# Investment Shortages in the Transportation System: Theoretical Discussion and Evidence from the Brazilian Agribusiness Case[1]


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**Abstract -** The objective of this article is to detail and reflect on insufficient Brazilian public investment in logistics and transportation infrastructure and its effects on agribusiness' transport and logistics markets. Brazilian agribusiness is understood to comprise a set of logistic-intensive services. Agribusiness is seriously limited by the lack of public infrastructure, especially transportation infrastructure. This shortage contributes to congestion and saturation along existing transport system. This article emphasizes aspects in the formation of market freight rates in sectors without an understandable linkage and among regions, addressing issues of location, income, consumption and system competitiveness. One finding of this article is that entrepreneurial solutions for logistic bottlenecks can have market-concentrating effects in the area of commercialization. In general, public transportation infrastructure constitutes itself as a strategic factor for future growth of agribusiness and expansion in the Midwest, North and Northeast regions.



**Keywords:** transportation system; logistics; Brazilian agribusiness



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## 1. Introduction

Public logistics or economic infrastructure brings important positive externalities. These are systems like transportation, energy, and telecommunications that are beyond the domain of the private sector and affect the competitiveness of the economy, influencing levels of efficiency, growth and development.

According to the World Bank, public logistics can be understood as the composition of sectors characterized by scale economies and positive externalities. Moreover, in order to more clearly refine this specification, infrastructure can be divided into three parts: a) electricity, telecommunications, water and sewer services, and trash collection; b) highways and irrigation and drainage systems; c) transportation systems: ports, urban and interurban railroad services, urban highway transportation, inland waterways and airports (WORLD BANK: 1994).

Pego Filho et al. (1999) note that public logistics justifies state intervention. The economic sectors that compose public logistics can be more rational in situations of high-scale production, at times monopolies, in the case of energy, or more difficult on account of non-exclusion of consumption, as in the case of transportation systems.

Public logistics affects economic activity in costs and service quality. According to Souza (2002), public expenditures in infrastructure are among the principal explanatory factors for the location of Brazilian industry in the 1970s and 1980s, ahead of other conventional indicators, such as market potential, fiscal incentives, and education of the labor force. At a regional level, this power of attraction generates inequalities that can also be interpreted in a historic perspective emanating from the complex relationship between basic economic activities and their interactions on demand for national public logistics infrastructure.

Analyzing the case of Brazilian agribusiness and its specific demands on transportation, the continental dimension of the Brazilian territory and its spatially dispersed agricultural production give strategic emphasis to transportation in investment decisions. With the opening of the economy, agriculture and livestock industries have passed through a series of transformations, guided by the development and strengthening of competitive forces, leading businesses to reduce costs and make improvements in quality and efficiency in product distribution. Moreover, agricultural production has expanded towards the country's interior, notably in the North, Midwest and vast areas of the Northeast, at a greater distance from the ports that enable access to external markets.

Agribusiness is characterized by the formation of extensive supply chains comprising a large number of agents involved from phases involving raw materials to the various market segments, with significant spatial dispersion. Agribusiness involves a substantial

number of operations of low value-added nature. In this context, the lack of adequate transport systems is seen as a growing obstacle to the competitiveness of Brazilian agribusiness.

With substantial increases in basic production and transport distances, the growing demand for transportation services has been verified as a decisive variable for the competitiveness of products in markets. Through the demand for transportation, the problem of transportation logistics is understood in its totality, which includes the insufficiency of storage at ports and regions of production, causing strong seasonal variations in freight rates and vehicle queues for loading and discharge.

## 1.1 Justification

Since the 1950s, the transport economics literature has developed with a focus on the economic aspects of transportation systems. In this period, studies that addressed methodologies, optimization of cargo freight rates and passenger tariffs, regulation, and identification of social benefits contributed to the consolidation of transportation analysis (Winston 1985).

One of the significant contributions of transportation economics was the promotion of a deeper understanding of the externalities provided by transportation systems. There is unanimity with regard to the strategic characteristics of transportation systems inasmuch as it is a public good with vital functions to the economy affecting nearly all economic activities, invoking the institutional presence of the State. In the case of the Brazilian transportation systems, investments do not occur with the regularity necessary nor at the levels required for effective application, given their potential externalities and the requirements for economic growth and spatial occupation.

Beginning with studies of the Brazilian Agricultural Research Corporation (EMBRAPA), the Ministry of Transportation (GEIPOT 2001) operates from the perspective that Brazil possesses approximately 90 million hectares suited for agricultural use and more than 150 million hectares apt for livestock raising (figure 1). For historical reasons due to the process of economic occupation and, more recently, by the spatial concentration of new manufacturing activities in the Brazilian Center-South, there is an economic backwardness present in the Midwest, North, and Northeast regions of Brazil. The lack of an equitable provision of infrastructure reinforces this backwardness among regions.

Notwithstanding this deficit, the so-called Brazilian “Cerrado” located in vast areas of these backward regions possess soils and climates favorable for grain expansion, especially of soybean and corn cultivation. As a result, these areas have a considerable need for transportation, in quantity and quality, capable of promoting access to agricultural inputs and the drainage of production at levels required by the logistics of agribusiness.

