The Development of Brazilian Railroads: How the Brazilian Economy can Benefit
from More Efficient Railroad Utilization

A thesis presented to
the faculty of
the Center for International Studies of Ohio University

In partial fulfillment
of the requirements for the degree
Master of Arts

Maria Martha Scaglioni
June 2009

© 2009 Maria Martha Scaglioni. All Rights Reserved.
The Development of Brazilian Railroads: How the Brazilian Economy can Benefit from More Efficient Railroad Utilization

by

MARIA MARTHA SCAGLIONI

has been approved for

the Center for International Studies by

Catherine N. Axinn
Professor of Marketing

Betsy J. Partyka
Director, Latin American Studies

Daniel Weiner
Executive Director, Center for International Studies
ABSTRACT

SCAGLIONI, MARIA MARTHA, M.A., June 2009, Latin American Studies

The Development of Brazilian Railroads: How the Brazilian Economy can Benefit from More Efficient Railroad Utilization (111 pp.)

Director of Thesis: Catherine N. Axinn

This research analyses the railroad infrastructure initially, with a broader look at the general railroad characteristics and moving to the specific railroad history and aspects of railroads in Brazil. While several countries with comparable economies have a strong rail infrastructure to transport their production, Brazil does not. This paper explores the goods that have the potential to be transported by rail, but for some reasons, are not. A deeper study of the railroads’ geographical distribution in Brazil and of the exact localization of the production of the selected products points to an answer to the research question of how the Brazilian economy can benefit from a more efficient railroad utilization. Furthermore, it proposes the use of the existing railroad infrastructure to the transportation of four types of grains (corn, rice, beans, and wheat) and coffee. The content presented in this thesis contributes to the understanding of the problems in the Brazilian transportation infrastructure. The usage of the existing railroads to transport grains and coffee is an idea that has the potential to work in the short-term and without the need for excessive initial investments.

Approved: ________________________________

Catherine N. Axinn

Professor of Marketing
ACKNOWLEDGEMENTS

It is a pleasure for me to thank those who made this thesis possible. Firstly I would like to show my gratitude to my family for always being so supportive and vibrant: Mom Iris and Dad José Luiz, for their endless trust and love, for believing in my dreams and never questioning my beliefs. My sweet sisters, Cecília and Beatriz, for their immeasurable words of encouragement and friendship. Thank you four for showing that no matter how far we are from each other, we will always have our love connecting us. My brother-in-law, Ricardo, for being an example of success and a source of great advice.

To my beloved sweetheart, Sérgio, for being by my side in every single step of this thesis. His constant presence, patience, and affection made my days joyful and exciting.

This thesis would not have been possible without my dear advisor Dr. Catherine Axinn, to whom I do not have enough words to appreciate. Thank you so much for being an inspiration, an example, an amazing professional, and from now on, a good friend. I am also grateful to the other members of my committee: Drs. Chimeli and Jokisch for participating of this project and believing in my ideas contributing with great suggestions and ameliorations.

I also owe my deepest gratitude to Dr. Betsy Partyka, for always being present throughout this academic journey and helping me finding directions to my success.

To the Ohio University Writing Center for helping me polish my thesis writing. I also would like to thank Irfana Steviano for his great help with the maps.
To Centro Universitário UNA and Cristiane Serpa, for trusting in my work and awarding me with this scholarship.

Last but not least, to my valued Brazilian friends in Ohio: Camila, Júlia, Sarah, Victor, and Maira, for making me feel closer to home. To my lovely American girls: Kerri, Rachel, Lauren, and Tracy, for never hesitating on helping me under any circumstance and making me feel welcome and comfortable in their country.

I am so grateful for your support! Thank you all!
# TABLE OF CONTENTS

ABSTRACT ........................................................................................................................3

ACKNOWLEDGEMENTS .......................................................................................................4

LIST OF TABLES ..................................................................................................................9

LIST OF FIGURES ............................................................................................................10

CHAPTER 1: INTRODUCTION ...............................................................................................12

1.1. Aim / Justification ........................................................................................................12

1.2. Research Questions .....................................................................................................13

1.3. Literature Review .......................................................................................................14

1.3.1. The Railroad System ...............................................................................................14

1.3.2. The Privatization of Railroads in Brazil .................................................................15

1.3.3. The Privatization Results in Brazil ..........................................................................17

1.3.4. The Railroads Transportation Problems in Brazil ..................................................19

1.3.5. Railroad System Conclusion ..................................................................................20

1.4. Methodology ...............................................................................................................21

1.5. Conclusion ..................................................................................................................22

CHAPTER 2: RAILROAD TRANSPORTATION - CONCEPTS ..............................................24

2.1. Basic Characteristics ....................................................................................................24

2.2. Functional Characteristics .........................................................................................24

2.3. Fixed and Variable Costs ...........................................................................................27

2.4. Constraints ..................................................................................................................28

2.5. Strengths .....................................................................................................................30

2.6. Freight Car Types .......................................................................................................32
LIST OF TABLES

Table 1: Railroads – Summary Functional Analysis ........................................ 26
Table 2: Freight Car Types ............................................................................ 33
Table 3: RFFSA Productivity Performance .................................................. 43
Table 4: RFFSA Financial Performance Before and After Privatization .......... 43
Table 5: Density of Railroads in Selected Countries .................................... 53
Table 6: Brazil: Grain Production ................................................................. 59
Table 7: Brazil: Coffee Production ................................................................. 60
Table 8: Brazil: Supply and Demand of Soy ................................................ 61
Table 9: Brazil: Corn – Production, Harvested Area, and Average Yield ....... 63
Table 10: Brazil: Rice – Production, Harvested Area, and Average Yield ...... 65
Table 11: Brazil: Beans – Production, Harvested Area, and Average Yield ..... 67
Table 12: Brazil: Wheat – Production, Harvested Area, and Average Yield .... 68
Table 13: Brazil: Coffee – Production, Harvested Area, and Average Yield .... 69
Table 14: Brazil: Supply and Demand of Selected Products ......................... 76
Table 15: Coffee: Total Production, Exports, Imports, and Domestic Consumption .......................................................... 77
Table 16: Railroads that Could be Utilized in the Shipment of Corn ............... 90
Table 17: Railroads that Could be Utilized in the Shipment of Rice ................. 93
Table 18: Railroads that Could be Utilized in the Shipment of Beans ............. 96
Table 19: Railroads that Could be Utilized in the Shipment of Wheat .......... 99
Table 20: Railroads that Could be Utilized in the Shipment of Coffee .......... 102
Table 21: Number of Hopper Car Loads Needed per Year .......................... 102
LIST OF FIGURES

Figure 1: Railroad Cost Function ................................................................. 29
Figure 2: Railroad Average Cost Function .................................................... 30
Figure 3: Main Railroads ............................................................................. 39
Figure 4: State Concentration of Railroads in Brazil ................................... 51
Figure 5: Volume Transported by Rail Freight in Brazil .............................. 56
Figure 6: Rail Production Generated by Rail Freight in Brazil .................... 57
Figure 7: Corn: Five Major State Producers ................................................. 63
Figure 8: Rice: Five Major State Producers ............................................... 64
Figure 9: Beans: Five Major State Producers .............................................. 66
Figure 10: Wheat: Five Major State Producers .......................................... 68
Figure 11: Coffee: Five Major State Producers .......................................... 70
Figure 12: Railroads’ density: Brazil Vs. United States ............................... 71
Figure 13: Map of Brazilian Railroads ......................................................... 72
Figure 14: Map of Brazilian Roads ............................................................... 73
Figure 15: Brazilian Roads’ Condition ......................................................... 74
Figure 16: Total Corn Production ................................................................. 81
Figure 17: Average Rice Production ............................................................. 83
Figure 18: Geographical Dispersion of Beans Production in Brazil ............ 84
Figure 19: Average Wheat Production ......................................................... 85
Figure 20: Geographical Dispersion of Coffee Beans’ Production in Brazil ... 87
Figure 21: Total Corn Production and Railroad Lines ....................................... 88
Figure 22: Total Corn Production Combined with Brazilian Railroads .......... 89
Figure 23: Average Rice Production and Railroad Lines ............................... 90
Figure 24: Total Rice Production Combined with Brazilian Railroads .......... 92
Figure 25: Geographical Dispersion of Bean Production in Brazil and Railroad
Lines .............................................................................................................. 93
Figure 26: Total Bean Production Combined with Brazilian Railroads .......... 95
Figure 27: Average Wheat Production and Railroad Lines ............................. 96
Figure 28: Total Wheat Production Combined with Brazilian Railroads ......... 98
Figure 29: Geographical Dispersion of Coffee Beans’ Production in Brazil and
Railroad Lines ................................................................................................. 99
Figure 30: Total Coffee Production Combined with Brazilian Railroads ....... 101
CHAPTER 1: INTRODUCTION

The Brazilian economy is facing an intense development period in its international trade with the rest of the world. Since the 1990s, opening up for trade has been an important goal for Latin American countries in order to recuperate their losses from the 1980s and start a new prosperous period. Several private investors were attracted to Latin America and the power of the economy now depends much more on foreign trade than domestic trade. Governments are not able to manipulate the economy anymore, which brings more stability to these countries. After this economy overture started, Latin American countries adopted a series of action-plans to make this commercial transformation work properly.

A country that intends to participate actively in the international trade scene must have an efficient domestic logistical structure. What is the reason for having funds to buy imports, if it is impossible for these products to arrive properly at the final destination? The poor transportation conditions in Brazil end up adding significant costs to the final prices of imports and exports. If these domestic transportation costs were not so high, economic growth and trade gains would become even more meaningful.

1.1. Aim / Justification

The international trade of Brazil with the rest of the world has always been a very interesting topic to me. Brazil is a rich country with regards to its natural
resources, consumption market and labor force. Since the country opened up completely to trade in the beginning of the 1990s, the economic benefits were clear. Given that it has always fascinated me, I decided to study International Trade more deeply for my undergraduate degree, and I also started working in an area of International Trade that also attracted me: International Logistics.

When I put together international trade with logistics, what I see is a nation with a lot of potential to grow, but it appears that all this capability is being wasted, specifically with railroads. Railroads require an initial investment that is very high, but the long term results seem to compensate for it. For that reason, my aim with this research is to understand why the Brazilian railroad is not producing better benefits with its activities.

1.2. Research Questions

This research will be based on the following set of questions and its implications:

- What are the main issues that are impeding Brazil from achieving better benefits from its railroad activities? What could be the benefits? What are the impediments? What can be done about these impediments? What changes should be made by railroads?

All these issues will have implications that will be explored in further sections of this study. For instance, I can analyze how the Brazilian railroad can be used as a means to facilitate trade within Mercosul. Also, I can try to
investigate if the Brazilian railroads have the potential to expand their territorial coverage in order to improve Brazil’s foreign trade activities.

1.3. Literature Review

1.3.1. The Railroad System

For each mode of transportation, there are specific types of goods that should be transported that offer more efficiency and effectiveness. Choosing the correct and most adequate mode of transportation will optimize not only the transportation itself, but will also reduce the transportation costs. In the railroad case, these elements are essential to an analysis of the benefits that Brazil can derive from a better use of the existing Railroad infrastructure. As Coyle et al state, “Railroads are primarily long-distance, large volume movers of low-value, high-density goods”. That means that the products that are more likely to be transported are usually commodities from specific sectors, such as products of agriculture, mines, and forests. (Coyle et al 2003:346) In other words, the use of railroad transportation provides advantages to long-distance transportation of large quantities of commodities at fairly low prices.

On the other hand, Coyle et al also emphasize the fact that to build a new railroad requires making large investments in terminals, tracks, and equipment to start the operation. For that reason, railroads are considered as a decreasing-cost structure. This suggests that “large-volume, long-distance movements lower the average production cost by increasing output (ton-miles) and thereby spreading the fixed costs over a greater output base.” (Coyle et al 2003:346).
However, the low accessibility, long transit times, different gauge widths, and the high packaging costs are still considered disadvantages of this means of transportation.

Specifically in Brazil, a study of Global Perspectives in Brazil points that "one of the more serious challenges in working within the Brazilian railroad system is low connectivity among the lines, due to the existence of two different gauge widths (1.60 meters and 1.10 meters)" (Brazil: Global Perspectives 2007:6). Additionally, there is the problem with the regulations that are not encouraging the articulation and partnerships between the railroad companies. These issues will be discussed more fully in the following section.

**1.3.2. The Privatization of Railroads in Brazil**

In the early 1990s, the Brazilian government started the process of railroad privatization, but the actual implementation began only around 1997. Even though the privatization course happened slowly, its importance is remarkable. Campos suggests that infrastructure privatization requires three steps:

“The first one was to clearly define the scope and nature of private property rights in the provision of public services. Second, this framework should also encourage the efficient flow of private resources to infrastructure by removing obstacles to private provision of services. (...) Finally, the legal and regulatory framework associated to these changes should also provide an efficient mechanism for resolving disputes between the parties and assure the private parties’ recourse to fair and speedy dispute resolution mechanisms.” (Campos 2001:86).
With the purpose of providing a better historical understanding of the privatization process in South America, Caviedes and Knapp dedicate a portion of their book to explaining why these trends towards privatization and free-trade areas were indispensable for the beginning of the neoliberalism era in the region. Understanding the origins of privatization measures may help explain the results derived from privatizing. The article explains most of the issues that Latin American countries are facing currently, mainly in regards to railroad transportation and its consequences in the international trade market (Caviedes and Knapp 1995:218).

As Estache et al. state, the necessity reorganizing the railway structure and its privatization have now grown to be a mainstream strategy alternative in most developing countries, which are improving and restructuring their transport sector. This point of view reinforces the significance that privatization represents in countries like Brazil, Mexico, and Argentina, whose economies rely on transportation to bridge the distance between producers and markets. (Estache et al. 2002:1885).

Petersen and Taylor have a similar position, highlighting that only with effective transportation it is possible to successfully transport the freight from origin to destination, into, out of, and through the Brazilian territory (Petersen 2000:849).

With the data provided by the Brazilian National Agency of Terrestrial Transportation, it can be inferred that the money earned with the privatization process was mostly used in order to pay down the international debt (Evolução
Estache et al. go deeper in this subject, claiming that the geographic characteristics of Brazil and its size represent a point in favor of the railroad reform after privatization. Estache et al. also provide further information about how the government organized this privatization process, by dividing the railway network into six integrated regional monopolies. In this article, Estache et al. also provide a brief summary of these six concessions, providing both their background and current development (Estache et al. 2002:1889). On the other hand, Campos concentrates his research in one of the six concessions owned by a huge industrial holding group called CVRD (Companhia Vale do Rio Doce). CVRD used to be a state-owned enterprise and its privatization in the early 1990s represented a major impact in the Brazilian economy. Therefore, this report by Campos is an important key for my study.

1.3.3. The Privatization Results in Brazil

Campos and Estache et al. analyze the specific results of the privatization process in Brazil. On one hand, Campos states that in terms of private contribution, the railways in Latin American countries have surpassed anywhere else in the world. While the reforms have increased private participation in the transportation area, Campos explains how the government still keeps some control over the sector by exercising its power through a regulatory role. In addition, the most important lesson to learn from the entire privatization process is that the concessioning process can overturn the weakening tendency of the industries. Nonetheless, the general improvements are obvious, but this positive
evolution should not be credited only to operational and technical enhancement or to newly generated need. Campos also highlights that the long-term results of a privatization process depend on how the corporations deal with the initial years of difficult economic circumstances (Campos 2001:94).

However, there is a gap in the literature in with regards to the analysis of the railway concessions. To date, no one has conducted a clear and conclusive analysis. Thus, Campos pronounces that, for the moment, it can only be concluded that actions are being taken correctly, even though a definitive analysis remains to be made (Campos 2001:95).

