

## Review

## Logistics and storage of soybean in Brazil

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Soybean is one of the most important cultures harvested in the world, and Brazil is ranked the second major producer and the top exporter of this oilseed. Brazil presents good edaphoclimatic conditions for soybean cropping, it has a strong research structure and has capacity to enhance its cropping area, and however, the faulty infrastructure in its own terrain hinders logistic operations for soybean flow and exportation. Brazil has a huge deficit in grain storing, forcing producers to flow their production right after harvesting. Brazilian transportation is centered on a road system, and it is not viable once road conditions are precarious and also there are long distances to run. Soybean should then be transported by water or railway, but these means of transportation are not enough in the country due to low exploitation of existing waterways and the short railway system. Besides, Brazilian ports are inefficient, when the soybean harvest flow is at its peak for exportation; there are long lines of trucks and ships. This series of internal barriers increase the costs of Brazilian soybean and reduces its competition in the foreign market. Thus, it is of pivotal importance that the Brazilian government performs investments in building warehouses. It is also vital to invest in the improvement of the road network, extend railways and waterways and enhance ports, so that the costs with soybean logistics drop and producers should be able to increase their profits and competitiveness in the overseas market.

**Key words:** *Glycine max* L., transport, packaging.

### INTRODUCTION

The soybean (*Glycine max* (L.) Mer.) is a legume and an oilseed harvested as a source of food for humans and animals and it is an essential culture in global economy. Its grains have been used more intensively by chemical and pharmaceutical industries, as well as by agribusiness, in the production of soy oil and bran. Into this perspective, there are various factors that have contributed for the

growth of the soy population in the last years, with its high levels of proteins (more than 40%) and oil (around 20%), its used as animal feed, there are even scientific findings that proof of grain efficiency in the production of cosmetics and medicine (Freitas, 2011).

While soy production has advanced through the interior of the country, the investments on flow alternatives of

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production were not sufficient. Currently the roads are precarious, mainly in the bordering regions of agriculture, there is a lack of connections among transportation modes, with the predominance of road transportation and infrastructure problems, making the flow harder and resulting in losses and reducing competitiveness for Brazilian soybeans (Zemolin, 2013).

Lack of investments is historical in this sector. In the 1980's and 1990's, government contribution to transportation infrastructure was Lilliputian: Around 0.2% of annual PIB (NGP), whereas in countries such as China, the average is of 3.5%. The absence of resource contributions in this period took a heavy toll on national logistics, which yielded around R\$ 350 billion in 2012, twice as much as ten years ago (PBLOG, 2013).

According to Correa and Ramos (2010), to reduce logistics inefficiency, projects that motivate transportation interconnection are imperative, along with the widening of the capacity of water and railway modals, besides the widening of ports' capacity and the development of seafaring/cabotage in the country.

This way, this work aims to make a literary review about the logistics and soybean storage in Brazil.

## THE IMPORTANCE OF SOYBEAN CULTURE

The soybean is the most important oilseed harvested in the world, standing out as 56% of grain production with oil content (US Soybean Export Council, 2008). The main producers are the U.S (32% of worldwide production), followed closely by Brazil (30%) and Argentina (19%), and in the harvest of 2013/14 the worldwide production was 285.3 million tons (USDA, 2014).

Soybean is the activity which presented a higher expansion among agricultural crops in 1970/71 and 2010/11, with a production increase of 526%. The greatest soy production increase may be attributed to various factors, among which five are highlighted: (1) The soybean presents a high levels of excellent quality protein (around 40%), either as animal or human feed; (2) The oilseed contains a considerable oil level (approximately 20%), that can be used for different purposes, specially related to human feed and biofuel production; (3) The soybean is a standard and uniform *commodity*, therefore, owning the characteristic of being produced and commercialized by producers in many countries; (4) The oilseed presents high levels of liquidity and demand and; (5) withal in the last decades, there has been an expressive raise in technological production offering, which allowed to enhance substantially the area and productivity of the oilseed (Hirakuri and Lazzarotto, 2011).

## SOYBEAN CULTURE IN BRAZIL

Brazilian soybean production in the harvest in 2013/2014

was of 86.121 million tons, being the main producers Mato Grosso (30.7% of national production), followed by Paraná (17%) and Rio Grande do Sul (15%). The Center-South accounts for 88.4% of the national production and the region North/Northeast for 11.6% (CONAB, 2014).

Although soybean had been introduced in Brazil at the end of the 19th century, it has been a declassified culture for several decades. However, in the early 1970's, the oilseed broke the boundaries from Rio Grande do Sul state and the traditional production system, to become one of the most important crops in the Brazilian agriculture. From 1970 to 1985, soybean expansion happened through the opening and consolidation of new agricultural areas in the South and Mid-West regions (Hirakuri and Lazzarotto, 2011).

Brazilian soybean production presented a great expansion, boosted not only by the increase of the production areas, but mainly by the enhancement of productivity. Considering the period between the harvests of 1976/77 to 2013/14, on the one hand, the area presented a growth rate of 334.2%, going from 6.95 to 30.17 million of hectares, on the other hand, production reached a growth rate of 609%, going from 12.14 to 86.12 millions of tons. In this same period, productivity went from 1.748 to 2.854 kg ha<sup>-1</sup> which represents an increase on productivity of 63% (CONAB, 2014).