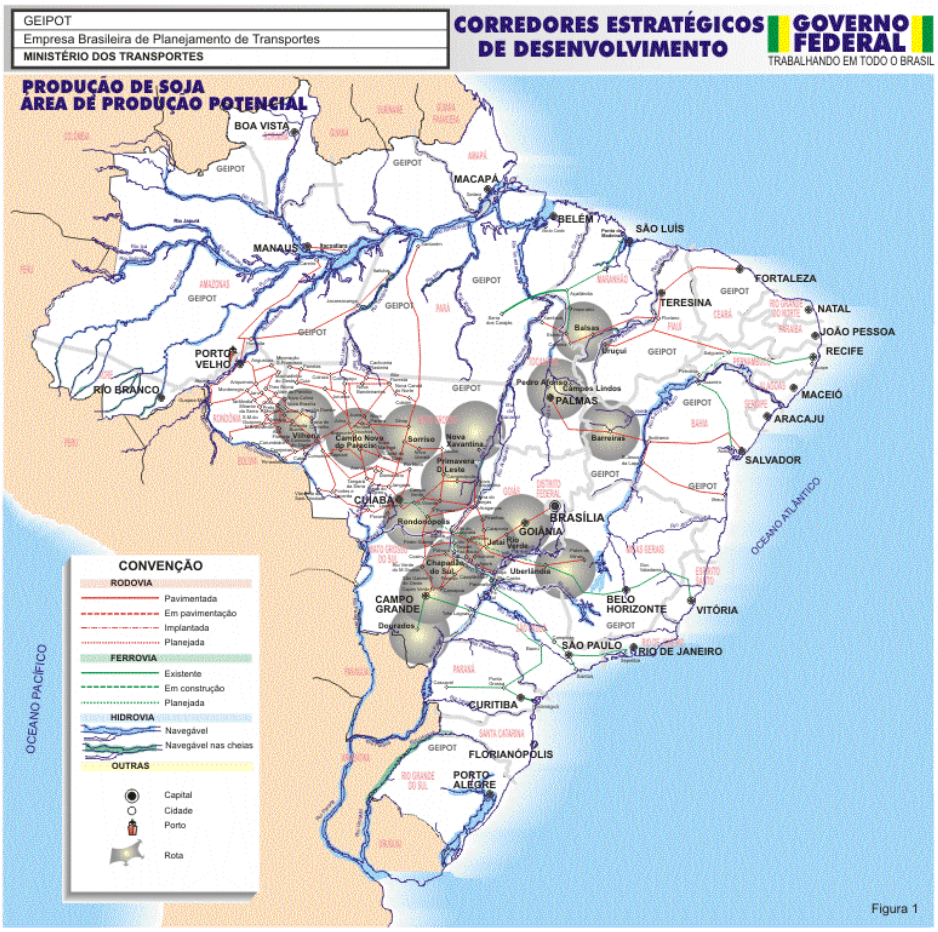


Figure 1 – Soybean Production Potential on the Brazilian Agricultural Frontier
Source: Geipot (2001).

The growth of economic occupation of these areas of the Cerrado is well underway, occurring slowly initially and more rapidly recently, radiating out from regions closest to the Center-South. For example, the area cultivated by soybeans grew from 10.6 million hectares in 1993 to 18.4 million hectares in 2003[2], resulting in the production of 52 million tons. This was aided by the expansion of the agricultural frontier and gains in the competitiveness of traditional regions. Figure 2 illustrates this phenomenon, showing the increasing share of the Midwest region in Brazilian production.

[2] According to the Ministry of Agriculture, Livestock, and Supply (www.agricultura.gov.br, information accessed on 9/17/2004).

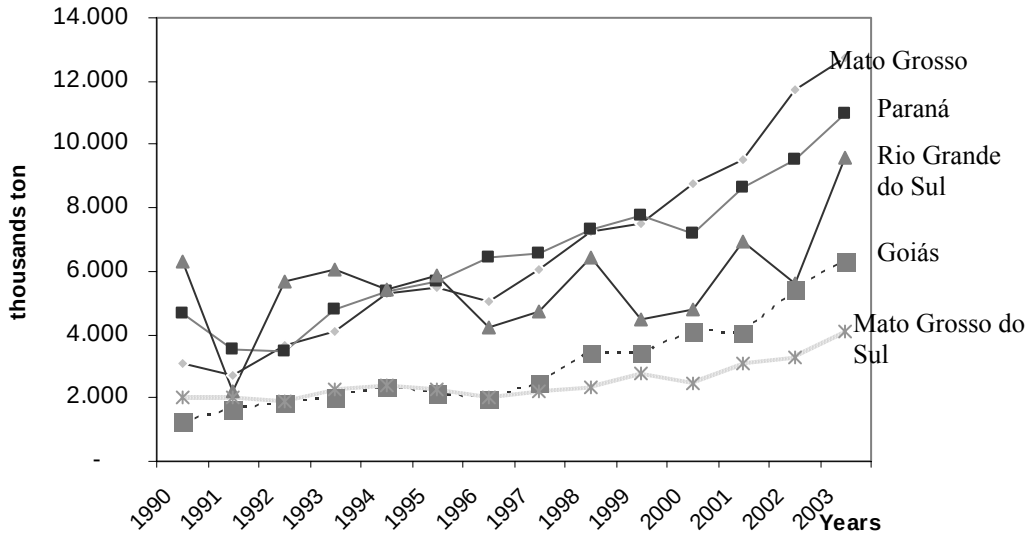


Figure 2 – Selected States' Share of Brazil Soybean Production (1990-2003)

Source: Data from Ministry of Agriculture, Livestock and Supply (www.agricultura.gov.br, accessed on 9/17/2004).

Barbosa and Assunção (2001) state that this expansion process is complemented by events linked to the grains processing industry. A spatial redistribution of the crushing industry has occurred, marked by significant growth in the states of Bahia, Goiás, Mato Grosso, Mato Grosso do Sul, and Minas Gerais. In these states, industrial plants with a greater scale of production have been built, leaving plants located in the states of Paraná, Rio Grande do Sul and São Paulo with high levels of idle capacity.

As a general rule, the development of the transportation system did not meet the infrastructure needs for assisting productive investments in Brazil. Features of Brazil's transportation matrix can be characterized by the following:

- For 80 years, Brazil has had practically the same railway infrastructure;
- A small parcel (just 10 percent) of the highways is paved;
- Of the paved highways, the majority (more than 80 percent) is in a precarious state of conservation according to the National Confederation of Transportation (CNT);
- The inland waterway potential is limited by the geographic location of rivers outside the principal economic corridors, the lack of direct connectivity to the sea, and the existence of hydroelectric power plants; and,
- The port network is basically technologically out-of-date leading to expensive services and low productivity.

An immediate implication of these deficiencies is the increase in logistics costs for the displacement of production. For example, the limited railway infrastructure and its low connectivity bring about potential losses when businesses become highly dependent on

the highway mode. On the other hand, Abdelwhab (1998) obtained results that suggest that the demand for transportation services is elastic in relation to price for almost all groups of commodities and almost all geographic regions of the United States. What is more, the elasticity estimates crossed with the modes were positive, signaling effective competition among the modes. Beuthe et al. (2001) show that agricultural products present high price-elasticities for rail transport, which represent the theoretical preference of this category of products for the rail mode. In Brazil, rail offers limited mileage, connectivity, and coverage of national territory.

On the other hand, the lack of an adequate endowment of infrastructure has the similar impact of effectively protecting from foreign presence. According to Limão and Venables (2002), transportation costs can be possible determinants of trade flows, sensitive to the quantity and quality of infrastructure. Based on a survey of 93 countries, the authors estimated the elasticity of trade flows in relation to transport costs to be –2.5.

The extreme lack of public infrastructure, especially transportation puts Brazil in a curious situation where the limit for expansion of agricultural production is actually determined by logistics and not by the availability of lands suitable for agricultural and livestock exploitation. Conversely, the investments in public transportation infrastructure can have important implications for the new geographic configuration of Brazilian agribusiness by consolidating the processes of economic occupation of the Midwest region and the "cerrado" areas of the North and Northeast regions.

What follows is an elaboration of the insufficiencies of investments in Brazilian public logistics infrastructure and their resulting impacts on the Brazilian economy. The purpose is to reveal evidence of consequences of this shortfall on the logistics and transportation markets that serve agribusiness.

