation of the interest rate level. While the interest rate at the low level of 2.5 % was considered for the basic calculations, an increase of the interest level was assumed. In the case of i = 5 %, total transport increased by two percent (route five) or three percent (route one to four) which represented additional transport costs of minimum 46.88 R$ in case of the shortest distance travelled (route five) and of maximum 206.25 R$ in case of the largest distance travelled (route one). At i = 7 % the change in transport costs for route five represented four percent (+84.38 R$), while the impact on route one was five percent (+371.25 R$). The analysis showed that an increase of the interest rate implies considerably increased transport costs per ton, diminishing the profit margin or increasing losses if the freight rate is below transport costs. The low interest rate of 2.5 % could be an appropriate measure to keep freight prices low and give incentives to invest in new equipment. Any increase of the interest rate and corresponding increases in transport costs can provoke losses of competitiveness of the soybean producers in regions far from the seaport.

Figure 4.15: Sensitivity analysis - interest rate



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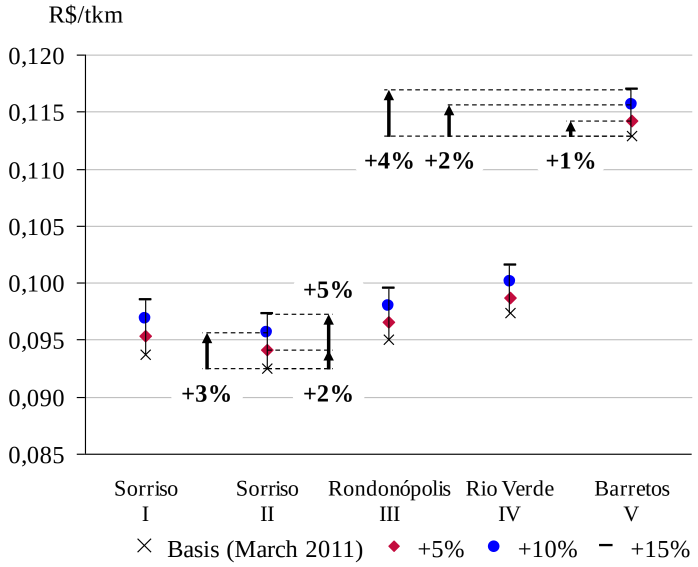
It was furthermore performed a sensitivity analysis by varying the fuel costs by five, ten and fifteen percent. Appendix 39 shows that the local fuel prices increased since 2004 by about 40 % until 2011. As fuel costs are reportedly one of the major elements of the freight composition (see chapter 4.2.1), the freight rate probably accompanies increases in fuel prices. The sensitivity analyses confirmed this assumption and revealed that a change in the level of fuel costs is reflected in a proportional increase of total transport costs, as illustrated in figure 4.16. For a change of five percent in fuel prices, absolute transportation costs represented the values 128.04 R$ (route one), 122.22 R$ (route two), 78.23 R$ (route three), 54.63 R$ (route four) and 24.66 R$ (route five).

These values doubled with ten percent increase and tripled with a fifteen percent increase in fuel prices. This means that additional costs are passed onto the producers with the effect of diminishing the price received by the producer for the soybeans.

In any case, it was observed that the percentage change of total transport costs decreased with the distance. It showed that the effect of changing a factor is magnified by the distance. Any variation resulting in lower transport costs would benefit the producers in the Center West more than producers of production regions closer to the export port. Likewise, any cost increasing factor variation will harm the former more than the latter.

Figure 4.16: Sensitivity analysis - fuel price



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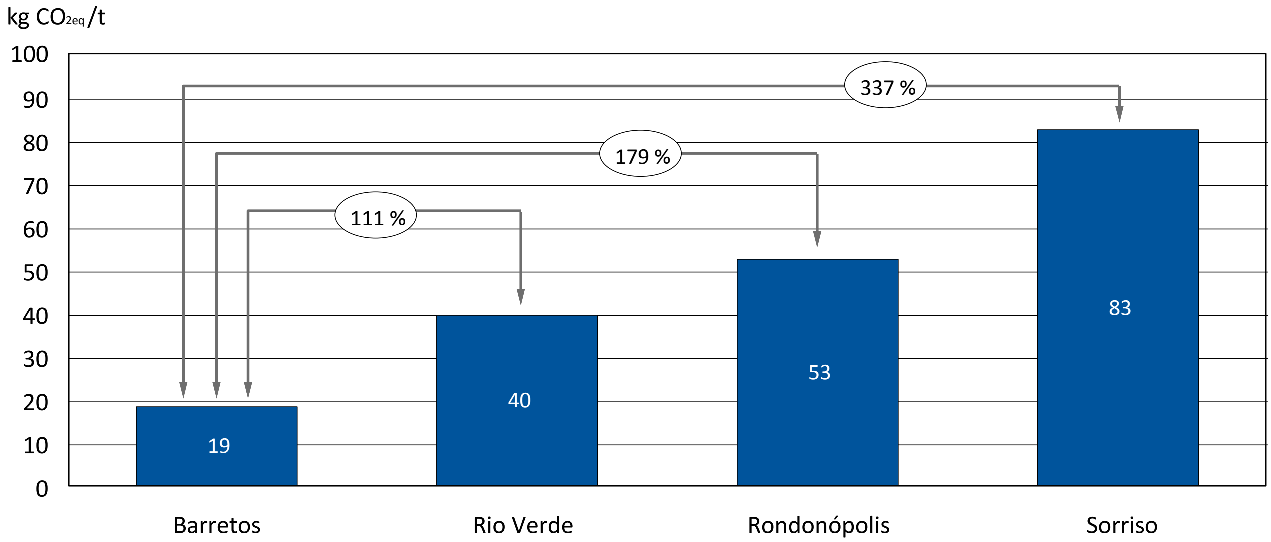
4.3 Impact assessment of soybean transports on climate change and interpretation

The field data provided first-hand information for the GHG inventory model and enabled to draw an exemplary picture of soybean transportation processes within the Sorriso-Santos corridor. The observed CO_2 fluxes ranged between 18.92 $kgCO_{2eq}$/t (500 km) and 83.24 $kgCO_{2eq}$/t (2,200 km).

GHG emissions from road and intermodal transportation were calculated for transport processes from each of the selected region. Figure 4.17 illustrates the impact of the distance on GHG emissions. Setting the shipping from the most distant region (Sorriso) into relation to the region, which is situated closest to Santos port (Barretos), revealed an increase in emission volume corresponding to the higher energy demand for longer distances. The emission quantity of the Sorriso-Santos route (83.24 $kgCO_{2eq}$/t) is 4.40 times as high as the emissions resulting during travelling from Barretos (18.92 $kgCO_{2eq}$/t) to Santos. The climatic impact caused by the exemplary soybean export processes for each analyzed region is represented in figure 4.18. The results give evidence of a reduced efficiency of soybeans produced in the Center West compared to soybeans produced closer to the export port. From this point of view Sorriso is least efficient and Barretos most efficient as a soybean production region in terms of carbon emissions from transportation. The emission based evaluation of the climate impact of both road and intermodal transports of rail and road shipping revealed that road transportation is the more damaging modality of the options. Due to a lower fuel combustion per tkm, a train emits only half (0.02 $kgCO_{2eq}$/t) of the GHG emissions that a truck emits (0.04 $kgCO_{2eq}$/t). This confirmed the results presented by SILVA ET AL. (2010) and BIAGGIONI/BOVOLENTA (2010).

Figure 4.17: GHG emissions through road transport over selected distances (kgCO_2eq/t)

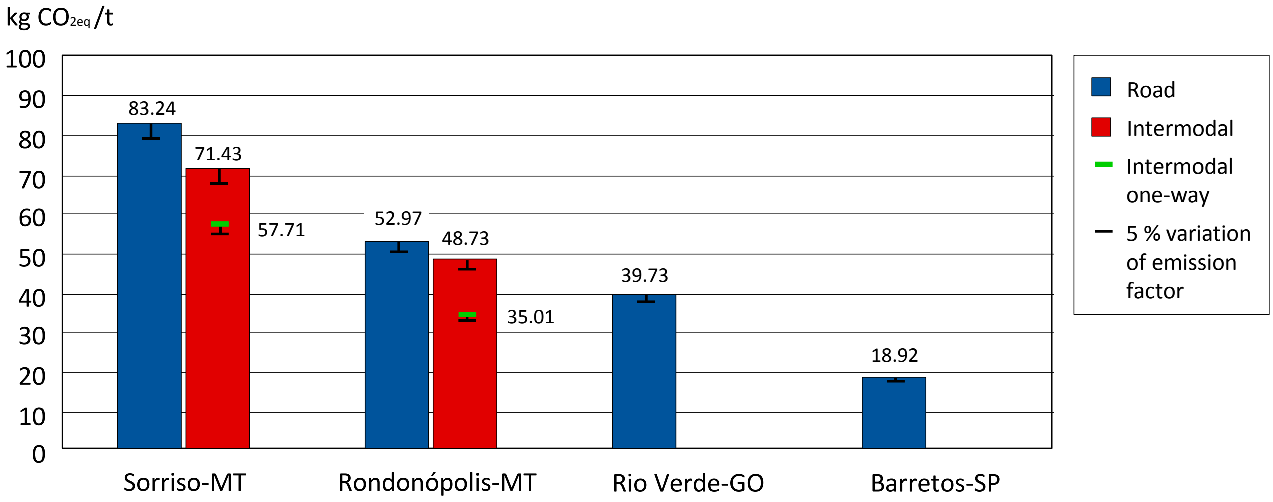


Source: Created by author.

The evaluation demonstrated that intermodality is more efficient if road transports to the rail terminal are over long distances (see case Sorriso). For the case of Rondonópolis, the competitive advantage of intermodality over road transports is only slightly distinct. This may be explained by the need to additionally consider 70 % of the gases (see chapter 3.6) that are emitted during the return travel to the terminal of Alto Araguaia. If considering that the train returns fully loaded with other products, emissions would be attributed to these other product process chains instead of the soybean export process. This would result in a mitigation of the GWP of soybean exports by 24 % (13.72 kgCO_{2eq}/t) compared to the previous assumption, or, by 31 % (25.53 kgCO_{2eq}/t) for the distance Sorriso-Santos (800 km road plus 1,400 km railroad) and 34 % (17.96 kgCO_{2eq}/t) for the distance Rondonópolis-Santos (200 km road + 1,400 km railroad).

In a sensitivity analysis, fuel efficiency was varied to examine the reduction potential for climate effects. In a first step, it was assumed that diesel quality will improve. The application of the emission factor of 2.8 was explained in chapter 3.6 with the low diesel quality utilized in Brazil, which was assumed to improve. The applied emission factor (2.8) was adjusted towards the IPCC default value (2.67). The variation showed that by consuming higher quality diesel GWP can be reduced up to five percent. The results are represented by the black marks in figure 4.18.

Figure 4.18: GHG emissions during soybean exportation for selected transportation routes and modalities



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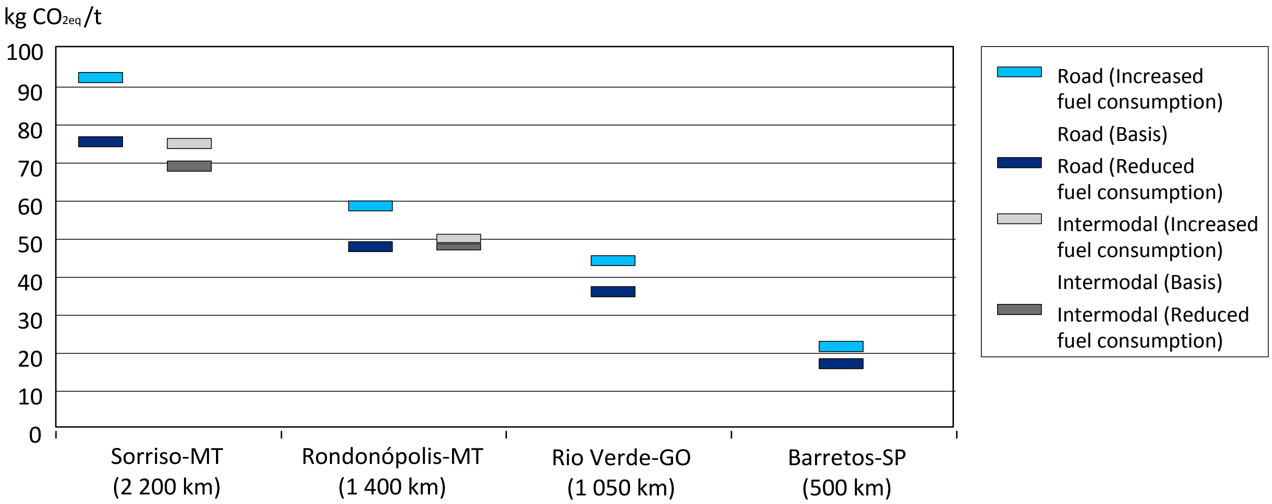
In a second step, a variation by ten percent of the fuel consumption of a truck was assumed. The target of Brazil to reduce the average age of the truck fleet might have a positive impact on fuel efficiency and thus on exhaust emissions (see appendix 40). As GHG emissions are tight to the fuel combustions, the variation of a truck's fuel consumption by ten percent resulted in a proportional reduction or increase in GHG emissions if soybeans are shipped only via road. The intermodal option displayed a more moderate change in emissions. In this case, a ten percent reduction in the trucks' fuel consumption reduced the GHG emissions by six percent for the Sorriso-Santos route and by four percent for the Rondonópolis-Santos route, respectively. The results shown in figure 4.19 give evidence that the intermodal option continues to be more efficient for transports from Sorriso to Santos. However, with an improved fuel efficiency road transport becomes more efficient when transports start in Rondonópolis. The breakeven point between road and intermodal transportation was calculated at a truck's fuel consumption of 0.46 l/km (-8 %). For the Sorriso-Santos route a decrease of fuel combustion per km to 0.39 l/km (-22 %) would equal the emission volume of road and intermodal transportation. In the other case of fuel-efficiency losses, e.g., due to worsened road conditions or a bad driving manner of the trucker, emissions increased by ten percent, proportionally to the assumed change in fuel consumption.

Figure 4.19: Sensitivity analysis - fuel efficiency



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For road transportation the principal factor of influence was the fuel efficiency of trucks, which represented the highest potential for GHG mitigation. An improved emission factor was the best option for intermodal transportation. However, domestic transports accounted for a much higher amount of GHG emissions compared to ocean freight shipping. According to the IEA (2009), a bulk carrier operating on the sea emits even in the worse case less than 10 kgCO_{2eq}/tkm (see appendix 41), which leads to the assumption that bulk carriers operating on the inland waterways correspondingly emit decisively less emissions than the road transport mode.

5 Bottlenecks and potential developments

A well functioning logistics network is a decisive factor to induce and facilitate competitiveness and development of the soybean sector. Brazil's current infrastructural system is underdeveloped relating to its continuously growing output of agricultural and industrial products. Governmental programs like the PNLT (see chapter 2.3.5) target a more balanced transport matrix with a higher participation of rail and water transportation modalities.

This chapter shall illustrate the bottlenecks and challenges of the Brazilian transport sector and give an outlook of the potential development of soybean logistics in Brazil.

5.1 Road transportation

ANONYMOUS 3 (2012) asserted that large parts of the highway infrastructure are antique. Roads were constructed in the 1970s and subsequently only maintained by clumsy mending and closing holes. Single lanes per direction of traffic cause congestion and dangerous overhauling maneuvers put traffic participants at risk (ANONYMOUS 4, 2012). CNT (2011, pp. 277, 286) reported that the condition of the road directly influences diesel consumption and losses of cargo. Worse road conditions force the driver to drive slower than optimum speed and more diesel is consumed. ANONYMOUS 4 (2012) reported an elevated level of losses at roads in worse conditions, which companies generally calculate with of 0.5 % of the total volume per year (AMARAL, 2012; ANTUNES, 2012; JESUS, 2012). Applying this number to the total export volume of Brazilian soybeans (2011: 32.99 mmt) reveals annual losses of 164,950 t of soybeans. Assuming a fob price of 524.69 R$/t (averaged fob price at Santos over the period of February to September 2011) Brazil lost in the 2011 export season 86.55 million R$ because of volume losses during transportation processes.

One major project is the pavement of the BR-163 from Sinop-MT to Santarém-PA (ANONYMOUS 3, 2012) (see appendix 42). Its completion was planned for 2008 (VERA-DIAZ/KAUFMANN/ NEPSTAD, 2009, p. 3) but to date there still remain 300 km to be paved (BIRKHAN, 2012). This unpaved part prejudices the export process to Santarém as during the rainy harvest season the track become impassable for the heavy-duty trucks (FRANÇA, 2012). VERA-DIAZ/ KAUFMANN/NEPSTAD (2009) revealed that paving the BR-163 to Santarém and the rerouting of soybean exports to the Santarém port could reduce the transit time and lower the cost of shipping by averaged 10 US$/t (20 R$/t) for soybeans produced in the northern part of Mato Grosso. USITC (2012, p. 3-5) reported a value of 20 US$/t (41 R$/t), while BIRKHAN (2012) estimated an impact on shipping costs by up to 30 US$/t (61 R$/t) and increasing local spot market prices.

The highways in the regions of Sorriso and Rondonópolis were in regular or good conditions while the road in the municipalities bordering to the major transshipment stations of the Center West in Alto Araguaia-MT and Alto Taquari-MT, were found in bad conditions (see appendix 33). Big holes in the pavement and bad surface of the pavement force trucks to drive slowly and lead to losses of cargo. The highways are steadily restored but suffer from the high volume of the heavy-duty transports. Investments in road refurbishing are apparently barely sufficient. Roads may have a good status at the beginning of the harvest season but deteriorate quickly during the harvesting periods of the soybeans and corn. In the region of Rio Verde, large road tracks were under construction. Anonymous 5 (2012) stated that road conditions were poor until 2010 but improved decisively since that time by renovation and duplication. Garcia da Silva (2012) pointed out that travel time has decreased decisively at certain tracks. He instanced that the travel time on the export route in direction to Santos from Rio Verde via the BR-452 Itumbiara-GO diminished from eight hours to three hours due to improvement of the infrastructure.

5.2 Rail transportation

High freight prices and line-ups at the gates of the rail terminals reflect the bottlenecks of the rail system (Klasener, 2012). The high prices are not only a result of monopolistic price setting but are also influenced by infrastructural deficiencies and administrative bottlenecks (Monteiro/Sebben/Golin, 2011). The capacities of rail equipment and terminal installations of the rail terminal in Alto Araguaia are not sufficient to cover the demand for transportation services in the designated time schedule (Sperandio et al., 2012). In the context of the PNLT (see chapter 2.3.5), a new rail network, called “agribusiness railroads” by Vencovsky (2011), is being implanted in planned corridors (see appendix 43) that are designed to link production and consumption regions (Castillo/Vencovsky/Braga, 2011, p. 20). A new rail terminal was established in June 2012 in Itiquira-MT (distance to Alto Araguaia: 120 km) (Ferreira, 2012) and a major terminal in Rondonópolis (distance to Alto Araguaia: 250 km) is planned to be inaugurated in 2013. It is expected that the completion of the project improves intermodal access to the Port of Santos for a broader range of production regions and opens up the opportunity of increasing intermodality. Aprosoja (2012) projects that the ALLMN railroad will transport an annual volume of 15.50 mmt of soybeans and corn in 2022 (+48 % relating to 2010, see chapter 2.3.2).

While one of the major targets of the projects of the PNLT is to lower the total logistics costs and increase efficiency, Sperandio et al. (2012) and França (2012) estimated that the extended railroad to Rondonópolis would not change the freight price. They instanced the case of the rail terminal of Alto Taquari-MT and Itiquira-MT, where freight rates did not drop. Sperandio et al. (2012) pointed out that expectations of lower transport costs and better access to Santos benefitting the regional producers by lower freight rates failed. In reality, the terminal benefitted only the big trading companies while even prejudicing the producers by high traffic densities causing road deterioration and heavy congestion. Nevertheless, as the soybean yields are continuously increasing, more freight will be moving on the highways. Thus, the installation of the rail terminal in Rondonópolis enables to relief the roads from imminent higher volume of traffic on the traditional export corridors by relocation large volumes from road to railroad. This might affect freight rates of trucking positively in the benefitting regions, as more trucks could be available for short distance transports due to shrinking demand (Antunes, A. 2012).

Some experts believe that lacking competition and restricted access to rail transport services will mitigate any cost advantages of the extended railroad. Any change in rail freight price changes will depend on the structure of the rail terminal, i.e., if the monopolistic structure of rail operations will continue, if volumes turned over will explore the handling capacities at maximum and if equipment and installations will enable a more competitive price due to low operational costs (França, 2012; Birkhan, 2012;). Thus, the effect of the railroad expansion on logistics costs remains uncertain.

Rail freight prices that do not necessarily offer a cost advantage compared to road freight rates, a faster transit time of trucks and the avoidance of waiting times at the rail terminal increase the attractiveness of road transportation for traders. França (2012) instanced that the trading company for which he worked (volume of soybeans traded ≥ 2 mmt/year) operated an own rail terminal in Alto Araguaia until 2011, which was closed due to the mentioned reasons. In order to improve the efficiency of the rail network the government reviewed in 2011 its concession model and implemented a new rail regulation (Resolution N°3.696/11). This asserted that any idle capacity of a rail section must be available to other operators in order to perform the right of way or mutual traffic (ANTT, 2011). The USDA (2011) forecasted a positive impact of the law on grain and soybean exports by facilitating the marketing of agricultural products. Even though, the USITC (2012, pp. 3-09) estimated that despite railroad utilization might be more efficient, rail prices won't decrease due to limited capacities and limited competition.

5.3 Water transportation

The highest potential of relieving the port of Santos of the great handling volumes and the Sorriso-Santos export corridor from the high traffic density is estimated to be in the development of the waterway system in the northern states (see appendix 44). Perrupato (2011) estimated a potential of 15,000 km for extending the network of waterways, with most of it being located in the North. Birkhan (2012) accredited the greatest potential for decreasing logistics costs for soybean exports from the Center West to the development of the Tapajós waterway. ANTAQ (2012, p. 16) confirmed this, projecting that, after developing the waterway and connecting it to Mato Grosso via the BR-163, the so called Sorriso-Santarém route, will become the principal export corridor for soybeans produces in central and north Mato Grosso.

5.4 Storage capacities

The reportedly lacking storage capacities (see chapter 2.3.4) force producers to market the soybeans before the corn *safrinha* harvest starts. These deficits in storing capacities result in logistic problems like congestion at farms, warehouses and ports during peak harvest season. Long line-ups at the warehouses in the production regions and at the gates of Santos port are a common picture during the peak of soybean exports in February, March and April (KLASENER, 2012). JESUS (2012) added that trucks are utilized as warehouses on wheels in order to overcome the scarcity, which in turn has a price driving effect when demand increases and truck capacities are getting scarce. According to EIU (2010, p. 11) insufficient storage space result in monetary losses of averaged one US$ per bushel of soybeans because producers are forced to sell at harvest time when prices are at the lowest level. Depending on the market conditions, this loss can be higher. KLASENER (2012) underlined that the decision to store the soybeans in order to benefit from higher prices in the period between the Brazilian and the U.S. harvest is an exceptional case even amongst large producers. Only highly capitalized producers, who are not dependent on the revenues for financing the inputs the next season, can afford storage over a longer period of time.

Table 5.1: Medium waiting time at port terminals (h) in Santos (2009, 2010).

Port terminal	2009	2010
ADM (Corex)	133	213
TGG	78	124
Cargill	77	60

Source: ANTAQ (2011a, p98).

The great need for strategic situated warehouses in rural production became apparent in the 2012 season, when optimum climate conditions during planting and grain fill stages as well as expanded planting area rendered a high output of the corn *safrinha* harvest. This resulted in a high demand for storage capacities. Consequentially, soybeans had to be rapidly sold to clear the warehouses in order to be able to take in the corn crop when freshly harvested. 86 % of the produced soybeans were marketed until the end of April 2012 (IMEA, 2012). Even though, large volumes of corn had to be stored on the field or open air, respectively, due to lacking storage capacities, raising the risk of losses due to spoilage and mold caused by warm temperatures and moist climate (no data on losses available) (KLASENER, 2012).

5.5 Port system

Experts agreed that the major bottleneck of the soybean export logistics is the deficient port infrastructure. The lack of sheltered ship loading space was recorded as one of the most important weaknesses as breakdowns during ship loading due to adverse weather conditions occur lead to long waiting times (see table 5.1). BIRKHAN (2012) calls for a replacement of prevailing precarious technical port installations and antique machines while ANONYMOUS 3 (2012) outlined the need for modernization of the port communication in Santos. Even though the time-limited concessions for running a port terminal might discourage long-term investments (ANONYMOUS 2, 2012), many concessionaires engage in developing new or improving existent port infrastructure.