To Brazil, the soybean complex has an expressive economic importance. Besides involving a great number of agents and organizations linked to the various economic sectors, it plays an important role for the national gross product (NGP), as well as generation of foreign currency. From 1995 to 2009 the soybean economic performance presented an expressive growth. While NGP grew under annual taxes of 2.86%, the gross value of soy production (derived from the sales prices times the quantity of product yielded) grew at an average rate close to 7.75% a year. The Brazilian soybean complex is accounted for job generation (Hirakuri and Lazzarotto, 2011). According to surveys conducted by Roessing and Lazzarotto (2004) this complex is responsible for generating approximately 5.0 million job openings. From this figure, it can be highlighted that for each hectare cultivated in Brazil, an average of 0.24-job would be generated by the whole complex.

The jobs generated by soybean's productive chain are related to agriculture activity and with several sectors that draw up this chain. According to Cavalett and Ortega (2007) soybean chain has several stages: Agricultural production, transportation up to grain crushing and processing industries, where the extraction of the main derivatives, bran and oil take place, also redirecting to refineries and other derivatives, and afterwards, market distribution through wholesale and retail.

## THE IMPORTANCE OF LOGISTICS

Logistics is unexpendable to any company in the world,

because more and more the transportation of goods, storing, inventory management, personalized customer service are basic premises for the success of any enterprise, and these are within the logistics role. Among the various logistic functions the one that stands out is transportation, for all sectors in economy, one way or the other, depend on transportation, either to carry their products or services or for purchasing raw material to produce them (Resende et al., 2007).

Logistics mission is to plan and coordinate all activities to reach quality levels at the lowest cost possible (Christopher, 2011). For Soares and Caixeta-Filho (1997) the productive systems have advanced significantly, especially regarding development and the spread of new production techniques, however, the final competitiveness of the products is impaired by the bottlenecks throughout a specific chain, being logistics and transportation fundamental in this context. Transportation is one the main logistics functions, because it accounts for the majority of the costs in most organizations.

The best transportation choice to haul a certain good is the greatest challenge for logistics operators, to reach a decision they take into consideration: Agility, flexibility, security, costs, transportation capacity and kind of cargo (Resende et al., 2007). Inside agribusiness logistics, the productive chain is divided into three segments: 'Anti gate' – includes inputs, machinery, equipment, chemicals, fertilizers, credit, rural insurance and whatever necessary for agricultural production; the segment 'in gate' from planting to harvesting; and 'post gate' – including all channels of product distribution up to the final destination (storing, industrialization and distribution) (Callado, 2008).

Agroindustrial products feature low relative value per weight unit or volume. Still, the productive and consumer regions are most of the times, far from each other. Altogether, these factors input considerable costs to product distribution. Its price fluctuation, due to seasonal characteristics of harvesting, is another aspect that has to be considered. During harvesting, there is a focus on offering, followed by a reduction in relative prices and a higher need for production flow. This context explains the increase on the demand for transportation services, which makes the prices skyrocket. Thus, there has the combination of low cargo price with high transportation price. This is the main characteristic of agribusiness logistics (Gameiro and Caixeta-Filho, 2010).

## THE IMPORTANCE OF STORING

Commercialization includes a series of activities, through which goods and services are allotted from productive sector to final consumers. These activities that compose the commercialization process have to do with processing, transportation and storing, wherein each of these phases add up value to the product (Barros, 2004).

Amongst the activities involved in the commercialization

process, storing stands as a relevant contribution, because agricultural production presents seasonal production, and can be transferred within time, assuring the availability of the product for consuming. When storing is performed in a competitive market environment, where individuals search for the maximization of gain, the decision of storing part of the production for the next period is made under future price expectation. Thus, storing will only be economically viable if the difference between the future and the current prices are higher than the costs for storing the product (Ferrari, 2006).

From a technological point of view, storing is an essential activity to reduce agricultural loss and for grain conservation. It is also considered to be a fundamental backup activity for the transportation and commerce phases, for the presence of storing units close to production areas, markets, ports and agribusiness makes it feasible rationalization of transportation costs, the strategical apportioning of inventory and still, favors inter-regional commerce (Biagi et al., 2002). Warehouses are also important, because during the commercialization process, the grains need to go through warehouses for cleaning up and for reduction of humidity, for product conservation and optimization of the right transportation modal to be deployed (Ferrari, 2006).

## CHARACTERIZATION OF THE STORING UNITS

Warehouses in general, can be grouped according to local features of the region where they will be set. Thereby, there are units installed in the farm, collection units, subterminal and terminal units. There is even other one known as intermediate unit, which is simply the grouping that involves collection and subterminal units (Ferrari, 2006).