In the sequence of this article, the next section addresses the theoretical discussion of the relationship between public infrastructure and economic growth presenting national and international experiences in which these interactions were subject to empirical tests to prove the relationships. Section 3 addresses the development or agribusiness corridor planning as a development tool. Section 4 presents methodological features adopted in this research while section 5 presents evidence of the impacts of the lack of public logistics infrastructure found in some activities of agribusiness. Finally, some considerations and directions for future research are presented in section 6.

## 2. Public Logistics and Economic Growth

While the causal relationship between public infrastructure and economic growth can be debated (Preston 2001; Leinbach 1995), it is not difficult to find a positive correlation among indicators of these variables.

The principal theoretical matrices of development give public infrastructure a direct, indirect or veiled role in diverse theories of regional development. Public logistics

infrastructure strengthens the process of development as posed by Gunnar Myrdal (Myrdal, 1963) and in the elaboration of Perroux's growth-pole theory (Perroux 1977). It has decisive roles in regional economic base theory (Schickler 1974) and in the theory of stages of economic growth as an obligatory phase (Rostow 1974).

The externalities brought on by public infrastructure lead to better conditions for undertaking economic activity. Directly, public infrastructure, intermediated through certain public services, is also considered a public good as it can improve the well-being and the quality of life of those that consume it. Indirectly, it creates favorable conditions for development of business, industry, and services, increasing output, productivity and at the same time reducing the unit costs of inputs. A higher productivity, in turn, can translate itself into an increase in the remuneration of factors, which stimulates investment and employment. Moreover, an adequate level of public infrastructure can provoke the effect of "crowding in" inasmuch as it brings attractive conditions to prospective private investments.

In this way, public infrastructure can affect the degree of regional development, stimulating or restricting the regional disparities and acting as an element in the decisionmaking process of public and private investment. This is because a greater endowment in public infrastructure raises the productivity of private investments and enhances local comparative advantages, with regard to other locations with less infrastructure. Conrad and Seitz (1997) show that infrastructure can be used as a tool for strategic commercial policy in the case of oligopolistic competition.

According to Martin and Rogers (1995), firms that operate with increasing returns tend to locate in countries with better domestic infrastructure when trade is integrated, eyeing the benefits that come from the advantages derived from economies of scale. As a result, the model developed by the authors suggests that public infrastructure can be used as a strategic tool for attracting industries. On the other hand, Castro (1995) emphasized the issue of logistics in the organization of production processes in order to meet the requirements of consumer markets with regard to quality of raw materials and products, delivery times, technical assistance, and innovation. In this manner, the efficiency of the logistics system becomes a basic condition for competitiveness of all sectors of the economy.

Concomitantly, Benitez (1999) highlights the addition of self-generating growth effects as a consequence of the incentive to individuals and firms when considering location decisions; effects on occupation of new agricultural frontiers; effects on land use via new accesses; and, consequently, economic and financial effects.

Cain (1997) calls attention to the direct and indirect effects of investment on public infrastructure. For example, citing Fogel (1960), the private rate of return on investment of the Union Pacific Railroad had been estimated at 11.6 percent. The social rate of return on the investment was estimated at 29.9 percent when considering the externalities in the form of social costs, such as incentives, expropriations and social benefits, including reduction in transport and inventory costs.

In this context, as part of public logistics infrastructure, transportation systems act as a strategic variable for regional and national development. The externalities of transportation infrastructure act as those elements considered priority in development policies: exploitation of resources, division of labor, increase in land values and large-scale production. In the historical context of the relationship between development and transportation, Fogel (1964) credits the American railroads as the principal variable explaining the spectacular growth of the United States in the 19th Century.

Barat (1969) states that investments in transportation are strategic for economic development policy, principally when their capital-intensive nature is taken into account, notably in regions found in early stages of development.

For Owen (1959), this close relationship between transportation and economic growth permits comparisons among countries in different stages of economic development. According to the author, national transportation indicators, such as paved highway mileage, number of cars per capita, and railroad traffic densities reflect the potential for production of wealth and can serve as indicators of local development.

Recent attention on the effects of public logistics infrastructure on output and productivity provoked the endogeneization of infrastructure sectors in economic growth models. These economic growth models allow the effects of temporary rates of growth, expenditures in infrastructure, and other tools of fiscal policy to be transformed into permanent effects.

Inside this new paradigm, some studies seek to delineate the effects of public investment on output and total factor productivity. In a seminal work, Aschauer (1989) demonstrated the effects that public infrastructure has on productivity gains of private investment. Aschauer estimated that an increase in 1 percent of public capital brings about a corresponding increase of 0.35 to 0.49 percent in factor productivity, while the elasticity of total output was estimated between 0.36 and 0.39 percent. Easterly and Rabelo (1993) estimated that the investment in transportation and communication appear to be consistently correlated with growth and possess elevated coefficients with no evidence of crowding out between public- and private-infrastructure investment.

In studies of Brazil, Ferreira (1996) evaluated the relationship between public infrastructure and aggregate income for the period from 1970 to 1993. In addition to showing the statistical co-integration between public capital stock and output, the income-elasticities showed coefficients ranging from 0.34 to 1.12 percent.

Benitez (1999) noted positive correlations between productivity and public infrastructure from Brazilian economic data, where a 1 percent increase in the rate between the infrastructure endowment and the endowment of labor and capital increases the factor productivity by 0.28 percent. This implies, therefore, an elasticity of 0.28, when all Brazilian states are considered.

Relationships between transportation and economic growth were also estimated. For the Brazilian Cerrado Lands, Castro (2001) found elasticities of agricultural production in relation to transport costs and roadway densities to be –0.21 and 0.33 respectively.

## 3. Corridor Planning in Agribusiness

In Brazilian agribusiness, the trade corridor has existed as useful planning unit and geo-economic space of contestation. The Brazilian centralized planning of the first National Development Plan (I PND) established working groups to develop policies to facilitate and open export trade corridors. Of fundamental importance, the transportation corridor was considered to be a segment of the transportation system linking areas or poles, which should exchange goods and services in the future (Barat 1972). The growth aspects and future traffic densities justified the capital-intensive investment in technologies of cargo handling, storage, and multimodal transport. The corridor as planning unit articulated and linked multimodal transportation investment (rail, inland waterway, seaport, transshipment terminals, pipelines, trunk and feeder highways) with industry (IPEA 1972). Corridor planning of the early 1970s had clear linkages to the need for investment in capital equipment and new technology, especially as it related to unitized and bulk cargoes.