ANONYMOUS 3 (2012) explained that the trading company for which he worked (volume of soybeans traded ≥ 2 mmt/year) invested in a recently implemented integrated information system, which works as scheduling system for reception. If ship loading is delayed or capacities are not fully explored the system transfers this information to the logistics department that immediately reduces or increases the volume sent to the seaport. According to ANONYMOUS 4 (2012) the effect was a 98 % reduction of the waiting time at the company's terminal.

The PNLT initiated projects for improving port infrastructure and access to land. UK TRADE AND INVESTMENTS (2011, pp. 10) estimated that the PNLT investments in infrastructure and port logistics will enable to increase the handling capacity of Brazil's ports up to 30 %.

Trading companies focus their investments in port infrastructure in northern Brazil. One large trading company, e.g., invests in port terminals in Santarém-PA where the company aims to double the storage capacities by 60,000 t (FRANÇA, 2012; ANONYMOUS 5, 2012). APROSOJA (2011) estimated an increase in mass flows to Santarém of 122 % and predicted the volumes exported via São Luiz to increase by 462 %. These ports are estimated to cover the major part of the projected volume increase during the next decade. Appendix 45 illustrates the projected development of soybean exports and shows the projected decrease of the area of influence of Santos port. The concentration of companies' investments in infrastructure development of the northern ports as stated by AMARAL (2012) and FRANÇA (2012) reflects the importance that is accredited to the northern ports of São Luiz-MA and Santarém-PA. However, difficult institutional processes for license granting and environmental protection measures required decelerate and hamper speedy completing of the project. Problems to obtain operational licenses due to environmental activism and bureaucracy impede a quick development (FRANÇA, 2012).

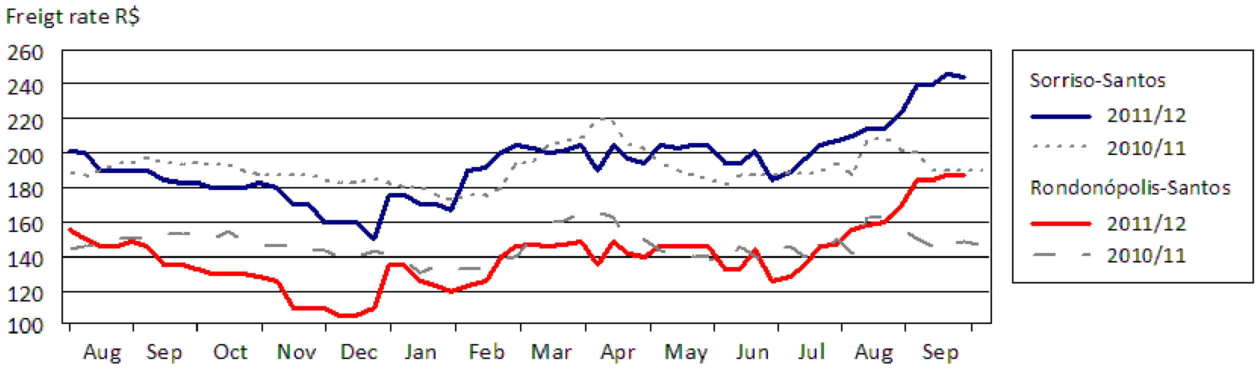
5.6 Truck drivers law

In September 2012, a new law (LEI DOS MOTORISTAS N°12.619), called the truck drivers law, was put into effect (PORTAL BRASIL, 2012). It regulates the working time of truck drivers, limiting the maximum permitted working time to eleven hours per day including rest breaks of minimum 30 minutes every four hours wherever the truck may be driving (GODINHO, 2012; JESUS, 2012).

Most experts estimated that the law will have a significant effect on operational time and operational costs. The monthly performance per truck and driver was predicted to decrease by approximately 35 % (GODINHO, 2012; JESUS, 2012). Transport service providers expected operational costs to increase by 30 % to 45 % in comparison to the freight rates before the law, as well as prolonged operational time (+30 %). Conservative estimates of a large trading company (volume of soybeans traded ≥ 2 mmt/year) predicted an increase of only ten percent. There was a consensus of the experts that costs due to supply shortages will be the major price driver. ANONYMOUS 5 (2012) assumed a 45 % increase in demand for trucks and drivers.

Regarding the development of selected freight rates for long distance hauls during a determined period of time (see figure 5.1), the increase of freight rates in 2012 is observable[1]. While the freight rate in September 2011 was still lower than in the previous year, the 2012 freight rates mostly surpassed the 2011 freight rates. The 2011 rates started to decrease with the ending of the export season in August. This market behavior could also be observed in the preceding years, whereas in 2012 freight prices began to rise in July (date of reference: July 04, 2012). The drivers law may not be the only driving factor of the price but surely plays a key role. A prominent volume of corn harvested in the respective season kept freight prices at a high level during May to July. At the beginning of September, the difference already achieved 30 %, where it stagnated in Sorriso while it further increased to a 39 % difference in Rondonópolis. PRESSINOTT (2012) reported a 40 % increase in freight prices for Mato Grosso and averaged 20 % for the whole country from January 2012 to August 2012, compared to the same period of the previous year. ROGÉRIO (2012) outlined that in São Paulo state, where a lot of trucking companies are registered, capacities are lacking. He assigned that to the high increase in freight prices of the Center West, which attract the haulers and lead to supply deficits in the other regions. JESUS (2012) concluded that the price drivers are shortages in labor and the lengthened delivery time.

Figure 5.1: Development of selected freight rates (2010-2012)



Source: Created by author. Based on data from IMEA (2012).

Experts estimate that freight rates will remain on a 30 % elevated level in the long term, while the monthly performance per truck and driver will decrease by approximately 35 % as a result of the law (GODINHO, 2012; JESUS, 2012). PARREIRA (2012) underlined the positive effects for the transport service providers by considering the reduction of kilometers travelled per month per truck and driver, which might positively impact on costs by reducing maintenance costs due to wastage. In combination with higher freight prices PARREIRA (2012) argued that even though the costs per driver increase, this will be offset by a higher increase in return and the savings at other cost positions. He concluded that the distribution of costs will shift but the level of costs will not

[1] Data were available only until September 2012, so that a comparison of freight rates later than September 2012 with the same period of the previous year was not possible.

change significantly and monthly turnover will continue equally. However, the law does not necessarily benefit the professional drivers. While prior to the law an extended working day to increase remuneration was eligible, this regulation is prejudicing particularly income opportunities for self-employed drivers who work according to JESUS (2012) for a ten percent lower rate than a transportation company with own fleet and employed drivers does.

6 Discussion of results

For being a high volume and low value-added product, high transportation costs might impact decisively on total costs of soybean exportation. The seasonality of soybean production and the corresponding seasonal demand for transport services is reflected in the freight price development. Given these peculiarities of the crop and considering the tight correlation to the world market prices, it can be concluded that a principal measure to increase competitiveness of the Brazilian soybeans should be the implementation of infrastructural programs in order to decrease transportation costs. Brazil's challenge is the improvement of the infrastructure in the medium term and investments to expand the network in the long term to diminish logistics and transportation costs and increase competitiveness of soybean exports from distant production areas.

Freight rates in the competitive road transportation sector are composed by the company's marginal costs plus a profit margin and are influenced by the market behavior. The price formation of rail freight, however, is rather intransparent. The market analysis revealed that soybean shipping via railroad from Mato Grosso, Goiás and São Paulo to Santos port is at harvest peak times more expensive than trucking. This might be an indication that ALL, which is the only railway service provider on this railroad, indeed exploits its customers based on a monopolistic market position. Higher competition in the rail transport sector and the improvement of the rail infrastructure might be an important factor to affect freight prices positively. Reforms are necessary to relocate the transportation matrix to the high volume and low cost transport modalities of railroad and waterway and to create more competition amongst operators.

Transport costs affect the competitiveness of soybeans produced in the inland of Brazil. The sensitivity analysis revealed that the longer the distance from production region to seaport, the larger are the effects of increased input prices. Supportive measures, such as the currently low interest rate on capital for truck financing (2.5 %, see chapter 4.2.2.2), may help keeping transport costs at a low level and indirectly support producer prices in remote regions. Any cost increase of input factors would result in higher transport costs and might result in losses of competitiveness if circumstances remain equal to the reference case. Any decrease, however, offers potential to increase the competitiveness of the soybeans. Strategic infrastructural investments link the remote agricultural areas to the infrastructure and open new export corridors to the north, like the Sorriso-Santarém corridor (BR-163). That way, an integrative system of different modalities could be realized. Logistics bottlenecks (see chapter 5) could be reduced. The access to more modalities than road transportation would benefit more producers as competition could create more competitive freight rates. Redirecting export volumes from the Sorriso-Santos corridor to the Sorriso-Santarém corridor could diminish congestion on the export corridor to Santos.

With the doubling of the soybean volume exported via Santos (2001: 4.60 mmt; 2011: 9.23 mmt; MDIC, 2012) it became apparent that access to the port is lacking and capacities are not sufficient for efficiently turning over the high volumes at low costs and small operational time (see chapter 2.2.5). Any further increase in the export volume could adversely affect the competitiveness of the Brazilian soybean exports if infrastructure is not improved or export volumes are not relocated to other ports. Investments in the infrastructure of the northern ports and of the northern export corridors would enable a relocation of mass flows from the traditional corridors to the southeastern ports, like the Sorriso-Santos corridor, to the north. This could relieve the southern ports, where port operations are currently inefficient.

Enhanced storage capacities could also positively influence competitiveness and would help avoiding demand excess like in the instanced case of 2012 (see chapter 5.4). Sufficient storage capacities would reduce the need for immediate shipping at harvesting and relieve intermodal terminal and port facilities from the high traffic volume at harvest peak. It would contribute to a well-functioning shipping process and help to avoid costs of demurrage, to diminish transit time and reduce transportation costs. Producers of the Center West could benefit from decreasing freight rates if transportation costs decrease (see chapter 4.2).

While the government lacked investments during the past two decades, a change in policies within the last five to seven years was observed (see chapter 2.3.5). This development is favorable because the great potentials to expand agricultural production in Brazil can only be efficiently explored if the production regions are connected to the economic centers by an appropriate infrastructural network. Large parts of the infrastructural system still have to be refurbished and continuous investments are required to keep it in a good condition. Whereas new projects were initiated, progress is reportedly slow. The Brazil cost (see chapter 4.2.1) including bureaucratic inertia and complicated environmental licensing hampers the quick complementation of the projects. Experts instanced that the completion of paving a 150 km road track of state or federally administered roads in south Mato Grosso took more than 25 years due to slow institutional processes (SPERANDIO ET AL., 2012). This bottleneck was observed to be a major challenge, which should to be overcome in the long term to improve the competitiveness of the soybean sector.

The long distance transports affect furthermore climate change. CNT (2011, p. 287) estimated that emissions from road transport will increase by 60 % until the year 2020 (related to 2009). With regard to the projections in chapter 2.1, it can be expected that the soybean business will increase its demand for transportation services decisively and contribute to the projected increase in GHG emissions. The expansion of the soybean production into remote rural regions like Sorriso resulted in a higher diesel consumption per route and a corresponding increase in GHG emissions, when compared to transports from the traditional agricultural production areas like Barretos. Distance is inferentially the major determinant for the volume of GHG emissions. The analysis showed that intermodal transportation is the most efficient option at present conditions. If fuel consumption remains on the same level or increases, the relocation of transport processes to the railroad is recommendable from the environmental point of view. A higher fuel-efficiency would make road transports become more competitive. If fuel consumption decreases by minimum 22 % in the case of Sorriso or eight percent in the case of Rondonópolis trucking would become even more efficient than rail. As truck technologies are already high developed, an improvement of the infrastructure is crucial for GHG mitigation in Brazil. CNT (2012, p. 358) estimated a significant reduction in fuel consumption until 2020 if road conditions will improve. If roads remain in the conditions of the time being the emissions will more than double due to a growing vehicle fleet and increasing demand for transportation services.

Brazil took an important step towards GHG mitigation by committing itself voluntarily to adopt measures for mitigating GHG emissions (CNT, 2011, p. 285, IPEA, 2011, p. 33). An important technical measure to diminish GHG emissions are fleet renewals. In economic terms, a fleet renewal might lead to increased freight prices, as costs of a new machine are clearly higher, e.g. due to high depreciation costs, than costs of an old truck. However, the technological innovations can help to reduce the energy demand, e.g., by reduced fuel consumption (see appendix 40). Such technical improvements like a higher performance in fuel combustion per kilometer implies the advance of the air quality program PROCONVE (see appendix 28). Further reductions from road transport should be supported by policies and operational measures. Political measures may also address the improvement in infrastructure as well as the development of vehicle technologies and alternative energies. Operational measures include driver training for optimum driving and an efficient logistics management. They further address the formation of environmental consciousness of the market participants. Governmental or customer incentives as well as the engagement of the company owners can foment such measures. ACEA (2010, p. 7) emphasized that a proper logistics management helps to improve fuel and CO_2 efficiency.

CORREA/RAMOS (2010) asserted that road transportation requires almost four times as much energy as water transportation and three times as much as rail transports. Concluding, a shift in the transportation matrix from road to rail and to waterway would positively affect climate change. If the loading factor of the return transports increases, the extension of the railroad network to Rondonópolis offers the potential for mitigating GHG. However, the demand for soybean transports will probably continue to exceed the demand for shipments of agricultural inputs. A decrease in $kgCO_{2eq}/t$ might thus not be achieved. Further studies addressing the climate effects and potentials of this soybean transports from the Center West are needed.

In conclusion, the future efficiency of the soybean export logistics depends on the integration of the total infrastructural system, which incorporates warehouses, railroads, roads, waterways and ports. Even though there are already a lot of initiatives and projects, it is not sufficient yet to ensure a smooth flow of goods on national level. This means that Brazil should pursue the strategy of investing in infrastructure and focus on the realization of the. That way, maximum utilization of capacities for minimizing costs and additional kilometers travelled could be achieved projects and the competitive position on the world market strengthened.

The study revealed that logistics processes are determinants of the competitiveness of Brazilian soybeans. The studied cases elucidated that logistics costs are dominated by freight prices, which are determined by the road transport costs. This applies to the road freight rate as well as to the rail freight rate, which in the cases under consideration was mostly tight to road freight prices. Costs and GHG emissions are closely related to the transport distance, so that the more distant regions like Sorriso can decisively lose in competitiveness compared to the regions closer to the seaport of Santos like Barretos. The need for investments was realized by the Brazilian government and many strategic projects are initiated or planned, even though, with regard to the past, most of the projects will probably not be complemented in the planned timeframes. It is estimated that if the country keeps the current strategic focus on infrastructure, the conditions of the infrastructural network will decisively improve in the next decade. Despite continuing infrastructural inefficiencies, Brazil will probably be a globally competitive soybean producer and exporter due to its natural resource abundance and supportive government policies.

7 Summary

Soybean exports in Brazil require often long distance transports. This study examined the relevance of domestic transportation and logistics processes of soybean exports in terms of costs and CO_2 emissions between farm gate and seaport for selected regions in Brazil. To estimate the impact of logistics on competitiveness of soybeans in a national comparison, the export processes over four different distances (2,200 km; 1,400 km; 1,050 km; 500 km) to the principal seaport for soybean exports, i.e., Santos, were evaluated in a market and a cost analysis.

Few large trading companies dominate 80 % of the national soybean trade. Cooperatives, who offer their services to farmers, cover 20 % and are mainly active in the southern regions. In the Center West, in contrast, producers and farmer unions typically negotiate directly with the trading companies.

The transport sector is fragmented. Road transport service providers act on a highly competitive market while only one railway service provider operates rail transports on the ALLMN railroad from Mato Grosso to Santos. Primarily, the large trading companies have access to rail transportation and export up to 80 % of their trading soybean volume originated in the Center West on the ALLMN railroad. Smaller companies ship their lower trading volumes mostly with trucks, due to high rail freight prices.

The state Mato Grosso is the principal soybean producer of the country and situated in central Brazil far from the seaports. As soybeans are a high volume and low value-added bulk good, the most efficient transportation modalities over long distances are in economic and climatic terms the rail and water mode. However, the infrastructural development in Brazil did not keep pace with the increase in agricultural production. Insufficient capacities of storage, rail and waterway transportation create inefficiencies and prejudice the competitiveness of the Brazilian soybeans produced in remote areas.

Road transport by truck accounts for 60 % of soybean transport in Brazil. Due to high diesel consumption and the fact that inland production regions are distant from ports, markets costs for soybeans produced in the remote areas of the Center West are generally high relative to other production regions closer to the seaports. The cost analysis for soybean export processes over four different distances (2,200 km; 1,400 km; 1,050 km; 500 km) revealed total logistics costs of 92.61 R$/t for transports from Barretos to the Santos (April 2011), which is closest to Santos port (500 km), and 230.08 R$/t for transports from Sorriso, which is the most distant but major soybean production region (2,200 km). Costs per tonne-kilometer varied from 0.19 R$/tkm for 500 km transports (Barretos to Santos) and 0.15 R$/tkm for 1,050 km (Rio Verde-Santos) to 0.13 R$/tkm for 1,400 km (Rondonópolis-Santos) and 0.10R$/tkm for transports over 2,200 km (Sorriso-Santos).

Logistics costs are composed by freight costs and export expenses, which include taxes, commission and brokerage, port fee and costs for damage of cargo. The calculation with data from April 2011 revealed that freight costs determine the major cost position of logistics costs, representing 66 % (September 2011: 63 %) in the case of Barretos and 86 % (September 2011: 84 %) in the case of Sorriso. For inland transports over 1,050 km from Rio Verde the transport costs represented 79 % and for 1,400 km from Rondonópolis 82 %, respectively.

Rail freight rates are on a comparable level with road freight prices or may be even more expensive. Due to lacking data, rail transport costs were not analyzed in detail.

Because transport costs represent the major element of total logistics costs, the costs of truck transportation were assessed. The major cost positions, which account for 63 % to 70 % of the total transport costs, are fuel cost, driver's gross labor rate and maintenance. The calculation was based on data from March 2011. Disparities of 71 % in total transportation costs were observed when comparing the transport from Barretos (4.18 R$/km; 0.11 R$/tkm) to the transport from Sorriso (3.42 R$/km 0.09 R$/tkm). Because fuel costs are related to the travelled distance, this cost position gained weight with increased distances. For the shortest distance, toll costs constituted a major element of 29 % of the transport costs, as highways are mainly tolled in the region close to Santos port. For the other distances this share varied from eight to sixteen percent.

The study showed that costs of truck transport and freight prices may differ as freight rates are demand driven. They increase, e.g., during harvest time when transport services are highly demanded and capacities get scarce. It was revealed that the more distant the production region, the higher the impact of transport costs on the local producer price. As higher logistics costs diminish the price received by the producer, elevated transport costs compromise the competitiveness of the production regions in the Center West. The sensitivity analysis demonstrated that a change in a factor is magnified by the distance. Any factor variation that results in higher transport costs would prejudice the producers in the Center West by a higher percentage than the producers of the production regions closer to the export port. Higher transport costs would reduce the producer price in the distant regions even more as logistics costs increase.

The assessment of GHG emissions that result from the soybean inland transport revealed that road transport is costly due to the high fuel consumption and corresponding CO_2 emissions. The documentation of the CO_2 emissions in a greenhouse gas inventory elucidated that the expansion of agricultural production to remote areas negatively affects climate change due to the longer the transport distances to the seaports. The observed CO_2 fluxes road transports increased proportionally to the distance from 18.92 kgCO_{2eq}/t (500 km) to 83.24 kgCO_{2eq}/t (2,200 km).

The analysis showed that intermodal transports are more competitive than unimodal transports. A GHG reduction potential of nine percent for transports starting in Rondonópolis and of 17 % for transports from Sorriso was revealed. A point of weakness in intermodal transportation is the low loading factor of the train at return. An increase of the loading factor offers potentials of up to

24 % (13.72 $kgCO_{2eq}/t$) to decrease GWP of soybean exports on the ALLMN railroad. In the case of unimodal road transports, the highest potential of climate change mitigation bears the improvement of fuel efficiency of trucks.

The large and steadily increasing Brazilian soybean production in remote areas calls for more public investments in infrastructure and for an expansion of the infrastructural network. Private companies invest particularly in port capacities to mitigate inefficiencies arising from insufficient infrastructure. The government implements measures for improving infrastructure to avoid further increases in transport costs and reduce inefficiencies arising from lacking infrastructure. Strategic policies, like the rail law, give incentives for a higher utilization of the existing infrastructural capacities, which may positively influence rail freight rates. On the other hand, legislation regulating the road transport sector like the truck drivers law reportedly drives road freight prices. The target to renew the Brazilian truck fleet, 32 % of which are older than 20 years, might be a further price driver in the transport sector. Long and complicated bureaucratic processes hamper the realization of projects in planned time spans. However, recent initiatives to improve the national infrastructure could lead to large improvements in the soybean logistics.

An efficient integrative logistics system, which is supported by a set of strategic investments and policies, is essential to keep costs and GHG emissions of the export processes on national level at a minimum and ensure mass flows without breakdowns. The strategic integration of any agent, institution and process is crucial to ensure the competitiveness of the Brazilian soybean export because at last a "trade supply chain is only as strong as its weakest link" (WORLD BANK, 2010a).

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Appendices

Appendix 1: Exemplary calculations of soybean production costs – international comparison

a) Brazil-USA. Average 2010 costs of production at various R$/$ exchange rates

		United States Heartland	Brazil					
			Paraná	Mato Grosso	Paraná	Mato Grosso	Paraná	Mato Grosso
		(Actual)	(Actual) R$1.76/$1		(Hypothetical) R$2.00/U$1=2.0		(Hypothetical) R$1.50/$1	
Seeds	ct/kg	4.14	2.19	1.01	1.93	0.89	2.57	1.19
Fertilizer	ct/kg	1.22	2.00	4.68	1.76	4.12	2.35	5.49
Chemical inputs	ct/kg	1.20	1.74	3.17	1.54	2.79	2.05	3.72
Labor	ct/kg	1.23	0.56	0.77	0.49	0.68	0.65	0.90
Other operational costs	ct/kg	3.25	1.86	1.60	1.64	1.41	2.19	1.88
Total variable costs	**ct/kg**	**11.04**	**8.35**	**11.23**	**7.35**	**9.89**	**9.80**	**13.18**
Land	ct/kg	12.58	3.09	1.88	2.72	1.65	3.63	2.20
Physical capital	ct/kg	5.37	5.33	2.45	4.69	2.16	6.25	2.87
Other fixed costs	ct/kg	0.67	1.30	1.47	1.15	1.29	1.53	1.72
Total fixed costs	**ct/kg**	**18.62**	**9.72**	**5.79**	**8.56**	**5.10**	**11.41**	**6.79**
Total	**ct/kg**	**29.66**	**18.07**	**17.02**	**15.91**	**14.98**	**21.21**	**19.97**

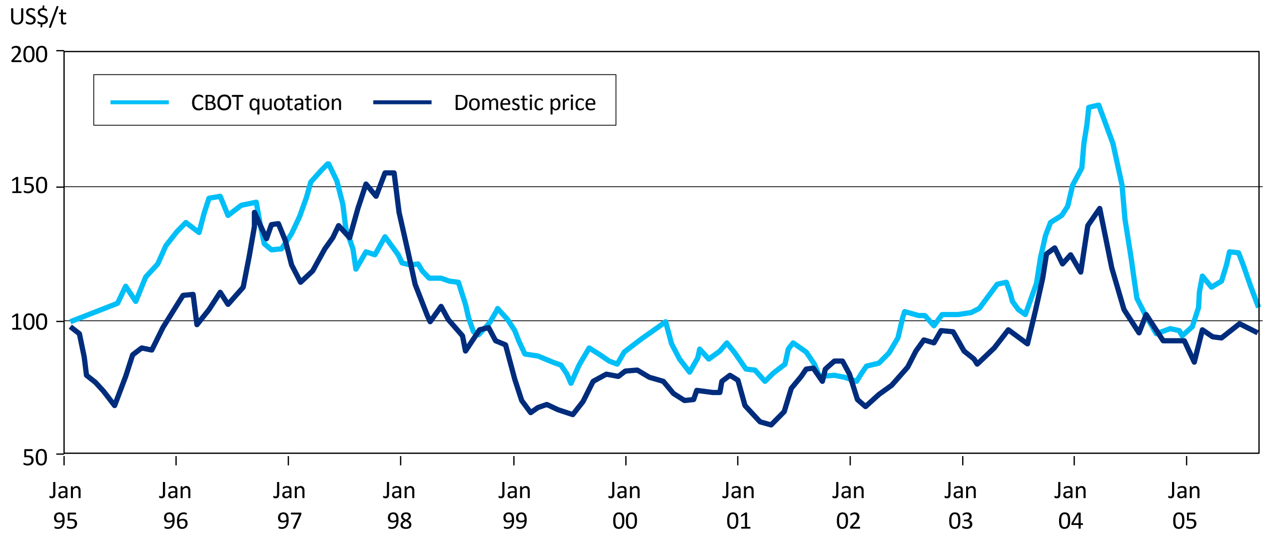
Source: CONAB, "Custo de Producao: Soja Plantio Directo" (May 2010); USDA, "Soybean Production and Returns" (2010); IMF, Exchange rates. Cited in USITC (2012, p6-10).

b) USA-Argentina-Brazil. Soybean production costs

		USA	Argentina	Brazil		
				South (RS)	Center West (MT)	Northeast (BA)
Seeds	US$/ha	144	46	48	55	34
Fertilizer	US$/ha	58	39	115	240	196
Pesticides	US$/ha	39	60	81	97	92
Operations	US$/ha	51	96	90	66	85
Labor	US$/ha	60	16	30	39	17
Other variable costs	US$/ha	2	137	80	138	81
Total variable costs	US$/ha	354	394	444	635	505
Depreciation	US$/ha	218	144	87	55	37
Land	US$/ha	299	244	174	96	58
Other fixed costs	US$/ha	62	0	34	35	23
Total fixed costs	US$/ha	579	388	295	186	118
Total	**US$/ha**	**933**	**782**	**739**	**821**	**623**

Source: Agroconsult and Conab (2010/11) cited in Aprosoja (2012). Modified by author.