Units installed in agricultural properties are generally for private usage. The existence of these units is fundamental to guarantee the producer's autonomy, making it possible to choose the right moment to perform the product sale and production flow (Frederico, 2008). Besides autonomy, the units in the farm hold a series of other advantages: They avoid the overload that the transportation system suffers at harvesting periods, increasing freight costs; they prevent the spread of humidity and impurities; they allow for cleanability, drying and storage at low cost; the producer keeps organic residues; they lower total cost per ton produced; among others (Weber, 2005).

The collection units, normally used by groups of producers, are located in the vicinage of the production area. The cooperatives and warehouse complexes, mainly set in the Brazilian Mid-West, can be fit into this category. The subterminal units are those installed close to the main road systems (railways and waterways included) and are operationally capable of receiving the incoming product from collection units and those set in the farms, in addition to perform staggering of products in

port terminals. Now the terminal units are those located in the consumer centers, ports and agribusiness (Ferrari, 2006).

According to Puzzi (2000) amongst these different units that form the storage net, it is noticeable that it is not necessary to follow the sequence for the categories presented, for specific cases, such as subterminal units, might not be needed to stagger flow. The different kinds of storing units should be set in such a way that they allow for a fast and continuous flow of goods and should be dimensioned so that none of the units get overloaded (Frederico, 2008).

In 2011 the static capacity regarding storage unit location was: 13% of static capacity was in farms, 35% was in the countryside, 45% in urban areas and 6% in waterfronts (Maia et al., 2013).

### **STORING CAPACITY OF GRAINS IN BRAZIL**

In accordance to Nogueira Junior and Tsunehiro (2011) there are many obstacles found in storing structure that have become chronic, because of the rhythm of crop harvesting growth in Brazil: (1) The mismatch between offer and demand of grains in years with high yields. In specific years there is a worsening in the situation resulting in logistics and harvest transportation problems and even jams in the ports due to the high flow of goods; (2) A direct effect from the inadequacy of the harvest flow system (transportation and storage) reducing product prices due to the necessity of readiness for commercialization right after harvesting. Because of the high offering in the Market, grain prices lower and producers do not avail the best moment to collect profits; (3) The growth in production for different goods (transgenic, organic, new grains, such as canola, millet and triticale) which require specific cell sorting; (4) Lack and inadequacy of storing units, either regarding quality or geographical location. Due to crop migration, various regions as the Mid-West of the country, where lots of important grain producing areas still do not have a satisfactory storing structure, forming the so called logistic void. However, in other regions like the state of São Paulo, because of the decrease of coffee culture, a lot of warehouses and silos are located in areas that do not produce coffee anymore, resulting in surpluses; (5) Profiles created by CONAB (2014) point out a great number of storing units with obstructions. Although, apparently, there is no veto, the working conditions of these units are not in accordance to servicing and for loss reduction after harvesting; (6) Substantial part of agriculturists still have outstanding bills, and a high sum of resources required for the construction of silos hardens the expansion and modernization for the sector. For small producers hiring financing is difficult, for a compensatory production volume is demanded; (7) Low storage capacity in rural properties do not reach 20%, resulting

an unfavorable position for Brazil in relation to major worldwide grain producers, who have in field the greatest parcel of units to store their products. Moreover, this condition compels the producer to commercialize his/her crops readily when prices are low. Besides, this causes logistics problems such as jams in intermediate and terminal storage networks; (8) High volumes of sugar and fertilizers contend storing space with grains. These products have not been taken into account in the statistics of storing demand, which masks economics analysis and; (9) Transportation headquarters focused on trucks result in jams and delay in unloading cargo in warehouses/silos and ports, also increasing transportation costs. Because of its extensive territory, the ideal stage for Brazil would be the use of railways and waterways for crop transportation, which would enhance partially competitiveness of products after harvesting.

In Table 1 the relation between soybean production and the statistical storing capacity is at display (CONAB, 2014) divided into states and into Brazilian regions. It is noticeable that only the Southeast region do not present shortage in storage, this is because of its low production of soybean, and the existence of several warehouses which were built for coffee storing and are not functioning (Nogueira Junior and Tsunehiro, 2011). The South region, which is the second major soybean producer, also has a deficit in storing, however, due to the fact that the producing regions are close to ports such as Paranaguá and Rio Grande, that makes production flow easier and this deficit is not as strong as it is in the Mid-West region.

In the Mid-West region, the major soybean producer and second grain producer, this shortage becomes more severe, for this region is far away from ports, and when producers perform harvesting, they are obliged to flow their production by paying high freight prices, due to the high demand of this service. If we give special attention to the state of Mato Grosso, the greatest Brazilian soybean and grain producer, this storage deficit is higher than 37%. The states forming what is called MATOPIBA (Maranhão, Tocantins, Piauí and Bahia) show a pretty high storage deficit, and the state of Piauí, for instance, presents a deficit above 65%. This high index is because these states presented and increase in soybean production for the past years (CONAB, 2014) and still have not built adequate and sufficient storing infrastructure. The macro regions North/Northeast and Mid-South show a deficit of 44.36 and 11.77%, respectively. However, the deficit in the Mid-South, in absolute values, is higher than in the region North/Northeast, because these regions present production of 172.4 and 23.1 million tons, respectively. Brazil presents a deficit of 15.62% which accounts for roughly 30 million tons.