Modern conceptions of corridor have evolved from transportation to encompass a more holistic supply chain focus drawing together the array of services and assets needed to for trade to take place. In this context, a trade corridor can be broadly defined to cover a geographical designated area over which significant trade flows from a given origin of production to a given destination across a transportation infrastructure met with a variety of services and linkages to labor, capital, production, and consumption. A trade corridor's components include:

- a commercial infrastructure comprising distribution and warehousing facilities, foreign trade zones, a regulatory system for customs and inspection, and trade incentives;
- an integrated regional technological infrastructure;
- business and professional know-how and expertise;
- well-developed social, political, and business linkages;
- a physical infrastructure of highways, rail, air, sea, pipeline, and inland waterway;
- direct access to multiple markets, and specific legislation and regulation (Boske and Cuttino 2003).

Transportation services are integrated in the processes of production, distribution, and consumption (Pedersen 2001). In this way, as systematized by Nielsen et al. (2003), the transportation systems are considered as an integral part of the supply chain and, thus, submitted to aggregate objectives at the regional or industrial levels.

Through corridor analysis of agribusiness activity, transportation of freight along a corridor can be viewed with attention to the policies and institutions that facilitate or impede such carriage. Thus, as Krugman states, policymakers see how "nations

matter…because they have governments whose policies affect the movement of goods and factors (Krugman 1991)." In the Brazilian context, insufficient investment policies can negatively affect the said movement of goods and factors.

Several analytical approaches insert themselves into an evolving concept of trade corridor. The "new economic geography," most closely associated with Krugman (1980, 1991a, 1991b), draws from theories of imperfect competition and information asymmetries to explain firm interest in increasing returns to scale, agglomeration economies, transport costs, and market access. From the business perspective, Michael Porter's assertion that "firms not nations compete" has crystallized the need to contemplate competitiveness across entire supply chains with transportation filling a fundamental role (Porter 1990). This has not only brought an interest in expanded market access, but also in improving competitive advantage across supply chains through the promotion of economic clusters of related industries and local productive arrangements (Porter 2003).

Much more evident in current times, the competitiveness of regions and countries in global markets is extremely sensitive to the impacts of changes in transportation systems. The mobility of people and goods are profoundly altering some aspects on which comparative and competitive advantages of regions are dependent. According to Nielsen et al. (2003), transportation networks can be considered as "locomotives" of new industrial systems and spatial organization. The endowment of public logistics and transportation infrastructure within trade/transport corridors are fundamental attractors of further development.

Recent corridor planning in Brazil anchored infrastructure investment in the late 1990s in eight federally designated priority corridors (GEIPOT 1999). The Brazilian multi-year budget plan, *Brazil in Action* (*Brasil em Ação*-1996-1999) and *Forward Brazil* (*Avança Brasil*-2000-2003) located these investments into federally designated corridors, dominated by the agro-export corridors delineated by GEIPOT and the Transportation Ministry. It is worth noting that many projects included in *Brazil in Action* were inherited policy legacies of unfinished public works. In that sense, the 42 projects (15 multimodal) represented a second-best strategy in the face of scarce resources.

During execution of *Brazil in Action*, the Ministry of Planning in conjunction with the Brazilian National Development Bank (Banco Nacional de Desenvolvimento Econômico e Social, BNDES) hired the *Consorcio Brasiliana*, comprising a construction and engineering firm, a management consultancy, and bank (Bechtel International, Booz Allen & Hamilton, ABN Amro Bank), to rethink Brazilian geo-economic space. The resulting project, the National Integration and Development Axes Study (*Eixos Nacionais de Integração e Desenvolvimento*) broke with the traditional corridor construct to stress analysis of real flows of goods and services and the derived demands placed on public service delivery and the environment. The next multi-year development plan, *Forward Brazil*, formally incorporated the axes, *eixos*, as planning unit, codified in budget and management.

The Brazilian concept of the development axes marks a qualitative leap in planning and programming, despite the difficulties to integrate this approach with a broad regional integration of the national territory. As late as the 1970s, some attempts in Brazil at delimiting a corridor area of influence were as simple as marking a 50-km radius from major highway routes (IPARDES 1975). As the transport corridor concept developed by GEIPOT evolved from the 1970s to 1990s, it stressed the actual and future flows of just a handful of select commodities. These corridor drivers include soybeans and derivatives, cattle, sugar, coffee, and steel. The GEIPOT analysis centers on these sectors' demand for transportation services while seeking to minimize transport costs, energy consumption, and damage to environment.

Despite domestic problems with securing public logistics investment, the Brazilian concept of integration axes has taken hold at the hemispheric level, being the basis for the creation of the South American Community of Nations at the meeting of the Heads of State in December 2004 in Cuzco, Peru. During the August 31-September 1, 2000 Meeting of the Heads of State of South America in Brasília, the Initiative for the Integration of Regional Infrastructure of South American (IIRSA) was launched identifying the 11 development axes that figure prominently in the South American Community of Nations. Important as the backbone in formation of this strategy in South America is the role of the multilateral development banks, such as the Interamerican Development Bank, which in 2000 published a position paper identifying the need to:

> **…complement its direct financial support with the creation of necessary conditions to attract the largest possible volume of private sector investment and financing, particularly in the following areas of activity: the design of integrated initiatives for the development of regional infrastructure based first and foremost on the identification of "integration and development corridors" throughout the continent** (IADB 2000).

The defined axes now are structured on trade and transport corridors and comprising bundles of integrating investments across various sectors. The logic of Brazilian transportation corridor planning of the 1970s and 1990s and that of the new IIRSA requires coordinated investments in public transportation infrastructure. With insufficient investment to link integrating projects, the result will be poorly structured corridors. Not only will planned corridors not achieve the desired goals related to agribusiness, corridors with insufficient investment may shape corridor development in ways that exacerbate regional inequalities and skew the choice of transportation mode in agribusiness away from the theoretically more appropriate mode. It is a situation of multiple negative externalities leading to higher costs, saturation and congestion along those transportation systems that exist reducing existing competitiveness, great opportunity cost vis-à-vis investment in other areas (social policy, industrial policy), and loss of the value of transportation investment made to date in unfinished public infrastructure among other factors.

## 4. Methodological Features

This paper can be characterized as an exploratory investigation that seeks to link the deficiencies in public logistics of transport infrastructure to their impacts on the logistics of Brazilian agribusiness. Such relationships will be supported by theory and data on agribusiness freight rates in addition to evidence addressing the determinants of transport costs along transportation and agribusiness corridors. Also worth noting are investigations into the existence of seasonality of freight rates.

It was studied freight rates along the Santos (São Paulo), Paranaguá (Paraná), São Francisco do Sul (Santa Catarina) and Rio Grande (Rio Grande do Sul) corridors as well as the Paraná agribusiness corridors vis-à-vis their influence on corridors and commodities (sugar, coffee, soymeal, corn, soybeans and wheat). Based on the available data, average freight rates were calculated by distance (kilometers) in the following units 0-200 km, 200-400 km, 400-700 km, and greater than 700 km.