Appendix 2: Soybean price – domestic price and CBOT quotation (US$/t, 1995-2005)



Source: MAPA (2007, p46).

Appendix 3: Brazil – macroregions and states

Source: USITC (2012, p. 1-7).

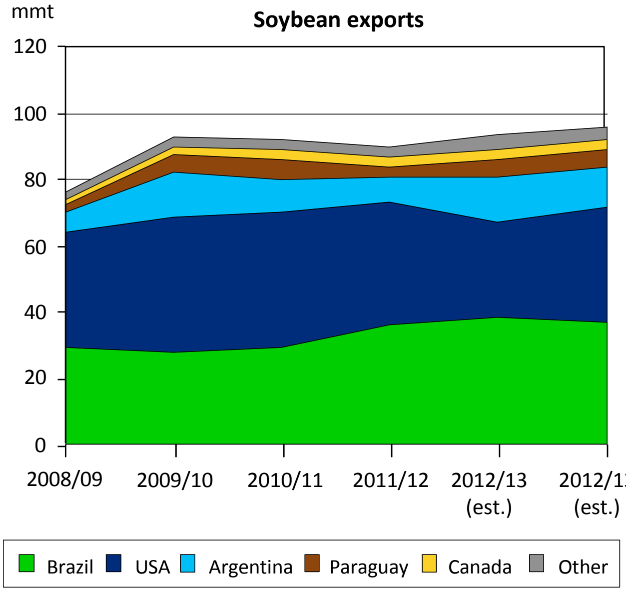
Appendix 4: Climate charts – Brazil

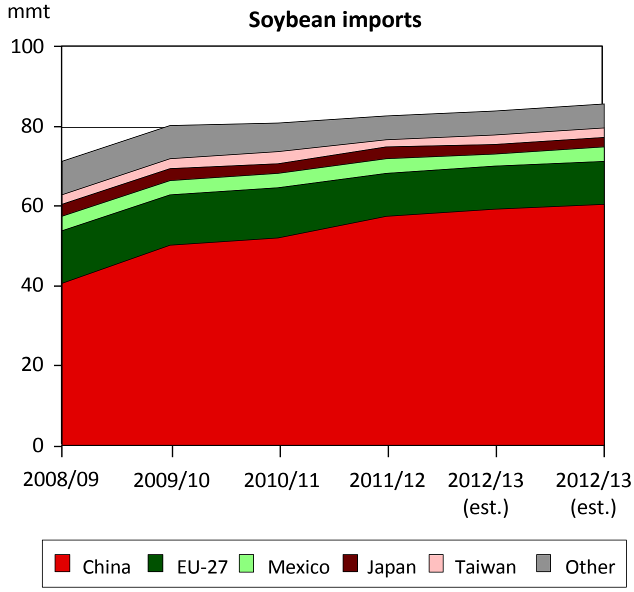
a) Precipitation Brazil.

b) Temperature Brazil.

Source: World Trade Press (2007).

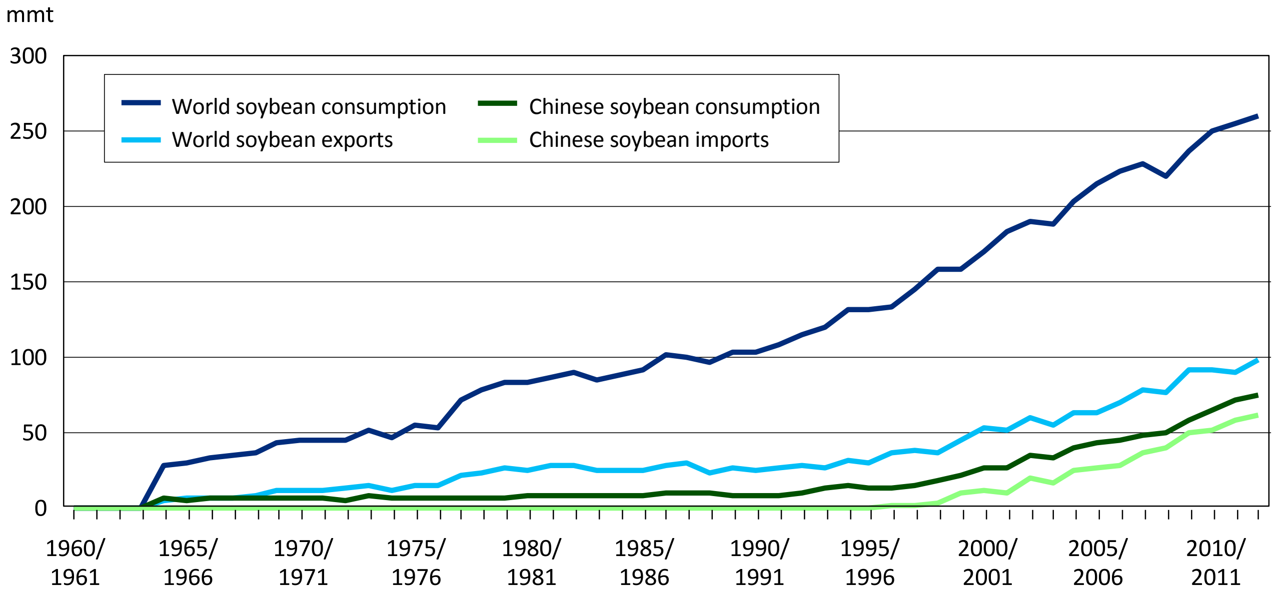
Appendix 5 und 6: Soybean exports and imports by country (2008-2013)





Source: Created by author. Based on data from USDA PSD (2012, table 7).

Appendix 7: World soybean consumption and exports (1960-2012)



Source: USDA PSD (2012, custom query).

Appendix 8: Cerrado region

Source: USITC (2012, p2-2).

Appendix 9: Brazilian agricultural policy development (1965-2005)

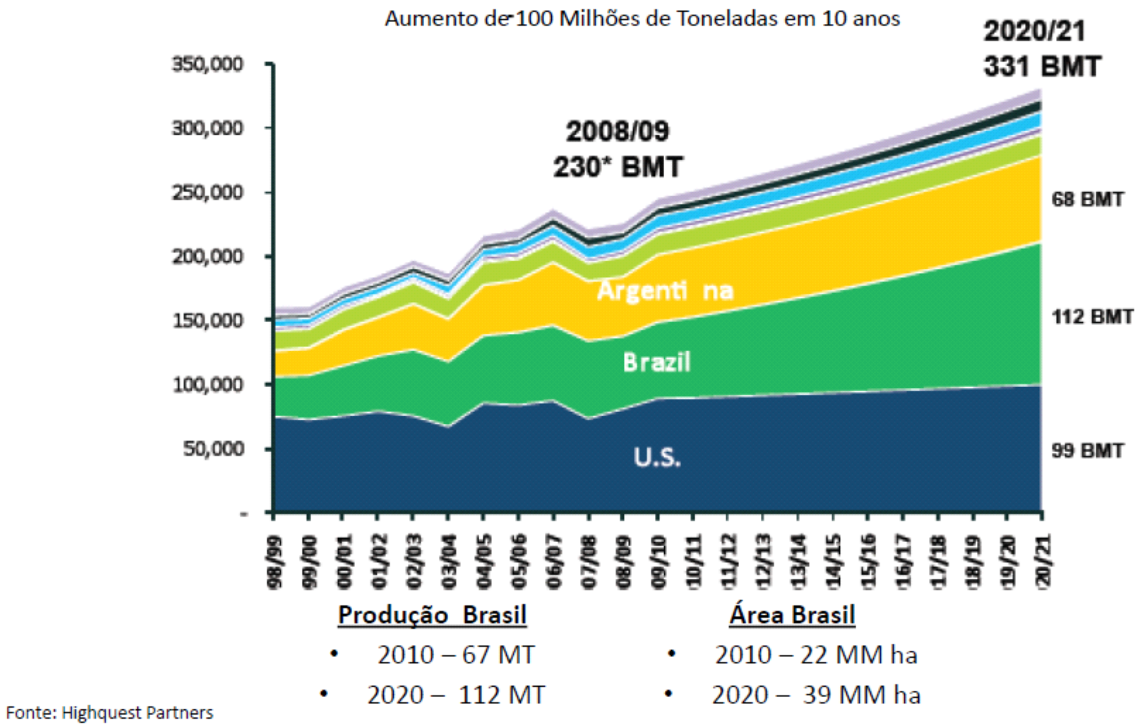
	Period and developments			
Item	1965–1985	1985–1995	1995–2005	2005 onward
Macroeconomic environment	• High inflation • Exchange rate controls • Fast growth • Increased government expenditures	• Stagflation • Debt crisis • Decreased government expenditures	• Controlled inflation • Exchange rate volatility • Modest growth rate • Privatization	• Lower inflation • Structural reforms • Stabilize exchange rate • Lower interest rates • Sustained growth • Infrastructure
Policy goals	• Food security	• Deregulation • Liberalization	• Land reform • Family farms • Social inclusion	• Competitiveness • Sustainability • Globalization
Price support	• Increase in food purchases and storage, price controls and support	• Decline in intervention • Market deregulation	• Targeted intervention	• Moderate, selective intervention
Rural credit	• Financed by Treasury • Negative real interest rates	• Decline in governmental rural credit supply and subsidies	• Family farms (PRONAF) • Specific investment credit (BNDES) • Debt restructuring	• Crop insurance • Private credit instruments • Special credit lines for family farms • Credit for development of cooperatives
Trade policy	• Import substitution • Export taxes	• Unilateral trade liberalization • Regional integration (Mercosul) • Elimination of export taxes	• Prosecution of agricultural trade barriers in WTO • Regional free trade agreement negotiations (FTAA, EU–Mercosul)	• Aggressive trade policy (negotiation, litigation) • Address NTMs (technical, sanitary, social) • Pursue FTAs
Research and extension	• Increased investment; Embrapa created • Extension network developed	• Public investment leveling	• Public investment declines	• Boost funding • Increase PPPs • Intellectual property protection
Family farms	• Minimal support	• Support begins (Extraordinary Ministry of Land Reform)	• Ministry of Agrarian Development created • Land reform, PRONAF programs developed	• Policy evaluation and monitoring • Redirect resources • Develop and modernize cooperatives

Source: Adapted from Chaddad and Jank, "The Evolution of Agricultural Policies," 2006, 86, table 1.

Note: Mercosul refers to the Mercado Comum do Sul [Common Market of the South]. Full members are Argentina, Brazil, Paraguay, and Uruguay. FTAA refers to the proposed Free Trade Agreement of the Americas.

Source: USITC (2012, p3-24).

Appendix 10: Projection of world soybean production



Annotations by author:
Produção [portug.] = Production [engl.]
Área Brasil [portug.] = Area Brazil [engl.]

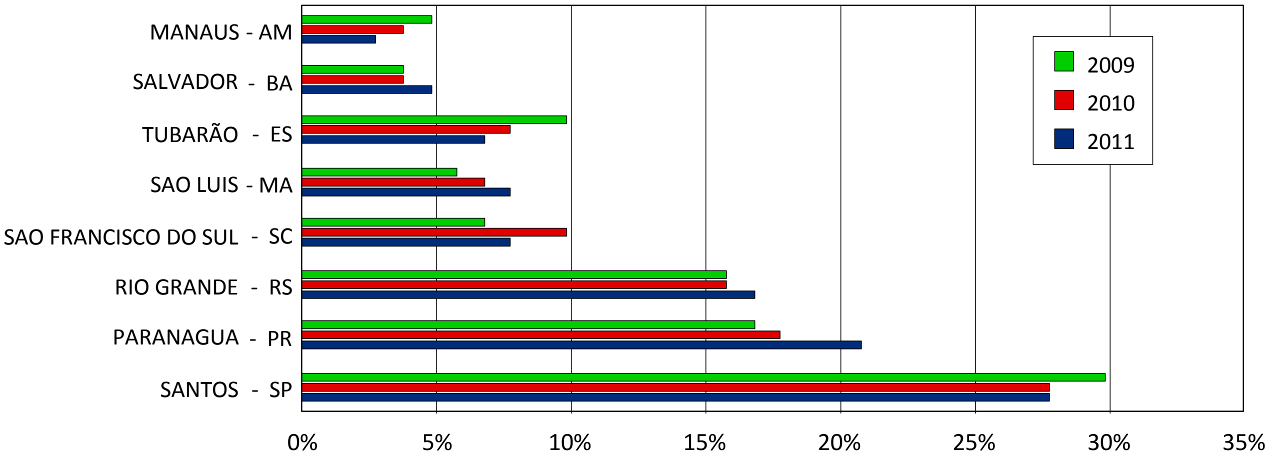
Source: HIGHQUEST PARTNERS cited by APROSOJA (2010).

Appendix 11: GDP and soy production of selected regions (2009)

	Gross domestic product (10^6 R$)				Soy production	
	Total	Agriculture	Industries	Service sector	Quantity (t)	Area (ha)
Sorriso	2,043	647	223	1,173	1,840,800	590,000
Rondonópolis	3,334	192	797	2,345	223,200	72,000
Rio Verde	3,883,063	676	1,407	1,780	735,000	245,000
Barretos	1,534	96	295	1,143	17,640	7,000
Mato Grosso	33,393	10,744	6,230	16,419	17,962,819	5,831,468
Goiás	44,753	5,978	11,624	27,151	6,809,187	2,315,888
São Paulo	611,970	11,265	193,981	406,724	1,327,105	494,551
Brasil	**1,842,253**	**105,163**	**539,316**	**1,197,774**	**57,345,382**	**21,761,782**

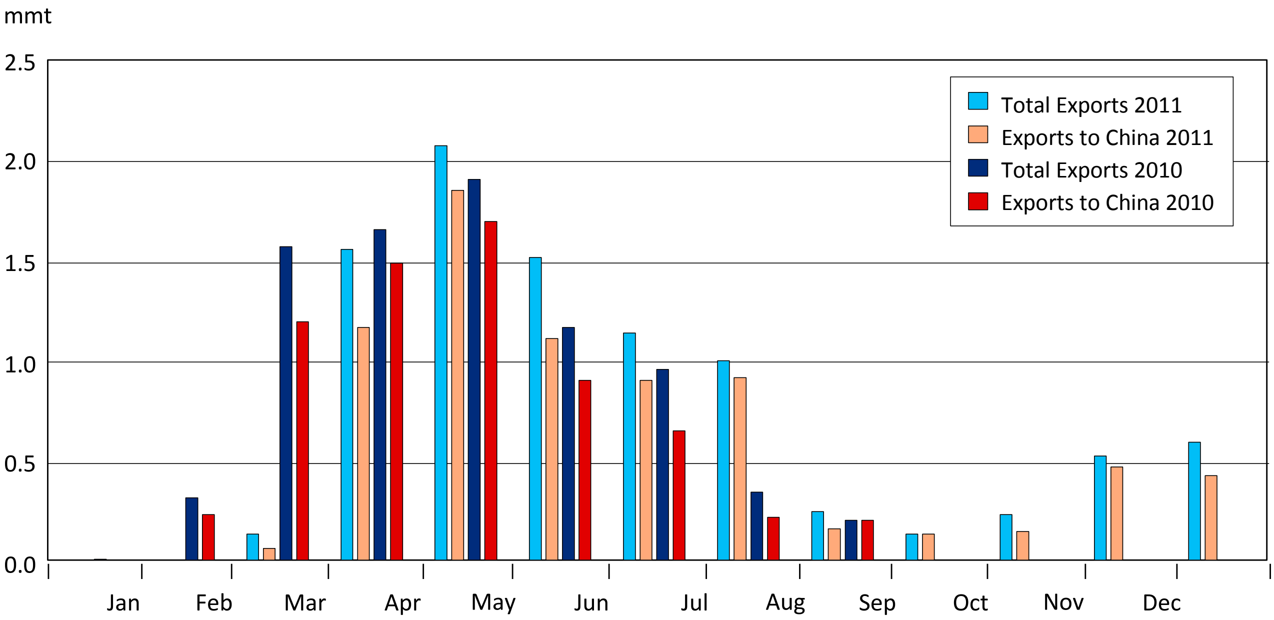
Source: IBGE (2010a), IBGE (2012).

Appendix 12: Brazilian soybean exports by port (2009-2011)



Source: MDIC (2012).

Appendix 13: Soybean exports via Santos port (2010-2011)



Source: Created by author. Based on data from MDIC (2012).

Appendix 14: Privatization efforts of the Brazilian government in the 1990s

BOX 3.2 Port Reforms and Investments in Brazil

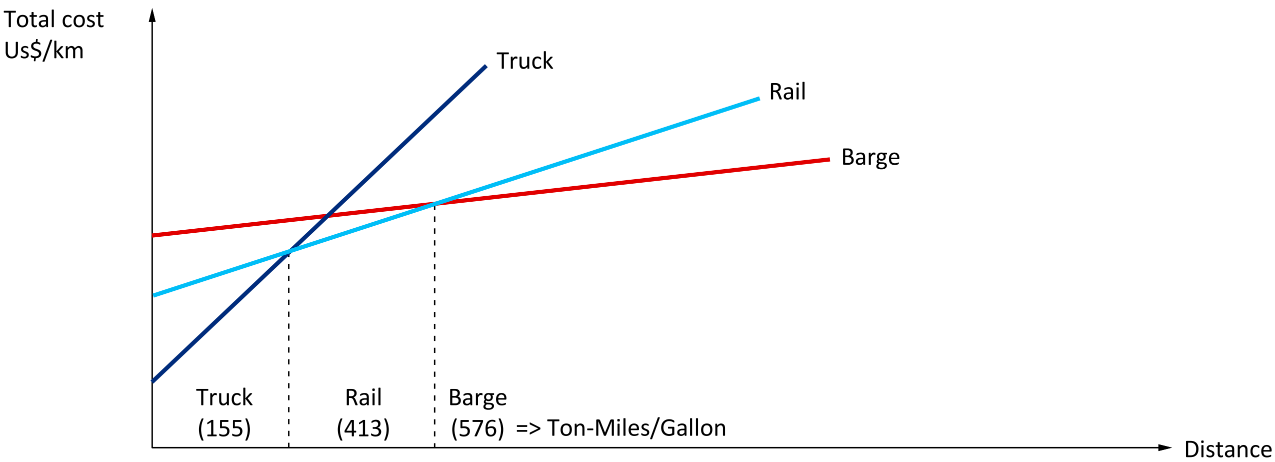
Beginning in the early 1990s, the Brazilian government enacted several reforms to improve the country's ports. Efforts to privatize public-sector infrastructure began with the Port Modernization Enactment of 1993, which opened public sector port operations to private companies under long-term concession contracts. In 2007, the government created the Special Secretariat for Ports (SEP), a presidential agency responsible for oversight of investments in Brazil's ports. The SEP, working alongside ANTAQ, established the National Dredging Plan to oversee an investment of R$1.2 billion ($615 million) in dredging operations to increase channel depths and mooring berths at 16 ports.[b] The program will allow larger ships to berth for loading, increase cargo-handling capacity, and help relieve port congestion. The government has allowed foreign companies to participate to spur investment and competition in order to reduce costs.[c]

Recent government reforms have enabled greater private participation and investments in Brazil's ports, and have helped to reduce handling costs for containers and goods at Brazil's ports.[d] In 2008, a government decree allowed both Brazilian and foreign companies to build and operate terminals and new public ports under concession. The decree also eliminated the requirement that private terminal operators handle private- or mixed-use cargoes.[e] As a result, private companies will be able to operate terminals without the need to own or handle cargo. The first ports offered under this model will be Manaus, Amazonas, and Ilhéus, Bahia.[f] These reforms are expected to attract R$19 billion ($11.3 billion) in private sector investments in the coming years.[g]

[a] ILOS, *Logistics Overview in Brazil 2008*, 2008, 4; Brazil Ministry of External Relations, *Brazilian Ports*, 2008, 14; WEF, *The Brazil Competitiveness Report 2009*, 2009, 35.
[b] Brazil Ministry of External Relations, *Brazilian Ports*, 2008, 10.
[c] Ibid.
[d] Ibid., 14.
[e] Brazil Ministry of External Relations, *Brazilian Ports*, 2008, 13, 16. Private cargoes are owned by the terminal operators. Mixed-use cargoes are private cargoes combined with cargoes owned by third parties.
[f] Brazil Ministry of External Relations, *Brazilian Ports*, 2008, 16.
[g] Brazil Ministry of External Relations, *Brazilian Ports*, 2008, 4.

Source: USITC (2012, p3-15)

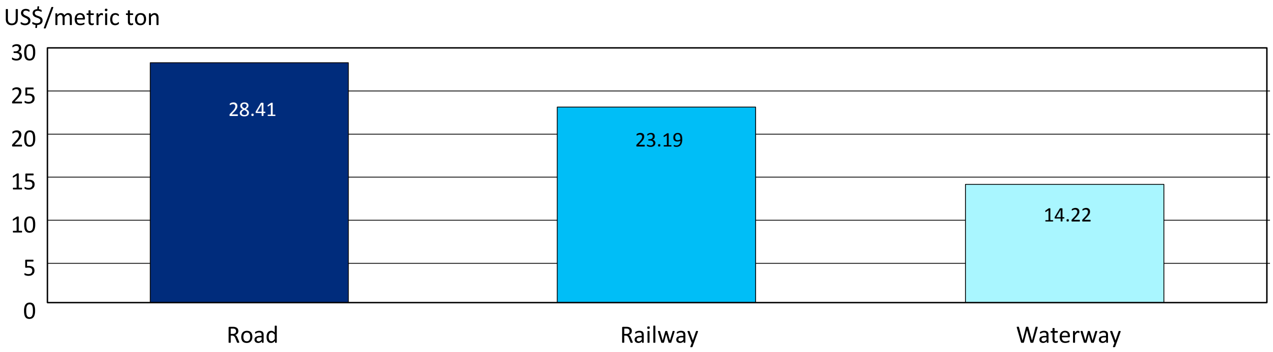
Appendix 15: Transport costs related to modality, distance and relative fuel efficiency



Source: USDA (2010, p500).