On the other hand, Estache et al. provide an analysis of the privatization results based more on productivity oriented quantitative research. The study in question investigates the railroad reforms by computing their total factor of productivity (TFP). Using a TFP economic research, Estache et al. affirm that an overall improvement can be clearly observed since the private operators took control over the sector. This observed development is mostly due to the reduction in employment, which was considered idle when the rail transportation system was still state-owned. In other words, now the railroad system has greater efficiency results mostly from lower employment rather than from more efficiency in the sector. Nonetheless, Estache et al. also mention that the productivity gains should not be associated with only the employment reductions, but are also due to a more competitive scenario and to an improvement in outputs (Estache et al. 2002:1892).
1.3.4. The Railroads Transportation Problems in Brazil

At this point, it is important to comment on a notable observation Petersen and Taylor make regarding the Brazilian transportation case. They observe that long-haul trucking exists due to a minimal structure connecting the existing highways with the rail systems; this happens mostly because of administrative and economic reasons. Petersen and Taylor are the only ones to emphasize the necessity of connecting the various components of the logistical chain to facilitate and support the shipping of the smaller producers’ production. Hence, Petersen and Taylor propose planning a railroad model that would interlink the Northern and Southern Brazil, connecting these regions to facilitate the processing, consumption, and export of materials. Their research indicates that an investment in constructing a new railroad network in Brazil, connecting two critical regions, although expensive, could have valuable results and consequences the long-term (Petersen and Taylor 2000:852).

However, the other authors analyze the Brazilian transportation issues from a different perspective. Campos describes two main issues in the sector. The first one is the management of cross-concession traffic. He argues that in the moment of privatization, the government concessions split important regions into different zones, which were not geographically well distributed. This unequal distribution impedes the integration objective that most producers and companies aimed for. As was noted in the introduction, the low connectivity between the
existent lines also represents a critical impediment against the development of Brazilian railroads.

The second issue indicated by Campos is the governmental neglect of the impediments to developing a cohesive transportation system. There was not enough effort from the state to address the disjointed nature of the various concessions in a reasonable way. Better coordination and collaboration of concessions would benefit consumers and producers more than the government itself (Campos 2001: 89).

Notwithstanding, Estache et al.’s analytical approach does not reveal any major problems. Their research is too positive and ignores facts that should not be forgotten. The only critique they present is the unemployment issue. Even so, this problem is excused once the output improvements are exposed. This research does not acknowledge problems pertaining to the physical fragmentation created by the privatization concession (Estache et al. 2002:1896).

1.3.5. Railroad System Conclusion

This brief literature review and analysis demonstrate how significant the development of railroads can be to Brazil. As in other large countries in Latin America, the economic growth in Brazil is happening at such a rapid pace that it is difficult for all the industries to keep pace.

These studies have emphasized several benefits and positive results from the railroads’ privatization and creation of multiple concessions in Brazil. However, benefits from the Brazilian transportation system could go beyond that.
Not only should the direct effects be examined, but also the indirect influences that such evolution could bring for the society, workers and, producers who sustain Brazil’s economic development. The main point is that the railroads themselves are being vastly analyzed, but their surroundings are simply being forgotten as if there was not a connection between them. This study will examine the railroad concessions within their geographic and economic context.

1.4. Methodology

This research will be mainly based on academic research and data analysis. I will divide my research in five phases in order to find the answers to my research questions and get to a final conclusion. These five phases are the following:

1- I will conduct academic research to identify the nature and the types of benefits that can come from an effective and efficient Railroad system. For that phase I will analyze the available international literature and theories about railroad transportation and logistics. For instance, I will analyze the transportation costs and what are the most optimal goods to be transported through Railroads that will provide more competitive prices on international markets.

2- In this phase I will analyze the Brazilian specific literature about Railroads and their development in Brazil. This phase will be divided into two steps:

   a) Understanding how privatization may have changed Railroad operation (efficiency and effectiveness) and availability (effectiveness);
b) Developing an understanding of some of the possible impediments to effective and efficient Railroad operations in Brazil.

3- The third phase will be composed of research based on data analysis. I will make an examination of Brazilian economic output with regards to what is being produced and where / how it is getting shipped. To find these data, I have free access to some governmental websites that provide several geographic and economic statistics about transportation, development, and trade. I will focus on five agricultural products (corn, rice, beans, wheat, and coffee) that have the potential to be transported by rail, utilizing the data available at the Brazilian Ministry of Agriculture website.

4- With all the information collected on the first three phases, I will start phase four. In this phase I will be comparing the geographic distribution of the existing Railroad infrastructure with the existing geographic distribution of agricultural products output. I will focus on four types of grains (corn, rice, beans, and wheat) and coffee.

5- In the last phase I will integrate the literature collected on phases one, two and three with the results achieved in phase four. According to that, I will make my own conclusions about how Brazil can better utilize the existing Railroad infrastructure to facilitate its economic growth.

1.5. Conclusion

The Brazilian potential to expand its logistical infrastructure is remarkable. The country currently faces a period of economic prosperity and growth. For that reason, Brazil is becoming continuously more reliable and trustworthy in the
international market place. Private international and domestic investments are finally arriving in the industries and production areas. Nevertheless, some sectors are growing more rapidly than others and this disparity is reflected in the national transportation sector.

The Brazilian growth potential is notable, however there should be more concern in regards to transportation. The need for railroad construction and expansion is a clear, but complicated solution, since it requires high investments, whose consequences can be observed only in a long term. Notwithstanding, this economic issue can be observed from an annalistic perspective. And the enormous potential that exists should not be dissipated anymore.
CHAPTER 2: RAILROAD TRANSPORTATION - CONCEPTS

2.1. Basic Characteristics

The Railroad transportation system is one of the first means of transportation utilized with great efficiency and effectiveness with the objective of enhancing trade relations. Back in the industrial revolution, the British had great trade expansion, and the development of the railroad constituted as a major force to empower that expansion.

The value of railroad transportation should be acknowledged due to its capacity for moving a wide range of goods, usually with relatively low costs and efficiency. In the United States there are in average 500 railroad lines, but only a dozen of those present revenues that exceed U$50 million per year. Still, as Coyle et al state:

“This rather limited number of carriers may suggest limited rail service availability, but the railroads are required to provide through service, which makes rail service available to points beyond a particular carrier’s geographic limits” Coyle et al 1996:324.

2.2. Functional Characteristics

Today, Railroads are not the main type of transportation, as used to be true in the nineteenth century, when the majority of raw materials and other types of products were almost always moved through rails. Currently, railroad transportation has improved its form to transport with more competence some specific types of goods, mostly large quantities of heavy-weight goods and low
valued bulk commodities. These aspects will be further explored in another
section of this chapter (Coyle et al 1980:128).

Nevertheless it is important to highlight that railroads are now struggling to
hold their market share, competing with motor carriers, pipelines, and water
transportation. Still, railroads have some technical characteristics that emphasize
their competitiveness and reinforce their competence. One of the main
advantages is the use of steel track with the application of steel wheel.
Therefore, the resistance in the contact between the smooth steel rail and the
steel wheel is very little, which requires less horsepower, and thus consumes
less energy or fuel (Harzard 1977: 128). For many years, steam technology used
to be the most used source of energy, however these technologies have
changed drastically over the years, and currently diesel is the major power
source for freight railroads. Still, electric power is also often used, mostly in
passenger trains rather than in freight transportation (Sussman 2000: 172).

The chart below presents a summary of the functional characteristics of
railroads in the United States as adapted from Hazard:
# Railroads – Summary Functional Analysis

## Railroads – Summary Functional Analysis

<table>
<thead>
<tr>
<th>Technical</th>
<th>Economic</th>
<th>Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated single system</td>
<td>Own rights-of-way and terminals</td>
<td>Relatively slow</td>
</tr>
<tr>
<td>Hauling primarily carloads in line-haul trains between industrial sidings and terminal yards on a fixed network of tracks employing flanged steel wheel principle</td>
<td>High fixed investment and costs Unit costs decline with volume Relatively low line-haul costs Marginal costs and prices low Difficult long-range financing</td>
<td>Incomplete Fairly inflexible Highly reliable</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Internal</th>
<th>CHIEF VARIABLES</th>
<th>Technological</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oligopolistic – difficult to enter Large organization, geographically dispersed Decentralizing organization New management requirements Multiple labor unions Limited potential – self determination</td>
<td>External Markets: Moving away from rail tracks Changing consumer and travel habits Government Environment: Restructuring and passenger services Environment:</td>
<td>Rail and way improvements New power equipment Rolling stock innovation Unit and integrated trains High speed passenger trains</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PROBLEMS AND PROGRAM</th>
<th>Alternatives</th>
<th>Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problems</td>
<td>Alternatives</td>
<td>Program</td>
</tr>
<tr>
<td>Inadequate cash flow and earnings Bankruptcy and recapitalization Restructuring rail excesses Revitalizing passenger service</td>
<td>Sources of capital Public and private roles Market strategies</td>
<td>Competitive outlook Future passenger and freight service</td>
</tr>
</tbody>
</table>

Source: Adapted from Hazard 1997:130.
In regards to the operational characteristics, scholars say that railroads are considered a highly integrated network when one is referring to the fact that railroads function as a single entity, which means that this system functions and changes either all together or not at all. Yet, “the railroads are a highly integrated system for hauling carloads in trains on a fixed system of tracks between major industrial sidings and terminal yards” (Harzard 1977:129).

2.3. Fixed and Variable Costs

Railroad transportation is usually considered a low-cost mode of transportation. However, several aspects make this assertion very relative to other factors. The railroad philosophy is that of high expenses in initial investments, such as the construction of new rails, locomotives, and train stations, both for passenger and freight transportation.

The initial idea is that by the development of this expensive and specialized main infrastructure, there are extremely high gains in the “ability to haul freight, often bulk commodities like coal and grain, at reasonable speed, safely, and at low cost” (Sussman 2000:172). On the other hand, since railroads require such a specialized sort of infrastructure, the geography and landscape of some regions simply do not support the construction of a railroad (Sussman 2000:172).

Fixed costs are considered high in this industry. Before the transportation of anything, there are considerable costs to be taken into account. Like pipelines, railroads are the mode of transportation where owners and operators that
maintain and own their own terminals and networks. For that reason, the ownership, maintenance, and operation of rights-of-way are considered the major cost element in the railroad industry. Another important component of railroads’ fixed costs is the high investment in the facilities of private terminals, which comprises terminal areas, sidings, and freight yards (Coyle 1980:136).

Semi variable costs also occur in the railroad industry and they have a significant impact on the overall costs, and most of them are related to the maintenance of the investments mentioned above. Two factors account for a major portion of variable costs: fuel and labor. Both components have been reducing over the years. Some labor positions, such as the fireman for the steam locomotives, no longer exist. Fuel accounts for the second highest variable cost in the railroad industry, but “railroads have a very efficient propulsion units and productivity and fuel efficiency have increased dramatically since 1929” (Coyle 1980:138).

2.4. Constraints

The major constraint in the railroad industry is caused by its permanent rights-of-way, which might generate a conflicting degree of service completeness. If there are no sidings connecting the origin (shipper) and destination (receiver), a door-to-door service does not exist. This lack of connectivity creates a less complete service which is still strongly dependent on other modes of transportation in order to be effective. And this issue brings to
light other problems: the ones of rate-division with multiple carriers and the one of delays in delivery (Coyle 1980:129).

Another constraint affecting the railroad industry as a whole is again the high fixed costs. As previously mentioned, before anything is transported through a railroad, substantial initial costs should be considered and investments must be made. Within the graph below (See graph in Figure 1), this condition can be better understood:

![Railroad Cost Function](image)

*Figure 1. Railroad Cost Function*

Source: From Sussman 2000:175

However, some advantages can be taken as a consequence of this great investment, as it will be further explained in the following section.
2.5. Strengths

Once the initial and expensive investment is made, variable costs with the operation and utilization of the railroad system tend to be relatively low, especially if there are high traffic volumes involved. As can be observed on the graph below (See graph in Figure 2), the average cost per ton-mile will go down substantially as ton-miles go up, because there are more ton-miles over which to spread the high fixed costs (Sussman 2000:175).

![Railroad Average Cost Function](image)

*Figure 2. Railroad Average Cost Function*

Source: From Sussman 2000: 175

The most obvious strength of a railroad system is its capacity of carrying really large volumes over long distances at a relatively low price. This fact places the railroads in a better position when compared to motor carriers, for instance, which have a limited volume and weight capacity. Another example are the pipelines, which compete directly with railroads in regards to the capacity and long distance, but are still limited to the movement of liquid and gas.
All these attributes of the railroads enable them to carry and handle almost all types of commodities. Furthermore, there is a large variety of freight car types that can provide a more flexible service.

Another strength is the limited risk of damage and loss that is typically assumed by the railroads. Even though the type of goods transported through railroads is usually of low value, this assumption is significant due to the fact that railroads have a comparatively high rate of goods damaged in transit (around 3% of total tonnage shipped in the United States is damaged in transit). These damages occur because of the rough trip with vibration and shocks, which the rail freight often experiences. Also, the occurrence of losses is normally elevated when compared to other modes of transportation because rail freight is usually handled more often than freight traveling via other modes.

Railroads are in constant renovation of their equipment and technology in order to keep up with their efficiency, despite the lack of attention that has been given to this fact. A clear example concerns the Association of American Railroads, which created a program to certify freight quality to make sure that both technical specifications and freight car quality follow their specifications and requirements.

The intermodal area is probably one that has experienced a lot of technological innovations. Investments have been made in order to improve the connections with motor carriers, for instance the development of terminal facilities that would generate a more efficiency for loading and unloading. Also there are significant changes in containers, railcars, and trailers that contribute to
a simpler and more adaptable operation between the different modes of freight transportation.

These new technologies tend to improve the relative performance of rail by decreasing the high statistics of loss and damage and to open space for new traffic share. Also, the locomotives are constantly being equipped with updated instrumentation packages that measure the forces that might be creating these problems and thus reduce the damage potential. (Coyle 1980:129-130)

2.6. Freight Car Types

Since there are quite a variety of goods that are likely to be transported by rail, the types of rail cars vary according to the shipper's needs. Sussman provides a good summary of these types and their main characteristics (See table 2):
Table 2.

*Freight Car Types*

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Box Car</strong></td>
<td>This is simply a box with a door. It is an enclosed vehicle, which gets the freight out of the weather.</td>
</tr>
<tr>
<td><strong>Flat Car</strong></td>
<td>A flat car is precisely flat. It is simply a set of wheels with a platform. Occasionally they will have a front and a back, but not sides; they are often used for containers, where one or two containers can be loaded appropriately fastened down.</td>
</tr>
<tr>
<td><strong>Intermodal Flat Car</strong></td>
<td>The intermodal flat car adapted to receive a regular truck container</td>
</tr>
<tr>
<td><strong>Gondola Car</strong></td>
<td>Gondola cars have no roof. They do not protect the freight from the elements; they are used for such items as grain and coal that are not especially perishable. Gondolas are rough-and-ready transportation.</td>
</tr>
<tr>
<td><strong>Hopper Car</strong></td>
<td>Hopper cars are shaped basically like gondola cars. The fundamental difference is they have provision for opening the bottom, and therefore, allow off-loading, of say grain, by a gravity feed. They can be covered or uncovered.</td>
</tr>
<tr>
<td><strong>Tank Cars</strong></td>
<td>Tank cars are cylindrically shaped. Chemical companies, for example, ship liquid chemicals in tank cars. There is always concern for damage in these kinds of cars, which are often carrying chemicals which, if spilled into a river or on the roadside when such car is in a crash or derailment, can be quite hazardous.</td>
</tr>
<tr>
<td><strong>Refrigerator Cars</strong></td>
<td>Refrigerator cars are specialized equipment. The term used in the industry is &quot;reefers.&quot; They have to operate reliably because, if the cooling unit goes out of service, the loss and damage is total.</td>
</tr>
<tr>
<td><strong>Auto-Rack</strong></td>
<td>There is specialized equipment for transportation of finished automobiles - auto-rack cars. Often they are fully enclosed in order to permit more secure operation - avoiding damage to high-value finished autos.</td>
</tr>
</tbody>
</table>

2.7. Commodities more likely to be transported by rail

As has been mentioned before, the goods more likely to be transported through a railroad system are usually high volume and with low value added. For that reason, these products are narrowed down to commodities, such as ore, grains, and minerals.