Relative to the statistical analyses, an analysis of variance test was applied with the objective of testing the statistical significance of transport costs in the different corridors studied. When the null hypothesis is accepted that HO: $\delta=0$ it can be concluded that the average transport costs between two corridors/commodities are equal. When, however, this hypothesis is rejected, the transport costs are distinct. In other words, over the same distance, the freights are different.

Nevertheless, when the null hypothesis is rejected HO: $\delta=0$ , the alternative hypothesis is accepted Ha: $\delta\neq0$ where the transport costs among the corridors/products are different.

This study includes tests for seasonality of transport costs, having as a base the principles of harmonic analysis. The analysis of seasonality developed in this research was based on a time series of transport costs for coffee, soybeans, soymeal, and wheat along different routes in Paraná and other states that had a Paraná point as origin or destination. Data are considered seasonal when containing components with systematic behavior within a determined time period. This could be related to weather conditions, calendar, agent behavior, and, in the case of this study, agricultural harvests.

The transport costs for these studies and for the evidence presented in this article are taken from the System of Freight Rates for Agricultural Cargoes (SIFRECA) of the Center for Applied Economics of the School of Agriculture "Luiz de Queiroz" of the State University of São Paulo in Piraçicaba (ESALQ-USP). SIFRECA includes freight rates from numerous origin/destination pairs in Brazil for agricultural cargoes over the period 1998-2004, organized by distance in kilometers.

## 5. Freight Rates: Theory and Evidence from Brazilian Agribusiness

The forces that influence the markets for freight are diverse and of a sufficiently differentiated intensity in light of the specifications of regions and cargoes. Generically,

the factors that influence the formation of transport costs can be organized into two groups. A first group consists of factors that affect the demand for transportation directly. The second group comprises factors that affect the costs of service provision, influencing demand in an indirect form.

Among the factors of the first group, the performance of the economy can be highlighted as demand for transportation is normally "derived demand". According to Ramanathan (2001), in India the movement of cargoes grows at a rate superior to that of industry as the industrial income-elasticity of transportation demand is estimated at 1.183. Malliagros (1997) estimated the aggregate income-elasticity of demand for transportation services in Brazil to be 0.57.

Other variables also exert influence on the movement of cargoes:

- Business strategies (location decisions, management policies for production of stocks and consolidation of cargoes);
- International trade institutions, such as Mercosul and NAFTA;
- Materials for packaging (innovations in much lighter and more resistant materials);
- Legislation; and,
- Management of reverse flows (unusable tires and chemical/pesticide packaging for recycling).

Some factors in the second group influence demand for transport via costs and services. These include compliance with regulatory requirements, deregulation, fuel prices, vehicle standards, weight limits and congestion.

The supply of transport has modernized in accordance with trends in business management to which it offers its services. According to Janelle and Buethe (1997), transportation demand incorporated some aspects in response to globalization. These include:

- Longer distance and more direct services;
- Greater time sensitivity for operations of loading and discharge;
- Greater reliance on communications and computer networks;
- Velocity in movements and transactions; and,
- Standardization of equipment and procedures.

Some studies have shown evidence of these new impacts on transportation demand. In Europe, Nielsen et al. (2003) state that in the last decade the structure of growth in demand for transport changed in several ways, the most important of which refers to the modal shift of cargo from train to truck and the growth of logistic networks. An explanation for this can be related to changes in the demand induced by logistics factors, especially the increase of flexibility of production and distribution structures and infrastructure improvements.

The new pattern of production systems requires newer and greater demand for transportation. In this way, transportation costs cannot be seen as an isolated element, like post-production, as previously considered by location theory, but instead as integral part of the production process. For example, Arcelus and Rowcroft (1993) state that the implementation of just-in-time supply strategies is often made impossible by increases in total logistics costs occurring as a result of higher unit costs of transport ($/ton) as shipping volumes decrease.

The different transportation modes should be seen as parts of the trade/transport chain, inserted in global strategies, together with management of inventory, packaging, shipping and insurance. In other words, insufficient investments in transportation systems normally lead to an unsatisfactory supply of transportation and logistics services, increasing the transport costs and preventing desirable intermodal practices over extremely long distances, as in the Brazilian case. On the other hand, it also inhibits the quality of services, prolongs travel time, increasing the needs for cargo handling and generating additional costs with robust information systems, such as satellite tracking systems that monitor the transport fleet. All of these factors influence the perceived and actual attractiveness of the Brazilian agribusiness corridor.

### 5.1 Evidence from Brazilian Agribusiness

In the search for explanatory variables of market freight rates, several approaches can be identified that consider distance as the principal factor for determining the price, independent of chosen mode. Correa Junior et al. (2001), citing Beilock et al. (1996) also affirms that, in general, studies that seek to identify the determinants of highway trucking costs are primarily dependent on distance and adjusted for other factors. The distance traveled influences the unit value of transport in the freight rate per ton (R$/ton), implying sensitivity of price in relation to distance traveled.

Some studies estimated coefficients that measure this relationship for Brazil. Castro (2002) states the estimated coefficients for the impacts of distance on the composition of freight rates to be 0.0366 for highway transport, 0.0154 for rail transport, and 0.0328 for inland waterway transport. Correa Junior (2001) found the coefficient specific to highway transport of soybeans to be 0.036. And Teixeira Filho (2001) estimated the relationship of freight rate to distance by shipment arriving at 0.0135 for highway mode and 0.6253 for rail mode.

In the case of Brazilian agribusiness, table 1 illustrates that greater distances bring greater unit costs of transport (US$/ton). Therefore, it can also be observed that the remuneration per ton-kilometer traveled (US$/ton kilometer), the spot transport cost, moves in an inverse pattern. This is the so-called principle of economy of distance, proven by McCann (2001) and will have more or less intense occurrences according to the competition and contestability of markets (Davies 1986). In Brazil, the decrease is sufficiently abrupt and shows the competitiveness of highway transport over distances that, in principle, ought to be more appropriate for rail, inland waterway and cabotage. This also reflects the excess supply of trucking services for highway transport (figure 3).