### **SOYBEAN TRANSPORTATION MODALS**

Transportation is the main compound in the logistics

**Table 1.** Static storage capacity (thousand tons), grain production (thousand tons) and percentage of deficit or surplus in storage, by region and states of Brazil.

Region/Federation unity	Static storage capacity (thousand tons.)	Grain production (thousand tons.)	Deficit/surplus (%)
NORTH	3.652.88	6.309.80	-42.11
RR	147.48	142.20	3.71
RO	733.55	1.223.70	-40.05
AC	29.28	123.80	-76.35
AM	347.60	42.00	727.62
AP	6.28	5.60	12.07
PA	856.13	1.416.50	-39.56
TO	1.532.57	3.356.00	-54.33
NORTHEAST	9.199.20	16.788.10	-45.20
MA	1.997.01	4.300.60	-53.56
PI	963.78	2.777.40	-65.30
CE	384.58	573.00	-32.88
RN	63.50	38.30	65.79
PB	99.84	58.20	71.54
PE	977.74	187.80	420.63
AL	550.72	67.20	719.52
SE	3.20	1.123.50	-99.72
BA	4.158.84	7.662.10	-45.72
MID-WEST	67.707.83	81.636.50	-17.06
MT	29.626.23	47.702.60	-37.89
MS	8.274.12	14.470.50	-42.82
GO	29.326.66	18.333.40	59.96
DF	480.82	1.130.00	-57.45
SOUTHEAST	22.194.62	17.887.70	24.08
MG	9.048.69	11.655.30	-22.36
ES	1.489.14	74.10	1909.63
RJ	184.50	15.90	1060.36
SP	11.472.29	6.142.40	86.77
SUL	62.177.66	72.845.00	-14.64
PR	28.316.26	35.840.60	-20.99
SC	5.201.62	6.572.20	-20.85
RS	28.659.79	30.432.20	-5.82
NORTH / EAST	12.852.09	23.097.90	-44.36
SOUTH CENTER	152.080.11	172.369.20	-11.77
BRAZIL	164.932.19	195.467.10	-15.62

Source: CONAB (2014).

system, and represents in average, 60% of total logistics resources employed in exportation operations. Besides, it is responsible for having a crucial role in the quality of logistics services, because it impacts directly on delivery times, on buyer's trust and product security (Vasques, 2009). A modal choice should be based not only on the time to be spent in transportation, but also with its cost and product to be used (Caixeta Filho, 2010).

Being a product of low aggregated value and which can be transacted in high volumes, the soybean needs a transportation modal with high capacity and at low unitary

cost, even though other attributes might not be considered, such as frequency and production delivery deadlines (Fleury, 2005).

The road modal turns to be the most adequate when it comes to transportation to short distances, that is, for trips up to 186 miles (300 km). This modal would be applied in the so called edges – from the original place (in this case the producing farms) to warehouses or railway or waterway terminals, which then, would be responsible for transportation to long distances, due to a greater cargo capacity and the possibility of cost and loss reduction

(Hijjar, 2004).

The Brazilian soybean, even when coming from regions that are more distant from the ports, is transported preferably through roads. This makes the transportation of the soybean produced in the Mid-West region to be inefficient, just because of the choice of road modal as a unimodal means – connecting the cargo origin to its final destination – instead of using it as a multimodal connection (road-waterway or road-railway) (Correa and Ramos, 2010).

According to Correa and Ramos (2010) although other means for the transportation of the produced soybean in the Mid-West exist, such as the waterways in Madeira and Tietê, the road modal is still predominant, and it accounts for 67% of existing modals, waterways only 5% and railways 28%.

### Road modal

It is the most expressive when it comes to cargo transportation in Brazil, practically reaching all ends of the national territory, because since the 50's, with the implementation of automobile industry and road paving, this modal expanded in such a way that today it is the most used one (Rodrigues, 2007).

Even with a low quality road system, it is responsible for 60% of everything that is transported in Brazil. It is a high index, even when compared to other countries with a huge continental extension: In the U.S. road participation accounts for only 26% of transported cargo and in Australia 24%. This scenario shows Brazil's dependence on this modal, and opens a spot in the need for actions that result in a balance in the national transportation matrix, giving other modals – railway, waterway and airway, more participation (PBLOG, 2013).

The usage of road modals, even for products and distances where it is not the most competitive, comes from the lack of options in the use of others modals for short, medium and long distances (Petraglia, 2009). This overdependence on road modal gets even worse when Brazilian great territorial extent is taken into account, as well as its precarious and insufficient infrastructure to cope with demand (Pontes et al., 2009).

According to the Department of Transportation (2014), Brazil has 1.7 million kilometers (1,056.331 miles) of roads, which 79.5% are not paved roads. In general, the preservation conditions of these roads is terrible and the bad pavement quality leads to higher maintenance costs, to breaks wear and tear, and also to more expenses with tires, which wear off faster once pavement quality is so low. These conditions cause an increase in operational costs. A study conducted by the extinct Departamento Nacional de Estradas e Rodagem (DNER) shows that when pavement is in great conditions, there is no increase in operational costs, when it is in good conditions there is an increase of 18.8%. Now roads under bad

conditions add 91.5% to operational costs. Thus, a transporter who drives on a road with great conditions would have operational costs of R\$ 100.00 in specific kilometers, whereas if an individual drove the same distance under bad conditions, one would have R\$ 191.50 in operational costs (CNT, 2014).