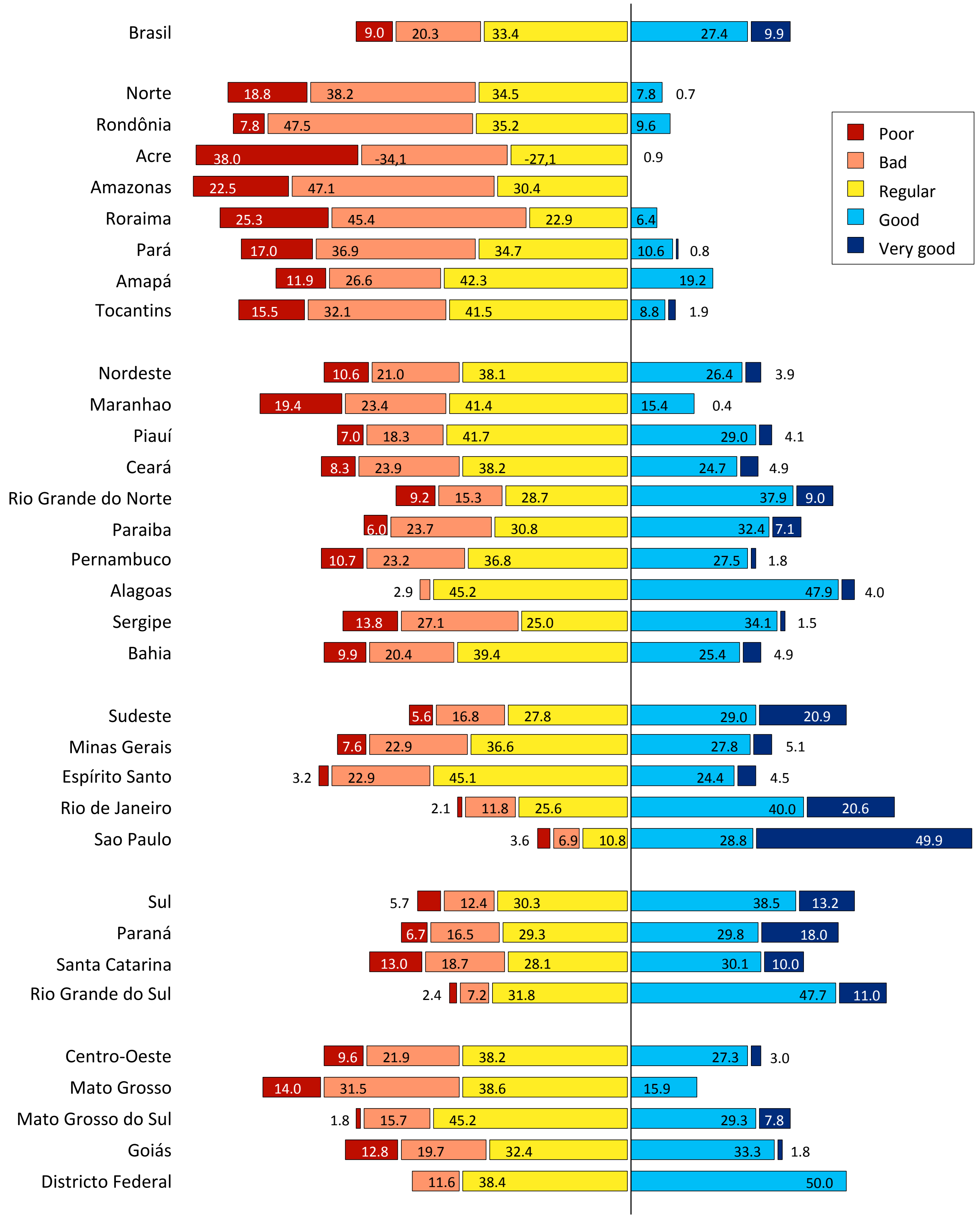
Appendix 16: Mean values of freights for soybeans

(620-930 miles, February 2001 to March 2004.)



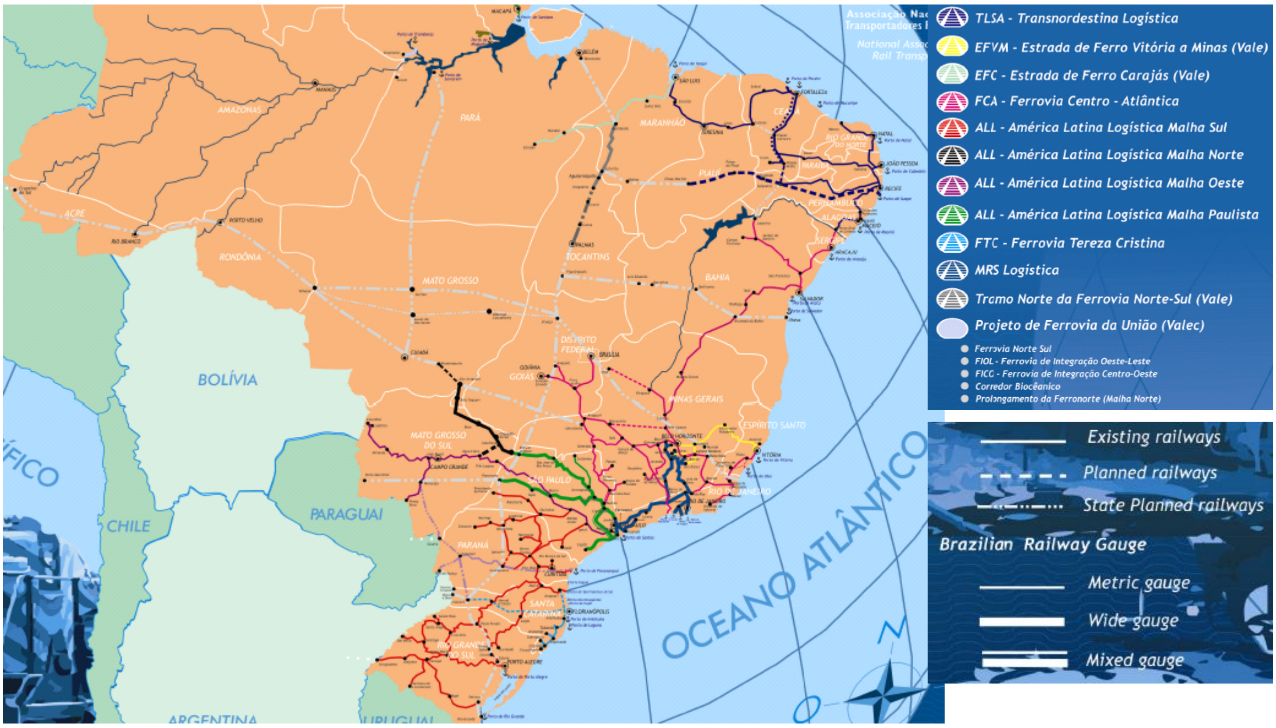
Source: SIFRECA cited by CAIXETA-FILHO (2006, p2

Appendix 17: State of the national road network by state (2011)



Source: CNT (2012a, pp313, 318).

Appendix 18: Brazilian cargo railways



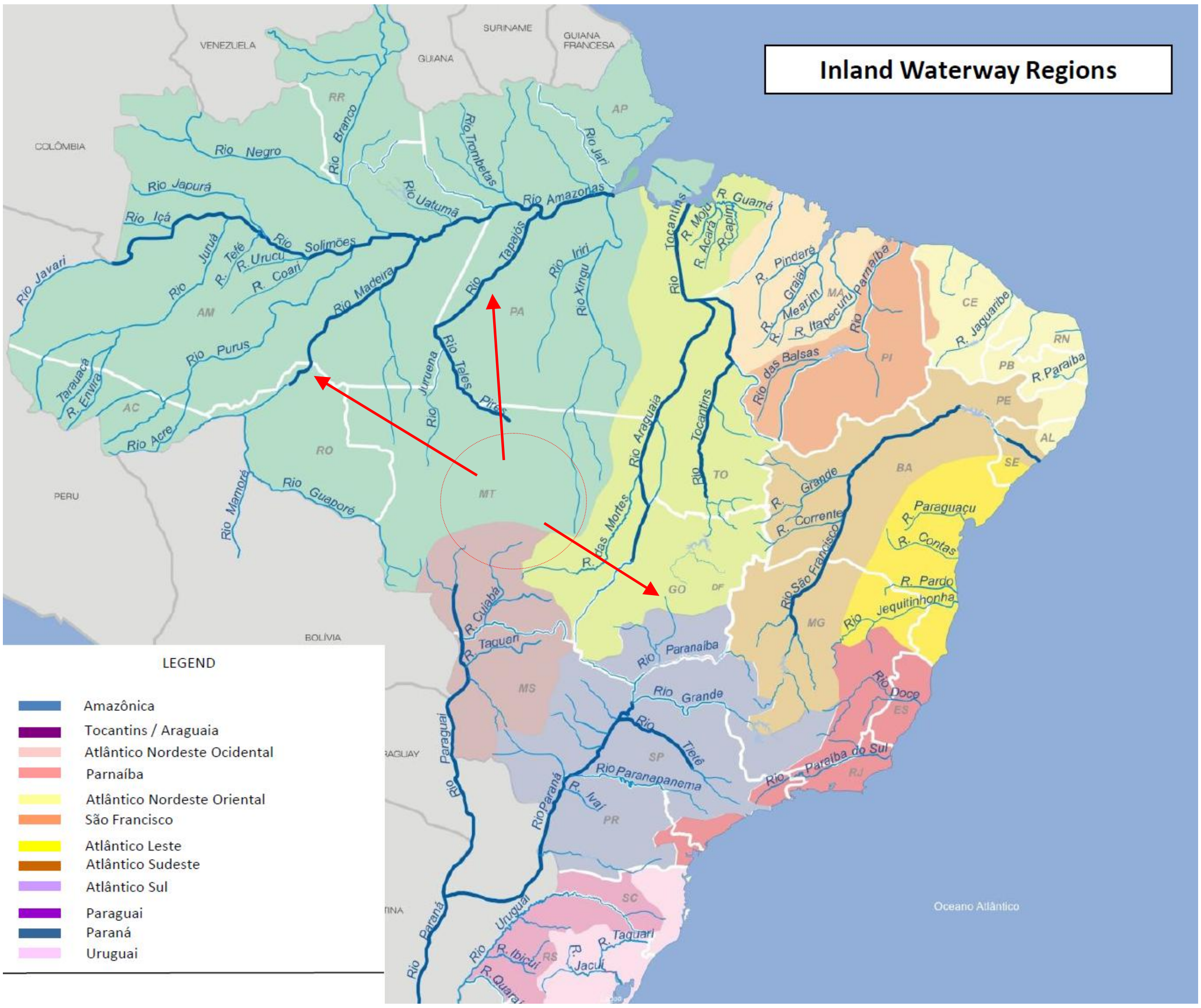
Source: ANTF (2012a)

Appendix 19: Extension of the rail network under concession by operator

Operators regulated by ANTT	Railroad network - extension in km			
	gauge			**Total**
	1.60 m	1.0 m	Mixed	
América Latina Logística Malha Oeste S.A. - ALLMO	-	1.95	-	**1.95**
Ferrovia Centro-Atlântica S.A. - FCA	-	7.91	156.00	**8.07**
MRS Logística S.A. - MRS	1.63	-	42.00	**1.67**
Ferrovia Tereza Cristina S.A. - FTC	-	164.00	-	**164.00**
América Latina Logística Malha Sul S.A. - ALLMS	-	7.25	11.00	**7.27**
Estrada de Ferro Paraná Oeste S.A. - FERROESTE	-	248.00	-	**248.00**
Estrada de Ferro Vitória a Minas - EFVM	-	905.00	-	**905.00**
Estrada de Ferro Carajás - EFC	892.00	-	-	**892.00**
Transnordestina Logística S.A. - TLSA	-	4.19	18.00	**4.21**
América Latina Logística Malha Paulista S.A. - ALLMP	1.46	243.00	283.00	**1.99**
América Latina Logística Malha Norte S.A. - ALLMN	617.00	-	-	**617.00**
VALEC/Subconcession: Ferrovia Norte-Sul - FNS	720.00	-	720.00	-
Total	**5.32**	**22.86**	**510.00**	**28.69**

Source: ANTT (2012a, p4). Modified by author.

Appendix 20: Inland waterways and navigable rivers



Annotation of author: The extension of the navigable rivers is represented by the dark blue lines. The red arrows point at the waterways of relevance for the selected regions (see chapter 2.2), i.e. the Madeira, Tapajós and Paraná-Tietê waterways. The red circle encompasses the major soybean production region of central Mato Grosso.

Source: PERRUPATO (2011). Modified by author.

Appendix 21: Soybeans - conditions at storage

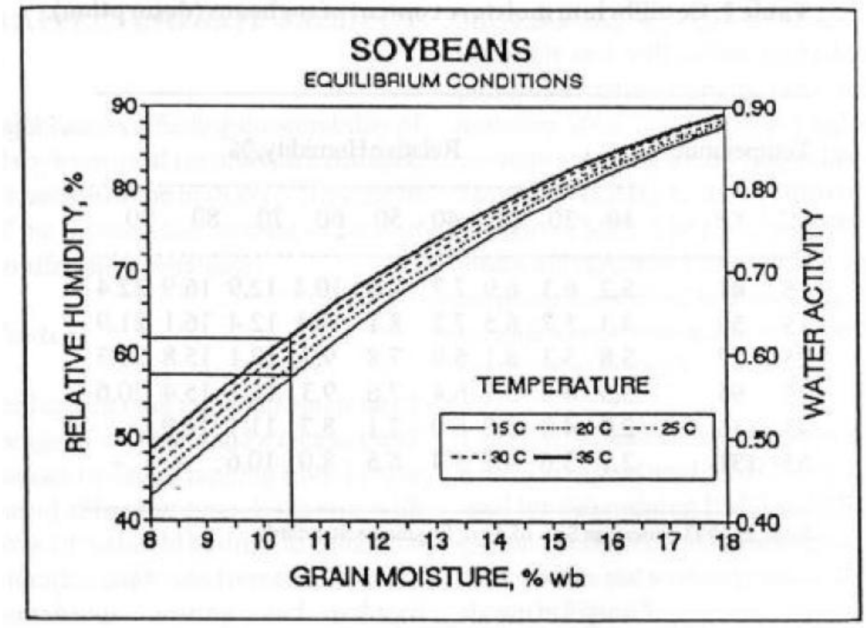


Figure 4. The equilibrium moisture content of soybeans by desorption based on the modified Chung-Pfost equation for various grains (Source: ASAE 1993 Standards).

Source: ACASIO (n.d., pp6, 7)

Table 1. Safe storage periods for soybeans at some moisture levels

Moisture content, % wet basis	Market stock	Safe storage period Seed Stock
10-11	4 years	1 year
10-12.5	1 - 3 years	6 months
13-14	6 - 9 months	poor germination
14-15	6 months	poor germination

Source: Barre (1976).

Appendix 22: Brazilian standard values for soybean exports

Export standard values	Impurities	≤ 1 %
	Humidity	≤ 14 %
	Breakage	≤ 30 %
	Rotten	≤ 4 %
	Damaged	≤ 8 %

Source: Created by author. Based on data from ANONYMOUS 1 (2012).

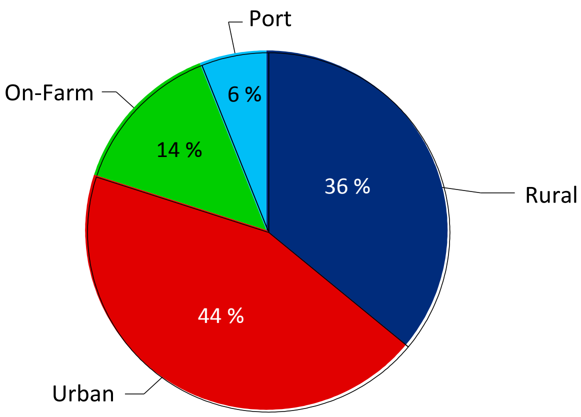
Appendix 23: Total volume of agricultural bulk goods produced (t) in 2011 vs. storage capacities (status quo 12/2012)

Brasil	Cotton	5,070,717	**Center West**	Cotton	3,187,523	**East South**	Cotton	154,18
	Rice	13,476,994		Rice	1,013,618		Rice	193,914
	Beans	3,435,366		Beans	588,836		Beans	817,031
	Corn	55,660,415		Corn	17,399,944		Corn	9,998,944
	Soybeans	74,815,447		Soybeans	33,768,154		Soybeans	4,212,294
	Sorghum	1,931,135		Sorghum	1,211,803		Sorghum	452,072
	Wheat	5,690,043		Wheat	102,329		Wheat	168,653
Total		**160,080,117**	**Total**		**57,272,207**	**Total**		**15,842,908**
Storage capacities		118,222,783	Storage capacities		44,663,410	Storage capacities		13,379,860
Difference		-41,857,334	Difference		-12,608,797	Difference		-2,463,048
South	Cotton	3,193	**North East**	Cotton	1,707,168	**North**	Cotton	18,653
	Rice	10,112,953		Rice	1,165,618		Rice	990,891
	Beans	1,091,132		Beans	818,484		Beans	119,883
	Corn	21,896,967		Corn	5,039,170		Corn	1,325,390
	Soybeans	28,666,010		Soybeans	6,228,019		Soybeans	1,940,970
	Sorghum	44,992		Sorghum	206,202		Sorghum	16,066
	Wheat	5,419,061		Wheat			Wheat	
Total		**67,234,308**	**Total**		**15,164,661**	**Total**		**4,411,853**
Storage capacities		51,267,099	Storage capacities		6,802,380	Storage capacities		2,110,034
Difference		-15,967,209	Difference		-8,362,281	Difference		-2,301,819

Annotation of author: No historical data for data on storage capacities available. Data refer to December 2012.

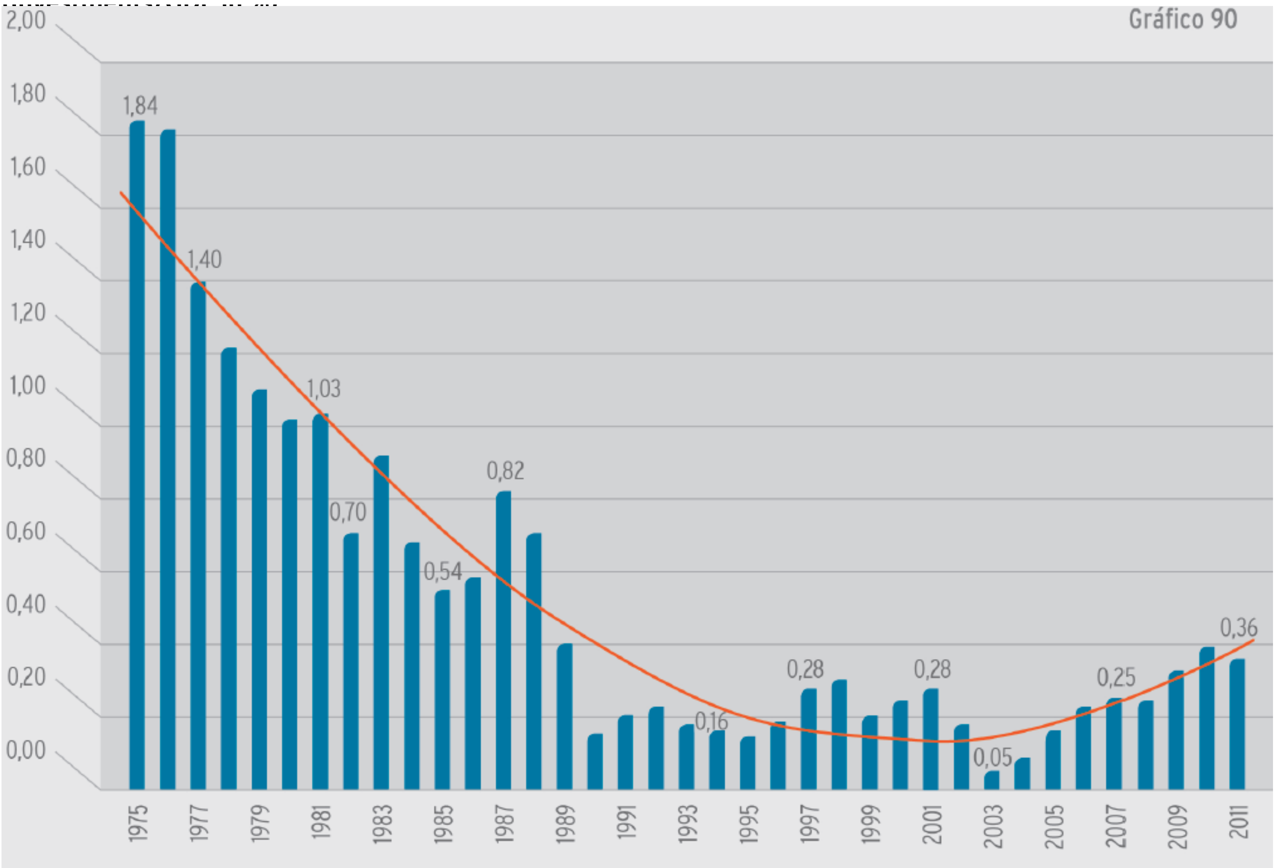
Source: Created by author. Data from SIDRA IBGE (2012) and CONAB (2012).

Appendix 24 Distribution of warehousing capacities by location



Source: MORCELI (2012). Modified by author

Appendix 25: Development of investments in infrastructure of federal government (1975-2011) (Investments/GDP in %)



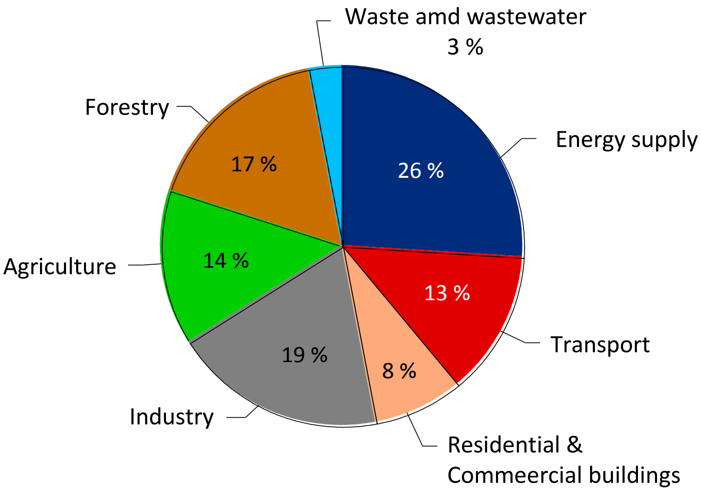
Source: CNT (2012, p328).

Appendix 26: PNLT investments (2008-2023)

2008-2023	Extension (km)/ Quantity	Investments (billion R$)	Share of total investments (%)
Road	43.20	74.19	43
Rail	20.26	50.56	29
Water	14.49	12.81	7
Port	169.00	25.16	15
Air	40.00	9.70	6
Total		**172.41**	**100**

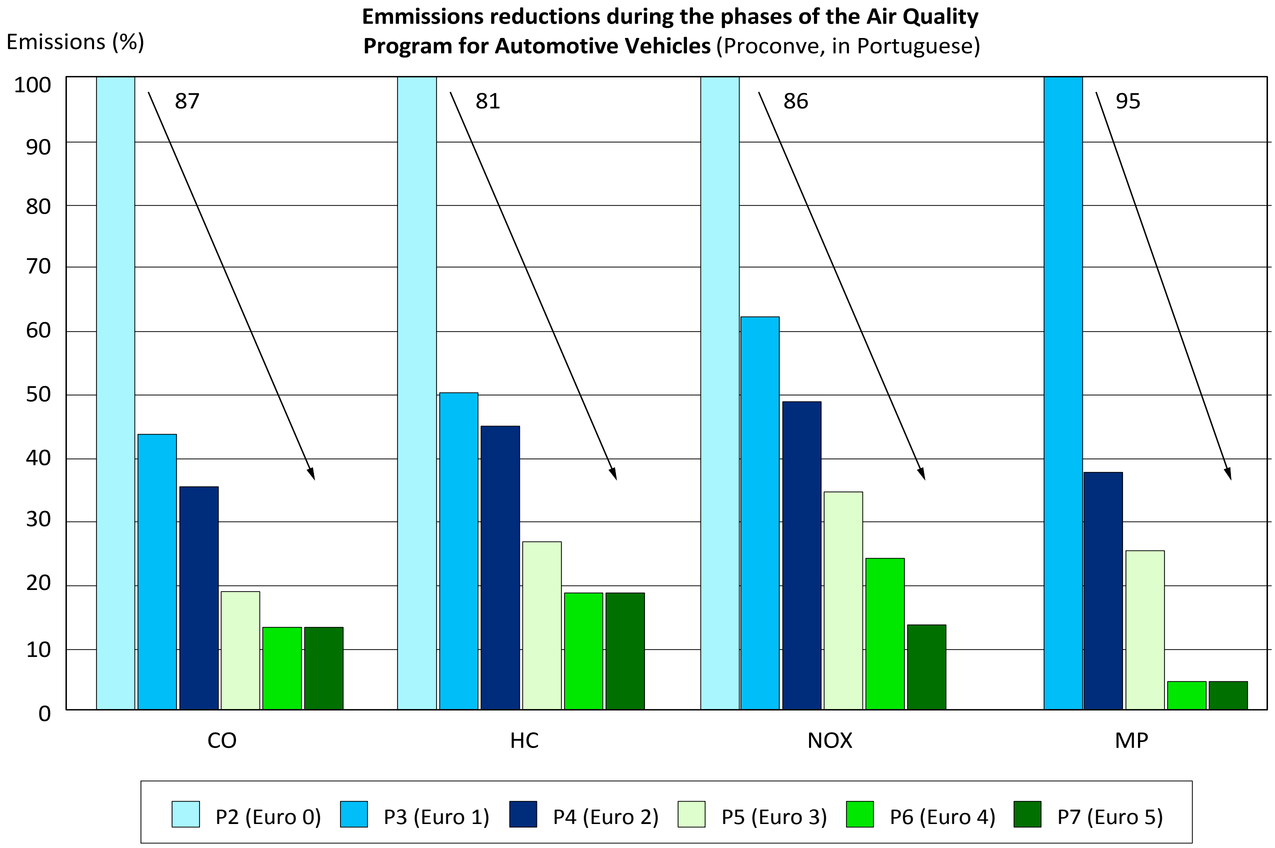
Source: Created by author. Based on Ministry of Transport/Ministry of Defense (2007).