Since this chapter is mainly based on American statistics and information, the numbers presented here are related to the railroads within the United States’ borders. Thus, the commodity that is by far the most transported through railroad freight is coal. Coal represents forty percent of tons carried by railroads in America. Even though coal is the chief support of the rail business, it is considered a low-value backbone, since it does not require high levels of service with high ton-mile or revenue/ton (Sussman 2000:179).

Farm products are the second biggest commodity carried by railroads, representing eleven percent. These farm commodities are largely composed of grains, including corn. And the third commodity is chemical products, which are more valuable and, therefore, generate more profit to the industry, at 9.4% of the tons carried by railroads in the United States. Nevertheless, it is important to remark that those are still low-value commodities if compared with manufactured goods (Sussman 2000:179).
CHAPTER 3: RAILROADS IN BRAZIL

3.1. Brief History of Railroads in Brazil

The railroad activities in Brazil had started by the middle of the nineteenth century. The construction of the first rail structures occurred because of the entrance of international private investment, which was attracted by interest return guarantees promised by the Brazilian Government (Nunes 2002:22).

Despite this entrance of international investments for the construction of railroads in Brazil, the actual rail structure development is considered relatively late, when compared to other large countries. The first railway law, authorizing the construction of railways in Brazil, was promulgated in 1835; but the conclusion of the first railroad project actually happened nineteen years latter. By 1914, the Brazilian rail network was concentrated in the Southeast region, and had a length of only 26,000 km. The United States, for instance, had reached this same size almost 70 years earlier (Estache et al. 2001:213).

The rail construction delay and small growth decreased the investment return for the private international investors. Nonetheless, this fact highlighted the indifference of the Brazilian authorities in regards to their transport infrastructure (Estache et al. 2001:213). These consequences had a tremendous impact on the development of railroads in Brazil and changed its direction. Due to the international investments’ disappearance, the Brazilian government had to find its own solutions to continue the rail network development.
Gradually, the Brazilian government regimes began the nationalization of its railroads through the implementation of subsidies. The results of this State intervention were clear; in 1919, 50% of the railways were already publicly owned and, by 1939 the length of the network had increased to 34,200 km. During this period of time, the most important railroads in Brazil were constructed.

In 1957 a mixed-economy enterprise called Rede Ferroviária Nacional (RFFSA) was created under the control of the Ministry of Transport, putting together a series of smaller private railroads that had to be bailed out of financial problems in the previous decades. And in 1971 another large railroad company was constituted unifying smaller systems in the state of São Paulo into FEPASA (Ferrovia Paulista S.A.). The last large railroad created in this period was possessed by a state-owned company called Companhia Vale do Rio Doce, which controlled two other great railways that connect its iron production center to the export ports (Estache et al. 2001:214).

Following the financial crisis in the 1980s, the Brazilian railroads underwent a new period of change. In order to pay its international debts, the government took the opposite way, reselling the railroad network and operation to the private sector. This privatization process will be further analyzed in the next section (Castro 2000:20).

In a summary, the Brazilian railroads were first developed as private enterprises with the aid of foreign investments, stimulated by promises of profit. Then, in the 1910s, the national government began a process of nationalization and gradually the railroads became government controlled to foster the growth in
the system. And later, in the early 1990s a privatization process was implemented and railroads were finally transferred back to the private sector as a government cost saving measure.

3.2. The Process of Railroads Privatization in Brazil

During the 1980s, a number of attempts to privatize the Railroads failed. The actual program was implemented only in 1991, when the National Program of “Destatization” (PND) was finally approved, as a response to the dire fiscal crisis the Brazilian economy was facing. This program created a strict legal outline for state reduction of expenditure, which has been implemented by various measures, several times as an answer to new pressures coming out from the privatization program itself (Estache et al. 2001:218).

In the early 1990s, the Brazilian government started the process of railroads privatization, but the actual implementation began only around 1997. Even though the privatization course happened slowly, its importance is remarkable. The economic framework was founded in three key aspects. The first one would be to create a clear and well-defined plan to set the capacity and origin of private property rights regarding the stipulation of public services. The second one was the necessity of private investments in the sector to support a competent course of private supply of infrastructure by eliminating any barrier to private services provision. The final key aspect is the necessity to offer a competent instrument for solving any sort of disagreement between the parties and guarantee that private parties have reasonable and fast dispute solution measures (Campos 2001:86).
The need for reorganization of the railway structure and the move its privatization in 1991 had grown to be a mainstream strategy alternative in most developing countries, which are improving and restructuring their transport sector. This affirmation reinforces the significance that privatization represented in countries like Brazil, Mexico, and Argentina, whose economies rely on transportation to make the connection across their long distances (Estache et al. 2001:1885). Only with effective transportation it is possible to successfully transport the freight from origin to destination, into, out of, and through the Brazilian territory (Petersen & Taylor 2001:849).

With the data provided by the Brazilian National Agency of Terrestrial Transportation, a significant amount of the Brazilian public debt was honored through the transfer to the private sector (Evolução Recente do Transporte Ferroviário 2007:3).

The geographic characteristics of Brazil and its size represent a point in favor of this reform. The Brazilian government organized this privatization process, by dividing the railway network into six integrated regional monopolies: the concessions (See map in Figure 2) (Estache et al. 2001:1889).
3.3. The Railroads Concessions

The origin of the railroad concessions in Brazil relies on a Constitutional reason: the 1988 Brazilian Constitution states that the provision of rail transport services in Brazil had to remain under federal government control. Therefore, the railroad network was vertically separated into six integrated regional monopolies, whose existing infrastructure would be leased to the private enterprises, but the Ministry of Transport would still control the rail services (Campos 2001:87).
The concessioning program established that these private enterprises, interested in acquiring the concessions, would have to assume the responsibility of operating and maintaining each area for a 30-year period, which could be renewed for another 30 years.

In 1996 and 1997 the government promoted a public competitive auction, in which the concessions were finally established and divided. The Brazilian federal government received a total amount of $950 million, but it did not impose any investment obligations to be accomplished by the new owners. The consequences of these acts will be discussed in the next section.

3.4. Railroads in Brazil - Present Situation

The current railroad network in Brazil is still very concentrated in the states of the Southeast Region and their service areas remain very limited when compared to the physical potential. Basically, for this reason, Brazil is still one of the few continental countries that, despite owning expressive industrial, mineral and agricultural sectors, still uses roads and trucks as the primary long-distance transportation system (Castro 2000:20). The privatization process kept this railroad regionalized instead of expanding it, as will be discussed in detail in another section.

The transfer of concessions to the private sector has benefitted some specific sectors, restricting most of their services to a limited market composed only of a particular sort of product, producers’ magnitude, and final destination of the goods produced that will be transported by rail freight.
First, there is only one type of product that is being transported through the railroad system: raw materials. This concentration in low value goods is actually normal, since railroad transportation is not the fastest or safest means of transportation available for more valuable goods. Nevertheless, it is cheap and railroads, for the most part, do not suffer from problems such as traffic, congestion, accidents, or climate changes (Nunes 2007:2).

Second, there is the restriction over the producer’s size and magnitude. In order to use the railroads, producers must be influential and have large production scales. This situation excludes small producers; even if they are unified in a cooperative, they rarely have enough power to access this transportation mode, once the current railroad network is highly limited to giant and powerful companies.

Third, there is the restriction in regards to the goods destination. The vast majority of goods transported through railroads are destined to exportation. The domestic market is rarely supplied by products that, in any phase of their transportation, were transported by a railroad. Often the locomotives even make their way back to the production center with their rail cars empty (Nunes 2007:12).

3.5. Positive Results after Privatization

Despite all of the restrictions that the railroad system entails, the majority or scholars concurs that industrial performance has substantially improved in Brazil since 1997. Firstly, for the National Treasury, there was a significant
contribution to the fiscal savings through the reduction of its subsidy payments (Estache et al. 2001: 224).

Secondly, the improvement in productivity is remarkable. Before privatization, the labor force was too idle. In the case of RFFSA (Rede Ferroviária Nacional S/A) Employment decreased from 32,187 in 1996 to about 12,000 in 1999. The railroad owner’s overall income was way below their potential. Right now, after the dismissal of part of the previously overstaffed labor force, labor productivity has increased in impressive numbers and decreased labor costs improved the financial performance of railroads’ activities (Estache et al. 2001: 224-225).

Finally, the concession process has been transparent and the new private owners are getting to increase the traffic and the scope of their services. Output in tons per kilometers increased from $38.7 million in 1996 to $46.3 million in 1999, which represents an important improvement of almost twenty per cent in the initial three years post-privatization (Estache et al. 2001: 225).

The two charts below (See charts in Tables 3 and 4), by Estache et al., provide more precise statistics before and after privatization. As it can be noticed, the year of 1998 has an unusual high source of income that represents a great volume of investments made by the concessionaries as part of their contractual obligations.
Table 3.

**RFFSA Productivity performance**

Chart 1: RFFSA productivity performance

<table>
<thead>
<tr>
<th></th>
<th>1993</th>
<th>1995</th>
<th>1997</th>
<th>1998</th>
<th>1999</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employees</td>
<td>59,440</td>
<td>48,106</td>
<td>21,622</td>
<td>15,475</td>
<td>11,687</td>
</tr>
<tr>
<td>Ton-kilometres (millions)</td>
<td>46,474</td>
<td>42,441</td>
<td>39,813</td>
<td>43,769</td>
<td>46,315</td>
</tr>
<tr>
<td>TKU/Employee (millions)</td>
<td>0.78</td>
<td>0.88</td>
<td>1.84</td>
<td>2.83</td>
<td>3.96</td>
</tr>
</tbody>
</table>


Table 4.

**RFFSA Financial performance before and after privatization.**

Chart 2: RFFSA financial performance before and after the privatization. All figures in US$.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>+ Gross operating revenues</td>
<td>757.8</td>
<td>799.4</td>
<td>572.6</td>
<td>34.1</td>
<td>77.9</td>
<td>21.9</td>
</tr>
<tr>
<td>+ Other income</td>
<td>28.1</td>
<td>35.8</td>
<td>473.4</td>
<td>273.8</td>
<td>1714.2</td>
<td>768.8</td>
</tr>
<tr>
<td>= Total gross revenues</td>
<td>785.9</td>
<td>835.2</td>
<td>1046</td>
<td>307.8</td>
<td>1792.1</td>
<td>790.7</td>
</tr>
<tr>
<td>- Taxes</td>
<td>34.5</td>
<td>40.9</td>
<td>66</td>
<td>15.3</td>
<td>12.6</td>
<td>18.8</td>
</tr>
<tr>
<td>= Net operating revenues</td>
<td>751.4</td>
<td>794.3</td>
<td>980</td>
<td>292.6</td>
<td>1779.5</td>
<td>771.9</td>
</tr>
<tr>
<td>+ Subsidies</td>
<td>14.5</td>
<td>21.3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>= Total net revenues</td>
<td>765.9</td>
<td>815.6</td>
<td>980</td>
<td>292.6</td>
<td>1779.5</td>
<td>771.9</td>
</tr>
<tr>
<td>+ Total operating expenses</td>
<td>850.4</td>
<td>974.7</td>
<td>533.3</td>
<td>63.8</td>
<td>821.2</td>
<td>520.1</td>
</tr>
<tr>
<td>= Net operating profits</td>
<td>-84.5</td>
<td>-159.1</td>
<td>446.7</td>
<td>228.9</td>
<td>958.3</td>
<td>252.8</td>
</tr>
</tbody>
</table>


3.6. Negative Results from the Privatization of Concessions

Even though the railroad privatization process is usually seen as a successful undertaking, a significant number of problems have already appeared or are projected to emerge in a short-term period if no change is made in operations and policies. Most of these issues are accumulated old problems that already existed in the railroads even before they were privatized. Other important
problems appeared as a result of the privatization process itself and the way it was designed. Based on these two origins, six main issues occurred following the privatization and creation of concessions will be analyzed.

3.6.1. Institutional Design

The institutional design problem is specifically the lack of a clear regulatory institution that would regulate how the concessions function. Since the first concessions were awarded, the official responsibilities have not been sorted out and their project voting remained in the Brazilian Congress for more than five years. During this idle period, the only regulation available was a guideline containing vague procedures and information requirements. That means that for quite a long period of time, rules were not clear enough and operators had to deal with at least three agencies responsible in some way for monitoring compliance.

In the meanwhile some guidelines had been issued by the Ministry of Transportation in an attempt to provide procedures and to format information requirements for the operators. However, these guidelines were considered vague and the intrusiveness of the process generated conflicts among operators (Estache et al 2001:228).

3.6.2. Limited Investment

It is clear that, since the implementation of the National Program of Destatization, the entrance of international investment in the rail sector would be
extremely necessary to ensure the progress of railroad development in Brazil. However, Estache et al. observed that foreign capital in the railroad sector represented only a minor presence when compared to other sectors of the Brazilian economy. Foreign investors are always looking for a safe sector in which to invest their funds and from which they can expect a solid return in the future. Investing in a sector that is not protected by a clear regulatory system provides no financial security. As Estache et al. state “foreign capital will be forthcoming in the Brazilian railroad sector only when there is a credible regulatory regime in place that provides reassurance that large sunk investments are not subject to ex post opportunistic behavior by the government” (Estache et al. 2001:229).

In addition, RFFSA (Rede Ferroviária Federal Sociedade Anônima) has a high level of indebtedness, which consequently limits its access to cheap funds and jeopardizes the company’s normal operation. Even though there is a contractual obligation, the São Paulo Stock Exchange has only two concessionaires listed on it and still the majority of railroad firms depend heavily on new capital from existing shareholders. (Estache et al. 2001:229).

3.6.3. The Ambiguities Regarding Transportation Fees

“The contractual requirement of minimum prices above long-term variable costs for each service is too general and unspecific, and remains controversial”, affirm Estache et al. (Estache et al. 2001: 230). Calculating the costs for each operation provided by the new railroad owners is a very complex task, mostly
because costs have varied greatly in regards to the different types of cargoes and services. Another reason for this complexity is the difficulty in establishing a clear value for variable and fixed costs, as well as in distinguishing joint costs in a conceptual and operational way.

The problem here is that in some situations, prices can indeed be kept at low levels, especially on return trips, for example. But nevertheless, when limits on prices are very low, it can be extremely harmful to competition, since it could require restrictions on the results of both the output targets and the investments established in the contract, by intimidating the entrance of new customers.

When the concessionaires were created after privatization, a series of obligations were established. There are two of these obligations that make the concessionaires fear that they could be “interpreted in a long-term sense in order to demand more investments than initially planned” (Estache et al. 2001:229). The problem here is not about adjusting prices according to inflation and other economic variations, but these clauses establish the concessionaires’ obligation to pursue economic and financial equilibrium and require new long-term investments that they might not be able to reach.

Because of these two main issues mentioned above, the necessity to clarify the ambiguity regarding tariffs became critical for the new regulator. Only with the solution of this issue, the provision of the concession contract will become less vague and less likely to evolve into conflicts of misinterpretation. (Estache et al. 2001:229).
3.6.4. The Problem of Captive Shippers

The problem with the establishment of minimum prices concerns principally the owners of the concessions. On the other hand, establishing maximum prices directly affects the users and producers. The captive shippers represent a portion of these users, since they have no economic access to alternate means of transport; they have no options and are strongly dependent on the prices instituted by the owners of the concessions. In other words, the railroad industry has all the supplier power, and, therefore, captive shippers do not have the buyer power necessary to impose their arguments. The problem is that the captive shippers can suddenly face high tariffs or abusive prices, but they are not big enough to demand fairer practices (Estache et al. 2001:230).