When one analyses the quality of the pavement in regional terms in Brazil, the scenario is even more critical for regions North and Mid-West, which present an increase to average cost between 37.6 and 27.5%, respectively. The regions South and Southeast show the best pavement conditions, which reflects on the estimate for cost increase for the regions that are below the national average of 26.0% (CNT, 2014). This increase in the operational costs pushes to freight price, and this way, the producers in Mid-West region, for instance, have their profits cut short compared to the ones in the South region. Because, besides having to transport the soybeans for a longer distance up to ports, they face the worst road conditions which make the price of freight more expensive.

Linked to the bad road conditions, soybean transportation suffers another problem. According to Agência Nacional de Transportes Terrestres (ANTT) the fleet responsible for cargo transportation is 13.1 years old in average (ANTT, 2014), that is, many of the vehicles used in soybean transportation do not meet adequate conditions, which results on quantitative and qualitative loss during the trips.

Although it presents a great number of disadvantages related to the sector such as: A lesser relative capacity of cargo, its more fragile security, because it is bound to theft and damage and its higher operational cost compared to railway modal, the advantages of this modal are centered in its door-to-door service capacity, in the frequency and availability of its access ways, a lesser time for loading and unloading cargo, and its facility of replacement in case of accidents or technical problems with the vehicles (Vasques, 2009).

### Railway modal

The first Brazilian railway started its operations in 1845 by Barão de Mauá, connecting Praia da Estrela to Petrópolis. From 1873 to 1930, it played a decisive role in coffee exportation (Rodrigues, 2007). Since 1922 the changes to Brazilian railways were incipient, which still counts on the same unbelievable 29 thousand kilometers (18.019 miles) of rail tracks. That is, the construction of railways in Brazil is still very incipient compared to other countries with similar territorial proportions, like the United States, which hold the world's longest railway system-225.000 km (139.808 miles). Russia registers 87.000 km (54.059 miles), followed by China 86.000 km (53.437 miles), India 64.000 km (39.767miles) and Canada 46.000 km (28.583 miles). In this *ranking*, Brazil

holds the 122<sup>nd</sup> place, behind Cuba and Ukraine (PBLOG, 2013).

The railway transportation sector is an economic transformation fact. There are several profit possibilities derived from a greater use of the railway modal for cargo transportation. Its convenience presents advantages to Brazil, which even more, consolidates its worldwide position as a major agricultural and mineral exporter. The physical-volumetric features of these goods make it feasible the use of railway transportation, generating economy to producers and competitiveness in the foreign market (CNT, 2014).

The railway modal is the most appropriate when it comes to the transportation of great volumes and which involves goods of the lowest aggregate value, which is the case of soybeans and grains in general. It is an extremely efficient and competitive means of transportation in trips of medium and long duration that do not need transshipment, because of its high cargo capacity added to its low freight cost. Moreover, the operational cost for freight and maintenance and backup structure is low (Faro and Faro, 2010).

For Brazil presents continental dimensions, the railway modal stands as a huge opportunity for cost reduction on terrestrial freight paid by soybean exporters in the flow of grains to the ports. However, this modal has been, in practice, left aside due to the high investments needed to amplify its operational capacity (Pontes et al., 2009).

According to ANTT (2014) in 2013, 20.5 million tons of soybeans and bran were hauled through railway modal, which is a very high figure. However, it is of pivotal importance that governments invest in this sector so that railway systems are to expand and reach the regions that produce soybeans, where this modal is yet not used as a means of transportation.

In accordance to PBLOG (2013), the federal government has as goal, the expansion of the railway system to 40 thousand kilometers until 2020, investing R\$ 200 billion. The new railway matrix that is being designed for the following years, will give the economy of the regions South, Southeast and Mid-West a new strength, allowing their production to reach the European, American, Caribbean and Asian markets through the regions North and Northeast. Besides that, this configuration will promote, concomitantly, inner integration, contributing to commerce dynamization between the North and the rest of Brazil. The federal government has presented five expansion proposals for the railway system, to interconnect the national territory as follows: (1) Construction of the railroad EF-354 – Transcontinental. This railroad will link the state of Rio de Janeiro to Acre, going through Minas Gerais, Goiás, Mato Grosso and Rondônia; (2) Railroad EF-170 - Cuiabá-Santarém. This railroad will be of great importance for production flow in the Mid-West – from 15 to 20 million tons of grains (soy and corn); (3) Conclusion of North-South railroad, Anápolis and Rio Grande (RS) (EF-151).