Appendix 27: Distribution of global GHG emissions by sector



Source: EPA (2012).

Appendix 28: Phases of the Airquality Program for Automotive Vehicles



Annotation of author: Permitted limits for exhaust emissions of new vehicles sold in EU member states, defined in the European emission standards. For detailed information see e.g. http://ec.europa.eu/enterprise/sectors/automotive/environment/eurovi/index_en.htm (accessed on November 29, 2012).

Source: IPEA (2011, p126).

Appendix 29: Emission factors considered

CO_2 (kg/l)				
IPCC	GEMIS	Brazil 2002 cited by Bartholomeu 2003	Bartholomeu 2001 cited by Bartholomeu 2006	Bartholomeu 2006
2.67	2.68	2.80	2.70	2.75

Source: Bartholomeu (2006, pp61).

Appendix 30: Frequently travelled warehouse-port routes

	Route	Highways
Ia	Sorriso/MT - Cuiabá/MT - Jataí/GO - São José do Rio Preto/SP - Araraquara/SP - Santos/SP	BR-163[3] - BR-364[3] - BR-153[3] - SP-310 - SP-330[1] - SP-348[1] - SP-160[1]
Ib	Sorriso/MT - Cuiabá/MT - Campo Grande/MS - Araçatuba/SP - Campinas/SP - Santos/SP	BR-163[3] - BR-364[3] - BR-163[3] - BR-262[3] - SP-300 - SP-2801 - SP-160[1]
II	Rondonópolis/MT - Jataí/GO - São José do Rio Preto/ SP - Araraquara/SP - Santos/SP	BR-364[3] - BR-153[3] - SP-310 - SP-330[1] - SP-348[1] - SP-160[1]
III	Rio Verde/GO - Itumbiara/GO - Uberaba/MG - Ribeirão Preto/SP - Campinas/SP - Santos/SP	BR-452 - BR-153 - BR-262[3] - SP-330[1] - SP-348[1] - SP-160[1]
IV	Barretos/SP - Araraquara/SP - Santos/SP	SP-326[2] - SP-310 - SP-348[1] - SP-160[1]

Road classification: [1] very good - [2] good - [3] regular

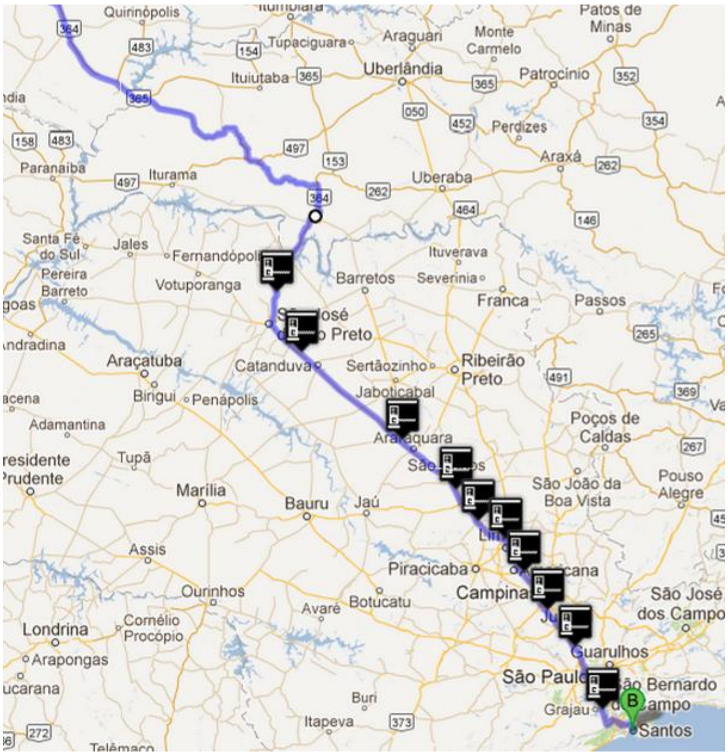
Source: Created by author. Based on expert discussions.

Appendix 31: Tower-silo storage on farm in Alto Araguaia-MT

Capacity: 11,400 t.

Source: Picture taken by author. Information from Klasener

Appendix 32: Tolled highway tracks on exemplary route



Source: Mapeia (2012) using Google Maps (10/12/2012).

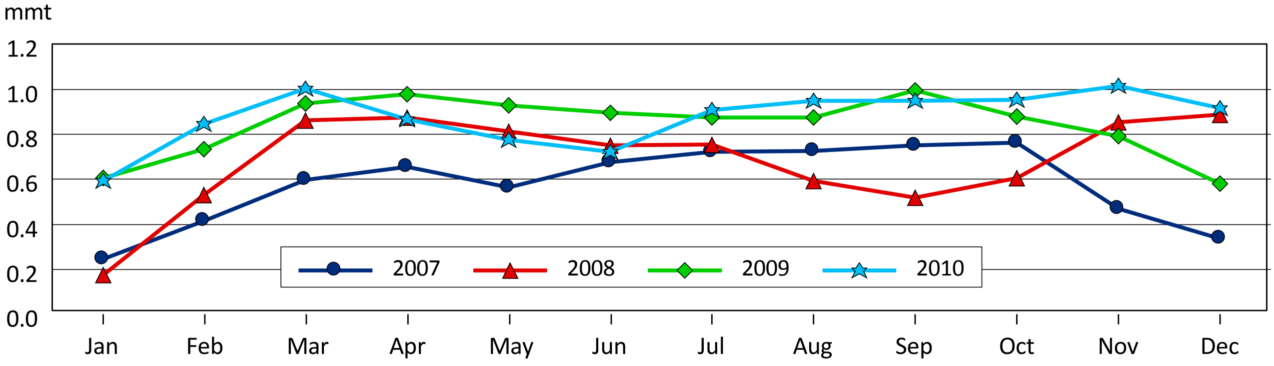
Appendix 33 Exemplary roads (MT, GO) Source: Photos taken by author.

BR-060 (county Rio Verde-GO) - roadworks.

MT-100 (municpality Alto Araguaia-MT).

Unpaved municipal road in dry-season (county Rio Verde--GO).

Appendix 34: Volume transported on the ALLMN railroad (mmt)



Annotation of author: As soybeans and corn are the major transported products on the ALLMN railroad (see chapter 2.3.2), this figure is representative for the seasonal demand for transportation services for grain shipping.

Source: Created by author. Based on ANTT (2010)/ANTT (2009)/ANTT (2008).

Appendix 35: Warehousing fees (2010)

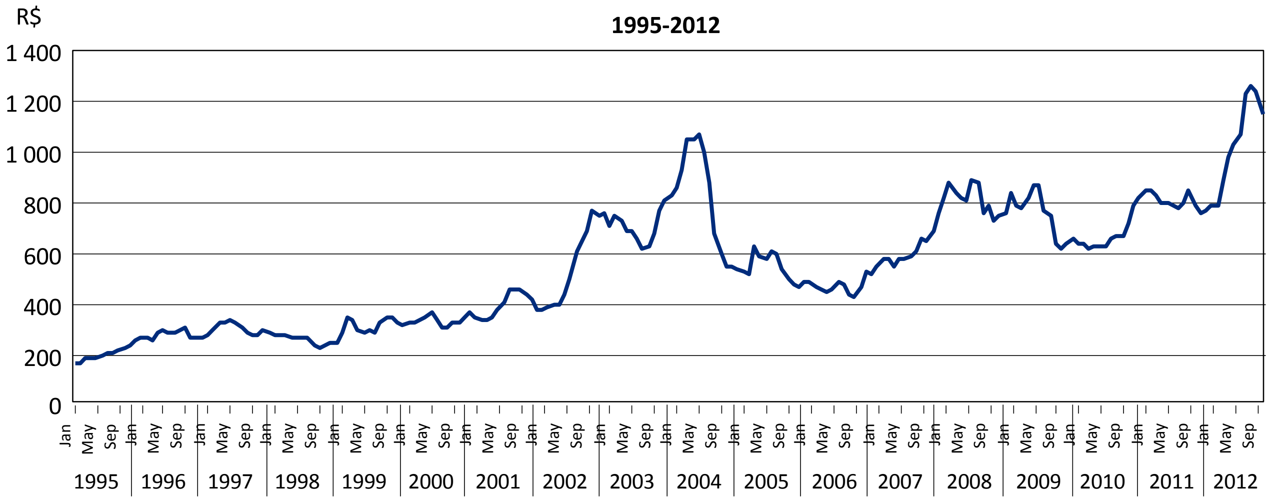
SOJA

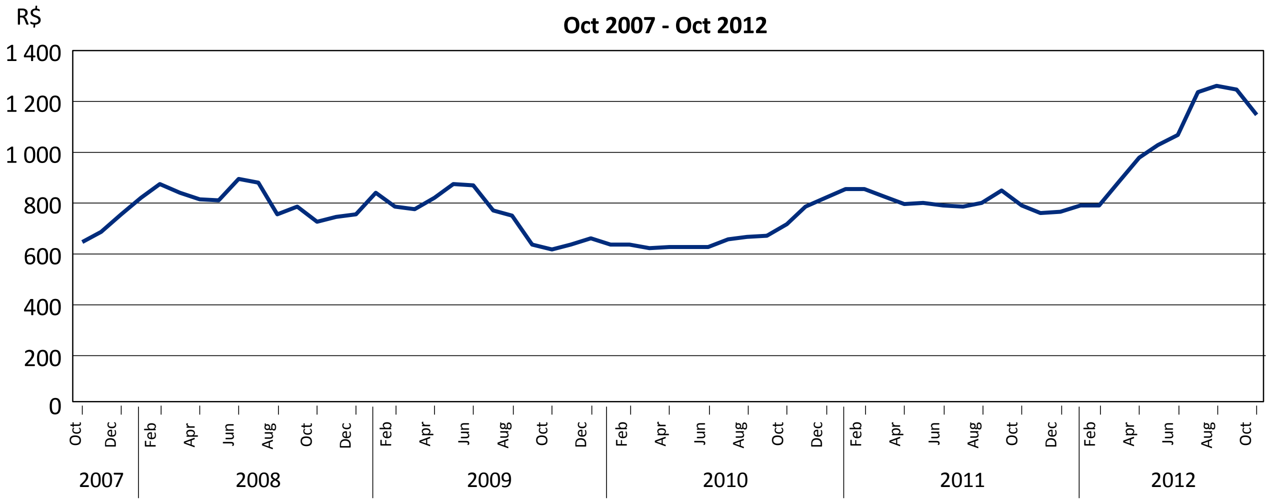
Estado	Tarifas de Armazenagem (R$/t)					
	1 mês	2 meses	3 meses	4 meses	5 meses	6 meses
GO	20,44	24,74	29,42	34,09	38,76	43,44
MS	24,49	28,77	33,15	37,43	41,72	46,00
MT	12,79	17,91	30,52	45,29	60,05	74,81
PR	20,05	24,15	29,02	33,12	37,21	41,31
MG	19,42	24,66	31,34	36,58	41,82	47,07
SP	17,43	22,09	26,76	31,42	36,09	40,75

Mesorregião	UF	Tarifas de Armazenagem (R$/t)					
		1 mês	2 meses	3 meses	4 meses	5 meses	6 meses
Centro Goiano	GO	37,69	44,97	52,25	59,53	66,81	74,09
Leste Goiano	GO	23,95	30,23	36,51	42,79	49,07	55,35
Sul Goiano	GO	22,10	28,25	35,01	41,76	48,51	55,26
Triângulo Mineiro/Alto Paranaíba	MG	20,38	25,62	32,30	37,54	42,79	48,03
Centro Norte de Mato Grosso do Sul	MS	22,69	27,92	33,14	38,37	43,59	48,82
Leste de Mato Grosso do Sul	MS	29,84	36,38	42,92	49,46	56,00	62,54
Sudoeste de Mato Grosso do Sul	MS	27,70	31,86	36,02	40,19	44,35	48,51
Norte Mato-grossense	MT	10,09	13,32	25,50	41,98	58,45	74,93
Sudeste Mato-grossense	MT	0,97	0,97	0,97	0,97	0,97	0,97
Sudoeste Mato-grossense	MT	20,88	21,18	21,48	21,78	22,08	22,38
Sudeste Paraense	PA	11,32	16,31	21,30	26,29	31,28	36,27
Centro Ocidental Paranaense	PR	22,02	27,62	35,52	41,12	46,72	52,32
Centro Oriental Paranaense	PR	27,48	33,35	39,22	45,09	50,96	56,83
Metropolitana de Curitiba	PR	13,30	13,30	13,30	13,30	13,30	13,30
Norte Central Paranaense	PR	27,48	33,35	39,22	45,09	50,96	56,83
Sudeste Paranaense	PR	8,04	14,48	20,92	27,35	33,79	40,23
Metropolitana de São Paulo	SP	18,94	19,87	20,81	21,74	22,68	23,61
Ocidental do Tocantins	TO	4,58	9,08	13,58	18,08	22,58	27,08

Source: SIARMA (2010).

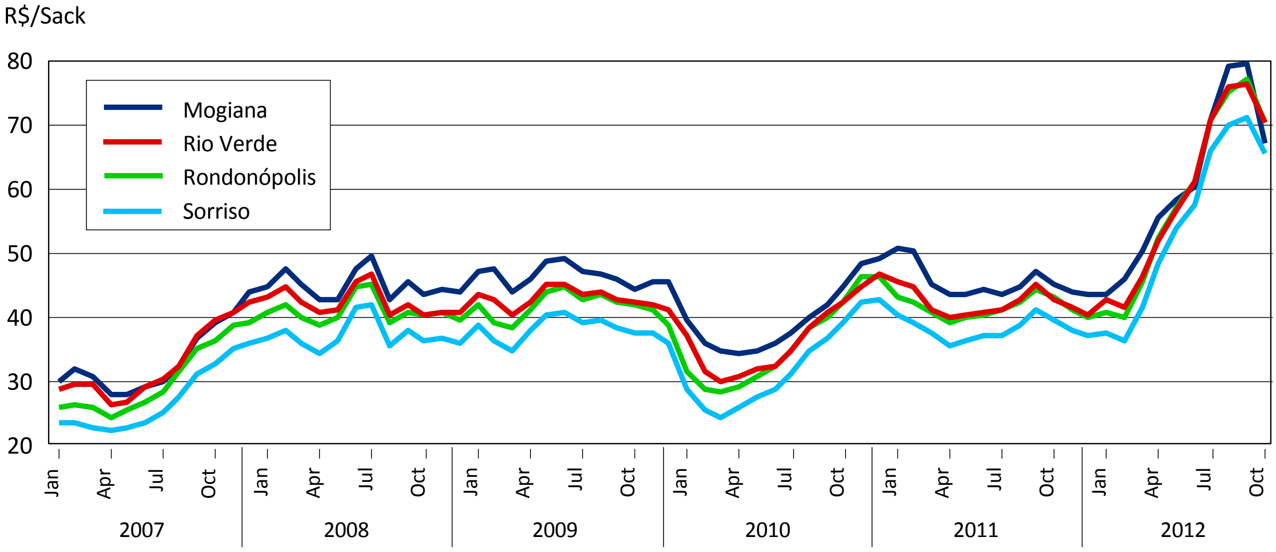
Appendix 36: Soybean world market prices - time series 1995-2012





Source: INDEXMUNDI (2012)

Appendix 37: Local spot market prices (2007-2012)



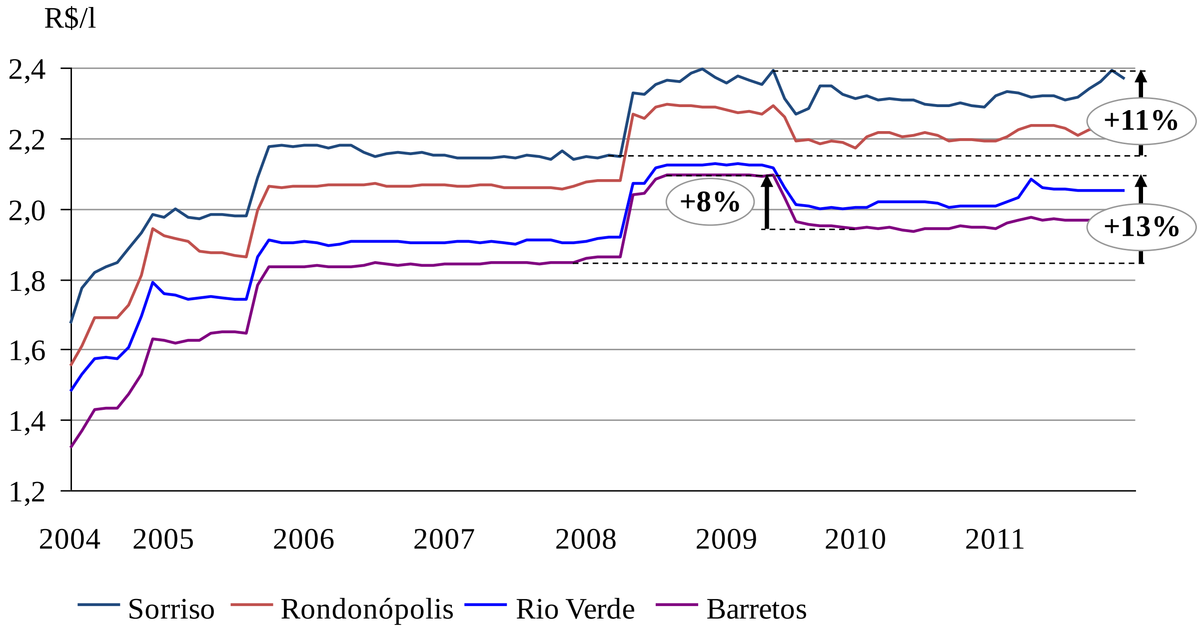
Source: Created by author. Based on data from CEPEA.

Appendix 38: Calculation of total logistics costs of soybean exports for selected regions (September 2011)

SEPTEMBER 2011						
Origin Distance to Santos			Sorriso-MT 2,200 km	Rondonópolis-MT 1,400 km	Rio Verde-GO 1,050 km	Barretos-SP 500 km
1. FOB Santos	**US$/t**	**504.85**				
2. Exchange rate	R$/US$	1.75				
3. Turnover (FOB Santos)	**R$/t**	**883.39**				
4. Export expenses	R$/t	35.04				
4.1 Port fee	R$/t	17.50				
4.2 Comissions, brokerage	R$/t	13.12				
4.3 Taxes	R$/t	0.00				
4.4 Damage	R$/t	4.42				
5. Price at port gate	**R$/t**	**848.35**				
6. Freight rate	R$/t		185.02	136.92	106.16	60.75
7. Total logistics costs	**R$/t**		**220.06**	**171.96**	**141.19**	**95.79**
8. Price at warehouse	**R$/t**		**663.33**	**711.43**	**742.19**	**787.60**
9. Price quoted at local spot market	R$/t		689.50	746.17	755.83	790.83
Difference [9]-[8]	R$/t		26.17	34.74	13.64	3.24
	%		*3.95*	*4.88*	*1.84*	*0.41*
Share [6]/[7]	*%*		*84*	*80*	*75*	*63*

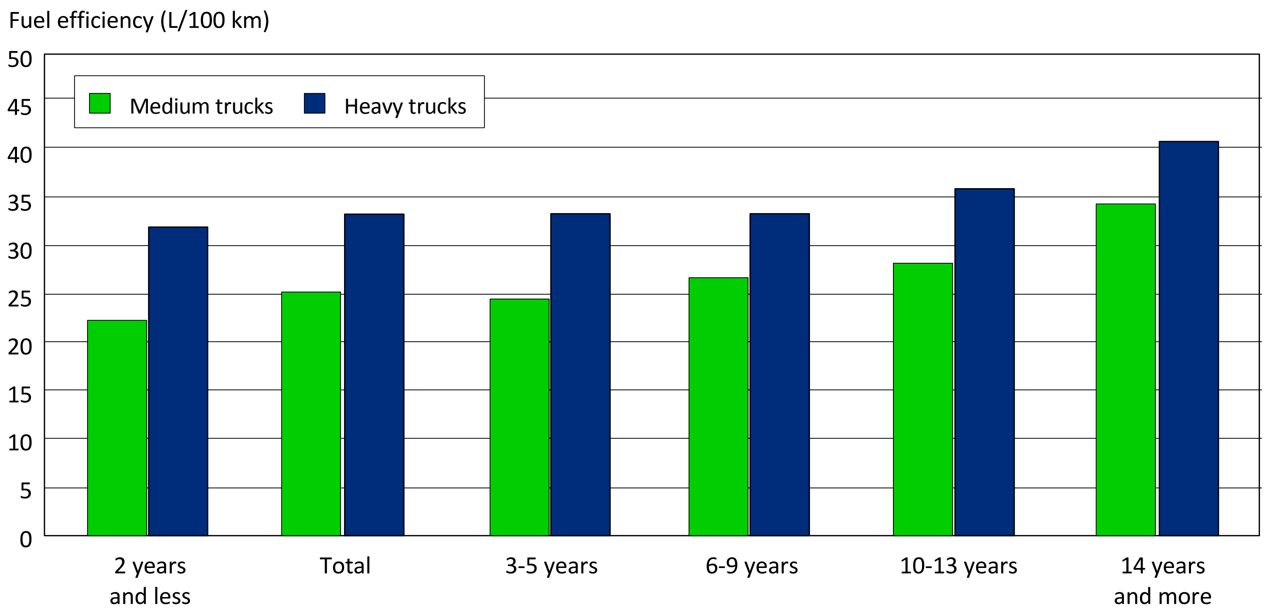
Source: Created by author.

Appendix 39: Local fuel prices of selected regions (2004-2011)



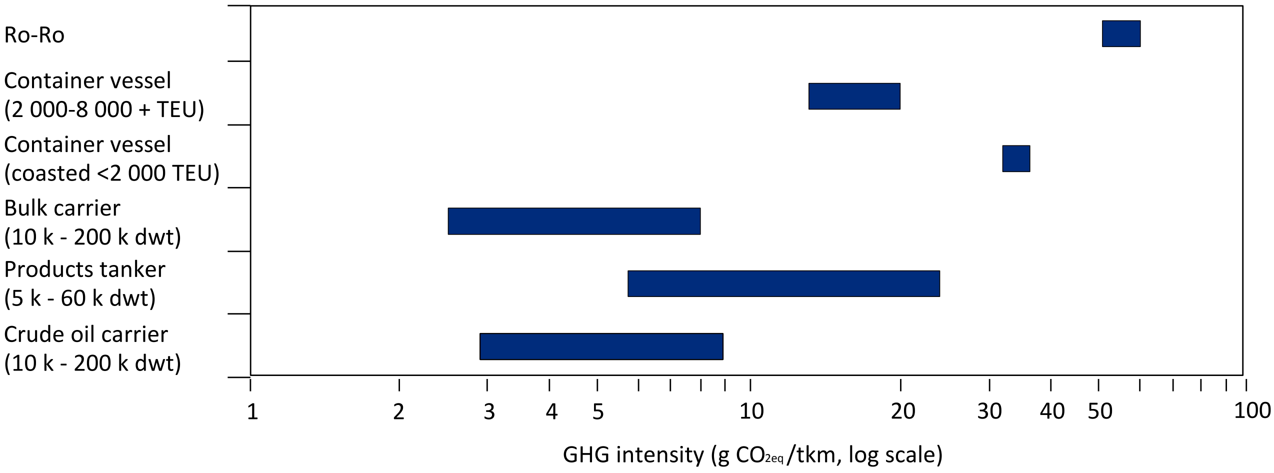
Source: Created by author. Based on data from ANP provided by BEDOYA (2012).

Appendix 40: Fuel efficiency versus fleet age



Source: TRANSPORT CANADA (2005) cited by IEA (2009).

Appendix 41: GHG intensity of selected maritime freight transport modes

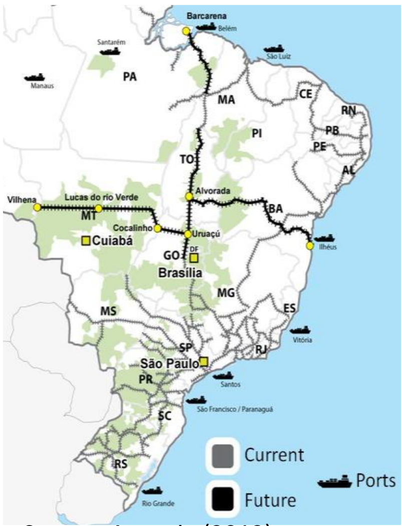


Source: ITF ESTIMATES and BUHAUG ET AL. (2008) cited by IEA (2009, p347)

Appendix 42: Development of Brazilian road network

Source: Aprooja (2012).