**Table 1: Soybean Transport Costs in June 2004**

| Origin | Destination | km | US$/ton | US$/ton.km |
|---|---|---|---|---|
| Rio Verde – GO | Jataí – GO | 88 | 3.50 | 0.0397 |
| Rio Verde – GO | Orlândia – SP | 547 | 12.40 | 0.0227 |

**Source**: Sifreca.esalq.usp.br.

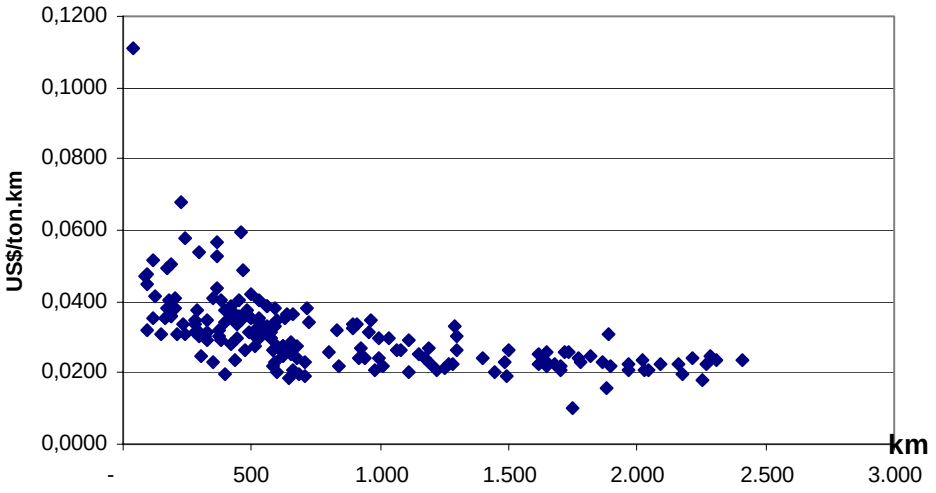


Figure 3 – Behavior of Soybean Transport Costs US$/ton.km (May 2004)

Source: Data from sifreca.esalq.usp.Br

In addition to intrinsic factors of the trucking market, the above also reflects the lack of investment in public infrastructure. The low remuneration per ton-kilometer accepted by the highway mode over distances greater than 1,000 km inhibits the demand and viability of rail over distances theoretically more compatible for the rail mode. This limits the feasibility analyses for rail investments in branch lines and trunk line expansion. In the case of inland waterways, the demand is stunted by the limited availability of storage (warehouses and silos) and irregular offer of service, in combination with conditions imposed by nature such as geographic location of the river basins.

The historical legacies of lacking investment in transportation infrastructure (highways, waterways, rail, ports, intermodal terminals and warehousing) have come to favor the dominance of highway transport and trucking. This comes in contrast to the principles of transportation economics that would favor a transportation matrix involving intermodal transportation or use of alternatives, such as rail or waterborne modes, for carrying low value-added agricultural commodities over great distances (Cann 2001). As a result of these distortions, effective competition among modes occurs over extremely short distances, more appropriate for highway transport, as in the case of the movement of soybeans between Maringá and Port of Paranaguá in the State of Paraná (Martins 2004b).

The lack of investment at necessary levels to make all modes viable and the inadequacy of investment in highway maintenance affect practically all sectors of the economy. Freight costs are formed along corridors (Martins 2004a) resulting in a negotiation among shippers, transport operators and agents, attentive to volume and cargo requirements associated with specific transportation assets. As a result, some cargoes pay freights associated with the soybeans market, even though they may not have the same market value.

In the context of agribusiness, for example, we have tested the hypothesis that the transport costs of soybeans influence the formation of transport costs for other commodities. Martins verified the influence of soybeans on the transport of wheat over distances of 200-400 km and 400-700 km along interstate corridors when the routes included origin/destination points outside of Paraná. In the transport of corn, the interference of soybeans was verified for distances of 200-400 km and 400-700 km, even though the harvests occur at similar times. For soymeal, soybean movements influenced transport costs for distances between 200-400 km and 400-700 km.

Taking into account the large volumes of Brazilian soybeans transported, which confers prominence to shippers of these cargoes, the lack of infrastructure overburdens the transport system during harvest periods. As a result of the seasonality of demand and the lack of an adequate supply of public logistics, transport costs follow peak-period pricing for services. During harvest times, costs are much higher in the month of March (peak summer harvest month) than in non-harvest periods of November (see table 2). In this case, seasonality reflects the lack of modal choice in regions with substantial conditions for expansion of agriculture and livestock production, as is the case in areas of the Brazilian Cerrado.

**Table 2: Trucking Costs for Soybeans on the Jataí (GO)- Uberlândia (MG) Route (November 2003 and March 2004)**

| Month | R$/t | R$/t.km |
|---|---|---|
| Nov/03 | 11.03 | 0.027 |
| Mar/04 | 14.24 | 0.035 |

**Source**: Informe Sifreca, 7(80), December 2003 and Informe Sifreca 8(84), April 2004.

While noticeable in a graphical analysis, proving seasonality statistically is not an easy undertaking. We developed tests for various commodities over several distances that did not yield statistically significant results for identifying seasonal behavior. In an estimation of transport costs on Paraná routes between 200-400 km, graphically (figure 5), the data are relatively well synchronized. Nevertheless, a reasonable adjustment of the statistical model was not obtained. Graphically, peak transport costs can be observed for the month of April, but statistical proof of seasonality for this period could also have been affected by recently observed changes in the marketplace.

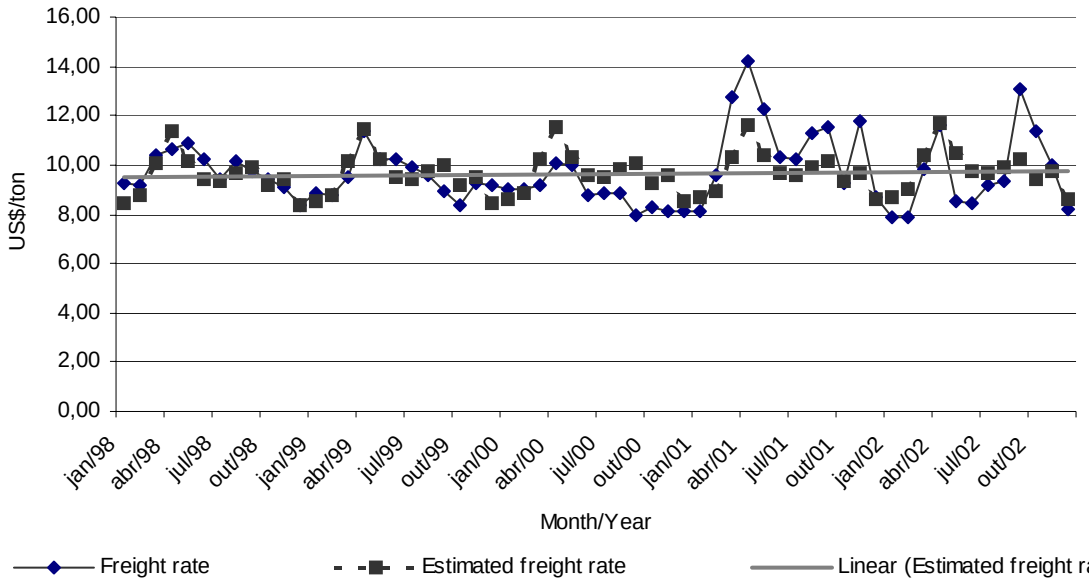


Figure 5- Real and Estimated Transport Costs – Soybeans along Paraná Routes of 200-400 km (1998-2002)

Among market changes related to unstable economic environment are different market strategies for negotiating harvests. First, at times of unexpectedly abundant harvests (so-called "superharvests'), there is a significant increase in demand for transport. This occurred in 2001 when there was static storage capacity. The surplus production had to be marketed and sold at the moment of harvest thus overburdening the market. Secondly, harvests that happen as expected and in volumes programmed for commercialization, exhibiting increasing prices or favorable exchange rate conditions, provoke retention of production. This happens as the market speculates on conditions of sale that continue to improve, leading to strategies that deplete storage capacity that could be utilized by corn and soymeal, as occurred in Paraná in 2002.