This railroad will link the state of Goiás to Rio Grande do Sul, going through São Paulo, Paraná and Santa Catarina; (4) Conclusion of EF-334 - West-East Figueirópolis (TO) to Ilhéus (BA). This railroad will open a new exportation corridor through the Atlantic Ocean, with benefits to Regions Mid-West, South and North and an important part of the Northeast and; (5) Integration Axis Maracaju and Guaíra (MS) to São Francisco port (SC) or to Paranaguá port (PR). It will also be a major route for grain flow.

To demonstrate the importance of railway modal for transportation of agricultural products, mainly soybeans, a Confederação Nacional do Transporte (CNT) has conducted a case study comparing possible routes of flow for soybeans in Mato Grosso, having as a distribution center the city of Lucas do Rio Verde. The route that presented the highest cost was the one with final destination at the Paranaguá port, using the road modal (R\$ 232.74 per ton) and the route with the lowest cost was the one with final destination in the Itaquí port, using the railway modal (R\$ 148.58 per ton). This route depends on the construction of the Mid-West Integration railroad (CNT, 2013). This study shows the loss of competitiveness for agribusiness when road modal is used for long distances, with an existing need for alternate routes for soybean flow with exportation ends.

### Waterway modal

Fluvial and lacustrine transportation are composed by waterways in interior navigation, performed in rivers and lakes, respectively. Due to its reduced operational cost, the waterway transportation allows the hauling of great quantities of cargo through long distances, which is ideal for *commodities* as soybeans. The waterway transportation is quite used in some regions of the world, like in Europe, whereas lacustrine transportation is practically narrowed down to the borderline between the U.S and Canada, in the region of the Greats Lakes (Faro and Faro, 2010).

According to Alfredini and Arasaki (2009) the waterway scenario is associated to an increase in the international competitiveness. Introducing this means would ensure a planned and omnibus development, connecting regions and promoting the shifting of inputs, products and people. The possibility of navigation creates a transportation alternative of low cost for shifting great cargo volumes at a low unit cost, less energetic expenses, not taking into account arising environmental costs, compared to direct competitive modes.

Brazil presents an immense potential for the use of fluvial navigation, with 63 thousand kilometers (39.146 miles) of rivers and lakes/ponds, distributed all over the national territory. Of this total, more than 40 thousand kilometers (24.854 miles) are potentially navigable. All the same, commercial navigation occurs in less than 13

thousand kilometers (8.077 miles), with relevant concentration in the Amazon, where rivers do not need greater investments and the population cannot afford having terrestrial modal options (Ministério dos Transportes, 2010).

The full potential of waterways is still little exploited. Only 13.6% the cargo amount transported in Brazil are performed through waterways – fluvial, seafaring and long haul transportation – despite of the comparative advantages with other models, due to the lowest operational costs, lowest environment impact, besides offering security and cargo concentration. The Agência Nacional de Transportes Aquaviários (Antaq) shows an idea of its comparative advantages between road and railroad modals: 1.5 thousand tons of cargo can be hauled in a single flatboat, whereas the same quantity would need 15 *Jumbo Hoppers* cars with capacity of 100 tons each, or 60 trucks with capacity of 25 tons each (PBLOG, 2013). For Afonso (2006), the use of waterway modal for cargo hauling would represent a cost reduction of 44% in relation to railroads, and 84% relative to road system.

According to Antaq data, Brazil has experienced a light, but consistent growth in cargo transportation through waterway modal. In 2011, 60.855 million of TKU (Tons per Useful Kilometers) were hauled, against 57.880 million of TKU, a growth of 5.1%. Being the main products transported through this modal in 2011: bauxite (36.71%); containers (15%); soybeans (9.80%); fuel and mineral oil and products (8.94%); altogether contributed with 70.80% of all hauled cargo in that year (PBLOG, 2013).

For the expansion of the waterway modal, the introduction of transshipment terminals and road/rail access to the waterways is vital. Thus, in spite of presenting environmental and economic advantages over the other modals, noticeably when it comes to shifting great quantities of cargo through long distances, this alternative depends heavily on the tentacles of the multimodal net to assure cargo access in the loading points, and to enable distribution in delivery points. In Brazil, the multimodal transportation resents on the difficulty of cargo transfer from one modal to another, for the quantity of terminals set to multimodality is yet to grow (Ministério dos Transportes, 2010).

The importance and advantages of waterway transportation, allied with the existing national hydrous potential, has stimulated Brazilian governments to make efforts to increase the participation of waterway modal in cargo transportation matrix. The Federal Government goal is to double the participation for waterway transportation (waterways and seafaring navigation), with a leap of 13% to 25% up to 2020. The waterway system will count on R\$ 2.7 billion for 48 projects which embrace the construction of 34 terminals and seven corridors. This will supply the country, up to 2020, with around 40 thousand kilometers (24.854 miles) of navigable ways.

For the expansion of this modal, it will be necessary some investments as the construction of locks to gain over of gaps caused mainly by the construction of dams, and also, it is essential that some dragging work is performed, to increase the depth of rivers (PBLOG, 2013). According to Alfredini and Arasaki (2009) the main fluvial networks in Brazil are the ones from Maderia-Amazonas, Araguaia-Tocantins, São Francisco, Paraguai-Paraná and Tietê-Paraná rivers.