Appendix 43: Development of Brazilian railroad network

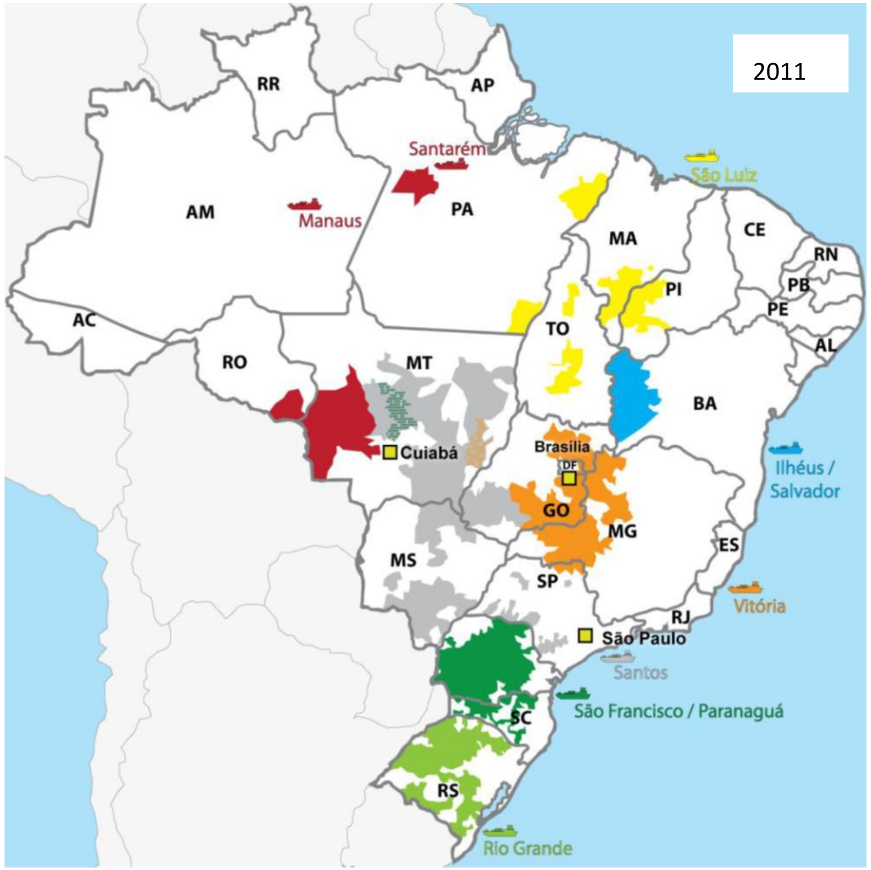


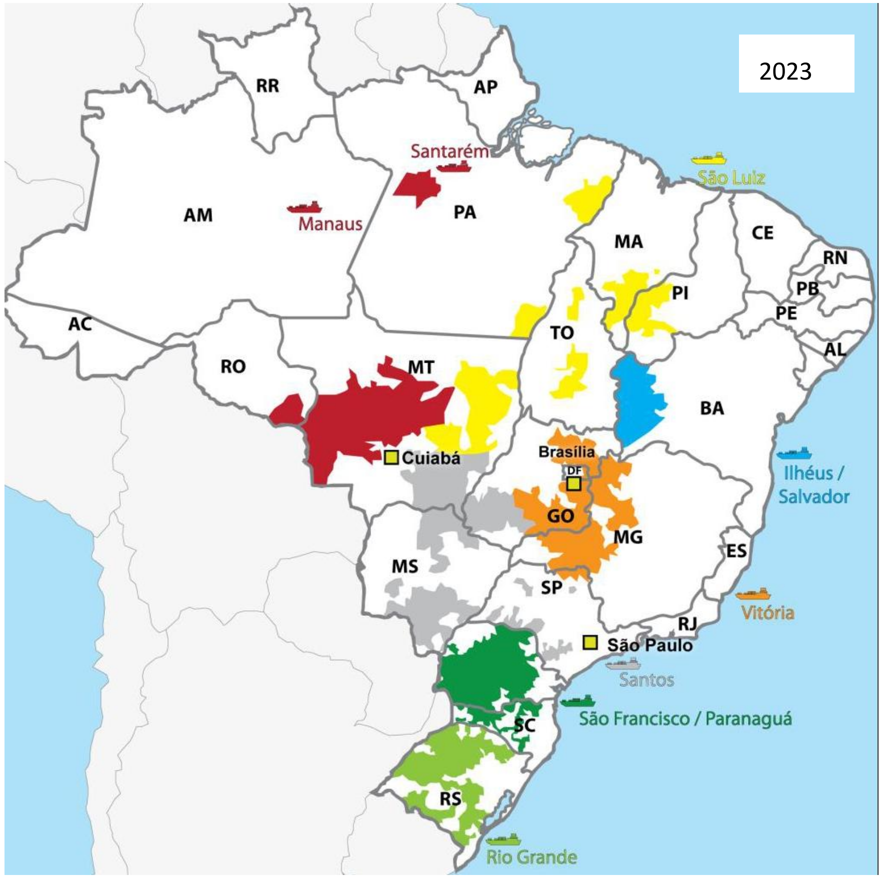
Source: Aprooja (2012).

Appendix 44: Development of the Brazilian waterway network

Source: Aprooja (2012).

Appendix 45: National export destinations of soybeans





Source: Aprosoja (2011).

Appendix 46 Exchange rate - Brazilian real (R$) / US dollar (US$)(2000-2012)

Exchange rate (IPEA)							
Year.month		Year.month		Year.month		Year.month	
2000.01	1.8037	2003.07	2.8798	2007.07	1.8828	2010.07	1.7696
2000.02	1.7753	2003.08	3.0025	2007.08	1.9660	2010.08	1.7596
2000.03	1.7420	2003.09	2.9228	2007.09	1.8996	2010.09	1.7187
2000.04	1.7682	2003.10	2.8615	2007.10	1.8010	2010.10	1.6860
2000.05	1.8279	2003.11	2.9138	2007.11	1.7699	2010.11	1.7133
2000.06	1.8083	2003.12	2.9253	2007.12	1.7860	2010.12	1.6934
2000.07	1.7978	2004.01	2.8518	2008.01	1.7743	2011.01	1.6748
2000.08	1.8092	2004.02	2.9303	2008.02	1.7277	2011.02	1.6680
2000.09	1.8392	2004.03	2.9055	2008.03	1.7076	2011.03	1.6591
2000.10	1.8796	2004.10	2.8529	2008.04	1.6889	2011.04	1.5864
2000.11	1.9480	2004.11	2.7860	2008.05	1.6605	2011.05	1.6135
2000.12	1.9633	2004.12	2.7182	2008.06	1.6189	2011.06	1.5870
2001.01	1.9545	2005.01	2.6930	2008.07	1.5914	2011.07	1.5639
2001.02	2.0019	2005.02	2.5978	2008.08	1.6123	2011.08	1.5970
2001.03	2.0890	2005.03	2.7047	2008.09	1.7996	2011.09	1.7498
2001.04	2.1925	2005.04	2.5792	2008.10	2.1729	2011.10	1.7726
2001.05	2.2972	2005.05	2.4528	2008.11	2.2663	2011.11	1.7905
2001.06	2.3758	2005.06	2.4135	2008.12	2.3944	2011.12	1.8369
2001.07	2.4660	2005.07	2.3735	2004.04	2.9060	2012.01	1.7897
2001.08	2.5106	2005.08	2.3606	2004.05	3.1004	2012.02	1.7184
2001.09	2.6717	2005.09	2.2944	2004.06	3.1291	2012.03	1.7953
2001.10	2.7402	2005.10	2.2565	2004.07	3.0368	2012.04	1.8548
2001.11	2.5431	2005.11	2.2108	2004.08	3.0029	2012.05	1.9860
2001.12	2.3627	2005.12	2.2855	2004.09	2.8911	2012.06	2.0492
2002.01	2.3779	2006.01	2.2739	2009.01	2.3074	2012.07	2.0287
2002.02	2.4196	2006.02	2.1619	2009.02	2.3127	2012.08	2.0294
2002.03	2.3466	2006.03	2.1520	2009.03	2.3138	2012.09	2.0281
2002.04	2.3204	2006.04	2.1293	2009.04	2.2059	2012.10	2.0298
2002.05	2.4804	2006.05	2.1781	2009.05	2.0609	2012.11	2.0678
2002.06	2.7140	2006.06	2.2483	2009.06	1.9576		
2002.07	2.9346	2006.07	2.1893	2009.07	1.9328		
2002.08	3.1101	2006.08	2.1559	2009.08	1.8452		
2002.09	3.3420	2006.09	2.1687	2009.09	1.8198		
2002.10	3.8059	2006.10	2.1483	2009.10	1.7384		
2002.11	3.5764	2006.11	2.1579	2009.11	1.7260		
2002.12	3.6259	2006.12	2.1499	2009.12	1.7507		
2003.01	3.4384	2007.01	2.1385	2010.01	1.7798		
2003.02	3.5908	2007.02	2.0963	2010.02	1.8402		
2003.03	3.4469	2007.03	2.0887	2010.03	1.7858		
2003.04	3.1187	2007.04	2.0320	2010.04	1.7576		
2003.05	2.9557	2007.05	1.9816	2010.05	1.8132		
2003.06	2.8832	2007.06	1.9319	2010.06	1.8059		

Source: IPEA (2012).

Appendix 47: Fob price and selected producer prices

Mês	Soja - Mogiana/SP Disponível - sc/60 kg	Soja - Rio Verde/GO Disponível - sc/60 kg	Soja - Sorriso/MT Disponível - sc/60 kg	Soja - Rondonópolis/MT Disponível - sc/60 kg	Soja FOB Santos
Jan.2007	30.16	29.14	23.65	26.23	
Feb.2007	32.10	29.66	23.87	26.69	
Mrz.2007	31.05	29.94	23.14	26.09	
Apr.2007	28.33	26.77	22.50	24.78	
Mai.2007	28.35	27.14	22.99	25.86	
Jun.2007	29.44	29.28	23.82	27.03	
Jul.2007	30.37	30.45	25.21	28.57	
Aug.2007	32.66	32.72	27.92	31.77	
Sep.2007	36.92	37.55	31.55	35.57	
Okt.2007	39.22	39.69	32.91	36.76	
Nov.2007	40.86	40.88	35.38	39.13	
Dez.2007	44.04	42.43	36.34	39.54	
Jan.2008	44.91	43.38	37.04	40.98	
Feb.2008	47.75	44.94	38.16	42.13	
Mrz.2008	45.21	42.47	36.18	40.03	
Apr.2008	42.87	41.11	34.54	38.97	
Mai.2008	42.84	41.31	36.53	40.14	
Jun.2008	47.91	45.78	41.61	45.18	
Jul.2008	49.67	47.08	42.12	45.56	
Aug.2008	43.05	40.56	35.96	39.58	
Sep.2008	45.66	42.27	38.16	41.12	
Okt.2008	43.98	40.66	36.62	40.43	
Nov.2008	44.40	41.04	37.17	41.05	
Dez.2008	44.26	40.96	36.36	39.89	
Jan.2009	47.22	43.94	38.91	42.21	
Feb.2009	47.65	43.06	36.67	39.49	
Mrz.2009	44.26	40.71	34.97	38.62	
Apr.2009	46.16	42.75	38.02	41.57	
Mai.2009	48.82	45.24	40.80	44.34	
Jun.2009	49.32	45.55	40.95	45.06	
Jul.2009	47.22	43.85	39.21	43.07	
Aug.2009	47.11	44.34	39.96	43.85	
Sep.2009	46.21	42.90	38.77	42.78	
Okt.2009	44.54	42.52	37.92	42.09	
Nov.2009	45.85	42.21	37.80	41.58	
Dez.2009	45.89	41.54	36.20	38.83	
Jan.2010	39.94	37.30	28.89	31.66	382.53
Feb.2010	36.03	31.96	25.73	29.15	362.01
Mrz.2010	34.89	30.38	24.73	28.76	359.95
Apr.2010	34.59	30.95	26.21	29.45	371.58
Mai.2010	35.01	32.02	27.91	31.13	366.83
Jun.2010	36.17	32.47	29.14	32.50	373.60
Jul.2010	37.88	34.99	31.57	35.11	406.32
Aug.2010	40.28	38.68	35.17	38.58	426.57
Sep.2010	42.17	40.81	36.95	40.16	454.91
Okt.2010	45.13	42.76	39.36	42.78	481.00
Nov.2010	48.43	44.86	42.80	46.78	497.41
Dez.2010	49.53	47.01	42.98	46.51	513.89
Jan.2011	50.86	45.95	40.64	43.44	535.57
Feb.2011	50.54	45.01	39.50	42.51	535.09
Mrz.2011	45.26	41.50	37.66	41.19	513.69
Apr.2011	43.83	40.18	35.95	39.31	515.95
Mai.2011	43.72	40.62	36.53	40.19	511.71
Jun.2011	44.73	41.14	37.43	40.68	521.40
Jul.2011	43.97	41.50	37.46	41.25	549.24
Aug.2011	44.97	42.88	38.98	42.50	545.58
Sep.2011	47.45	45.35	41.37	44.77	504.85
Okt.2011	45.21	43.09	39.61	43.29	469.13
Nov.2011	44.27	41.97	38.19	41.35	461.19
Dez.2011	43.66	40.69	37.24	40.31	457.10
Jan.2012	43.88	43.13	37.77	40.84	479.50
Feb.2012	46.26	41.90	36.71	40.21	498.35
Mrz.2012	50.61	46.75	41.91	45.65	531.78
Apr.2012	55.94	52.32	48.43	52.48	560.37
Mai.2012	58.58	57.07	54.04	57.58	551.30
Jun.2012	60.41	61.36	57.89	61.32	545.82
Jul.2012	71.16	71.11	66.00	70.93	nd
Aug.2012	79.45	76.02	70.10	75.38	nd
Sep.2012	79.63	76.42	71.54	77.32	608.44
Okt.2012	67.41	70.51	65.96	70.56	573.34

Source: Data from CEPEA, provided by ALVES (2012).

Appendix 48: Freight rates for selected routes (2011-2012)

ANO	MES	PRODUTO	ORIGEM	UF	DESTINO	UF	R$/t	R$/t.km	Distância (km)
2011	Janeiro	Soja	Rio Verde	GO	Santos	SP	93.56	0.0945	990
2011	Fevereiro	Soja	Barretos	SP	Santos	SP	60.50	0.1205	502
2011	Fevereiro	Soja	Rio Verde	GO	Santos	SP	96.39	0.0974	990
2011	Fevereiro	Soja	Sorriso	MT	Santos	SP	175.00	0.0791	2211
2011	Março	Soja	Barretos	SP	Santos	SP	61.50	0.1225	502
2011	Março	Soja	Rio Verde	GO	Santos	SP	109.33	0.1104	990
2011	Abril	Soja	Barretos	SP	Santos	SP	61.00	0.1215	502
2011	Abril	Soja	Rio Verde	GO	Santos	SP	113.84	0.1150	990
2011	Abril	Soja	Sorriso	MT	Santos	SP	183.60	0.0830	2211
2011	Maio	Soja	Barretos	SP	Santos	SP	61.00	0.1215	502
2011	Maio	Soja	Rio Verde	GO	Santos	SP	109.55	0.1107	990
2011	Maio	Soja	Sorriso	MT	Santos	SP	183.60	0.0830	2211
2011	Junho	Soja	Barretos	SP	Santos	SP	61.00	0.1215	502
2011	Junho	Soja	Rio Verde	GO	Santos	SP	108.46	0.1096	990
2011	Junho	Soja	Sorriso	MT	Santos	SP	199.80	0.0904	2211
2011	Julho	Soja	Barretos	SP	Santos	SP	61.00	0.1215	502
2011	Julho	Soja	Rio Verde	GO	Santos	SP	109.62	0.1107	990
2011	Julho	Soja	Sorriso	MT	Santos	SP	204.90	0.0927	2211
2011	Agosto	Soja	Barretos	SP	Santos	SP	61.00	0.1215	502
2011	Agosto	Soja	Rio Verde	GO	Santos	SP	109.65	0.1108	990
2011	Agosto	Soja	Rondonópolis	MT	Santos	SP	154.30	0.0990	1559
2011	Setembro	Soja	Barretos	SP	Santos	SP	61.00	0.1215	502
2011	Setembro	Soja	Rio Verde	GO	Santos	SP	100.07	0.1011	990
2011	Setembro	Soja	Rondonópolis	MT	Santos	SP	154.30	0.0990	1559
2011	Outubro	Soja	Barretos	SP	Santos	SP	61.00	0.1215	502
2011	Outubro	Soja	Rio Verde	GO	Santos	SP	96.76	0.0977	990
2011	Outubro	Soja	Rondonópolis	MT	Santos	SP	160.00	0.1026	1559
2011	Outubro	Soja	Sorriso	MT	Santos	SP	178.00	0.0805	2211
2011	Novembro	Soja	Barretos	SP	Santos	SP	61.00	0.1215	502
2011	Novembro	Soja	Rio Verde	GO	Santos	SP	101.68	0.1027	990
2011	Dezembro	Soja	Barretos	SP	Santos	SP	61.00	0.1215	502
2011	Dezembro	Soja	Rio Verde	GO	Santos	SP	105.24	0.1063	990
2012	Janeiro	Soja	Barretos	SP	Santos	SP	61.00	0.1215	502
2012	Janeiro	Soja	Rio Verde	GO	Santos	SP	97.95	0.0989	990
2012	Janeiro	Soja	Rondonópolis	MT	Santos	SP	154.00	0.0988	1559
2012	Fevereiro	Soja	Barretos	SP	Santos	SP	62.33	0.1242	502
2012	Fevereiro	Soja	Rio Verde	GO	Santos	SP	107.55	0.1086	990
2012	Fevereiro	Soja	Rondonópolis	MT	Santos	SP	154.00	0.0988	1559
2012	Fevereiro	Soja	Sorriso	MT	Santos	SP	200.13	0.0905	2211
2012	Março	Soja	Rio Verde	GO	Santos	SP	111.82	0.1129	990
2012	Abril	Soja	Rio Verde	GO	Santos	SP	113.48	0.1146	990
2012	Maio	Soja	Barretos	SP	Santos	SP	72.00	0.1434	502
2012	Maio	Soja	Rio Verde	GO	Santos	SP	111.67	0.1114	1002
2012	Maio	Soja	Rondonópolis	MT	Santos	SP	162.80	0.1044	1559
2012	Maio	Soja	Sorriso	MT	Santos	SP	205.38	0.0929	2211
2012	Junho	Soja	Rio Verde	GO	Santos	SP	108.08	0.1079	1002
2012	Junho	Soja	Rondonópolis	MT	Santos	SP	153.27	0.0983	1559

Source: Data from ESALQ-LOG, provided by NUNES (2012).

Appendix 49: Calculation of total logistics costs of soybean exports for selected (2012)

APRIL 2012						
Origin			**Sorriso-MT**	**Rondonópolis-MT**	**Rio Verde-GO**	**Barretos-SP**
Distance to Santos			2,200 km	1,400 km	1,050 km	500 km
1. CBOT Chicago	US$/Bushel*	14.34				
	US$/t	527.07				
2. Bonus Santos	US$/bushel	0.91				
	US$/t	33.44				
3. FOB Santos	US$/bushel	15.25				
	US$/t	**560.37**				
	R$/sack	62.36				
4. Exchange rate	R$/US$	1.85				
5. Turnover (FOB Santos)	**R$/t**	**1039.37**				
6. Export expenses	R$/t	39.51				
6.1 Port fee	R$/t	20.40				
6.2 Comissions, brokerage	R$/t	13.91				
6.3 Taxes	R$/t	0.00				
6.4 Damage	R$/t	5.20				
7. Price at port gate	**R$/t**	**999.86**				
	R$/sack	59.99				
8. Freight rate	R$/t		198.00	136.92	n/d	n/d
	R$/sack		11.88	8.2152	n/d	n/d
9. Total logistics costs	**R$/t**		**237.51**	**176.43**	**-**	**-**
10. Price at warehouse	R$/t		**801.86**	**862.94**	**-**	**-**
	R$/sack		48.11	51.78	**-**	**-**
11. Price quoted at local	R$/sack		**48.43**	**52.48**	**52.32**	**55.94**
spot market	R$/t		**807.17**	**874.67**	**872.00**	**932.33**
Difference [10], [11]	R$/t		5.30	11.72	-	-
	%		0.66	1.36	-	-
Share of transport costs						
over total logistics costs	*%*		*83*	*78*	n/d	n/d

SEPTEMBER 2012						
Origin			**Sorriso-MT**	**Rondonópolis-MT**	**Rio Verde-GO**	**Barretos-SP**
Distance to Santos			2,200 km	1,400 km	1,050 km	500 km
1. CBOT Chicago	US$/Bushel*	16.84				
	US$/t	618.77				
2. Bonus Santos	US$/bushel	-0.28				
	US$/t	-10.31				
3. FOB Santos	US$/bushel	16.56				
FOB Santos	**US$/t**	**608.44**				
	R$/sack	36.51				
4. *Exchange rate*	R$/US$	2.03				
5. Turnover (FOB Santos)	**R$/t**	**1233.96**				
6. Export expenses	R$/t	43.69				
6.1 Port fee	R$/t	22.31				
6.2 Comissions, brokerage	R$/t	15.21				
6.3 Taxes	R$/t	0.00				
6.4 Damage	R$/t	6.17				
7. Price at port gate	**R$/t**	**1190.28**				
Price at port gate	R$/sack	71.42				
8. Freight rate	R$/t		245.74	187.46	n/d	n/d
	R$/sack		14.7444	11.2476	n/d	n/d
9. Total logistics costs	**R$/t**		**289.43**	**231.15**	**-**	**-**
10. Price at warehouse	R$/t		**944.54**	**1,002.82**	**-**	**-**
	R$/sack		56.67	60.17	-	-
11. Price quoted at local	R$/sack		**71.54**	**77.32**	**76.42**	**79.63**
spot market	R$/t		**1,192.33**	**1,288.67**	**1,273.67**	**1,327.17**
Difference ? [10], [11]	R$/t		247.80	285.85	-	-
	%		26.23	28.50	-	-
Share of transport costs over total logistics costs	%		*85*	*81*	n/d	n/d

Source: Author's calculation.