Notwithstanding, an issue that still remains unclear is the definition of who actually is the captive shipper. Estache et al. makes an interesting observation regarding this question:

“Following international experience, the method proposed by the regulators requires a petitioning shipper to submit information aimed at providing a complete definition of the market served, the volume and type of affected cargoes, the current and potential competition in the transport and final product markets and the cost structure of the company. An important regulatory challenge will be to insure that these requirements are not so burdensome as to render captive shipper protection ineffectual.” Estache et al. 2001:230.

Once again, the need for an established guideline and a formal regulatory environment is clear. Captive shippers are facing considerable losses as a result
of this type of conflict and the absence of an agency with the ability to defend their rights.

3.6.5. Interconnections and Joint Traffic

The management of cross-concession traffic can also be considered an issue. In the moment of privatization, the government concessions split important regions into different zones, which were not well distributed geographically, as it can be clearly observed on the map below (See map in Figure 3) provided by the Brazilian National Agency of Terrestrial Transportation:

![Main Railroads](image)

Figure 3: Main Railroads

It can be observed that the main railroads are very concentrated in the Southeast Region (around Rio de Janeiro, São Paulo, and Belo Horizonte) and in the South Region of Brazil (around Curitiba and Porto Alegre). This unequal distribution impedes the integration objective that most producers and companies aimed for. The six concession areas exchange little traffic with one another and the possibility of creating more joint traffic among the concessions comes up against political issues. Nonetheless, the Brazilian government neglected this issue. There has not been enough effort from the government to solve this physical inequality in a reasonable way, which would benefit consumers and producers more than the government itself (Campos, 2001, 89).

Another issue that still remains is the existence of long haul trucks due to a lack of intermodal structure connecting the existing highways with the rail systems; this happens mostly because of administrative and economic reasons. There is a necessity of connecting the various components of the logistical network to facilitate and support the shipping of the smaller producers’ production.

Hence, there are plans to propose a railroad system that would connect the Northern and Southern region of Brazil, connecting all the logistical modes in order to facilitate the processing, consumption, and export of materials. The results of this, as Petersen and Taylor indicate, is that an investment in constructing a new railroad network in Brazil connecting two critical regions is
truly expensive, but the results and consequences in a long-term period would be invaluable (Petersen & Taylor 2001:852).

### 3.6.6. Ownership Structure and Its Consequences

Once again, another issue is related to the slowness of regulatory advances in Brazil. There is a constant ambiguity regarding who should be solving each problem, how the problems should be addressed and who should address them. The solution to this issue not easy, since there is not a very well-defined structure or regulatory policies. First, as in any other industry, predatory behavior or price discrimination problems should be dealt by a competition tribunal. However, "many of these items (...) appear to be stipulated in the contracts and should then be addressed by the body in charge of monitoring contract compliance", (Estache et al. 2001:233)

When the government decided to sell the railroads concessions, the new owners had no strong control in regards to their rights and had limited power. The results of this badly organized structure are an accumulation of a number of disputes that remains unsolved and with no expectation to be resolved (Estache et al. 2001:232).

### 3.7. Current Railroad Infrastructure in Brazil

The railroad system in Brazil is comprised of 29,798 km of rail, a very low number when compared to the Brazilian area \((8,514,877 \text{ km}^2)\) and to the Brazilian volume of highways \((1,724,929 \text{ km})\). Fifty percent of these railroads are
concentrated in the four major states: Rio Grande do Sul (RS), Minas Gerais (MG), São Paulo (SP), and Rio de Janeiro (RJ). (See map in Figure 4):

*Figure 4:* State Concentration of Railroads in Brazil.

Source: Adapted from Espaço Educar 2009:1.

As presented in the previous chapter, in the United States, the commodities most carried by railroads are coal, farm products, and chemical products. In Brazil, the situation is not very different. The main commodities transported by rail are agricultural products, iron ore, steel products, and coal. When it comes to iron ore, almost eighty five percent of the transported volume is destined to exports. Yet, even with all the problems previously mentioned, from 1996 to 2003 the transported volume of cargo grew from 128 billion tons per
kilometer to 180 billion tons per kilometer (forty percent growth). (Brazil: Global Perspectives 2007:6)

3.8. A Comparison with other Nation's Railroads

After presenting the main issues with Brazilian railroads through the point of view of the main scholars in the field, this section will stress the tremendous difference between the total extension of rail per total area in Brazil versus other countries. Within the data retrieved from the Central Intelligence Agency (2009:1), the chart below presents both the total area of the chosen countries and the total rail length of those nations. The third and most important column presents the extension of rail in kilometers per total area in square kilometers. This information illustrates how behind Brazil and its railroads’ density are from countries such as Chile, Mexico, Argentina, India, United States, United Kingdom, and Belgium (See chart in Table 5):
Each of these other countries was chosen for some specific comparison reasons. First there is Argentina, which is geographically located very close to Brazil and whose economy presents several similarities to the Brazilian economy. Just like the Brazilian railroads, Argentinean railroads were first built and financed by British and other European investors at the end of the 19th Century and beginning of the 20th Century. Even though the Argentinean rail industry is passing through a period of decline, its rail density is three times the Brazilian rail density.

Chile and Mexico are somewhat similar to Argentina. In Chile, the rail network goes against the landscape limitations with over 6 thousand kilometers of rail and, since Chile has been passing through a period of economic prosperity, major investments have been made in the rail infrastructure since

Table 5.

Density of railroads in selected countries

<table>
<thead>
<tr>
<th>Land Area (km $^2$)</th>
<th>Rail Length (km)</th>
<th>Rail per Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>8,456,510</td>
<td>29,295</td>
</tr>
<tr>
<td>Chile</td>
<td>748,800</td>
<td>6,585</td>
</tr>
<tr>
<td>Mexico</td>
<td>1,923,040</td>
<td>17,665</td>
</tr>
<tr>
<td>Argentina</td>
<td>2,736,690</td>
<td>31,902</td>
</tr>
<tr>
<td>India</td>
<td>2,973,190</td>
<td>63,221</td>
</tr>
<tr>
<td>United States</td>
<td>9,161,923</td>
<td>226,612</td>
</tr>
<tr>
<td>United Kindom</td>
<td>241,590</td>
<td>16,567</td>
</tr>
<tr>
<td>Belgium</td>
<td>30,278</td>
<td>3,536</td>
</tr>
</tbody>
</table>

Source: Adapted from Central Intelligence Agency 2009:1.
2005. Therefore, despite the nature of the terrain, the Chilean rail density is more than twice the Brazilian density. In Mexico, the rail density is almost three times bigger than in Brazil, partially due to an earlier beginning of the rail history, which started early in the 19th Century. In addition, several multinational corporations sponsored the investment in railroads in order to improve transportation costs (Campos 2001:90).

In the case of India, the United Kingdom, and Belgium, it is necessary to consider the population density, which is much higher than in Brazil. For instance, while in Brazil there are only 23 inhabitants per square kilometer, in the UK, Belgium, and India this number surpasses 340 inhabitants per square kilometer (Central Intelligency Agency 2009:1); this fact justifies the necessity of a tremendous transportation structure, including rail transportation. Furthermore, these nations experienced the industrial revolution with much more intensity than Brazil did.
CHAPTER 4: BRAZILIAN ECONOMIC OUTPUT

This chapter will focus on the study of the Brazilian commodities that are likely to be transported by rail. Firstly, there will be a section focused on what specific products are produced in Brazil. This is followed by a section in which there will be an analysis of where exactly these goods are produced, based on the five major agricultural products with the most potential to be transported by rail: Corn, Rice, Wheat, Beans, and Coffee Beans. Then, the next two sections of this chapter will analyze how these products are currently transported and where they are shipped. Once all this information is reviewed, the chapter concludes with a detailed overview of the Brazilian economic output with respect to the rail industry.

4.1. What is being produced

Before this section begins, it is necessary to briefly review Chapter One, where there is a more general analysis of the commodities that are likely to be transported by rail. First of all, goods transported by rail are usually high volume and low value added commodities. For that reason, generally they are narrowed down to commodities, such as ore, grains, and minerals.

In Brazil some of these products are already being shipped by rail and some are not. Therefore, this section will be divided into two parts: Products that are already shipped by rail, and products with the potential to be shipped by rail. Since the main focus of this thesis is on how the Brazilian economy can benefit
from more efficient railroad utilization, the rest of this study will concentrate on the goods that are not being shipped by rail.

4.2. Goods already transported by rail

The Brazilian Railroad Concessions have clearly favored some specific sectors of the Brazilian economy. The concessions' owners are often the producers of products being shipped; and, hence, they are the primary direct users of the rail network. Charts provided by the Brazilian National Association of Rail Transporters (2009:1) indicate a concentration in the mineral industry, especially for iron ore and mineral coal, which correspond to over 75% of the total volume transported by rail in tons and over 80% of the total rail production in TKU (tons per kilometer), in 2007 (see graphs in Figures 5 and 6).

Figure 5. Volume Transported by Rail Freight in Brazil

The production of iron ore and mineral coal is concentrated in the hands of two major companies: Companhia Vale do Rio Doce (CVRD) and Companhia Siderúrgica Nacional (CSN). CVRD and CSN are the two biggest stock-holders in the Brazilian Railroads. Together, these two companies exclusively utilize 15,601 km of rail (53% of the total), they produce 155 billion TKU per year (85% of the total) and they invested R$3.7 billion (68% of the total) in the railroad sector after privatization (Vencovsky 2007:124). Some scholars even suggest the possibility of a monopoly, but this topic will not be discussed in this thesis.

The other goods transported by rail in Brazil represent only 24% of the total volume transported by rail in tons and just 19% of the total rail production in
TKU (tons per kilometer) in 2007. These products are mainly agricultural products, of which the vast majority is soy beans, soy flour, or soy oil, destined for exports (Vencovsky 2007:129).

4.3. Goods transported by other means of transportation

At this point, it is important to highlight that the mineral production (iron ore and mineral coal) is concentrated in the hands of big companies, which already have their own railroad concessions for shipping goods. Therefore, the goods that have the potential to be transported by rail and that are being transported by other means of transportation can be narrowed down to agricultural products, more specifically to grains.

According to the Brazilian Ministry of Agriculture, there are eight types of grains that are the most cultivated both for domestic and external consumption. They are: beans, corn, cotton (seed), oats, peanuts, rice, soy, and wheat. As can be observed in the chart below (See table 6), the production of soy in Brazil has been increasing rapidly, surpassing the production of corn in 2001/2002; and since 2002, it is the most produced grain of the Brazilian Agricultural Economy, representing over 45% of the country’s total production of grains.
Table 6.

Brazil: Grain Production

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>1999/00</th>
<th>2000/01</th>
<th>2001/02</th>
<th>2002/03</th>
<th>2003/04</th>
<th>2004/05</th>
<th>2005/06</th>
<th>2006/07</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton (seed)</td>
<td>1,187</td>
<td>1,522</td>
<td>1,245</td>
<td>1,365</td>
<td>2,099</td>
<td>2,129</td>
<td>1,686</td>
<td>2,176</td>
</tr>
<tr>
<td>Peanut</td>
<td>172</td>
<td>197</td>
<td>189</td>
<td>175</td>
<td>217</td>
<td>302</td>
<td>268</td>
<td>243</td>
</tr>
<tr>
<td>Rice</td>
<td>11,423</td>
<td>10,386</td>
<td>10,626</td>
<td>10,367</td>
<td>12,829</td>
<td>13,228</td>
<td>11,579</td>
<td>11,315</td>
</tr>
<tr>
<td>Oat</td>
<td>194</td>
<td>331</td>
<td>285</td>
<td>390</td>
<td>411</td>
<td>433</td>
<td>517</td>
<td>378</td>
</tr>
<tr>
<td>Bean</td>
<td>3,098</td>
<td>2,592</td>
<td>2,983</td>
<td>3,205</td>
<td>2,978</td>
<td>3,046</td>
<td>3,471</td>
<td>3,621</td>
</tr>
<tr>
<td>Corn</td>
<td>31,641</td>
<td>42,290</td>
<td>35,281</td>
<td>47,411</td>
<td>42,129</td>
<td>35,007</td>
<td>42,515</td>
<td>47,924</td>
</tr>
<tr>
<td>Soy</td>
<td>32,345</td>
<td>38,432</td>
<td>41,917</td>
<td>52,018</td>
<td>49,793</td>
<td>51,452</td>
<td>53,414</td>
<td>56,316</td>
</tr>
<tr>
<td>Wheat</td>
<td>1,658</td>
<td>3,194</td>
<td>2,914</td>
<td>5,851</td>
<td>5,851</td>
<td>5,846</td>
<td>4,873</td>
<td>2,234</td>
</tr>
<tr>
<td>Brazil</td>
<td>81,718</td>
<td>98,943</td>
<td>95,440</td>
<td>120,782</td>
<td>116,308</td>
<td>111,442</td>
<td>118,322</td>
<td>124,205</td>
</tr>
</tbody>
</table>

Source: Adapted from Ministério da Agricultura 2009:1.

The production of corn had been leading the ranks as the most produced agricultural grain until the years 1999/2000. Due to the high investments in the soy industry, the production of corn continued to be stable, but now it represents around 38% of the total grains produced. Together, soy and corn represent the greatest share of the total agricultural production of grains in Brazil: 83.9%, as calculated based on the table above.

The production of rice is the third largest grain crop, representing over 9% of the total production of grains in Brazil, followed by the production of, beans, wheat and cotton seed, which correspond approximately to 2.1% of the total production of grains each. The production of oats and peanuts has not been increasing significantly in the last eight years.

The production of coffee beans should also be taken into account. Even though the Ministry of Agriculture does not include the culture of coffee in its
grains information, this crop is vastly produced and it is one of the most exported goods in the Brazilian economy. Since the coffee produced in Brazil is transported in the form of coffee beans, then it is also a type of product likely to be transported by rail. The numbers below (See table 6) show the significance of the production of coffee in Brazil:

Table 7.

Brazil: Coffee Production

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006¹</th>
<th>2007¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coffee</td>
<td>3,264</td>
<td>3,807</td>
<td>3,639</td>
<td>2,650</td>
<td>1,987</td>
<td>2,466</td>
<td>2,140</td>
<td>2,586</td>
<td>2,131</td>
</tr>
</tbody>
</table>

Note: 1 Estimated

Source: Adapted from Ministério da Agricultura 2009:1.