## THE PORT SYSTEM AND SOYBEAN EXPORTATION

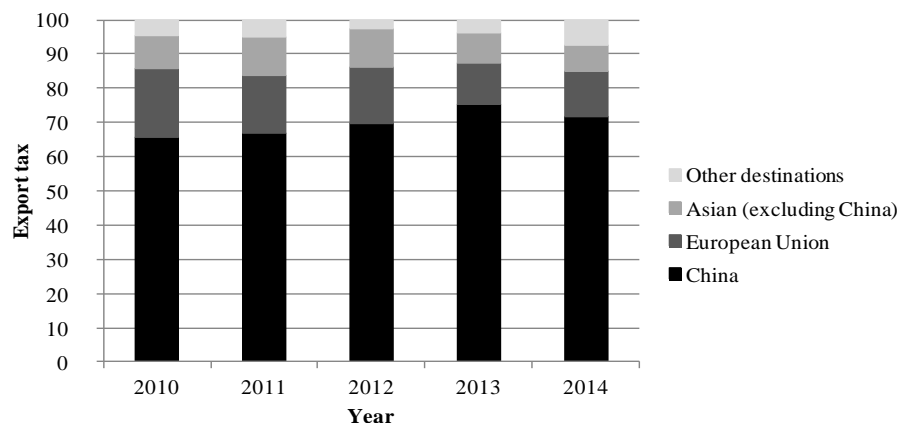
According to Goularti Filho (2007) in the Brazilian port system offering has always been dragged by demand, that is, investments applied in the ports (upgrading, re-equipping and modernization) have always been insufficient to cope with the increasing volume of Brazilian external commerce. Investments matured rapidly going through strangling, demanding more and new investments, yet, more complex and expensive than the previous one.

A grand problem faced by ports, to be highlighted, is the one encountered by the users of the Brazilian port system, in relation to the average of waiting time for mooring. For ships with containers, this term has been reduced between 2006 and 2007 from 13.5 to 9 h per ship. In terms of grains, waiting is much longer: In 2007, the national average for the several solid grains was of 54 hours/ship. the situation reaches the extremes in Paranaguá port, for instance, where waiting times for transshipping comes to 389 h/ship (approximately 16 days waiting) (Neto et al., 2009). This problem with delays for boarding increases the “Brazil Cost” (a set of structural, economic and bureaucratic difficulties which enhance investments), because the costs with demurrage (A charge required as compensation for the delay of a ship or freight car or other cargo beyond its scheduled time of departure) is of US\$ 50 thousand, a day, in average (Hijjar, 2004).

An inefficient and expensive port system implies in significant additional costs for a series of productive endeavors, engendering, as a direct consequence, a less propitious environment for the growth at the economic activity level and the appeal for new investments (Uderman et al., 2012).

The port sector presents strategical importance for the country's economy, due to its expressive participation in the total shift of goods. In 2013, the sector shifted in tons, 98.3% for exportation and 90.4% for imports, it also has shifted, a total of 931 million tons – according to data from Ministério do Desenvolvimento, Indústria e Comércio Exterior e da Antaq. The Brazilian port system is formed by 37 public ports – located in 16 Federative Units, being 34 salt-water and 3 fluvial – and 130 terminals for private use. Among public ports, 14 are empowered, granted or managed by state or district





**Figure 1.** Brazilian soybean exports in grain (%) according to the destinations, between the years 2010 and 2014. Source: ABIOVE (2014).

**Table 2.** Quantity exported and the participation of ports used in soybean exports in the years 2013 and 2014 of Brazil.

Port	Unit federation	2013		2014	
		Tons	Participation (%)	Tons	Participation (%)
Santos	SP	12.892.151	30	12.719.177	28
Rio Grande	RS	8.206.122	19	8.078.602	18
Paranaguá	PR	7.723.033	18	7.526.407	17
São Francisco do Sul	SC	4.032.264	9	4.910.909	11
Vitória	ES	2.823.224	7	3.148.465	7
São Luís	MA	2.974.624	7	3.116.084	7
Salvador	BA	1.778.558	4	2.015.194	4
Manaus	AM	1.251.487	3	1.411.104	3
Barcarena	PA	0	0	1.110.852	2
Others	-	1.073.197	3	1.516.626	3
Grand total		42.754.659	100	45.553.419	100

Source: ABIOVE (2014).

governments, whereas the remaining 23 are managed by Companhias Docas, a mix economic society, whose majority shareholder is the federal government. In 2011, from private terminals, 73 presented marine activity. The fluvial and lacustrine ports, however, are under Ministério dos Transportes management (CNT, 2014).

According to a research conducted by USDA (2014) Brazilian soybean exportation hit the charts of 46.83 millions of tons in 2014, although, according to Associação Brasileira das Indústrias de Óleos Vegetais (ABIOVE). Brazil exported 45.6 millions of tons (ABIOVE, 2014). In both researches, Brazilian soybean exportation was superior to the North-American, that exported 44.82 millions of tons in 2014 (USDA, 2014). Therefore, in that year Brazil was the worldwide top exporter of soybeans.