Appendix 50: Calculation of transport costs for soybean shipping from selected regions to Santos port

Fixed costs	average fixed capital	300,000	R$/year	300,000	R$/year
	Interest on capital	7,500	R$/year	7,500	R$/year
	Depreciation	40,000	R$/year	40,000	R$/year
	Maintenance costs (incl. tires)	5,000	R$/month	60,000	R$/year
	Gross driver labor rate	3,500	R$/month	42,000	R$/year
	Truck insurance	8,000	R$/year	8,000	R$/year
	Truck licence	1,300	R$/year	1,300	R$/year
	Total fixed costs per truck and year			**158,800**	**R$**
	Total fixed costs per km			**1.99**	**R$/km**
	Total fixed costs per tkm			**0.0536**	**R$/tkm**

	Mar 2011		**Route 1**	**Route 2**	**Route 3**	**Route 4**	**Route 5**
Variable costs	Origin		**Sorriso, via MS**	**Sorriso-MT, via GO**	**Rondonópolis-MT**	**Rio Verde-GO**	**Barretos-SP**
	Distance	km	2,200	2,100	1,400	1,050	500
	Local fuel price	R$/l	2.33	2.33	2.24	2.08	1.97
	Fuel costs	R$/route	2560.80	2444.40	1564.50	1092.53	493.25
		R$/t	**69.21**	**66.06**	**42.28**	**29.53**	**13.33**
	Toll costs	R$/route	702.10	578.20	578.20	604.80	603.40
		R$/tkm	**0.01**	**0.01**	**0.01**	**0.02**	**0.03**
	Variable costs	**R$/route**	3262.90	3022.60	2142.70	1697.33	1096.65
		R$/tkm	**0.0401**	**0.0389**	**0.0414**	**0.0437**	**0.0593**
	Fixed costs	**R$/route**	4367.00	4168.50	2779.00	2084.25	992.50
		R$/tkm	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
	TOTAL COSTS	**R$/route**	7629.90	7191.10	4921.70	3781.58	2089.15
		R$/tkm	**0.09**	**0.09**	**0.10**	**0.10**	**0.11**
		R$/route/t	**206.21**	**194.35**	**133.02**	**102.20**	**56.46**
	Freight rate	R$/t	213.33	213.33	163.33	109.33	61.00
	Difference		7.12	18.98	30.31	7.13	4.54

	Apr 11		Route 1	Route 2	Route 3	Route 4	Route 5
Variable costs	Origin		**Sorriso, via MS**	**Sorriso-MT, via GO**	**Rondonópolis-MT**	**Rio Verde-GO**	**Barretos-SP**
	Distance	km	2,200	2,100	1,400	1,050	500
	Local fuel price	R$/l	2.31	2.31	2.24	2.06	1.97
	Fuel costs	R$/route	2545.40	2429.70	1564.50	1080.45	492.25
		R$/tkm	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
	Toll costs	R$/route	702.10	578.20	578.20	604.80	603.40
		R$/tkm	**0.01**	**0.01**	**0.01**	**0.02**	**0.03**
	Variable costs	**R$/route**	3247.50	3007.90	2142.70	1685.25	1095.65
		R$/tkm	**0.0399**	**0.0387**	**0.0414**	**0.0434**	**0.0592**
	Fixed costs	**R$/route**	4367.00	4168.50	2779.00	2084.25	992.50
		R$/tkm	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
	TOTAL COSTS	**R$/route**	7614.50	7176.40	4921.70	3769.50	2088.15
		R$/tkm	**0.09**	**0.09**	**0.10**	**0.10**	**0.11**
		R$/route/t	**205.80**	**193.96**	**133.02**	**101.88**	**56.44**
	Freight rate	R$/t	198.13	198.13	145.63	113.84	61.00
	Difference		-7.67	4.17	12.61	11.96	4.56

	Sep 11		Route 1	Route 2	Route 3	Route 4	Route 5
Variable costs	Origin		**Sorriso, via MS**	**Sorriso-MT, via GO**	**Rondonópolis-MT**	**Rio Verde-GO**	**Barretos-SP**
	Distance	km	2,200	2,100	1,400	1,050	500
	Local fuel price	R$/l	2.34	2.34	2.23	2.05	1.97
	Fuel costs	R$/route	2572.90	2455.95	1559.60	1076.25	491.75
		R$/tkm	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
	Toll costs	R$/route	702.10	578.20	578.20	604.80	603.40
		R$/tkm	0.01	0.01	0.01	0.02	0.03
	Variable costs	**R$/route**	3275.00	3034.15	2137.80	1681.05	1095.15
		R$/tkm	**0.0402**	**0.0390**	**0.0413**	**0.0433**	**0.0592**
		R$/t	88.51	82.00	57.78	45.43	29.60
	Fixed costs	**R$/route**	4367.00	4168.50	2779.00	2084.25	992.50
		R$/t	118.03	112.66	75.11	56.33	26.82
		R$/tkm	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
		R$/route	7642.00	7202.65	4916.80	3765.30	2087.65
	TOTAL COSTS	**R$/tkm**	**0.09**	**0.09**	**0.09**	**0.10**	**0.11**
		R$/t	**206.54**	**194.67**	**132.89**	**101.76**	**56.42**
	Freight rate	R$/t	185.00	185.00	136.88	100.07	61.00
	Difference		-21.54	-9.67	3.99	-1.69	4.58

Source: Author's calculation.

Appendix 51: Sensitivity analysis - maintenance costs

Sensitivity - maintenance costs _ -10%

Fixed costs	average fixed capital	300,000	R$/year	300,000	R$/year
	Interest on capital	7,500	R$/year	7,500	R$/year
	Depreciation	40,000	R$/year	40,000	R$/year
	Maintenance costs (incl. tires)	4,500	R$/month	54,000	R$/year
	Gross driver labor rate	3,500	R$/month	42,000	R$/year
	Truck insurance	8,000	R$/year	8,000	R$/year
	Truck licence	1,300	R$/year	1,300	R$/year
	Total fixed costs per truck and year			**152,800**	**R$**
	Total fixed costs per km			**1.91**	**R$/km**

	Mar 2011		**Route 1**	**Route 2**	**Route 3**	**Route 4**	**Route 5**
Variable costs	Origin		**Sorriso, via MS**	**Sorriso-MT, via GO**	**Rondonópolis-MT**	**Rio Verde-GO**	**Barretos-SP**
	Distance	km	2,200	2,100	1,400	1,050	500
	Local fuel price	R$/l	2.33	2.33	2.24	2.08	1.97
	Fuel costs	R$/route	2560.80	2444.40	1564.50	1092.53	493.25
		R$/tkm	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
	Toll costs	R$/route	702.10	578.20	578.20	604.80	603.40
		R$/tkm	**0.01**	**0.01**	**0.01**	**0.02**	**0.03**
	Variable costs	**R$/route**	3262.90	3022.60	2142.70	1697.33	1096.65
		R$/tkm	**0.04**	**0.04**	**0.04**	**0.04**	**0.06**
	Fixed costs	**R$/route**	4202.00	4011.00	2674.00	2005.50	955.00
		R$/tkm	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
	TOTAL COSTS	**R$/route**	7464.90	7033.60	4816.70	3702.83	2051.65
		R$/tkm	**0.09**	**0.09**	**0.09**	**0.10**	**0.11**
		R$/route/t	**201.75**	**190.10**	**130.18**	**100.08**	**55.45**
	Freight rate	R$/t	213.33	213.33	163.33	109.33	61.00
	Difference		11.58	23.23	33.15	9.25	5.55

	Apr 11		**Route 1**	**Route 2**	**Route 3**	**Route 4**	**Route 5**
Variable costs	Origin		**Sorriso, via MS**	**Sorriso-MT, via GO**	**Rondonópolis-MT**	**Rio Verde-GO**	**Barretos-SP**
	Distance	km	2,200	2,100	1,400	1,050	500
	Local fuel price	R$/l	2.31	2.31	2.24	2.06	1.97
	Fuel costs	R$/route	2545.40	2429.70	1564.50	1080.45	492.25
		R$/tkm	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
	Toll costs	R$/route	702.10	578.20	578.20	604.80	603.40
		R$/tkm	**0.01**	**0.01**	**0.01**	**0.02**	**0.03**
	Variable costs	**R$/route**	3247.53	3007.93	2142.73	1685.28	1095.68
		R$/tkm	**0.04**	**0.04**	**0.04**	**0.04**	**0.06**
	Fixed costs	**R$/route**	4202.00	4011.00	2674.00	2005.50	955.00
		R$/tkm	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
	TOTAL COSTS	**R$/route**	7449.53	7018.93	4816.73	3690.78	2050.68
		R$/tkm	**0.09**	**0.09**	**0.09**	**0.10**	**0.11**
		R$/route/t	**201.34**	**189.70**	**130.18**	**99.75**	**55.42**
	Freight rate	R$/t	198.13	198.13	145.63	113.84	61.00
	Difference		-3.21	8.43	15.45	14.09	5.58

	Sep 11		**Route 1**	**Route 2**	**Route 3**	**Route 4**	**Route 5**
Variable costs	Origin		**Sorriso, via MS**	**Sorriso-MT, via GO**	**Rondonópolis-MT**	**Rio Verde-GO**	**Barretos-SP**
	Distance	km	2,200	2,100	1,400	1,050	500
	Local fuel price	R$/l	2.34	2.34	2.23	2.05	1.97
	Fuel costs	R$/route	2572.90	2455.95	1559.60	1076.25	491.75
		R$/tkm	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
	Toll costs	R$/route	702.10	578.20	578.20	604.80	603.40
		R$/tkm	0.01	0.01	0.01	0.02	0.03
	Variable costs	**R$/route**	3275.03	1517.09	2137.83	1681.08	1095.18
		R$/tkm	**0.04**	**0.02**	**0.04**	**0.04**	**0.06**
	Fixed costs	**R$/route**	4202.00	4011.00	2674.00	2005.50	955.00
		R$/tkm	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
		R$/route	7477.03	5528.09	4811.83	3686.58	2050.18
	TOTAL COSTS	**R$/tkm**	**0.09**	**0.07**	**0.09**	**0.09**	**0.11**
		R$/t	**202.08**	**149.41**	**130.05**	**99.64**	**55.41**
	Freight rate	R$/t	185.00	185.00	136.88	100.07	61.00
	Difference		-17.08	35.59	6.83	0.43	5.59

Sensitivity - maintenance costs _ +10%

Fixed costs	average fixed capital	300,000	R$/year	300,000	R$/year
	Interest on capital	7,500	R$/year	7,500	R$/year
	Depreciation	40,000	R$/year	40,000	R$/year
	Maintenance costs (incl. tires)	5,500	R$/month	66,000	R$/year
	Gross driver labor rate	3,500	R$/month	42,000	R$/year
	Truck insurance	8,000	R$/year	8,000	R$/year
	Truck licence	1,300	R$/year	1,300	R$/year
	Total fixed costs per truck and year			**164,800**	**R$**
	Total fixed costs per km			**2.06**	**R$/km**

	Mar 2011		**Route 1**	**Route 2**	**Route 3**	**Route 4**	**Route 5**
Variable costs	Origin		**Sorriso, via M**	**Sorriso-MT, v**	**Rondonópolis-**	**Rio Verde-GO**	**Barretos-SP**
	Distance	km	2,200	2,100	1,400	1,050	500
	Local fuel price	R$/l	2.33	2.33	2.24	2.08	1.97
	Fuel costs	R$/route	2560.80	2444.40	1564.50	1092.53	493.25
		R$/tkm	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
	Toll costs	R$/route	702.10	578.20	578.20	604.80	603.40
		R$/tkm	**0.01**	**0.01**	**0.01**	**0.02**	**0.03**
	Variable costs	**R$/route**	3262.90	3022.60	2142.70	1697.33	1096.65
		R$/tkm	**0.04**	**0.04**	**0.04**	**0.04**	**0.06**
	Fixed costs	**R$/route**	4532.00	4326.00	2884.00	2163.00	1030.00
		R$/tkm	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**
	TOTAL COSTS	**R$/route**	7794.94	7348.64	5026.74	3860.37	2126.71
		R$/tkm	**0.10**	**0.09**	**0.10**	**0.10**	**0.11**
		R$/route/t	**210.67**	**198.61**	**135.86**	**104.33**	**57.48**
	Freight rate	R$/t	213.33	213.33	163.33	109.33	61.00
	Difference		2.66	14.72	27.47	5.00	3.52

	Apr 11		**Route 1**	**Route 2**	**Route 3**	**Route 4**	**Route 5**
Variable costs	Origin		**Sorriso, via M**	**Sorriso-MT, v**	**Rondonópolis-**	**Rio Verde-GO**	**Barretos-SP**
	Distance	km	2,200	2,100	1,400	1,050	500
	Local fuel price	R$/l	2.31	2.31	2.24	2.06	1.97
	Fuel costs	R$/route	2545.40	2429.70	1564.50	1080.45	492.25
		R$/tkm	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
	Toll costs	R$/route	702.10	578.20	578.20	604.80	603.40
		R$/tkm	**0.01**	**0.01**	**0.01**	**0.02**	**0.03**
	Variable costs	**R$/route**	3247.53	3007.93	2142.73	1685.28	1095.68
		R$/tkm	**0.04**	**0.04**	**0.04**	**0.04**	**0.06**
	Fixed costs	**R$/route**	4532.00	4326.00	2884.00	2163.00	1030.00
		R$/tkm	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**
	TOTAL COSTS	**R$/route**	7779.57	7333.97	5026.77	3848.32119	2125.735834
		R$/tkm	**0.10**	**0.09**	**0.10**	**0.10**	**0.11**
		R$/route/t	**210.26**	**198.22**	**135.86**	**104.01**	**57.45**
	Freight rate	R$/t	198.13	198.13	145.63	113.84	61.00
	Difference		-12.13	-0.09	9.77	9.83	3.55

	Sep 11		**Route 1**	**Route 2**	**Route 3**	**Route 4**	**Route 5**
Variable costs	Origin		**Sorriso, via M**	**Sorriso-MT, v**	**Rondonópolis-**	**Rio Verde-GO**	**Barretos-SP**
	Distance	km	2,200	2,100	1,400	1,050	500
	Local fuel price	R$/l	2.34	2.34	2.23	2.05	1.97
	Fuel costs	R$/route	2572.90	2455.95	1559.60	1076.25	491.75
		R$/tkm	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
	Toll costs	R$/route	702.10	578.20	578.20	604.80	603.40
		R$/tkm	0.01	0.01	0.01	0.02	0.03
	Variable costs	**R$/route**	3275.03	1517.09	2137.83	1681.08	1095.18
		R$/tkm	**0.04**	**0.02**	**0.04**	**0.04**	**0.06**
	Fixed costs	**R$/route**	4532.00	4326.00	2884.00	2163.00	1030.00
		R$/tkm	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**
		R$/route	7807.07	5843.11	5021.87	3844.120974	2125.23578
	TOTAL COSTS	**R$/tkm**	**0.10**	**0.08**	**0.10**	**0.10**	**0.11**
		R$/t	**211.00**	**157.92**	**135.73**	**103.90**	**57.44**
	Freight rate	R$/t	185.00	185.00	136.88	100.07	61.00
	Difference		-26.00	27.08	1.15	-3.83	3.56

Source: Author's calculation.

Appendix 52: Sensitivity analysis - interest rate.

Fixed costs	average fixed capital		300,000	R$/year	300,000	R$/year
	Interest on capital	i = 0.05	15,000	R$/year	15,000	R$/year
	Depreciation		40,000	R$/year	40,000	R$/year
	Maintenance costs (incl. tires)		5,000	R$/month	60,000	R$/year
	Gross driver labor rate		3,500	R$/month	42,000	R$/year
	Truck insurance		8,000	R$/year	8,000	R$/year
	Truck licence		1,300	R$/year	1,300	R$/year
	Total fixed costs per truck and year				**166,300**	**R$**
					2.08	**R$/km**
	Total fixed costs per km				**0.06**	**R$/tkm**

	Mar 2011		**Route 1**	**Route 2**	**Route 3**	**Route 4**	**Route 5**
Variable costs	Origin		**Sorriso, via MS**	**Sorriso-MT, via GO**	**Rondonópolis-MT**	**Rio Verde-GO**	**Barretos-SP**
	Distance	km	2,200	2,100	1,400	1,050	500
	Local fuel price	R$/l	2.33	2.33	2.24	2.08	1.97
	Fuel costs	R$/route	2560.80	2444.40	1564.50	1092.53	493.25
		R$/tkm	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
	Toll costs	R$/route	702.10	578.20	578.20	604.80	603.40
		R$/tkm	**0.01**	**0.01**	**0.01**	**0.02**	**0.03**
	Variable costs	**R$/route**	3262.90	3022.60	2142.70	1697.33	1096.65
		R$/tkm	**0.04**	**0.04**	**0.04**	**0.04**	**0.06**
	Fixed costs	**R$/route**	4573.25	4365.38	2910.25	2182.69	1039.38
		R$/tkm	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**
	TOTAL COSTS	**R$/route**	7836.15	7387.98	5052.95	3880.01	2136.03
		R$/tkm	**0.10**	**0.10**	**0.10**	**0.10**	**0.12**
		R$/route/t	**211.79**	**199.68**	**136.57**	**104.87**	**57.73**
	Freight rate	R$/t	213.33	213.33	163.33	109.33	61.00
	Difference		1.54	13.66	26.76	4.46	3.27

	Apr 11		**Route 1**	**Route 2**	**Route 3**	**Route 4**	**Route 5**
Variable costs	Origin		**Sorriso, via MS**	**Sorriso-MT, via GO**	**Rondonópolis-MT**	**Rio Verde-GO**	**Barretos-SP**
	Distance	km	2,200	2,100	1,400	1,050	500
	Local fuel price	R$/l	2.31	2.31	2.24	2.06	1.97
	Fuel costs	R$/route	2545.40	2429.70	1564.50	1080.45	492.25
		R$/tkm	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
	Toll costs	R$/route	702.10	578.20	578.20	604.80	603.40
		R$/tkm	**0.01**	**0.01**	**0.01**	**0.02**	**0.03**
	Variable costs	**R$/route**	3247.53	3007.93	2142.73	1685.28	1095.68
		R$/tkm	**0.04**	**0.04**	**0.04**	**0.04**	**0.06**
	Fixed costs	**R$/route**	4367.00	4168.50	2779.00	2084.25	992.50
		R$/tkm	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
	TOTAL COSTS	**R$/route**	7614.53	7176.43	4921.73	3769.53	2088.18
		R$/tkm	**0.09**	**0.09**	**0.10**	**0.10**	**0.11**
		R$/route/t	**205.80**	**193.96**	**133.02**	**101.88**	**56.44**
	Freight rate	R$/t	198.13	198.13	145.63	113.84	61.00
	Difference		-7.67	4.17	12.61	11.96	4.56

	Sep 11		**Route 1**	**Route 2**	**Route 3**	**Route 4**	**Route 5**
Variable costs	Origin		**Sorriso, via MS**	**Sorriso-MT, via GO**	**Rondonópolis-MT**	**Rio Verde-GO**	**Barretos-SP**
	Distance	km	2,200	2,100	1,400	1,050	500
	Local fuel price	R$/l	2.34	2.34	2.23	2.05	1.97
	Fuel costs	R$/route	2572.90	2455.95	1559.60	1076.25	491.75
		R$/tkm	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
	Toll costs	R$/route	702.10	578.20	578.20	604.80	603.40
		R$/tkm	0.01	0.01	0.01	0.02	0.03
	Variable costs	**R$/route**	3275.03	3034.18	2137.83	1681.08	1095.18
		R$/tkm	**0.04**	**0.04**	**0.04**	**0.04**	**0.06**
	Fixed costs	**R$/route**	4367.00	4168.50	2779.00	2084.25	992.50
		R$/tkm	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
		R$/route	7642.03	7202.68	4916.83	3765.33	2087.68
	TOTAL COSTS	**R$/tkm**	**0.09**	**0.09**	**0.09**	**0.10**	**0.11**
		R$/t	**206.54**	**194.67**	**132.89**	**101.77**	**56.42**
	Freight rate	R$/t	185.00	185.00	136.88	100.07	61.00
	Difference		-21.54	-9.67	3.99	-1.70	4.58

Fixed costs	average fixed capital		300,000	R$/year	300,000	R$/year
	Interest on capital	i = 0.06	15,000	R$/year	18,000	R$/year
	Depreciation		40,000	R$/year	40,000	R$/year
	Maintenance costs (incl. tires)		5,000	R$/month	60,000	R$/year
	Gross driver labor rate		3,500	R$/month	42,000	R$/year
	Truck insurance		8,000	R$/year	8,000	R$/year
	Truck licence		1,300	R$/year	1,300	R$/year
	Total fixed costs per truck and year				**169,300**	**R$**
					2.12	**R$/km**
	Total fixed costs per km				**0.06**	**R$/tkm**

	Mar 2011		**Route 1**	**Route 2**	**Route 3**	**Route 4**	**Route 5**
Variable costs	Origin		**Sorriso, via MS**	**Sorriso-MT, via GO**	**Rondonópolis-MT**	**Rio Verde-GO**	**Barretos-SP**
	Distance	km	2,200	2,100	1,400	1,050	500
	Local fuel price	R$/l	2.33	2.33	2.24	2.08	1.97
	Fuel costs	R$/route	2560.80	2444.40	1564.50	1092.53	493.25
		R$/tkm	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
	Toll costs	R$/route	702.10	578.20	578.20	604.80	603.40
		R$/tkm	**0.01**	**0.01**	**0.01**	**0.02**	**0.03**
	Variable costs	**R$/route**	3262.90	3022.60	2142.70	1697.33	1096.65
		R$/tkm	**0.04**	**0.04**	**0.04**	**0.04**	**0.06**
	Fixed costs	**R$/route**	4655.75	4444.13	2962.75	2222.06	1058.13
		R$/tkm	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**
	TOTAL COSTS	**R$/route**	7918.65	7466.73	5105.45	3919.39	2154.78
		R$/tkm	**0.10**	**0.10**	**0.10**	**0.10**	**0.12**
		R$/route/t	**214.02**	**201.80**	**137.99**	**105.93**	**58.24**
	Freight rate	R$/t	213.33	213.33	163.33	109.33	61.00
	Difference		-0.69	11.53	25.34	3.40	2.76

	Apr 11		**Route 1**	**Route 2**	**Route 3**	**Route 4**	**Route 5**
Variable costs	Origin		**Sorriso, via MS**	**Sorriso-MT, via GO**	**Rondonópolis-MT**	**Rio Verde-GO**	**Barretos-SP**
	Distance	km	2,200	2,100	1,400	1,050	500
	Local fuel price	R$/l	2.31	2.31	2.24	2.06	1.97
	Fuel costs	R$/route	2545.40	2429.70	1564.50	1080.45	492.25
		R$/tkm	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
	Toll costs	R$/route	702.10	578.20	578.20	604.80	603.40
		R$/tkm	**0.01**	**0.01**	**0.01**	**0.02**	**0.03**
	Variable costs	**R$/route**	3247.53	3007.93	2142.73	1685.28	1095.68
		R$/tkm	**0.04**	**0.04**	**0.04**	**0.04**	**0.06**
	Fixed costs	**R$/route**	4655.75	4444.13	2962.75	2222.06	1058.13
		R$/tkm	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**
	TOTAL COSTS	**R$/route**	7903.28	7452.06	5105.48	3907.34	2153.80
		R$/tkm	**0.10**	**0.10**	**0.10**	**0.10**	**0.12**
		R$/route/t	**213.60**	**201.41**	**137.99**	**105.60**	**58.21**
	Freight rate	R$/t	198.13	198.13	145.63	113.84	61.00
	Difference		-15.47	-3.28	7.64	8.24	2.79

	Sep 11		**Route 1**	**Route 2**	**Route 3**	**Route 4**	**Route 5**
Variable costs	Origin		**Sorriso, via MS**	**Sorriso-MT, via GO**	**Rondonópolis-MT**	**Rio Verde-GO**	**Barretos-SP**
	Distance	km	2,200	2,100	1,400	1,050	500
	Local fuel price	R$/l	2.34	2.34	2.23	2.05	1.97
	Fuel costs	R$/route	2572.90	2455.95	1559.60	1076.25	491.75
		R$/tkm	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
	Toll costs	R$/route	702.10	578.20	578.20	604.80	603.40
		R$/tkm	0.01	0.01	0.01	0.02	0.03
	Variable costs	**R$/route**	3275.03	1517.09	2137.83	1681.08	1095.18
		R$/tkm	**0.04**	**0.02**	**0.04**	**0.04**	**0.06**
	Fixed costs	**R$/route**	4655.75	4444.13	2962.75	2222.06	1058.13
		R$/tkm	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**
		R$/route	7930.82	5961.24	5100.62	3903.183474	2153.36078
	TOTAL COSTS	**R$/tkm**	**0.10**	**0.08**	**0.10**	**0.10**	**0.12**
		R$/t	**214.35**	**161.11**	**137.85**	**105.49**	**58.20**
	Freight rate	R$/t	185.00	185.00	136.88	100.07	61.00
	Difference		-29.35	23.89	-0.97	-5.42	2.80

Fixed costs	average fixed capital		300,000 R$/year		300,000 R$/year
	Interest on capital	i = 0.07	21,000 R$/year		21,000 R$/year
	Depreciation		40,000 R$/year		40,000 R$/year
	Maintenance costs (incl. tires)		5,000 R$/month		60,000 R$/year
	Gross driver labor rate		3,500 R$/month		42,000 R$/year
	Truck insurance		8,000 R$/year		8,000 R$/year
	Truck licence		1,300 R$/year		1,300 R$/year
	Total fixed costs per truck and year				**172,300 R$**
					2.15 R$/km
	Total fixed costs per km				**0.06 R$/tkm**

	Mar 2011		**Route 1**	**Route 2**	**Route 3**	**Route 4**	**Route 5**
Variable costs	Origin		**Sorriso, via MS**	**Sorriso-MT, via GO**	**Rondonópolis-MT**	**Rio Verde-GO**	**Barretos-SP**
	Distance	km	2,200	2,100	1,400	1,050	500
	Local fuel price	R$/l	2.33	2.33	2.24	2.08	1.97
	Fuel costs	R$/route	2560.80	2444.40	1564.50	1092.53	493.25
		R$/tkm	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
	Toll costs	R$/route	702.10	578.20	578.20	604.80	603.40
		R$/tkm	**0.01**	**0.01**	**0.01**	**0.02**	**0.03**
	Variable costs	**R$/route**	3262.90	3022.60	2142.70	1697.33	1096.65
		R$/tkm	**0.04**	**0.04**	**0.04**	**0.04**	**0.06**
	Fixed costs	**R$/route**	4738.25	4522.88	3015.25	2261.44	1076.88
		R$/tkm	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**
	TOTAL COSTS	**R$/route**	8001.15	7545.48	5157.95	3958.76	2173.53
		R$/tkm	**0.10**	**0.10**	**0.10**	**0.10**	**0.12**
		R$/route/t	**216.25**	**203.93**	**139.40**	**106.99**	**58.74**
	Freight rate	R$/t	213.33	213.33	163.33	109.33	61.00
	Difference		-2.92	9.40	23.93	2.34	2.26

	Apr 11		**Route 1**	**Route 2**	**Route 3**	**Route 4**	**Route 5**
Variable costs	Origin		**Sorriso, via MS**	**Sorriso-MT, via GO**	**Rondonópolis-MT**	**Rio Verde-GO**	**Barretos-SP**
	Distance	km	2,200	2,100	1,400	1,050	500
	Local fuel price	R$/l	2.31	2.31	2.24	2.06	1.97
	Fuel costs	R$/route	2545.40	2429.70	1564.50	1080.45	492.25
		R$/tkm	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
	Toll costs	R$/route	702.10	578.20	578.20	604.80	603.40
		R$/tkm	**0.01**	**0.01**	**0.01**	**0.02**	**0.03**
	Variable costs	**R$/route**	3247.53	3007.93	2142.73	1685.28	1095.68
		R$/tkm	**0.04**	**0.04**	**0.04**	**0.04**	**0.06**
	Fixed costs	**R$/route**	4738.25	4522.88	3015.25	2261.44	1076.88
		R$/tkm	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**
	TOTAL COSTS	**R$/route**	7985.78	7530.81	5157.98	3946.72	2172.55
		R$/tkm	**0.10**	**0.10**	**0.10**	**0.10**	**0.12**
		R$/route/t	**215.83**	**203.54**	**139.40**	**106.67**	**58.72**
	Freight rate	R$/t	198.13	198.13	145.63	113.84	61.00
	Difference		-17.70	-5.41	6.23	7.17	2.28

	Sep 11		**Route 1**	**Route 2**	**Route 3**	**Route 4**	**Route 5**
Variable costs	Origin		**Sorriso, via MS**	**Sorriso-MT, via GO**	**Rondonópolis-MT**	**Rio Verde-GO**	**Barretos-SP**
	Distance	km	2,200	2,100	1,400	1,050	500
	Local fuel price	R$/l	2.34	2.34	2.23	2.05	1.97
	Fuel costs	R$/route	2572.90	2455.95	1559.60	1076.25	491.75
		R$/tkm	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
	Toll costs	R$/route	702.10	578.20	578.20	604.80	603.40
		R$/tkm	0.01	0.01	0.01	0.02	0.03
	Variable costs	**R$/route**	3275.03	1517.09	2137.83	1681.08	1095.18
		R$/tkm	**0.04**	**0.02**	**0.04**	**0.04**	**0.06**
	Fixed costs	**R$/route**	4738.25	4522.88	3015.25	2261.44	1076.88
		R$/tkm	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**
		R$/route	8013.32	6039.99	5153.12	3942.558474	2172.11078
	TOTAL COSTS	**R$/tkm**	**0.10**	**0.08**	**0.10**	**0.10**	**0.12**
		R$/t	**216.58**	**163.24**	**139.27**	**106.56**	**58.71**
	Freight rate	R$/t	185.00	185.00	136.88	100.07	61.00
	Difference		-31.58	21.76	-2.39	-6.49	2.29

Source: Author's calculation.