As has been previously mentioned, soy beans, soy flour, and soy oil are already shipped by rail. The Brazilian soy industry has been stimulated by high foreign investments and almost 50% of its production is for exports. Therefore, this industry is more developed than other grains, as can be observed on the table below (See table 8), provided by the Brazilian Ministry of Agriculture:
### Table 8:

**Brazil Supply and Demand of Soy**

**Brazil: Supply and Demand of Soy**

(Thousand tons)

<table>
<thead>
<tr>
<th>Type of Soy</th>
<th>Annual Crop</th>
<th>Initial Stock</th>
<th>Production</th>
<th>Imports</th>
<th>Supplement</th>
<th>Domestic Consumption</th>
<th>Exports</th>
<th>Final Stock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soy Beans</td>
<td>1997/98</td>
<td>2,129.4</td>
<td>31,370.0</td>
<td>406.0</td>
<td>33,905.4</td>
<td>22,400.0</td>
<td>9,287.9</td>
<td>2,217.5</td>
</tr>
<tr>
<td></td>
<td>1998/99</td>
<td>2,217.5</td>
<td>30,765.0</td>
<td>582.0</td>
<td>33,564.5</td>
<td>22,300.0</td>
<td>8,917.0</td>
<td>2,347.5</td>
</tr>
<tr>
<td></td>
<td>2000/01</td>
<td>2,073.2</td>
<td>38,431.8</td>
<td>849.6</td>
<td>41,288.6</td>
<td>24,380.0</td>
<td>15,675.0</td>
<td>1,233.6</td>
</tr>
<tr>
<td></td>
<td>2001/02</td>
<td>1,233.6</td>
<td>42,230.0</td>
<td>1,045.2</td>
<td>44,408.8</td>
<td>27,405.0</td>
<td>15,970.0</td>
<td>1,133.8</td>
</tr>
<tr>
<td></td>
<td>2002/03</td>
<td>1,133.8</td>
<td>52,017.5</td>
<td>1,189.2</td>
<td>54,304.5</td>
<td>29,928.0</td>
<td>19,690.5</td>
<td>4,522.0</td>
</tr>
<tr>
<td></td>
<td>2003/04</td>
<td>4,522.0</td>
<td>49,988.9</td>
<td>349.0</td>
<td>54,937.9</td>
<td>31,090.0</td>
<td>19,247.7</td>
<td>4,522.2</td>
</tr>
<tr>
<td></td>
<td>2004/05</td>
<td>4,522.2</td>
<td>52,304.6</td>
<td>368.0</td>
<td>57,194.8</td>
<td>32,025.0</td>
<td>22,435.1</td>
<td>2,734.7</td>
</tr>
<tr>
<td></td>
<td>2005/06</td>
<td>2,734.7</td>
<td>53,413.9</td>
<td>807.0</td>
<td>56,020.9</td>
<td>30,383.0</td>
<td>24,957.9</td>
<td>1,167.7</td>
</tr>
<tr>
<td></td>
<td>2006/07</td>
<td>1,167.7</td>
<td>56,316.3</td>
<td>400.0</td>
<td>60,716.3</td>
<td>30,400.0</td>
<td>25,200.0</td>
<td>2,284.0</td>
</tr>
</tbody>
</table>

| Soy Powder  | 1997/98     | 402.2         | 16,590.0   | 161.0   | 17,151.2   | 5,900.0               | 10,447.0| 806.2       |
|             | 1998/99     | 806.2         | 16,511.0   | 78.0    | 17,289.2   | 6,300.0               | 10,431.0| 664.2       |
|             | 1999/00     | 664.2         | 16,669.0   | 98.7    | 17,431.9   | 6,800.0               | 9,375.0 | 1,256.9     |
|             | 2000/01     | 1,256.9       | 18,051.5   | 218.7   | 19,270.2   | 7,200.0               | 11,270.7| 1,056.4     |
|             | 2001/02     | 1,056.4       | 20,263.5   | 367.5   | 21,631.0   | 7,580.0               | 12,517.2| 1,590.2     |
|             | 2002/03     | 1,590.2       | 21,762.0   | 305.4   | 23,857.6   | 8,100.0               | 13,602.2| 2,155.4     |
|             | 2003/04     | 2,154.4       | 22,673.0   | 187.8   | 25,016.2   | 8,500.0               | 14,485.6| 2,030.6     |
|             | 2004/05     | 2,030.6       | 23,127.0   | 188.7   | 25,715.8   | 9,100.0               | 14,421.7| 1,824.6     |
|             | 2005/06     | 1,824.6       | 21,918.0   | 100.0   | 23,842.6   | 9,600.0               | 12,332.4| 1,910.2     |
|             | 2006/07     | 1,910.2       | 21,918.0   | 100.0   | 23,928.2   | 10,000.0              | 12,500.0| 1,428.2     |

| Soy Oil     | 1997/98     | 271.0         | 3,990.0    | 223.1   | 4,484.1    | 2,740.0               | 1,366.9 | 377.2       |
|             | 1998/99     | 377.2         | 3,971.0    | 159.2   | 4,504.2    | 2,780.0               | 1,515.8 | 175.6       |
|             | 1999/00     | 275.6         | 4,009.0    | 105.4   | 4,390.0    | 2,860.0               | 1,072.9 | 457.1       |
|             | 2000/01     | 457.1         | 4,341.5    | 72.0    | 4,870.6    | 2,935.0               | 1,651.5 | 284.1       |
|             | 2001/02     | 284.1         | 4,873.5    | 135.0   | 5,292.6    | 2,920.0               | 1,934.8 | 437.8       |
|             | 2002/03     | 437.8         | 5,282.0    | 36.0    | 5,575.8    | 2,950.0               | 2,485.9 | 319.9       |
|             | 2003/04     | 319.9         | 5,510.4    | 27.0    | 5,857.3    | 3,010.0               | 2,517.2 | 330.1       |
|             | 2004/05     | 330.1         | 5,692.8    | 3.2     | 6,026.0    | 3,050.0               | 2,697.1 | 279.0       |
|             | 2005/06     | 279.0         | 5,479.5    | 50.0    | 5,808.5    | 3,150.0               | 2,419.4 | 239.1       |
|             | 2006/07     | 239.1         | 5,339.0    | 10.0    | 5,588.1    | 3,200.0               | 2,200.0 | 188.1       |

Source: Adapted from Ministério da Agricultura 2009:1.

4.4. Where it is being produced

At this point, there will be an analysis of where the corn, rice, wheat, and beans are being produced in Brazil, according to the data provided by the Brazilian Ministry of Agriculture. For each of the grains, there will first be an
analysis of the total Brazilian production an then a report of the five biggest producer states.

4.4.1. Corn

Corn is the second largest grain crop produced in Brazil, behind only the production of soy. Preliminary data in Table 8 below, show that in 2005, Brazil produced over 35 million tons of corn, which places Brazil among the top 10 producers of corn in the world. The state of Paraná produced 24% of the national production in 2005, occupying a harvested area of 2,028 thousand hectares. Minas Gerais and São Paulo also had a great production of corn, representing 17% and 11% of the total national production respectively, as can be calculated based on the data in the table and the shown on the map (See map in figure 7) below:
Table 9.

**Brazil: Corn – Production, Harvested Area, and Average Yield**

Brazil: Corn – production, harvested area, and average yield – 1990 to 2005

<table>
<thead>
<tr>
<th>Year</th>
<th>Brazil Production (Thousand tons)</th>
<th>Brazil Harvested Area (Thousand hectares)</th>
<th>Average Yield (kg/ha)</th>
<th>Paraná Production</th>
<th>Paraná Harvested area</th>
<th>Minas Gerais Production</th>
<th>Minas Gerais Harvested area</th>
<th>São Paulo Production</th>
<th>São Paulo Harvested area</th>
<th>Mato Grosso Production</th>
<th>Mato Grosso Harvested area</th>
<th>Goiás Production</th>
<th>Goiás Harvested area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>21,348</td>
<td>11,394</td>
<td>1,874</td>
<td>5,161</td>
<td>2,080</td>
<td>2,273</td>
<td>1,411</td>
<td>2,766</td>
<td>1,151</td>
<td>270</td>
<td>1,848</td>
<td>874</td>
<td></td>
</tr>
<tr>
<td>1991</td>
<td>23,624</td>
<td>13,064</td>
<td>1,808</td>
<td>4,827</td>
<td>2,359</td>
<td>3,763</td>
<td>1,527</td>
<td>4,075</td>
<td>1,566</td>
<td>670</td>
<td>2,886</td>
<td>881</td>
<td></td>
</tr>
<tr>
<td>1992</td>
<td>30,506</td>
<td>13,364</td>
<td>2,283</td>
<td>8,175</td>
<td>2,561</td>
<td>7,280</td>
<td>1,476</td>
<td>4,075</td>
<td>1,566</td>
<td>764</td>
<td>2,777</td>
<td>800</td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>30,056</td>
<td>11,870</td>
<td>2,532</td>
<td>8,175</td>
<td>2,301</td>
<td>3,801</td>
<td>1,476</td>
<td>3,685</td>
<td>1,349</td>
<td>908</td>
<td>2,598</td>
<td>734</td>
<td></td>
</tr>
<tr>
<td>1994</td>
<td>32,488</td>
<td>13,749</td>
<td>2,363</td>
<td>8,162</td>
<td>2,513</td>
<td>3,683</td>
<td>1,487</td>
<td>3,199</td>
<td>1,309</td>
<td>1,164</td>
<td>3,176</td>
<td>913</td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>36,267</td>
<td>13,946</td>
<td>2,600</td>
<td>8,988</td>
<td>2,699</td>
<td>3,745</td>
<td>1,497</td>
<td>4,175</td>
<td>1,243</td>
<td>1,226</td>
<td>3,477</td>
<td>880</td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>29,653</td>
<td>11,976</td>
<td>2,476</td>
<td>7,933</td>
<td>2,450</td>
<td>3,329</td>
<td>1,294</td>
<td>3,544</td>
<td>1,155</td>
<td>1,515</td>
<td>3,404</td>
<td>869</td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td>32,948</td>
<td>12,562</td>
<td>2,623</td>
<td>7,762</td>
<td>2,415</td>
<td>3,915</td>
<td>1,330</td>
<td>3,910</td>
<td>1,207</td>
<td>1,521</td>
<td>3,777</td>
<td>951</td>
<td></td>
</tr>
<tr>
<td>1998</td>
<td>29,602</td>
<td>10,585</td>
<td>2,786</td>
<td>7,932</td>
<td>2,229</td>
<td>3,709</td>
<td>1,263</td>
<td>3,656</td>
<td>1,100</td>
<td>949</td>
<td>2,544</td>
<td>668</td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td>32,239</td>
<td>11,611</td>
<td>2,777</td>
<td>8,777</td>
<td>2,520</td>
<td>3,912</td>
<td>1,285</td>
<td>3,811</td>
<td>1,216</td>
<td>1,119</td>
<td>3,468</td>
<td>811</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>32,321</td>
<td>11,890</td>
<td>2,718</td>
<td>7,354</td>
<td>2,230</td>
<td>4,232</td>
<td>1,241</td>
<td>3,060</td>
<td>1,084</td>
<td>1,430</td>
<td>3,659</td>
<td>840</td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>41,952</td>
<td>12,335</td>
<td>3,402</td>
<td>12,647</td>
<td>2,617</td>
<td>4,021</td>
<td>1,209</td>
<td>4,200</td>
<td>1,123</td>
<td>1,743</td>
<td>4,157</td>
<td>908</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>35,941</td>
<td>11,761</td>
<td>3,066</td>
<td>9,798</td>
<td>2,457</td>
<td>4,808</td>
<td>1,204</td>
<td>3,943</td>
<td>1,064</td>
<td>2,311</td>
<td>3,390</td>
<td>731</td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>48,327</td>
<td>12,966</td>
<td>3,727</td>
<td>14,300</td>
<td>2,846</td>
<td>5,328</td>
<td>1,259</td>
<td>4,732</td>
<td>1,114</td>
<td>3,193</td>
<td>3,633</td>
<td>716</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>41,788</td>
<td>12,411</td>
<td>3,367</td>
<td>10,935</td>
<td>2,470</td>
<td>5,952</td>
<td>1,319</td>
<td>4,674</td>
<td>1,074</td>
<td>3,409</td>
<td>3,523</td>
<td>696</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>35,134</td>
<td>11,559</td>
<td>3,040</td>
<td>8,572</td>
<td>2,028</td>
<td>6,244</td>
<td>1,354</td>
<td>4,094</td>
<td>1,075</td>
<td>3,506</td>
<td>2,854</td>
<td>615</td>
<td></td>
</tr>
</tbody>
</table>

Note: 1 Preliminary

Source: Adapted from Ministério da Agricultura 2009:1.

---

**Figure 7.** Corn: Five Major State Producers

Source: Adapted from Espaço Educar 2009:1.
4.4.2. Rice

The production of rice in Brazil is quite concentrated among the five major states producing of the product. The two biggest producers are Rio Grande do Sul, accounting with over 46% of the total production in 2005, followed by the state of Mato Grosso, producing 17% of the total production. These two states are by far the ones with the largest areas of harvest as well. The other three biggest producers are Santa Catarina, Maranhão, and Pará, as it can be observed in the map below illustrating the five major state producers of rice in Brazil (See Figure 8).

Figure 8. Rice: Five Major State Producers

Source: Adapted from Espaço Educar 2009:1.
Together, the five states produced 81.3% of the total Brazilian production of rice in 2005. The table 9 below presents the Brazilian production of rice from 1990 to 2005:

Table 10.

Brazil: Rice – Production, Harvested Area, and Average Yield

<table>
<thead>
<tr>
<th>Year</th>
<th>Production (Thousand tons)</th>
<th>Harvested Area (Thousand hectares)</th>
<th>Average Yield (kg/ha)</th>
<th>Brazil</th>
<th>Rio Grande do Sul</th>
<th>Mato Grosso</th>
<th>Santa Catarina</th>
<th>Maranhão</th>
<th>Pará</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>7,421</td>
<td>3,947</td>
<td>1,880</td>
<td>3,194</td>
<td>421</td>
<td>355</td>
<td>568</td>
<td>152</td>
<td>465</td>
</tr>
<tr>
<td>1991</td>
<td>9,488</td>
<td>4,122</td>
<td>2,302</td>
<td>3,809</td>
<td>804</td>
<td>466</td>
<td>304</td>
<td>130</td>
<td>970</td>
</tr>
<tr>
<td>1992</td>
<td>10,006</td>
<td>4,687</td>
<td>2,135</td>
<td>4,570</td>
<td>898</td>
<td>851</td>
<td>572</td>
<td>150</td>
<td>401</td>
</tr>
<tr>
<td>1993</td>
<td>10,107</td>
<td>4,411</td>
<td>2,291</td>
<td>4,965</td>
<td>982</td>
<td>588</td>
<td>491</td>
<td>146</td>
<td>632</td>
</tr>
<tr>
<td>1994</td>
<td>10,541</td>
<td>4,415</td>
<td>2,388</td>
<td>4,231</td>
<td>977</td>
<td>812</td>
<td>477</td>
<td>150</td>
<td>1,036</td>
</tr>
<tr>
<td>1995</td>
<td>11,226</td>
<td>4,374</td>
<td>2,567</td>
<td>5,038</td>
<td>989</td>
<td>762</td>
<td>417</td>
<td>154</td>
<td>952</td>
</tr>
<tr>
<td>1996</td>
<td>8,652</td>
<td>3,255</td>
<td>2,658</td>
<td>4,357</td>
<td>863</td>
<td>722</td>
<td>429</td>
<td>114</td>
<td>555</td>
</tr>
<tr>
<td>1997</td>
<td>8,352</td>
<td>3,058</td>
<td>2,731</td>
<td>4,083</td>
<td>800</td>
<td>695</td>
<td>355</td>
<td>116</td>
<td>559</td>
</tr>
<tr>
<td>1998</td>
<td>7,716</td>
<td>3,062</td>
<td>2,520</td>
<td>3,592</td>
<td>832</td>
<td>777</td>
<td>364</td>
<td>119</td>
<td>381</td>
</tr>
<tr>
<td>1999</td>
<td>11,710</td>
<td>3,813</td>
<td>3,071</td>
<td>5,630</td>
<td>990</td>
<td>1,727</td>
<td>727</td>
<td>126</td>
<td>646</td>
</tr>
<tr>
<td>2000</td>
<td>11,135</td>
<td>3,805</td>
<td>3,038</td>
<td>4,981</td>
<td>944</td>
<td>1,852</td>
<td>699</td>
<td>135</td>
<td>727</td>
</tr>
<tr>
<td>2001</td>
<td>10,184</td>
<td>3,143</td>
<td>3,240</td>
<td>5,256</td>
<td>950</td>
<td>1,152</td>
<td>450</td>
<td>137</td>
<td>624</td>
</tr>
<tr>
<td>2002</td>
<td>10,446</td>
<td>3,142</td>
<td>3,325</td>
<td>5,486</td>
<td>981</td>
<td>1,181</td>
<td>435</td>
<td>137</td>
<td>629</td>
</tr>
<tr>
<td>2003</td>
<td>10,335</td>
<td>3,181</td>
<td>3,249</td>
<td>4,697</td>
<td>962</td>
<td>1,253</td>
<td>440</td>
<td>1,035</td>
<td>144</td>
</tr>
<tr>
<td>2004</td>
<td>13,277</td>
<td>3,733</td>
<td>3,557</td>
<td>6,338</td>
<td>1,044</td>
<td>2,177</td>
<td>738</td>
<td>1,012</td>
<td>151</td>
</tr>
<tr>
<td>2005</td>
<td>13,192</td>
<td>3,916</td>
<td>3,369</td>
<td>6,103</td>
<td>1,006</td>
<td>2,263</td>
<td>854</td>
<td>1,058</td>
<td>151</td>
</tr>
</tbody>
</table>

Note: * Preliminary

Source: Adapted from Ministério da Agricultura 2009:1.