From the Brazilian soybean exportations in 2014, 72% went to China, 13% to European Union, 8% to Asia (except China) and 7% to other countries. Figure 1 depict the exportation destinations for Brazilian soybean from 2010 to 2014.

Table 2 show the amount exported and the participation of ports used in the soybean exportations in 2013 and 2014.

The ports in the regions South and Southeast in 2014 were responsible for 81% of the exportations, whereas the remaining ones represent only 19% of the exported volume, and only three ports (Santos, Rio Grande and Paranaguá) are responsible for 63% of soybean exportations. This scenario shows the inefficiency of the Brazilian logistics structure, because ports like Santarém and Itacoatiara that could be used for soybean exportation, are not even shown in the statistics.

## PERSPECTIVES FOR SOYBEAN LOGISTICS INFRASTRUCTURE

From the moment when the economic functions of transportation infrastructure and its importance became crystal clear for development, the internal affairs of a



**Figure 2.** Structural Axis proposed by Projeto de Integração Nacional from the federal government, Brazil. Source: CNT (2014).

country are more debated, with the aim to boost its insertion into globalization. Therefore, the establishment of a set of national objectives that would make the country more competitive in the global scenario is of extreme importance for the success in international trade (Caixeta Filho, 2010).

For Roessing et al. (2007) the issue on logistics optimization for Brazilian soybean is related to the need for the enhancement of competitiveness in the national production compared to external ones, on this account, among the segments that infer in the efficiency of several sectors of an economy, transportation is the most significant one. This way, the Brazilian soybean producer suffers an average loss of 25% of his/her income with transportation costs, whereas for a North-American producer this average expense is less than 10% of the total income.

The increase in competitiveness of the country's productive structure and, therefore, the soybean production in the Mid-West region, for instance, depends on investments in the expansion of transportation

infrastructure, both in the development of alternative modals (rail and waterway) and revitalization of the road system (Correa and Ramos, 2010).

The expansion for soybean production for bordering areas has demanded more efficient modal flow means, besides alternatives to routes used by traditional regions. An alternative route for the flow of soybeans produced in the Northern Mato Grosso and in the states of the North region is that one destined to the ports of the North region of the country, like the port of Itacoatiara (AM). Because they are close to grain producing regions and even closer to external consumer markets, such as Europe, these exportation spots provide more competitive advantages, if compared to traditional ones. Besides the shorter distance, these ports offer a better structure, taking in bigger ships, that among other factors provide smaller operational costs and, this way, lower marine freights (Timossi, 2003).

According to Almeida et al. (2013) an alternative route for soybean harvest flow China bound would be the Transoceânica road. This road connects Brasil to Peru

and to Chile, coming from the city of Porto Velho (RO) up to the ports of Ilo and Matarani in Peru and up to the port of Arica in Chile. This alternative might be used by the states of Rondônia and Acre which have their agricultural productions increased even more. The Northern Mato Grosso can also benefit from this route.

The federal government, through Projetos de Integração Nacional, Brazil, intends to enhance the logistics infrastructure of the country, by the creation of Structural Axis, which consist of adequacy and construction of aero/port, terminal, rail, inner navigation, ports and road infrastructure. Nine Structural Axes were defined altogether, being the majority multimodal (Figure 2); there are seven axes with infrastructure with at least two modals and two with only one modal. The axes are described as follows: (1) Northeast-South Axis: Composed by road and railway modals; (2) Coastal Axis: Comprised of roads only; (3) North-South Axis: Constitutes water and road ways; (4) Amazon Axis: Containing only waterway mode; (5) Central-North Axis: Constituted water and road ways; (6) North-Southeast Axis: Formed by roads, railways and waterways; (7) East-West Axis: Comprised of roads and waterways; (8) Northeast-Southeast Axis: Composed of roads, railroads and waterways and; (9) Cabotage Axis: Connecting the main Brazilian marine ports through possible operational navigation cabotage routes, from Macapá (AP) to Rio Grande (RS) (CNT, 2014).

## FINAL CONSIDERATIONS

Each year, Brazil has been increasing its soybean production and the perspectives are that briefly, it will go past the U.S. and will become the major worldwide producer, due to favorable weather conditions, to innovation in production technology, to the possibility of increasing the cropping area, among others. In the harvest of 2013/14, Brazil achieved the title of the world's greatest soybean exporter, which is of great importance regarding foreign exchange to the country. However, Brazilian soybean competitiveness stumbles on difficulties found in a crippled logistics infrastructure regarding storing, transportation and ports in the country. Overall, railroads and waterways are not enough, making road modal the main way of production flow, encumbering costs due to the high freight price. Because of this scenario, the Brazilian producer suffers an average income loss of 25% with flow expenses, whereas for a North-American producer this expense is less than 10%.

It is vital that Federal Government invest in revitalization of Brazilian roads, in the expansion of rail and waterway systems, in the construction of warehouses and improvement of ports infrastructure. Furthermore, release of lines of credit for producers to build warehouses in their properties, so that they are able to store their production, avoiding the hindrance of having to flow their soybeans right after harvest, improving their income.

## Conflict of Interests

The authors have not declared any conflict of interests.

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