The lack of public logistics is a typically Brazilian variable, additional to the complex freight markets. It produces substantial differences in transportation costs. As the results have stated, congestion brought about by the lack of modal choice and insufficient storage leads to a differential formation of freight rates among regions. It also creates disputes among shippers of varied cargoes for transport services that have the effect of leveling the transport costs of commodities with different market values, as in the case of soybeans interfering with corn. This is a symptom of the unequal distribution of the stock of public infrastructure (Barros and Raposo 2002).

We concluded that transport costs differentiate themselves on corridors of the Brazilian Center-South (figure 6). The higher rates are practiced on routes with destination Santos. As a result of the geographic location, data suggest that transportation logistics structured to serve the Port of Rio Grande are well consolidated, handling easily predictable volumes with little power to attract cargoes from other regions, such as the Brazilian

Midwest. In other words, the freight market in the area of influence of the Port of Rio Grande is less susceptible to demand shocks. This can be attributed to the competition of inland waterway and railway modes available to the productive regions in the interior of Rio Grande do Sul. In the case of other corridors, the availability of other modes notwithstanding, soybeans compete for the available vehicles that also serve equally seasonal cargoes that coincide with soy, such as cotton and sugar in addition to other regular cargoes like coffee that are transported year-round.

The higher costs attributed to cargoes with the destination of Santos also suggest a greater premium is placed on accessibility to foreign markets. With more diversified services to foreign destinations than any other Brazilian port, cargo has more alternatives. Santos is also less limited to physical restrictions, such as landside access, cranage, berth lengths, or draft than alternative ports. Moreover, as the most consolidated Brazilian port with the greatest number of fixed-day services, the likelihood for backhaul cargo is greater, making routes with origin/destination Santos more attractive for transport operators and the autonomous trucker. Embedded in the data may be the influence that liner companies and ocean transportation providers have on freight rates by their selection of specific ports of call.

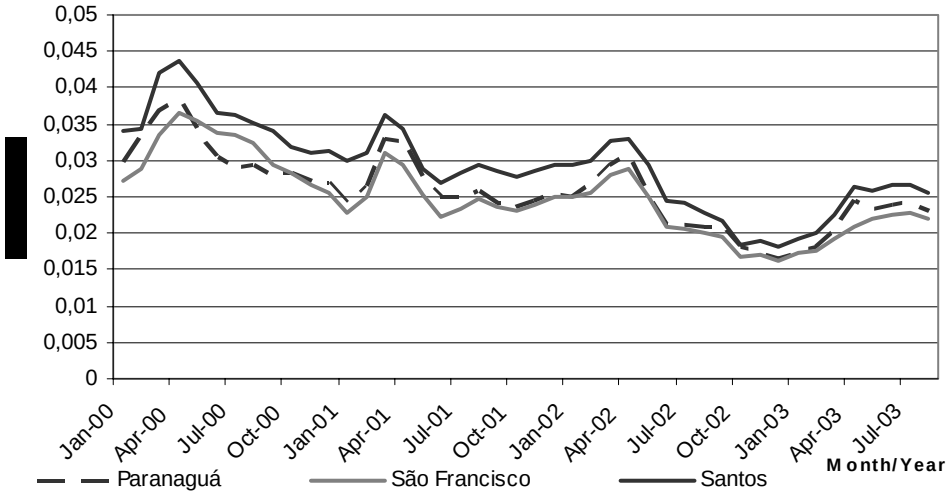


Figure 6 – Evolution of Soymeal Transport Costs along Principal Export Corridors for Distances Greater than 1,201 km (February 2003-August 2003)

## 6. Final Considerations

The objective of this paper was to elaborate on the consequences of insufficient investment in Brazilian public logistics and search for evidence of impacts in the logistics and transportation markets serving agribusiness. Considering the great availability of suitable land in regions with unsatisfactory transportation networks, Brazilian agribusiness potential is limited, first and foremost, by the lack of public logistics, especially transportation infrastructure.

Such restrictions have especially severe impacts on the economy. The logistics deficit is creating certain linearity in market transportation costs, with profound effects on low-value cargoes. Even industrial sectors devoid of seasonality of production witness effects brought on by cost increases. Regions with better locations vis-à-vis agribusiness logistics (such as proximity to ports and consumption centers) are paying higher transport costs in virtue of the saturation of their transportation network because of its relative desirability not to mention the lack of alternatives for repositioning. As a result, the producer loses income, large companies lose competitiveness, and the consumer pays higher prices for the products.

Because of these restrictions in the quality of services, shippers have defined new strategies for contracting freight rates, with lesser emphasis on price and more emphasis on reliability and security. Increases in general costs, among them, transport costs and tolls, combined with the inflexibility of international prices and insufficient storage and warehousing at ports, have spurred businesses to change management practices with regard to negotiating freight rates. Businesses are searching for more established service providers reducing negotiation with independent truck operators, offering cargoes with year-round frequency for a more secure contractual relationship that makes planning a logistics strategy viable.

As agribusiness was conceived in terms of developing export trade and transport corridors, it is worth noting the perverse effects of failing to complete investment projects. First, Brazil is unable to achieve the theoretically rational allocation of mode choice. Where effective competition for transport service exists among modes, it favors the highway mode and prevents growth and investment in multimodal transport (rail, inland waterway, cabotage). Second, this places increasing pressures on the private sector to find alternatives, leading to a race to the most consolidated and diverse infrastructures, such as those presented at the Port of Santos. As a result, the lack of viable alternatives drives prices up and adds to congestion, reducing system competitiveness. Continuation of such scenario could lead to a system collapse. Table 2 illustrates the differences between a functional trade corridor and the Brazilian experience.