4.4.3. Beans

Among the four groups of grains analyzed here, the production of beans is the smallest one. Nevertheless, in 2005, it is estimated that Brazil produced over three million tons of the product. Even though the consumption of beans is a strong part of the daily diet of Brazilians, it is basically only used as beans. Unlike corn and wheat, beans do not have many sub-products that derive from it. Yet,
the production of beans in Brazil is more geographically distributed than the production of rice (See map in Figure 9).

*Figure 9. Beans: Five Major State Producers*

Source: Adapted from Espaço Educar 2009:1.

The states that represent the five biggest producers of rice represent together only 69.8% of the total national production, being that the states of Minas Gerais and Paraná are the leaders producing around 18% of the national production each (see Table 10).
Table 11.

Brazil: Beans – Production, Harvested Area, and Average Yield

<table>
<thead>
<tr>
<th>Year</th>
<th>Production</th>
<th>Harvested Area</th>
<th>Minas Gerais</th>
<th>Production</th>
<th>Harvested Area</th>
<th>Paraná</th>
<th>Production</th>
<th>Harvested Area</th>
<th>Bahia</th>
<th>Production</th>
<th>Harvested area</th>
<th>Goiás</th>
<th>Production</th>
<th>Harvested area</th>
<th>São Paulo</th>
<th>Production</th>
<th>Harvested area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>2,234</td>
<td>4,680</td>
<td>477</td>
<td>293</td>
<td>523</td>
<td>276</td>
<td>551</td>
<td>227</td>
<td>593</td>
<td>119</td>
<td>181</td>
<td>368</td>
<td>293</td>
<td>368</td>
<td>279</td>
<td>227</td>
<td>368</td>
</tr>
<tr>
<td>1991</td>
<td>2,745</td>
<td>5,434</td>
<td>505</td>
<td>330</td>
<td>545</td>
<td>348</td>
<td>624</td>
<td>358</td>
<td>704</td>
<td>122</td>
<td>177</td>
<td>283</td>
<td>310</td>
<td>310</td>
<td>332</td>
<td>283</td>
<td>332</td>
</tr>
<tr>
<td>1992</td>
<td>2,797</td>
<td>5,149</td>
<td>543</td>
<td>284</td>
<td>503</td>
<td>451</td>
<td>582</td>
<td>449</td>
<td>740</td>
<td>113</td>
<td>147</td>
<td>310</td>
<td>323</td>
<td>323</td>
<td>313</td>
<td>310</td>
<td>310</td>
</tr>
<tr>
<td>1993</td>
<td>2,478</td>
<td>3,884</td>
<td>638</td>
<td>362</td>
<td>522</td>
<td>474</td>
<td>578</td>
<td>313</td>
<td>630</td>
<td>125</td>
<td>143</td>
<td>306</td>
<td>277</td>
<td>277</td>
<td>306</td>
<td>277</td>
<td>277</td>
</tr>
<tr>
<td>1994</td>
<td>3,370</td>
<td>5,471</td>
<td>616</td>
<td>386</td>
<td>553</td>
<td>526</td>
<td>589</td>
<td>303</td>
<td>591</td>
<td>145</td>
<td>152</td>
<td>294</td>
<td>332</td>
<td>332</td>
<td>332</td>
<td>294</td>
<td>332</td>
</tr>
<tr>
<td>1995</td>
<td>2,946</td>
<td>5,006</td>
<td>588</td>
<td>344</td>
<td>522</td>
<td>454</td>
<td>514</td>
<td>251</td>
<td>530</td>
<td>132</td>
<td>134</td>
<td>230</td>
<td>230</td>
<td>230</td>
<td>230</td>
<td>230</td>
<td>230</td>
</tr>
<tr>
<td>1996</td>
<td>2,452</td>
<td>4,301</td>
<td>570</td>
<td>263</td>
<td>455</td>
<td>490</td>
<td>594</td>
<td>322</td>
<td>660</td>
<td>110</td>
<td>86</td>
<td>174</td>
<td>182</td>
<td>182</td>
<td>182</td>
<td>174</td>
<td>182</td>
</tr>
<tr>
<td>1997</td>
<td>2,840</td>
<td>4,402</td>
<td>645</td>
<td>351</td>
<td>452</td>
<td>475</td>
<td>555</td>
<td>473</td>
<td>808</td>
<td>167</td>
<td>103</td>
<td>221</td>
<td>213</td>
<td>213</td>
<td>213</td>
<td>221</td>
<td>221</td>
</tr>
<tr>
<td>1998</td>
<td>2,191</td>
<td>3,314</td>
<td>661</td>
<td>339</td>
<td>433</td>
<td>495</td>
<td>565</td>
<td>221</td>
<td>440</td>
<td>185</td>
<td>108</td>
<td>254</td>
<td>208</td>
<td>208</td>
<td>208</td>
<td>254</td>
<td>208</td>
</tr>
<tr>
<td>1999</td>
<td>2,831</td>
<td>4,154</td>
<td>681</td>
<td>381</td>
<td>454</td>
<td>570</td>
<td>633</td>
<td>349</td>
<td>652</td>
<td>199</td>
<td>144</td>
<td>294</td>
<td>262</td>
<td>262</td>
<td>262</td>
<td>294</td>
<td>262</td>
</tr>
<tr>
<td>2000</td>
<td>3,056</td>
<td>4,333</td>
<td>705</td>
<td>407</td>
<td>436</td>
<td>495</td>
<td>541</td>
<td>540</td>
<td>827</td>
<td>200</td>
<td>112</td>
<td>238</td>
<td>213</td>
<td>213</td>
<td>213</td>
<td>238</td>
<td>213</td>
</tr>
<tr>
<td>2001</td>
<td>2,454</td>
<td>3,450</td>
<td>711</td>
<td>388</td>
<td>416</td>
<td>463</td>
<td>431</td>
<td>246</td>
<td>558</td>
<td>222</td>
<td>120</td>
<td>321</td>
<td>220</td>
<td>220</td>
<td>220</td>
<td>321</td>
<td>220</td>
</tr>
<tr>
<td>2002</td>
<td>3,064</td>
<td>4,141</td>
<td>740</td>
<td>496</td>
<td>436</td>
<td>619</td>
<td>523</td>
<td>375</td>
<td>758</td>
<td>235</td>
<td>123</td>
<td>302</td>
<td>216</td>
<td>216</td>
<td>216</td>
<td>302</td>
<td>216</td>
</tr>
<tr>
<td>2003</td>
<td>3,302</td>
<td>4,091</td>
<td>807</td>
<td>544</td>
<td>439</td>
<td>708</td>
<td>540</td>
<td>356</td>
<td>730</td>
<td>289</td>
<td>140</td>
<td>303</td>
<td>222</td>
<td>222</td>
<td>222</td>
<td>303</td>
<td>222</td>
</tr>
<tr>
<td>2004</td>
<td>2,967</td>
<td>3,979</td>
<td>746</td>
<td>464</td>
<td>408</td>
<td>666</td>
<td>506</td>
<td>331</td>
<td>705</td>
<td>210</td>
<td>104</td>
<td>282</td>
<td>160</td>
<td>160</td>
<td>160</td>
<td>282</td>
<td>160</td>
</tr>
<tr>
<td>2005¹</td>
<td>3,021</td>
<td>3,748</td>
<td>806</td>
<td>560</td>
<td>433</td>
<td>557</td>
<td>440</td>
<td>462</td>
<td>690</td>
<td>289</td>
<td>118</td>
<td>247</td>
<td>165</td>
<td>165</td>
<td>165</td>
<td>247</td>
<td>165</td>
</tr>
</tbody>
</table>

Note: ¹ Preliminary

Source: Adapted from Ministério da Agricultura 2009:1.

4.4.4. Wheat

Brazil is a large-scale producer of wheat as well. In 2004, the total production reached 5.8 million tons and occupied a total harvested area of 2,807 thousand hectares. The production of wheat in Brazil is extremely concentrated in five states: Paraná, Rio Grande do Sul, Mato Grosso do Sul, São Paulo, and Santa Catarina. Together, these five states manage over 97% of the national production in 2005, being that Paraná alone produced 59.4% of the total production and Rio Grande do Sul produced 29.8% (See Table 11 and Map in Figure 10).
### Table 12.

**Brazil: Wheat – Production, Harvested Area, and Average Yield**

Brazil: Wheat – production, harvested area, and average yield – 1990 to 2005

<table>
<thead>
<tr>
<th>Year</th>
<th>Brazil Production</th>
<th>Brazil Harvested Area</th>
<th>Brazil Average Yield (kg/ha)</th>
<th>Brazil Production Harvested Area</th>
<th>Brazil Production Harvested Area</th>
<th>Brazil Production Harvested Area</th>
<th>Brazil Production Harvested Area</th>
<th>Brazil Production Harvested Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>3,094</td>
<td>2,681</td>
<td>1,154</td>
<td>1,394</td>
<td>1,197</td>
<td>988</td>
<td>203</td>
<td>108</td>
</tr>
<tr>
<td>1991</td>
<td>2,917</td>
<td>2,049</td>
<td>1,423</td>
<td>1,826</td>
<td>1,138</td>
<td>683</td>
<td>617</td>
<td>150</td>
</tr>
<tr>
<td>1992</td>
<td>2,796</td>
<td>1,956</td>
<td>1,430</td>
<td>1,556</td>
<td>1,183</td>
<td>903</td>
<td>487</td>
<td>114</td>
</tr>
<tr>
<td>1993</td>
<td>2,197</td>
<td>1,482</td>
<td>1,482</td>
<td>1,556</td>
<td>993</td>
<td>683</td>
<td>917</td>
<td>598</td>
</tr>
<tr>
<td>1994</td>
<td>2,096</td>
<td>1,349</td>
<td>1,554</td>
<td>1,076</td>
<td>976</td>
<td>630</td>
<td>807</td>
<td>554</td>
</tr>
<tr>
<td>1995</td>
<td>1,534</td>
<td>995</td>
<td>1,542</td>
<td>1,069</td>
<td>683</td>
<td>637</td>
<td>335</td>
<td>270</td>
</tr>
<tr>
<td>1996</td>
<td>3,265</td>
<td>1,796</td>
<td>1,833</td>
<td>2,104</td>
<td>963</td>
<td>1,085</td>
<td>551</td>
<td>554</td>
</tr>
<tr>
<td>1997</td>
<td>2,489</td>
<td>1,522</td>
<td>1,636</td>
<td>1,748</td>
<td>954</td>
<td>604</td>
<td>482</td>
<td>47</td>
</tr>
<tr>
<td>1998</td>
<td>2,270</td>
<td>1,409</td>
<td>1,611</td>
<td>1,594</td>
<td>952</td>
<td>538</td>
<td>377</td>
<td>49</td>
</tr>
<tr>
<td>1999</td>
<td>2,462</td>
<td>1,250</td>
<td>1,970</td>
<td>1,548</td>
<td>754</td>
<td>726</td>
<td>397</td>
<td>71</td>
</tr>
<tr>
<td>2000</td>
<td>1,726</td>
<td>1,136</td>
<td>1,518</td>
<td>700</td>
<td>490</td>
<td>885</td>
<td>555</td>
<td>35</td>
</tr>
<tr>
<td>2001</td>
<td>3,367</td>
<td>1,728</td>
<td>1,948</td>
<td>2,013</td>
<td>962</td>
<td>1,076</td>
<td>613</td>
<td>107</td>
</tr>
<tr>
<td>2002</td>
<td>3,106</td>
<td>2,105</td>
<td>1,475</td>
<td>1,677</td>
<td>1,115</td>
<td>1,127</td>
<td>794</td>
<td>75</td>
</tr>
<tr>
<td>2003</td>
<td>6,154</td>
<td>2,560</td>
<td>2,403</td>
<td>3,203</td>
<td>1,254</td>
<td>2,396</td>
<td>1,063</td>
<td>169</td>
</tr>
<tr>
<td>2004</td>
<td>5,819</td>
<td>2,807</td>
<td>2,073</td>
<td>3,051</td>
<td>1,359</td>
<td>2,061</td>
<td>1,125</td>
<td>197</td>
</tr>
<tr>
<td>2005</td>
<td>4,659</td>
<td>2,361</td>
<td>1,973</td>
<td>2,767</td>
<td>1,276</td>
<td>1,390</td>
<td>844</td>
<td>130</td>
</tr>
</tbody>
</table>

Note: * Preliminary

Source: Adapted from Ministério da Agricultura 2009:1.

### Figure 10. Wheat: Five Major State Producers

Source: Adapted from Espaço Educar 2009:1.
4.4.5. Coffee

Among all the products selected to be analyzed in this paper, the production of coffee beans is the only one below 3 million tons in the year 2005. Alike beans, coffee is also a product included in the daily diet of Brazilians, but the numbers are not so high as in the case of soy, corn, and rice due to the fact that coffee is not used to produce as many derivate products. Still, according to the information provided by the International Coffee Organization, Brazil is the biggest world producer of coffee, followed by Vietnam and Colombia (International Coffee 2009:1)

Table 13.

Brazil: Coffee – Production, Harvested Area, and Average Yield

<table>
<thead>
<tr>
<th>Year</th>
<th>Production</th>
<th>Harvested Area</th>
<th>Average Yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Brazil</td>
<td>Maiores Estados Produtores</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Minas Gerais Production</td>
<td>Minas Gerais Harvested Area</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Espírito Santo Production</td>
<td>Espírito Santo Harvested Area</td>
</tr>
<tr>
<td></td>
<td></td>
<td>São Paulo Production</td>
<td>São Paulo Harvested Area</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bahia Production</td>
<td>Bahia Harvested Area</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Paraná Production</td>
<td>Paraná Harvested Area</td>
</tr>
<tr>
<td>1990</td>
<td>2,930</td>
<td>2,909</td>
<td>1,007</td>
</tr>
<tr>
<td>1991</td>
<td>3,041</td>
<td>2,763</td>
<td>1,100</td>
</tr>
<tr>
<td>1992</td>
<td>2,589</td>
<td>2,500</td>
<td>1,035</td>
</tr>
<tr>
<td>1993</td>
<td>2,558</td>
<td>2,259</td>
<td>1,132</td>
</tr>
<tr>
<td>1994</td>
<td>2,615</td>
<td>2,098</td>
<td>1,246</td>
</tr>
<tr>
<td>1995</td>
<td>1,890</td>
<td>1,870</td>
<td>1,236</td>
</tr>
<tr>
<td>1996</td>
<td>2,738</td>
<td>1,920</td>
<td>1,426</td>
</tr>
<tr>
<td>1997</td>
<td>2,457</td>
<td>1,988</td>
<td>1,236</td>
</tr>
<tr>
<td>1998</td>
<td>3,379</td>
<td>2,070</td>
<td>1,632</td>
</tr>
<tr>
<td>1999</td>
<td>3,264</td>
<td>2,223</td>
<td>1,468</td>
</tr>
<tr>
<td>2000</td>
<td>3,807</td>
<td>2,268</td>
<td>1,679</td>
</tr>
<tr>
<td>2001</td>
<td>3,639</td>
<td>2,336</td>
<td>1,558</td>
</tr>
<tr>
<td>2002</td>
<td>2,611</td>
<td>2,371</td>
<td>1,101</td>
</tr>
<tr>
<td>2003</td>
<td>1,987</td>
<td>2,396</td>
<td>1,830</td>
</tr>
<tr>
<td>2004</td>
<td>2,466</td>
<td>2,368</td>
<td>1,041</td>
</tr>
<tr>
<td>2005</td>
<td>2,536</td>
<td>2,342</td>
<td>1,083</td>
</tr>
</tbody>
</table>