Appendix 53 Sensitivity analysis - fuel costs

FUEL +5%

Fixed costs	average fixed capital	300,000	R$/year	300,000	R$/year
	Interest on capital	7,500	R$/year	7,500	R$/year
	Depreciation	40,000	R$/year	40,000	R$/year
	Maintenance costs (incl. tires)	5,000	R$/month	60,000	R$/year
	Gross driver labor rate	3,500	R$/month	42,000	R$/year
	Truck insurance	8,000	R$/year	8,000	R$/year
	Truck licence	1,300	R$/year	1,300	R$/year
	Total fixed costs per truck and year			**158,800**	**R$**
	Total fixed costs per km			**1.99**	**R$/km**
				0.05	**R$/tkm**

	Mar 2011		**Route 1**	**Route 2**	**Route 3**	**Route 4**	**Route 5**
Variable costs	Origin		**Sorriso, via MS**	**Sorriso-MT, via GO**	**Rondonópolis-MT**	**Rio Verde-GO**	**Barretos-SP**
	Distance	km	2,200	2,100	1,400	1,050	500
	Local fuel price	R$/l	2.44	2.44	2.35	2.19	2.07
	Fuel costs	R$/route	2688.84	2566.62	1642.73	1147.15	517.91
		R$/tkm	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
	Toll costs	R$/route	702.10	578.20	578.20	604.80	603.40
		R$/tkm	**0.01**	**0.01**	**0.01**	**0.02**	**0.03**
	Variable costs	**R$/route**	3390.94	3144.82	2220.93	1751.95	1121.31
		R$/tkm	**0.04**	**0.04**	**0.04**	**0.05**	**0.06**
	Fixed costs	**R$/route**	4367.00	4168.50	2779.00	2084.25	992.50
		R$/tkm	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
	TOTAL COSTS	**R$/route**	7757.94	7313.32	4999.93	3836.20	2113.81
		R$/tkm	**0.10**	**0.09**	**0.10**	**0.10**	**0.11**
		R$/route/t	**209.67**	**197.66**	**135.13**	**103.68**	**57.13**
	Freight rate	R$/t	213.33	213.33	163.33	109.33	61.00
	Difference		3.66	15.67	28.20	5.65	3.87

	Apr 11		**Route 1**	**Route 2**	**Route 3**	**Route 4**	**Route 5**
Variable costs	Origin		**Sorriso, via MS**	**Sorriso-MT, via GO**	**Rondonópolis-MT**	**Rio Verde-GO**	**Barretos-SP**
	Distance	km	2,200	2,100	1,400	1,050	500
	Local fuel price	R$/l	2.43	2.43	2.35	2.16	2.07
	Fuel costs	R$/route	2672.67	2551.19	1642.73	1134.47	516.86
		R$/tkm	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
	Toll costs	R$/route	702.10	578.20	578.20	604.80	603.40
		R$/tkm	**0.01**	**0.01**	**0.01**	**0.02**	**0.03**
	Variable costs	**R$/route**	3374.80	3129.42	2220.96	1739.30	1120.29
		R$/tkm	**0.04**	**0.04**	**0.04**	**0.04**	**0.06**
	Fixed costs	**R$/route**	4367.00	4168.50	2779.00	2084.25	992.50
		R$/tkm	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
	TOTAL COSTS	**R$/route**	7741.80	7297.92	4999.96	3823.55	2112.79
		R$/tkm	**0.10**	**0.09**	**0.10**	**0.10**	**0.11**
		R$/route/t	**209.24**	**197.24**	**135.13**	**103.34**	**57.10**
	Freight rate	R$/t	198.13	198.13	145.63	113.84	61.00
	Difference		-11.11	0.89	10.50	10.50	3.90

	Sep 11		**Route 1**	**Route 2**	**Route 3**	**Route 4**	**Route 5**
Variable costs	Origin		**Sorriso, via MS**	**Sorriso-MT, via GO**	**Rondonópolis-MT**	**Rio Verde-GO**	**Barretos-SP**
	Distance	km	2,200	2,100	1,400	1,050	500
	Local fuel price	R$/l	2.46	2.46	2.34	2.15	2.07
	Fuel costs	R$/route	2701.55	2578.75	1637.58	1130.06	516.34
		R$/tkm	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
	Toll costs	R$/route	702.10	578.20	578.20	604.80	603.40
		R$/tkm	0.01	0.01	0.01	0.02	0.03
	Variable costs	**R$/route**	3403.68	3156.98	2215.81	1734.89	1119.77
		R$/tkm	**0.04**	**0.04**	**0.04**	**0.04**	**0.06**
	Fixed costs	**R$/route**	4367.00	4168.50	2779.00	2084.25	992.50
		R$/tkm	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
		R$/route	7770.68	7325.48	4994.81	3819.14	2112.27
	TOTAL COSTS	**R$/tkm**	**0.10**	**0.09**	**0.10**	**0.10**	**0.11**
		R$/t	**210.02**	**197.99**	**134.99**	**103.22**	**57.09**
	Freight rate	R$/t	185.00	185.00	136.88	100.07	61.00
	Difference		-25.02	-12.99	1.89	-3.15	3.91

FUEL +10%

Fixed costs	average fixed capital	300,000 R$/year	300,000	R$/year
	Interest on capital	7,500 R$/year	7,500	R$/year
	Depreciation	40,000 R$/year	40,000	R$/year
	Maintenance costs (incl. tires)	5,000 R$/month	60,000	R$/year
	Gross driver labor rate	3,500 R$/month	42,000	R$/year
	Truck insurance	8,000 R$/year	8,000	R$/year
	Truck licence	1,300 R$/year	1,300	R$/year
	Total fixed costs per truck and year		**158,800**	**R$**
	Total fixed costs per km		**1.99**	**R$/km**
			0.05	**R$/tkm**

			256.08	**244.44**	**156.45**	**109.25**	**49.32**
	Mar 2011		**Route 1**	**Route 2**	**Route 3**	**Route 4**	**Route 5**
	Origin		**Sorriso, via MS**	**Sorriso-MT, via GO**	**Rondonópolis-MT**	**Rio Verde-GO**	**Barretos-SP**
Variable costs	Distance	km	2,200	2,100	1,400	1,050	500
	Local fuel price	R$/l	2.56	2.56	2.46	2.29	2.17
	Fuel costs	R$/route	2816.88	2688.84	1720.95	1201.78	542.58
		R$/tkm	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
	Toll costs	R$/route	702.10	578.20	578.20	604.80	603.40
		R$/tkm	**0.01**	**0.01**	**0.01**	**0.02**	**0.03**
	Variable costs	**R$/route**	3518.98	3267.04	2299.15	1806.58	1145.98
		R$/tkm	**0.04**	**0.04**	**0.04**	**0.05**	**0.06**
	Fixed costs	**R$/route**	4367.00	4168.50	2779.00	2084.25	992.50
		R$/tkm	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
	TOTAL COSTS	**R$/route**	7885.98	7435.54	5078.15	3890.83	2138.48
		R$/tkm	**0.10**	**0.10**	**0.10**	**0.10**	**0.12**
		R$/route/t	**213.13**	**200.96**	**137.25**	**105.16**	**57.80**
	Freight rate	R$/t	213.33	213.33	163.33	109.33	61.00
	Difference		0.20	12.37	26.08	4.17	3.20

	Apr 11		**Route 1**	**Route 2**	**Route 3**	**Route 4**	**Route 5**
	Origin		**Sorriso, via MS**	**Sorriso-MT, via GO**	**Rondonópolis-MT**	**Rio Verde-GO**	**Barretos-SP**
Variable costs	Distance	km	2,200	2,100	1,400	1,050	500
	Local fuel price	R$/l	2.55	2.55	2.46	2.26	2.17
	Fuel costs	R$/route	2799.94	2672.67	1720.95	1188.50	541.48
		R$/tkm	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
	Toll costs	R$/route	702.10	578.20	578.20	604.80	603.40
		R$/tkm	**0.01**	**0.01**	**0.01**	**0.02**	**0.03**
	Variable costs	**R$/route**	3502.07	3250.90	2299.18	1793.33	1144.90
		R$/tkm	**0.04**	**0.04**	**0.04**	**0.05**	**0.06**
	Fixed costs	**R$/route**	4367.00	4168.50	2779.00	2084.25	992.50
		R$/tkm	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
	TOTAL COSTS	**R$/route**	7869.07	7419.40	5078.18	3877.58	2137.40
		R$/tkm	**0.10**	**0.10**	**0.10**	**0.10**	**0.12**
		R$/route/t	**212.68**	**200.52**	**137.25**	**104.80**	**57.77**
	Freight rate	R$/t	198.13	198.13	145.63	113.84	61.00
	Difference		-14.55	-2.39	8.38	9.04	3.23

	Sep 11		**Route 1**	**Route 2**	**Route 3**	**Route 4**	**Route 5**
	Origin		**Sorriso, via MS**	**Sorriso-MT, via GO**	**Rondonópolis-MT**	**Rio Verde-GO**	**Barretos-SP**
Variable costs	Distance	km	2,200	2,100	1,400	1,050	500
	Local fuel price	R$/l	2.57	2.57	2.45	2.26	2.16
	Fuel costs	R$/route	2830.19	2701.55	1715.56	1183.88	540.93
		R$/tkm	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
	Toll costs	R$/route	702.10	578.20	578.20	604.80	603.40
		R$/tkm	0.01	0.01	0.01	0.02	0.03
	Variable costs	**R$/route**	3532.32	3279.78	2293.79	1788.71	1144.35
		R$/tkm	**0.04**	**0.04**	**0.04**	**0.05**	**0.06**
	Fixed costs	**R$/route**	4367.00	4168.50	2779.00	2084.25	992.50
		R$/tkm	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
		R$/route	7899.32	7448.28	5072.79	3872.96	2136.85
	TOTAL COSTS	**R$/tkm**	**0.10**	**0.10**	**0.10**	**0.10**	**0.12**
		R$/t	**213.50**	**201.30**	**137.10**	**104.67**	**57.75**
	Freight rate	R$/t	185.00	185.00	136.88	100.07	61.00
	Difference		-28.50	-16.30	-0.22	-4.60	3.25

FUEL +15%

Fixed costs	average fixed capital	300,000	R$/year	300,000	R$/year
	Interest on capital	7,500	R$/year	7,500	R$/year
	Depreciation	40,000	R$/year	40,000	R$/year
	Maintenance costs (incl. tires)	5,000	R$/month	60,000	R$/year
	Gross driver labor rate	3,500	R$/month	42,000	R$/year
	Truck insurance	8,000	R$/year	8,000	R$/year
	Truck licence	1,300	R$/year	1,300	R$/year
	Total fixed costs per truck and year			**158,800**	**R$**
	Total fixed costs per km			**1.99**	**R$/km**
				0.05	**R$/tkm**

	Mar 2011		**Route 1**	**Route 2**	**Route 3**	**Route 4**	**Route 5**
Variable costs	Origin		**Sorriso, via MS**	**Sorriso-MT, via GO**	**Rondonópolis-MT**	**Rio Verde-GO**	**Barretos-SP**
	Distance	km	2,200	2,100	1,400	1,050	500
	Local fuel price	R$/l	2.68	2.68	2.57	2.39	2.27
	Fuel costs	R$/route	2944.92	2811.06	1799.18	1256.40	567.24
		R$/tkm	**0.04**	**0.04**	**0.03**	**0.03**	**0.03**
	Toll costs	R$/route	702.10	578.20	578.20	604.80	603.40
		R$/tkm	**0.01**	**0.01**	**0.01**	**0.02**	**0.03**
	Variable costs	**R$/route**	3647.02	3389.26	2377.38	1861.20	1170.64
		R$/tkm	**0.04**	**0.04**	**0.05**	**0.05**	**0.06**
	Fixed costs	**R$/route**	4367.00	4168.50	2779.00	2084.25	992.50
		R$/tkm	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
	TOTAL COSTS	**R$/route**	8014.02	7557.76	5156.38	3945.45	2163.14
		R$/tkm	**0.10**	**0.10**	**0.10**	**0.10**	**0.12**
		R$/route/t	**216.60**	**204.26**	**139.36**	**106.63**	**58.46**
	Freight rate	R$/t	213.33	213.33	163.33	109.33	61.00
	Difference		-3.27	9.07	23.97	2.70	2.54

	Apr 11		**Route 1**	**Route 2**	**Route 3**	**Route 4**	**Route 5**
Variable costs	Origin		**Sorriso, via MS**	**Sorriso-MT, via GO**	**Rondonópolis-MT**	**Rio Verde-GO**	**Barretos-SP**
	Distance	km	2,200	2,100	1,400	1,050	500
	Local fuel price	R$/l	2.66	2.66	2.57	2.37	2.26
	Fuel costs	R$/route	2927.21	2794.16	1799.18	1242.52	566.09
		R$/tkm	**0.04**	**0.04**	**0.03**	**0.03**	**0.03**
	Toll costs	R$/route	702.10	578.20	578.20	604.80	603.40
		R$/tkm	**0.01**	**0.01**	**0.01**	**0.02**	**0.03**
	Variable costs	**R$/route**	3629.35	3372.39	2377.41	1847.35	1169.52
		R$/tkm	**0.04**	**0.04**	**0.05**	**0.05**	**0.06**
	Fixed costs	**R$/route**	4367.00	4168.50	2779.00	2084.25	992.50
		R$/tkm	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
	TOTAL COSTS	**R$/route**	7996.35	7540.89	5156.41	3931.60	2162.02
		R$/tkm	**0.10**	**0.10**	**0.10**	**0.10**	**0.12**
		R$/route/t	**216.12**	**203.81**	**139.36**	**106.26**	**58.43**
	Freight rate	R$/t	198.13	198.13	145.63	113.84	61.00
	Difference		-17.99	-5.68	6.27	7.58	2.57

	Sep 11		**Route 1**	**Route 2**	**Route 3**	**Route 4**	**Route 5**
Variable costs	Origin		**Sorriso, via MS**	**Sorriso-MT, via GO**	**Rondonópolis-MT**	**Rio Verde-GO**	**Barretos-SP**
	Distance	km	2,200	2,100	1,400	1,050	500
	Local fuel price	R$/l	2.69	2.69	2.45	2.26	2.16
	Fuel costs	R$/route	2958.84	2824.34	1715.56	1183.88	540.93
		R$/tkm	**0.04**	**0.04**	**0.03**	**0.03**	**0.03**
	Toll costs	R$/route	702.10	578.20	578.20	604.80	603.40
		R$/tkm	0.01	0.01	0.01	0.02	0.03
	Variable costs	**R$/route**	3660.97	3402.58	2293.79	1788.71	1144.35
		R$/tkm	**0.04**	**0.04**	**0.04**	**0.05**	**0.06**
	Fixed costs	**R$/route**	4367.00	4168.50	2779.00	2084.25	992.50
		R$/tkm	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
		R$/route	8027.97	7571.08	5072.79	3872.96	2136.85
	TOTAL COSTS	**R$/tkm**	**0.10**	**0.10**	**0.10**	**0.10**	**0.12**
		R$/t	**216.97**	**204.62**	**137.10**	**104.67**	**57.75**
	Freight rate	R$/t	185.00	185.00	136.88	100.07	61.00
	Difference		-31.97	-19.62	-0.22	-4.60	3.25

Source: Author's calculation.

Appendix 54: Calculation of GHG emissions of soybean shipping from selected regions to Santos port

Calculation I - Basis

	Route		CO_2 equivalent kgCO_{2eq}/tkm	*Distance (km)*		CO_2 equivalent kgCO_{2eq}/t	CO_2 equivalent kgCO_{2eq}/t	CO_2 equivalent kgCO2eq/7000t
	Origin	*Destination*		*truck*	*train*	*per route and ton*	*per route and ton*	*per route and 7000t*
Road	Sorriso-MT	Santos-SP	0.038	2,200		83.24	83.24	582,702.70
Road-rail			0.038	800		30.27		
			0.020		1,400	27.44	71.43	500,011.89
			0.014		1,400	13.72		
Road	Rondonópolis	Santos-SP	0.038	1,400		52.97	52.97	370,810.81
Road-rail	-MT		0.038	200		7.57	48.73	341,092.97
			0.020		1,400	27.44		
			0.014		1,400	13.72		
Road	Rio Verde-GO	Santos-SP	0.038	1,050		39.73	39.73	278,108.11
Road	Barretos-SP	Santos-SP	0.038	500		18.92	18.92	132,432.43

Source: Author's calculation.

Appendix 55: Sensitivity analysis - increased loading factor (40%) and higher fuel consumption

Calculation II - Increased train loading factor (40%), higher fuel consumption (0.006 l/km)

	Route		CO_2 equivalent kgCO_{2eq}/tkm	*Distance (km)*		CO_2 equivalent kgCO_{2eq}/t	CO_2 equivalent kgCO_{2eq}/t	CO_2 equivalent kgCO2eq/7000t
	Origin	*Destination*		*truck*	*train*	*per route and ton*	*per route and ton*	*per route and 7000t*
Road	Sorriso-MT	Santos-SP	0.038	2,200		83.24	83.24	582,702.70
Road-rail			0.038	800		30.27		
			0.020		1,400	27.44	70.65	494,523.89
			0.0154		1,400	12.94		
Road	Rondonópolis	Santos-SP	0.038	1,400		52.97	52.97	370,810.81
Road-rail	-MT		0.038	200		7.57	46.77	327,372.97
			0.020		1,400	27.44		
			0.014		1,400	11.76		
Road	Rio Verde-GO	Santos-SP	0.038	1,050		39.73	39.73	278,108.11
Road	Barretos-SP	Santos-SP	0.038	500		18.92	18.92	132,432.43

Source: Author's calculation

Appendix 56: Sensitivity analysis - reduced fuel consumption

Calculation III - Reduced fuel consumption truck (0.45 l/km)

	Route		CO_2 equivalent $kgCO_{2eq}/tkm$	*Distance (km)*		CO_2 equivalent $kgCO_{2eq}/t$	CO_2 equivalent $kgCO_{2eq}/t$	CO_2 equivalent kgCO2eq/7000t
	Origin	*Destination*		*truck*	*train*	*per route and ton*	*per route and ton*	*per route and 7000t*
Road	Sorriso-MT	Santos-SP	0.034	2,200		74.92	74.92	524,432.43
Road-rail			0.034	800		27.24		
			0.020		1,400	27.44	68.40	478,822.70
			0.014		1,400	13.72		
Road	Rondonópolis	Santos-SP	0.034	1,400		47.68	47.68	333,729.73
Road-rail	-MT		0.034	200		6.81	47.97	335,795.68
			0.020		1,400	27.44		
			0.014		1,400	13.72		
Road	Rio Verde-GO	Santos-SP	0.034	1,050		35.76	35.76	250,297.30
Road	Barretos-SP	Santos-SP	0.034	500		17.03	17.03	119,189.19

Source: Author's calculation

Appendix 57: Sensitivity analysis - decreased emission factor

Calculation IV - Decreased emission factor (approaching IPCC 2.67)

	Route		CO_2 equivalent $kgCO_{2eq}/tkm$	*Distance (km)*		CO_2 equivalent $kgCO_{2eq}/t$	CO_2 equivalent $kgCO_{2eq}/t$	CO_2 equivalent kgCO2eq/7000t
	Origin	*Destination*		*truck*	*train*	*per route and ton*	*per route and ton*	*per route and 7000t*
	Sorriso-MT	Santos-SP	0.036	2,200		79.38	79.38	555,648.65
			0.036	800		28.86		
			0.019		1,400	26.17	68.11	476,797.05
			0.01335		1,400	13.08		
	Rondonópolis	Santos-SP	0.036	1,400		50.51	50.51	353,594.59
	-MT		0.036	200		7.22	46.47	325,256.51
			0.019		1,400	26.17		
			0.01335		1,400	13.08		
	Rio Verde-GO	Santos-SP	0.036	1,050		37.89	37.89	265,195.95
	Barretos-SP	Santos-SP	0.036	500		18.04	18.04	126,283.78

Source: Author's calculation

Appendix 58: Interview guideline

Company information
Which are the areas of activity of your company?
What is the annual volume of soybeans traded?
Export process
Please describe the export process.
Which are the export routes to Santos and which are the modalities of transportation used?
What is the travelled distance to Santos?
What is the medium time of travelling from origin (warehouse) to destination (port)?
How long does it take to load, travel and unload the vehicle?
Which is the condition of the regional infrastructure and how does the state of conservation of the
Which are the logistic risks in exporting soy and which is the rate of losses per year?
Logistic costs
Please specify the company's costs related to soybean logistics (freight, storage, transshipment, port,
Which factor interferes most in the logistic costs (freight, transshipment, port costs) ?
How is the freight price composed and which are major determinants and cost factors?
Does waiting time at the port impact on the transport costs?
Please describe the commercialization process.
Transportation
Which truck is used for soybean transports?
Average utilization of fleet in 1 year (%) ? How many days per year does one truck stand still?
How many journeys does a truck in its util life?
Renovation of fleet - After how many years do you renew your fleet?
Which are the major problems of maintenance?
Is maintenance outsourced?
Which is the emission volume of a truck over one route?
Are the return travels used for the transportation of goods? Please specify.
Storage
Please describe the warehousing infrastructure of the region and of the company.
Please specify the costs of storage for the warehouse operator.
What percentage of farmers have on farm warehouses?
Other
Is bureaucracy a limiting factor to the process flow?
Is there any governmental support?
Please estimate the impact of the new driver's law.
Where do you see major bottlenecks or challenges in the logistics processes?
Please describe the development of the transport sector over the last five to ten years.
Please describe the development of the transport sector over the next five to ten years.

Source: Elaborated by author.

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