It is understood that the consolidation of this new scenario could lead to a vigorous concentration not only in the transport industry but also in agribusiness per se. In this situation, the changes bring about voluminous sums of resources accessible only to big business. This has already been observed in the Midwest where large shippers with national scope recently defined a new logistics strategy to invest in origin storage and warehousing in order to locally receive the harvest. In addition to this, agribusiness firms have developed their own logistics, with investments in railways, inland waterways, rolling and floating stock, and terminal and warehousing infrastructure.

In general terms, public logistics plays an important strategic role for the growth of agribusiness corridors in agricultural frontier areas in the Midwest, North and Northeast. However, corridors with not enough transportation infrastructure to drain production may

bring the compound effects of raising costs, losing business opportunities, and reducing income. A well-planned corridor beset insufficient investment may have the effect of adding to poverty and regional imbalances instead of promoting growth. In this respect, it is worth noting the difference between a transportation corridor and a trade corridor. Trade may or may not take place on a determined transport corridor. Trade requires transport along with a host of other facilities and services. In the case of Brazil, the risk is creating many pockets transport corridors where, for the lack of investment, no significant trade takes place at great cost to agribusiness and the public well-being.

Table 2 compares ideal trade corridor with Brazilian reality.

**Table 2. Comparing Ideal Trade Corridor with Brazilian Trade Corridors**

| Functional Corridor Features | Brazilian Corridor Features |
|---|---|
| • Covers wide geographical area with regionally significant trade flows. | • Covers shorter geographical areas with dense trade flows, concentrating transport demand along limited infrastructure. |
| • Aids economies of scale with access to multiple markets | • Market access for economies of scale limited to immediate region, leading to proliferation of distribution centers with limited scope. |
| • Commercial infrastructure, including storage, distribution, customs, and professional services | • Scarcity of commercial infrastructure outside the primate ports (Santos) and Southeast region resulting in saturation and congestion along trunk infrastructure (road, rail) connecting to principal ports. |
| • Rational modal choice, sensitive to economy of distance | • Perverse transport matrix, favoring highway mode for lack of viable alternatives. |
| • Connects to multimodal transportation infrastructure offering wide modal choice (ports, highway routes, rail, intermodal, inland waterway, pipeline) | • Connects to few ports, fewer intermodal opportunities |
| • Competition among modes brings cost reductions, opens business opportunities, and generates positive externalities | • Modal competition only over short distances. Lack of competition along with concentration on specific infrastructures leads to higher costs and lost opportunities. |
| • Trade corridor an asset for business location | • Trade corridor's lack of infrastructure a deterrent for attracting industry. |
| • Rule of law and regulatory framework facilitates intermodal transport operations | • Lack of effective implementation of multimodal regulatory framework inhibits intermodalism and favors trucking. |
| • Functional public infrastructure is a strategic component, asset, and opportunity for a firm's supply chain, adding value. | • Lack of public infrastructure is an obstacle to growth. Actually, in perverse sense, unintended effect of poor landside port access result in vehicle queues that serve as storage facilities in absence of port storage and warehousing capacity. |

In this context, we must consider the relationships among inventory management, location of facilities, and the simultaneous determination of transportation policy in a distribution network environment that results in a significant loss of freedom in determining logistical strategies for supply chain management.

**Directions for Future Research**

Over the years, considerable research has been undertaken to examine the linkages among public infrastructure, the efficiency of freight transportation, and the economic performance of nations and their regions. Three broad analytical approaches have been used to examine these linkages: macroeconomic; microeconomic (partial equilibrium); and general equilibrium. A high proportion of research studies have been macroeconomic analyses, focusing on the aggregate contribution of transport infrastructure to the larger economy. As we have seen elsewhere in this paper, these analyses have identified to various degrees a persistent, positive influence of transportation infrastructure investments on economic performance. Brazil occupies a privileged position in global agribusiness as it has vast areas of the Midwest and Northeast suitable for expanding its agricultural frontier. The positive influence that transportation infrastructure investment can exert on regional economic development in the Brazilian case, however, is limited by the inadequacies of public logistics.

While it is certainly important to know that public infrastructure and other transportation investment programs are conferring economic benefits to identifiable economic sectors, regions and nations, macroeconomic analyses do little to increase our understanding about the actual mechanisms and processes through which these benefits arise. More detailed micro-level research into the performance of transportation systems in Brazil can help reveal a greater understanding of these inadequacies and potentials. Microeconomic research, particularly benefit-cost analysis within the context of specific transportation corridors, has yielded detailed information on short-term (first order) benefits that are derived from investments in infrastructure projects: transportation provider operating-cost savings, accident reductions, travel-time savings, and positive environmental impacts. Nevertheless, future microeconomic analyses need to examine the nature of longer-term second-order and third-order benefits. Second-order benefits include the gains from improvement in logistics such as rationalized inventory, stock location, networks, and service levels for shippers. Third-order benefits include the effects of improved product quality and the introduction of new products. Other effects worth investigating and probably are of great interest to policymakers include likely increases in regional employment and increases in the rate of growth in regional income. Integrating the first-order benefits with those second-and third order benefits into a spatial analysis present greater research opportunities for examining questions of impacts, diffusion, and learning.

Many of these issues can be best answered by conducting *ex post* assessments of public investments in transportation infrastructure projects in which one can determine: to what extent did improved infrastructure increase specialization and expansion of markets?; to delineate the manner in which freight transport providers took advantage of improved

infrastructure to offer cheaper and better services; to ascertain what logistical and locational innovations followed after the project's completion; and to show how these adjustments translated into higher regional productivities and incomes. As has been shown in this paper, transportation corridors (via analysis origin/destination freight rates) lend themselves well units of analysis for *ex post* assessments and comparisons in addition to their common use in planning, economic impact, or feasibility studies.

A different direction for future research concerns mechanisms for funding necessary transportation infrastructure projects. It was previously mentioned in this paper that agribusiness firms are developing their own long-term logistics strategy when confronted with the lack of adequate public infrastructure. Virtually every country in the world currently is experiencing inadequate public transportation funding. This phenomenon has sparked research in the United States, Europe, and elsewhere which examines innovative funding techniques, especially public/private partnerships (PPPs). The opportunity should not be lost to vigorously pursue this line of research in Brazil and elsewhere in light of government policies focused on PPPs (Public-Private Parternship) with far reaching externalities. Research is needed not only to ascertain the distribution of benefits among participating partners, but also to determine the investment priorities of the various partners. For example, private-sector transportation firms will have their own investment priorities to address their systemwide investment needs. These priorities will factor into their willingness to participate in the financing of specific infrastructure investments. A larger implication is that future research of innovative funding of transportation infrastructure needs to address entire transportation networks, not just individual projects or corridors. Following this line of research can also aid in generating more diverse types of data used to measure impacts, efficiency, effectiveness, system performance as well as identifying shortfalls and bottlenecks.

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