Note: 1 Preliminary

Source: Adapted from Ministério da Agricultura 2009:1.
According to the numbers presented above (See Table 12), it can be calculated that among the five states that represent the biggest producers of coffee, Minas Gerais accounts with 50% of the total national production and, together, the total production of the other four states (Espírito Santo, São Paulo, Bahia, and Paraná) is still over 150 tons below the production in Minas Gerais. The map below illustrates the geographical distribution of these five states in Brazil (See map in Figure 11):

![Map of Brazil showing five major state producers of coffee](image)

*Figure 11. Coffee: Five Major State Producers*

*Source: Adapted from Espaço Educar 2009:1.*

4.5. How it is being shipped

As has already been observed, Brazilian railroad infrastructure has been utilized in large scale for the transportation of iron ore, mineral coal, and soy
products. The maps below (See maps in Figure 12) clearly show how low the density of railroads is in Brazil when compared to the United States. As previously discussed in Chapter 3, the density of railroads in Brazil is only 0.0035 kilometers of rail per square kilometer whereas in the United States this number is more than seven times higher, with a density of 0.0247 kilometers of rail per square kilometer:

![Maps showing railroads' density: Brazil vs. United States](image)

*Figure 12: Railroads’ density: Brazil Vs. United States*

Source: Centro de Estudos 2002:43

Brazil is still a nation that relies a lot on its roads for transportation. According to a study by the Brazilian National Confederation of Transportation, while the density of railroads in Brazil equals to 3.4 km/1000 km², the density of roads is of 17.3 km/1000 km². In other words, Brazil has a road network that is over five times bigger than its railroad network. (Centro de Estudos 2002:43). The study also points out that the road transportation in Brazil is very low cost and, therefore, this mode of transportation is the most utilized by producers and buyers in Brazil. The maps below (See maps in Figures 13 and 14), provided by
the Brazilian National Confederation of Transportation, allow a clear comparison between the railroad network and the road network, emphasizing the obvious difference between them:

Figure 13. Map of Brazilian Railroads

Source: From Confederação Nacional 2009:1
Since the Brazilian road network is so strong, cheap, and pervasive in Brazil, the transportation of grains is mainly done through trucks. However, according to the research from the Brazilian Center of Logistics Studies, 78% of the Brazilian roads are considered poor or deficient, whereas only 22% are
considered good or great, as it can be observed on the chart below (Centro de Estudos 2002:20) (See Figure 15):

![Brazilian Road's Condition](chart)

*Figure 15. Brazilian Roads' Condition*

*Source: From Centro de Estudos 2002:20.*

In addition, there is a very high number of accidents on the Brazilian roads; for instance, in 1998, the number of accidents in Brazilian roads was 226% higher than accidents on American roads (Centro de Estudos 2002:22).

4.6. Where is it being shipped?

Among the four grains analyzed, the great majority is shipped domestically to the centers of manufacture and distribution. The two tables below (See tables 13 and 14) present the final destination of the national production of rice, bean, corn, wheat, and coffee. It can be calculated that only corn and coffee have a significant share of its production destined to exports (6.5 million tons of corn, 13.5% of total corn production in 2006/2007 and 1.4 million tons of coffee, 67% of total coffee production in 2005).
Another interesting observation about the tables below is the fact that Brazil imports a lot more wheat than it produces. While the production of wheat in 2006/2007 was 2,233 thousand tons, the country imported 7,933 thousand tons in order to supply the domestic demand for the product. In other words, in 2006/2007 Brazil imported almost 75% of the wheat consumed domestically. Therefore, the domestic traffic of wheat in Brazil has the opposite directionality, given that it is transported by trucks from the ports of entrance to the interior of the country.
Brazil: Supply and Demand of Selected Products

### Brazil: Supply and Demand of selected products

(Thousand Tons)

<table>
<thead>
<tr>
<th>Grain</th>
<th>Annual Crop</th>
<th>Initial Stock</th>
<th>Production</th>
<th>Imports</th>
<th>Suppliment</th>
<th>Domestic Consumption</th>
<th>Exports</th>
<th>Final Stock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>1997/98</td>
<td>1,575.5</td>
<td>8,462.9</td>
<td>2,009.0</td>
<td>12,047.4</td>
<td>11,750.0</td>
<td>9.9</td>
<td>287.5</td>
</tr>
<tr>
<td>1998/99</td>
<td>287.5</td>
<td>11,582.2</td>
<td>1,338.0</td>
<td>13,207.7</td>
<td>11,700.0</td>
<td>37.7</td>
<td>1,470.0</td>
<td></td>
</tr>
<tr>
<td>1999/00</td>
<td>1,958.5</td>
<td>10,326.1</td>
<td>936.5</td>
<td>12,851.6</td>
<td>12,000.0</td>
<td>47.6</td>
<td>637.5</td>
<td></td>
</tr>
<tr>
<td>2000/01</td>
<td>327.2</td>
<td>10,367.1</td>
<td>1,601.6</td>
<td>12,596.2</td>
<td>12,250.0</td>
<td>23.5</td>
<td>332.7</td>
<td></td>
</tr>
<tr>
<td>2001/02</td>
<td>1,470.0</td>
<td>11,423.1</td>
<td>936.5</td>
<td>13,829.6</td>
<td>11,850.0</td>
<td>21.1</td>
<td>1,507.2</td>
<td></td>
</tr>
<tr>
<td>2002/03</td>
<td>1,958.5</td>
<td>10,386.0</td>
<td>951.6</td>
<td>13,296.1</td>
<td>11,950.0</td>
<td>24.4</td>
<td>1,321.7</td>
<td></td>
</tr>
<tr>
<td>2003/04</td>
<td>637.5</td>
<td>10,626.1</td>
<td>737.3</td>
<td>12,606.2</td>
<td>12,250.0</td>
<td>23.5</td>
<td>332.7</td>
<td></td>
</tr>
<tr>
<td>2004/05</td>
<td>332.7</td>
<td>12,829.4</td>
<td>1,097.3</td>
<td>14,259.4</td>
<td>12,660.0</td>
<td>92.2</td>
<td>1,182.4</td>
<td></td>
</tr>
<tr>
<td>2005/06</td>
<td>1,507.2</td>
<td>13,227.5</td>
<td>728.2</td>
<td>15,462.9</td>
<td>12,900.0</td>
<td>430.0</td>
<td>1,182.4</td>
<td></td>
</tr>
<tr>
<td>2006/07</td>
<td>2,183.2</td>
<td>11,315.0</td>
<td>1,200.0</td>
<td>13,977.4</td>
<td>13,100.0</td>
<td>200.0</td>
<td>397.4</td>
<td></td>
</tr>
</tbody>
</table>

| Bean | 1997/98 | 185.3 | 2,206.3 | 211.3 | 2,602.9 | 2,500.0 | 6.2 | 96.7 |
| 1998/99 | 96.7 | 2,895.7 | 92.9 | 3,085.3 | 2,950.0 | 2.6 | 132.7 |
| 1999/00 | 132.7 | 3,098.0 | 78.8 | 3,309.5 | 3,050.0 | 4.7 | 254.8 |
| 2000/01 | 254.8 | 2,587.1 | 130.3 | 2,972.2 | 2,880.0 | 2.3 | 89.9 |
| 2001/02 | 89.9 | 2,983.0 | 82.3 | 3,155.2 | 3,050.0 | 16.2 | 89.0 |
| 2002/03 | 89.0 | 3,205.0 | 103.3 | 3,397.3 | 3,130.0 | 2.8 | 264.5 |
| 2003/04 | 264.5 | 2,978.3 | 79.2 | 3,322.0 | 3,150.0 | 2.3 | 169.7 |
| 2004/05 | 169.7 | 3,045.5 | 100.7 | 3,159.5 | 3,200.0 | 2.3 | 113.6 |
| 2005/06 | 113.6 | 3,473.2 | 70.0 | 3,658.6 | 3,300.0 | 1.5 | 355.3 |
| 2006/07 | 355.3 | 3,620.8 | 69.4 | 4,045.5 | 3,300.0 | 6.0 | 739.5 |

| Corn | 1997/98 | 9,548.6 | 30,187.8 | 1,728.9 | 41,465.3 | 35,000.0 | 7.2 | 6,456.1 |
| 1998/99 | 6,458.1 | 32,393.4 | 822.1 | 39,673.6 | 35,000.0 | 7.5 | 4,661.1 |
| 1999/00 | 4,666.1 | 31,640.9 | 1,770.5 | 38,077.5 | 34,480.0 | 6.7 | 3,590.8 |
| 2000/01 | 3,590.8 | 42,289.3 | 624.0 | 46,504.1 | 36,135.5 | 5,629.0 | 4,739.6 |
| 2001/02 | 4,739.6 | 35,280.7 | 345.0 | 40,365.3 | 36,410.0 | 2,747.0 | 1,208.3 |
| 2002/03 | 1,208.3 | 47,410.9 | 800.6 | 49,419.8 | 37,300.0 | 3,566.2 | 8,553.6 |
| 2003/04 | 8,553.6 | 42,128.5 | 330.5 | 51,012.6 | 38,180.0 | 5,030.9 | 7,801.7 |
| 2004/05 | 7,801.7 | 35,006.7 | 597.0 | 43,405.4 | 39,100.0 | 1,070.0 | 3,235.4 |
| 2005/06 | 3,235.4 | 42,514.9 | 450.0 | 46,200.3 | 37,000.0 | 3,856.0 | 5,344.3 |
| 2006/07 | 5,344.3 | 42,923.6 | 100.0 | 53,367.9 | 39,500.0 | 6,500.0 | 7,367.9 |

| Wheat | 1999/00 | 609.1 | 2,402.8 | 7,718.1 | 10,730.0 | 9,977.8 | 2.3 | 750.0 |
| 2000/01 | 750.0 | 1,658.4 | 7,324.4 | 10,040.8 | 9,325.7 | 1.3 | 758.8 |
| 2001/02 | 718.8 | 3,194.2 | 7,045.7 | 10,955.6 | 10,180.2 | 2.4 | 773.1 |
| 2002/03 | 773.1 | 2,913.9 | 6,853.2 | 10,540.2 | 10,240.5 | 4.0 | 295.6 |
| 2003/04 | 295.6 | 6,073.5 | 5,707.5 | 12,076.6 | 10,314.1 | 1,372.3 | 390.3 |
| 2004/05 | 390.3 | 5,845.9 | 5,311.0 | 11,547.2 | 10,430.3 | 1.8 | 1,112.4 |
| 2005/06 | 1,112.4 | 4,873.1 | 6,266.1 | 12,251.6 | 10,989.8 | 786.1 | 475.6 |
| 2006/07 | 475.6 | 2,233.7 | 7,933.3 | 10,642.7 | 10,393.4 | 2.0 | 247.3 |

Source: Adapted from Ministério da Agricultura 2009:1.
Table 15.

Coffee: Total Production, Exports, Imports, and Domestic Consumption

Brazil: Coffee – total production, exports, imports, and domestic consumption – 1996 to 2005 (thousand tons)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Production</td>
<td>2,738</td>
<td>2,457</td>
<td>3,379</td>
<td>3,264</td>
<td>3,807</td>
<td>3,639</td>
<td>2,650</td>
<td>1,987</td>
<td>2,466</td>
<td>2,140</td>
</tr>
<tr>
<td>Exportações</td>
<td>835</td>
<td>921</td>
<td>1,034</td>
<td>1,316</td>
<td>1,013</td>
<td>1,311</td>
<td>1,613</td>
<td>1,438</td>
<td>1,485</td>
<td>1,433</td>
</tr>
<tr>
<td>Importações</td>
<td>1.11</td>
<td>0.33</td>
<td>0.11</td>
<td>0.10</td>
<td>0.20</td>
<td>0.12</td>
<td>0.14</td>
<td>0.13</td>
<td>0.12</td>
<td>0.12</td>
</tr>
<tr>
<td>Domestic Consumption</td>
<td>1,905</td>
<td>1,536</td>
<td>2,345</td>
<td>1,948</td>
<td>2,794</td>
<td>2,328</td>
<td>1,037</td>
<td>549</td>
<td>981</td>
<td>707</td>
</tr>
</tbody>
</table>

Source: Adapted from Ministério da Agricultura 2009:1.
CHAPTER 5: A COMPARISON – RAILROAD INFRASTRUCTURE VS. PRIMARY RESOURCES

Chapter five is the core analysis section of this paper and it will firstly analyze the geography of the Brazilian Railroad infrastructure and secondly the geographic dispersion of the four grains discussed here: corn, rice, wheat, and beans, as well as coffee. The last section of the chapter will combine the information of these two sections in an attempt to propose a new and better logistics strategy for the transportation of these goods, better utilizing the existing railroad network.

5.1. Geographic Analysis of Railroad Infrastructure

The Brazilian Railroad Infrastructure includes only 29,798 kilometers of rail, presenting a density of just 3.4 kilometers of rail per thousand square kilometers, which is a very low number when compared to other countries such as the United States, India, Mexico, Argentina, Chile, Belgium, and the United Kingdom.

Geographically, these railroads are extremely concentrated in the South and Southeast of Brazil, as can be observed on the map of Brazilian Railroads, as shown previously in Figure 3 and on the following page.
Figure 3: Main Railroads


5.2. Geographic Analysis of Primary Resources Dispersion

This paper has narrowed its research to the production of four grains and coffee with the potential to be transported by rail, as was discussed in the previous chapter. Therefore, this section of chapter four will be divided between these four grains and coffee and presents the exact localization of their production.
5.2.1. Corn

The growing of corn in Brazil is spread all over the nation. The map from the United States Department of Agriculture - Foreign Agricultural Service (See map in Figure 16) clearly illustrates this situation showing that each of the five regions of Brazil has a significant production of corn. A study from Criar e Plantar points out that, in regards to the latitude, corn is cultivated worldwide between the latitudes 58º North and 40º South and Brazil is completely comprised between those parallels. This same study also states that in Brazil, despite the region that surrounds the Amazon Basin, where weather is too humid, and the Sertão (backlands) in the Northeast, where weather is too dry, corn is widely produced. (Criar e Plantar 2009:1).
Average Total Corn Production (2004-2006)

Figure 16. Average Total Corn Production

5.2.2. Rice

According to the Brazilian Ministry of Agriculture, in 2005 the production of rice reached over 13 million tons. The map below (See map in Figure 17) emphasizes the leadership of the state Rio Grande do Sul as the only state that produced an average of over 250,000 tons of rice. Still, it is remarkable to observe how the production of rice has such a geographical scope, being produced both in the extreme south of Brazil and the North. According to Criar e Plantar, the culture of rice should follow an average temperature of 32º C (89º F), under constant ground humidity. In Rio Grande do Sul, where the ground humidity is not so favorable, producers irrigate their crops artificially, resulting in an efficient production of rice, accounting for over 46% of the total national production in 2005 (Criar e Plantar 2009:1).
Figure 17: Average Rice Production


5.2.3. Beans

The production of beans is more well-distributed in Brazil. As mentioned previously, the five major producer states (Minas Gerais, Paraná, Bahia, Goiás, and São Paulo) together accounted with only 69.7% of the total national
production. This fact happens due to the fact that there are not many limitations unfavorable to the growing of beans in Brazil. Extremely high or low temperatures can harm the harvest and also regular rains are favorable. Several producers have to utilize artificial irrigation. (Criar e Plantar 2009:1). Refer to the map below (Figure 18) for the exact localization of production areas in the five major producer states:

Figure 18. Geographical Dispersion of Beans Production in Brazil

Source: Adapted from from Espaço Educar 2009:1 and Unifeijão 2009:1
5.2.4. Wheat

The production of Wheat is the least distributed in Brazil. Wheat cannot be cultivated in regions with temperatures above 79º F, a fact that limits a lot of regions in Brazil. That is the reason why the growing of wheat is so concentrated in Paraná and Rio Grande do Sul (See map in Figure 19). Still, the production in Mato Grosso and Goiás, that is not so significant currently, has the potential to increase its production in the next few years (Criar e Plantar 2009:1).

Figure 19. Average Wheat Production

5.2.5. Coffee

The production of coffee is very concentrated in the states of Minas Gerais, Espírito Santo, São Paulo, Bahia, and Paraná. Together, these five states produce 93.7% of the total national production. Minas Gerais is by far the leader, producing over a million tons per year. The most favorable average temperature to cultivate coffee ranges between 64º F and 72º F, according to Criar e Plantar (Criar e Plantar 2009:1). However, it is not only the average temperature that determines the geographical dispersion of coffee production in Brazil; it is also important not to have extremely low temperatures at any circumstance, which can burn the crop. Therefore, the South region of Brazil, where temperatures might reach lower 30'sº F during winter time, does not have ideal conditions as the Southeast Region of Brazil does. On the other hand, the state of Bahia usually presents higher temperatures that would not foster the growing of coffee, but the areas with higher altitude have lower temperatures that enable the culture of coffee. The map below provides a more specific dispersion of coffee production in Brazil (Figure 20):
Figure 20. Geographical Dispersion of Coffee Beans’ Production in Brazil

Source: Adapted from The Brazil Travel 2008:1.

5.3. Integrating Existing Railroads with the Production of Grains and Coffee

This last section integrates the information collected about the existing Brazilian railroad network with the maps of the geographical dispersion of the four grains selected and coffee as the products with the most potential to utilize rail freight in stead of road freight. In order to have a visual understanding of the goals of this section, the two maps (rail network + grain production) will be overlapped and finally the potential new use of the existing railroads will be proposed.
The production of corn is extremely spread all over Brazil. The overlap of the two maps above suggests the utilization of at least eight railroads (See Table 15) in four of the five major producer states of the grain, as it can be observed on the map in Figure 22. Only the state of Mato Grosso, which is the fourth biggest producer of corn, has no railroads at all passing through their area of production. (See map in Figure 22)
Figure 22. Total Corn Production Combined with Brazilian Railroads Table 15.

Data Source for Crop Production by Municipality: Instituto Brasileiro de Geografia e Estatística (IBGE)
Table 16.

*Railroads that Could be Utilized in the Shipment of Corn*

<table>
<thead>
<tr>
<th>State</th>
<th>Railroads that could be utilized:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paraná</td>
<td>América Latina Logística SA</td>
</tr>
<tr>
<td></td>
<td>Estrada de Ferro Paraná Oeste SA</td>
</tr>
<tr>
<td>Minas Gerais</td>
<td>Ferrovia Centro Atlântica</td>
</tr>
<tr>
<td>São Paulo</td>
<td>Ferrovia Bandeirantes SA</td>
</tr>
<tr>
<td>Mato Grosso</td>
<td>None</td>
</tr>
<tr>
<td>Goiás</td>
<td>Ferrovia Centro Atlântica</td>
</tr>
</tbody>
</table>

5.3.2. Rice

*Figure 23. Average Rice Production and Railroad Lines*

Source: from United States Department 2009:1 and Centro de Estudos 2002:43.

As previously observed, the production of rice is mainly concentrated in the state of Rio Grande do Sul. In this state there is a great potential for the utilization of América Latina Logística SA railroad in order to distribute the rice to
the rest of the country. In the state of Mato Grosso, the second producer of rice, there are no railroads constructed. The state of Santa Catarina could also utilize América Latina Logística SA railroad, whereas both in Maranhão and Pará shipments could be made through Estrada de Ferro Carajás.
Figure 24. Total Rice Production Combined with Brazilian Railroads
Table 17.

*Railroads that Could be Utilized in the Shipment of Rice*

<table>
<thead>
<tr>
<th>State</th>
<th>Railroads that could be utilized:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rio Grande do Sul</td>
<td>América Latina Logística SA</td>
</tr>
<tr>
<td>Mato Grosso</td>
<td>None</td>
</tr>
<tr>
<td>Santa Catarina</td>
<td>América Latina Logística SA</td>
</tr>
<tr>
<td>Maranhão</td>
<td>Cia. Ferroviária Nordeste</td>
</tr>
<tr>
<td>Pará</td>
<td>Estrada de Ferro Carajás</td>
</tr>
</tbody>
</table>

5.3.3. Beans

*Figure 25. Geographical Dispersion of Bean Production in Brazil and Railroad Lines*

Source: adapted from Espaço Ensinar 2009:1 and Centro de Estudos 2002:43.

In regards to the shipment of beans, Ferrovia Centro Atlântica railroad would surely be utilized the most, since it could be used in the state of Minas.
Gerais (biggest producer), Bahia, and Goiás. Once again, in the state of Paraná there is a great potential for the use of América Latina Logística railroad. In this same state, Estrada de Ferro Paraná Oeste could also be utilized on a smaller scale. And in the state of São Paulo, Ferrovia Bandeirantes Railroad also has the potential to be used in the shipment of beans. (See map in Figure 26 and Table 17)
Figure 26. Total Bean Production Combined with Brazilian Railroads
Table 18.

_Railroads that Could be Utilized in the Shipment of Beans_

<table>
<thead>
<tr>
<th>State</th>
<th>Railroads that could be utilized:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minas Gerais</td>
<td>Ferrovia Centro Atlântica</td>
</tr>
<tr>
<td>Paraná</td>
<td>América Latina Logística SA</td>
</tr>
<tr>
<td></td>
<td>Estrada de Ferro Paraná Oeste SA</td>
</tr>
<tr>
<td>Bahia</td>
<td>Ferrovia Centro Atlântica</td>
</tr>
<tr>
<td></td>
<td>Cia. Ferroviária Nordeste</td>
</tr>
<tr>
<td>Goiás</td>
<td>Ferrovia Centro Atlântica</td>
</tr>
<tr>
<td>São Paulo</td>
<td>Ferrovia Bandeirantes SA</td>
</tr>
<tr>
<td></td>
<td>Ferrovia Novoeste SA</td>
</tr>
</tbody>
</table>

5.3.4. Wheat

_Figure 27. Average Wheat Production and Railroad Lines_

Without a doubt, the railroad América Latina Logística is the one with the biggest potential to ship the production of wheat, especially in Paraná, the biggest national producer of wheat, and in Rio Grande do Sul. The state of Santa Catarina could also benefit from this same railroad infrastructure. It is also important to notice that in the state of Mato Grosso do Sul, Ferrovia Novoeste SA railroad could also serve as an interesting alternative for the shipment of wheat. The map below (Figure 28) illustrates this situation.
Figure 28. Total Wheat Production Combined with Brazilian Railroads
Table 19.

*Railroads that Could be Utilized in the Shipment of Wheat*

<table>
<thead>
<tr>
<th>State</th>
<th>Railroads that could be utilized:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paraná</td>
<td>América Latina Logística SA</td>
</tr>
<tr>
<td></td>
<td>Estrada de Ferro Paraná Oeste SA</td>
</tr>
<tr>
<td>Rio Grande do Sul</td>
<td>América Latina Logística SA</td>
</tr>
<tr>
<td>Mato Grosso do Sul</td>
<td>Ferrovia Novoeste SA</td>
</tr>
<tr>
<td>São Paulo</td>
<td>Ferrovia Bandeirantes SA</td>
</tr>
<tr>
<td>Santa Catarina</td>
<td>América Latina Logística SA</td>
</tr>
</tbody>
</table>

5.3.5. *Coffee*

*Figure 29. Geographical Dispersion of Coffee Beans Production in Brazil and Railroad Lines*

Source: Adapted from *The Brazil Travel Site* 2009:1 and Centro de Estudos 2002:43.
There are three main railroads that have a great potential to be used in the shipment of coffee: Ferrovia Centro Atlântica, Estrada de Ferro Minas-Vitória, and MRS Logística. These three railroads serve the four biggest states producing coffee in Brazil: Minas Gerais, Espírito Santo, São Paulo, and Bahia. In São Paulo, Ferrovia Bandeirantes SA railroad could be utilized especially for the shipment of the coffee grown on the border with Paraná state. In Paraná, the production could also be shipped towards the South of Brazil via América Latina Logística SA railroad.
Figure 30. Total Coffee Production Combined with Brazilian Railroads

Railroad lines:

- **América Latina Logística SA**
- **Estrada de Ferro Paraná Oeste SA**
- **Ferrovia Tereza Cristina**
- **Ferrovia Bandeirantes SA**
- **Ferrovia Novoeste SA**
- **Ferrovia Norte Brasil SA**
- **MRS Logística**
- **Ferrovia Centro Atlântica**
- **Estrada de Ferro Vitória-Minas**
- **Cia. Ferroviária Nordeste**
- **Estrada de Ferro Carajás**
- **Estrada de Ferro Amapá**

Centers of Coffee Production
Table 20.

*Railroads that Could be Utilized in the Shipment of Coffee*

<table>
<thead>
<tr>
<th>State</th>
<th>Railroads that could be utilized:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minas Gerais</td>
<td>Ferrovia Centro Atlântica</td>
</tr>
<tr>
<td></td>
<td>MRS Logística</td>
</tr>
<tr>
<td></td>
<td>Estrada de Ferro Vitória-Minas</td>
</tr>
<tr>
<td>Espírito Santo</td>
<td>Estrada de Ferro Vitória-Minas</td>
</tr>
<tr>
<td>São Paulo</td>
<td>Ferrovia Bandeirantes SA</td>
</tr>
<tr>
<td></td>
<td>MRS Logística</td>
</tr>
<tr>
<td>Bahia</td>
<td>Ferrovia Centro Atlântica</td>
</tr>
<tr>
<td>Paraná</td>
<td>América Latina Logística SA</td>
</tr>
</tbody>
</table>

5.4. The Usage of Hopper Cars

The alternative presented in the previous section suggests the use of Hopper Cars to transport the five agricultural products selected through an existing railroad. Considering that on average, a hopper car has a capacity to move 70 tons, the table below points out the quantity of hopper cars that would be necessary to the transportation of these goods by rail (See Table 20):

Table 21.

*Number of Hopper Car Loads Needed per Year*

<table>
<thead>
<tr>
<th>Agricultural Product</th>
<th>Total Production in 2005 (tons)</th>
<th>Total Production in 5 major states* (tons)</th>
<th>Hopper Car Capacity (tons)</th>
<th>Number of Hopper Car loads needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>35,134,000</td>
<td>21764000</td>
<td>70</td>
<td>310914</td>
</tr>
<tr>
<td>Rice</td>
<td>13,192,000</td>
<td>8463000</td>
<td>70</td>
<td>120900</td>
</tr>
<tr>
<td>Beans</td>
<td>3,021,000</td>
<td>2106000</td>
<td>70</td>
<td>30086</td>
</tr>
<tr>
<td>Wheat</td>
<td>4,659,000</td>
<td>4400000</td>
<td>70</td>
<td>62857</td>
</tr>
<tr>
<td>Coffee</td>
<td>2,536,000</td>
<td>2378000</td>
<td>70</td>
<td>33971</td>
</tr>
</tbody>
</table>

* Excluding the state of Mato Grosso, which does not have any railroad constructed.
CONCLUSIONS

“The distortions of our transportation network create a braking effect over the Brazilian economy. It feels like we are all trying to drive a car with the handbrake on.” (Rohn cited in Centro de Estudos 2002:29)

This thesis was designed to answer the following question: How can the Brazilian economy can benefit from more efficient railroad utilization? After researching both the general and specific railroad literature, the answers to that question started to naturally take shape.

Initially, even before I proposed this research, while I was examining articles about the subject, I found a couple authors who proposed the construction of new railroad lines, connecting some important economic areas in Brazil. However, when it comes to costs, they are extremely high. As was observed in chapter 2 of this paper, the initial investments for the construction of a new railroad are huge and they start to pay off only in the long run. Similarly, proposing the creation of other new rail lines sounds too utopian.

Without any doubt, the Brazilian railroad infrastructure is still weak, especially when compared with several other large countries, including nations such as Mexico and Argentina, which have an economy comparable to the Brazilian economy. Due to this weakness in the rail infrastructure, Brazil relies heavily on truck transportation.

Knowing that only a few companies are using the existing rail infrastructure, why not eliminate these great initial costs by better utilizing the
infrastructure that Brazil already has? In Chapter 4, the analysis of the goods that are currently transported by rail and the ones that have the potential to be transported by rail became a focus of this research. Brazil produces grains and coffee abundantly and those were the key to this study.

A deeper study of the railroads’ geographical distribution in Brazil and of the exact localization of the production of the selected grains pointed to an answer to my research question. After overlapping the railroad map with the maps of the geographical distribution of production of the selected products (corn, rice, beans, wheat, and coffee), a transportation alternative became clear. For each of the five products analyzed there are at least four different railroad lines that can be used in their transportation. In other words, the results mean that:

1. The opportunity to transport corn, rice, beans, wheat, and coffee by rail freight exists. The infrastructure is already there and it would only be necessary to investment in acquiring the appropriate freight cars to transport the grains. The hopper cars (See Table 2, page 30) would be the most appropriate type of car.

2. The deterioration of the existing highways and roads would decrease, since one of the reasons for their terrible conditions is the enormous amount of heavy trucks transporting grains that utilize them daily.

It is possible to speculate on the reason why agricultural products such as corn, rice, beans, wheat, and coffee are not being transported by rail currently. The fact that soy is currently transported by rail, but not the other grains, suggests that there might be costs other than the costs of transportation involved
in the decision of which mode of transportation to utilize. According to Williamson, these costs are called transaction costs and they can determine how each market is organized, either through a spot market, long-term contracts, or vertical integration, creating the governance structure (Williamson 2002: 178). Perhaps the soy market is dominated by these long-term contracts, which could be justified if soy is sold mostly through future contracts or if its price is high enough to compensate for the costs involved. On the other hand, other agricultural products, such as rice, corn, and beans, whose prices might be lower, may be destined to the domestic market, where there are several producers and consumers who use the spot market. In that case, it would not make sense to use long-term transportation contracts, and that might be the reason why these producers are not using rail transportation yet.

The fact that the agricultural products analyzed here are mostly consumed domestically, might also be a barrier to the utilization of railroads. When most of the production is towards exports, investments are probably higher and importers are probably willing to make long-term investments in order to ensure efficient transportation and secure supply lines. Perhaps the domestic market cannot invest in an alternative form of transportation that would only deliver long-term compensations, which is the case of utilizing rail transportation.

Another point that might be a reason to justify not using of the existing railroads to transport grains could be legal impediments. Since this thesis did not involve a study of the legal aspects that regulate the use of the concessions for the transportation of other goods, perhaps there are clear official obstacles
preventing. Or perhaps strong alliances exist among the providers of road transportation that, together, do not facilitate the creation of new alternatives of transportation. Also, the extremely low costs of highway and road transportation are probably another barrier to the use of rail freight.

Another speculation would be in regards to the transportation costs involved. Further research would have to be made in order to understand exactly how prices are formed both for road transportation and rail transportation. An alternative would be to compare the costs for soy transportation for both modes, since it is a situation that already exists in Brazil. A better understanding of the composition of these prices, including fuel costs, could maybe be the reason why these agricultural products (corn, rice, beans, wheat, and coffee) are not yet being transported by rail as soy is.

Further studies and research would be necessary in order to understand the legal aspects that regulate the utilization of the rail lines by other companies. There may be a need to create an agreement with the concession owners to allow the passage of different trains on their rail lines. It would be interesting to have a study highlighting the economic gains for both the new users of the railroads and the concession owners, who could provide this service as another source of income.

With the content presented in this thesis, I hope to have contributed to the understanding of the problems in the Brazilian transportation infrastructure. It is clear that some measures have to be taken. The usage of the existing railroads
to transport grains and coffee is an idea that has the potential to work in the short-term and without the need for excessive initial investments.
REFERENCES


