FORECAST FOR THE DEMAND OF GRAIN TRANSPORT AND POSSIBLE INFRASTRUCTURE BOTTLENECKS IN THE STATE OF PARANÁ

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ABSTRACT

Demand forecasts can be used to identify the needs and priorities of investments in transport infrastructure allowing a better use of resources with optimized management and operation. Given some singularities of agricultural commodities, transport rationalization has strong economic repercussions, an issue of special concern for the State of Paraná. The general objective of the present study was to provide a prognosis referring to transport demand and planning for corn, soya bean and soya meal in the State of Paraná. Linear programming models were used to estimate the potential grain production, the inter-zone flow, and the optimized modal distribution for the goods in Paraná. As a conclusion, the urgent review of the State Highway Planning System is evident, with stimulus to railway expansion, maintenance of the modernization process of Paranaguá Harbor, and the strengthening of the logistic service companies specialized in the problems of agribusiness in order to increase the States competitiveness when compared to others that invest in infrastructure.

Key words: Agribusiness, Agroindustrial logistics, agro-economy of Paraná.

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1 Introduction

A series of "crowding" in effects in investments are associated to the transportation sector. The adequate availability of services in this activity can provide other sectional investments, which can lead to regional development through allowing economic expertise and acting as an important propulsive power in the decision making process concerning the placement of industrial productive units. (Martin & Rogers, 1995).

Mello (1984) calls attention to the singularities involved in agro-business and transportation. Given some peculiarities of agricultural raw materials, such as seasonality of production and consequent seasonality of transport demand, perishable products, strong sensitivity to international prices and spatially dispersed production, plans for increased grain production require simultaneous plans for transport and storage.

Transport also constitutes one of the recent worries to Brazilian traders because of its importance for the so called "Custo Brasil". Due to inadequate availability of transport infrastructure and concentration of highway transport, there are several times in which the production achieves low costs, but the Free on Board (FOB) price does not match the conditions of international markets.

The problem is especially important in the case of the State of Paraná since the agro-business is so relevant in the income of the State economy, with emphasis on the grain production and industrialization The rationalization of the transport system results in increasing the income of producers and favoring the production regional specialization, due to the distances the products must go and the transport costs' share in the final price of grain products (Miklius et al., 1976).

According to Gonçalves & Kawamoto (1995), predicting transportation demand can be an important tool for planning freight transport, a relatively recent and less extensive preoccupation compared to passengers. In the case of Paraná, where transport infrastructure is private, information of this nature may serve as signs for private investments and government planning, and can imply important gain in competitiveness for the state production.

Thus, the general objective of the present study is to provide a prognosis of transport demand for of corn, soya bean and soya meal in the State of Paraná for transportation planning.

2 Materials and Methods

This section's goal is to introduce the theoretical approaches, the concepts, and the procedures adopted in this study. The data was processed by the software General Algebraic Modeling System (GAMS) (Brooke et al., 1996).

2.1 Studies on Transportation Demand

The identification of transportation demand is a first step towards the identification of bottlenecks, investment prediction, and the possible actions in transports planning .

The analysis of transport demand is performed based on the economic theory of demand and is adopted to express a need for transport. The need for transport is felt in the volume of real or potential traffic.

This analysis is the process of relating the needs for transport to the economic activities which create them, and its main purpose is to understand the determining facts, and the way in which they interact and affect the evolution of traffic volume.

Different approaches can be used in the analysis of freight transport demand. The microeconomic approach deals with transport as sub-product: the firm may require the transport of certain merchandise, becoming, thus, a consumer of transport. The spatial interaction models are made operative from merchandise surplus and deficits associated to points in space , allowing the identification of possible freight flows between points with surplus supply and surplus demand. The problems are usually presented in the form of severity and mathematical optimizing models. This is the case of the studies performed the Brazilian Group for Transport Planning (GEIPOT). The macroeconomic models, on the other hand, presuppose a relationship between the sectors of economy, being transportation one of them, and are commonly analyzed with the help of the input/product models, as in the case of the analysis of impact of MERCOSUL on Brazilian systems in Resende et al. (1997).

In the microeconomic analysis of the transport activity, the basic supposition that involves the transportation services is that a firm uses transport either to obtain inputs, or to distribute its products. In this sense, according to Kanafani (1983), the microeconomic approach must take into account the firms demand for an input and then derive the demand function for transport, from the product's production process, specifying the technological level and amount produced.

The initial steps to obtain the transport demand are given by the production and costs functions. In the production function, P, where the product is given by (1)

$$P(\mathbf{Z}, \mathbf{X}) = 0 \qquad (1)$$

where $\mathbf{Z}$ is the vector of products and $\mathbf{X}$ is the vector of inputs. Within economic rationality, the production process to be used results from the optimization, which minimizes costs given input prices, such as (2)

$$C(\mathbf{Z}, \mathbf{W}) \qquad (2)$$

Being $\mathbf{W}$ the vector of prices for inputs, the process of production can be represented by minimizing (3) subject to (1), that is, minimizing total production costs subject to the input combination given by the production function.

$$\text{Minimize} \qquad C(\mathbf{Z}, \mathbf{W}) = \mathbf{WX} \qquad (3)$$

$$\text{Subject to} \qquad P(\mathbf{Z}, \mathbf{X}) = 0 \qquad (4)$$

This process brings about the knowledge of level of production. The transportation demand of the firm may be derived from the demand for several inputs. The transportation demand function to the firm can then be obtained taking into account the cost function and re-specifying the cost of each input by adding the transport cost, as follows in (5)

$$W'_i = W_i + T_i \tag{5}$$

where T_i stands for the unit transport cost related to input *i*.

The transportation demand function will, then, be given by

$$V_i = \frac{\partial(Z, W_i')}{\partial T_i} \tag{6}$$

where V_i is the volume of transport of input *i* demanded by the firm.

The microeconomic models operate the inter-sectional flux of goods and services, on an aggregate level. The econometric models establish the requirements for transport by the other sectors of economy through systems of simultaneous equations.

The input/product models are more often used in the analysis of transportation demand. Variations in transportation demand, in terms of model, in the transportation section, are identified from variations in the final demand. At the same time, it is possible to identify consequent variations in transportation section demand before the other sectors of the economy. Kanafani (1983) exemplifies the use of input/product models for transport studies.

The spatial interaction models establish that the flow of products between regions is derived directly from some measure of the economic interaction between them. Thus, the volumes of production and consumption volumes between regions are identified. The transport between the regions with surplus and deficit is expected to take place.

Therefore, the typical transportation problem is formulated in a model that aims at determining the product flow between regions, producers and consumers, which minimizes the cost of transport. Since the models have supply and demand restrictions in each region, the condition of spatial balance is met (Koo & Larson, 1985).

For the purposes of this study, the models of spatial interaction are the most adequate in order to deal with the proposed matter.

2.2 Models Used

2.2.1 Prognosis of Grain Production in Paraná

The products selected for this study were corn and soya bean, and from the latter as a sub-product, soy-meal. According to information from the Rural Economy Department of the Agriculture Undersecretary of the State of Paraná (DERAL/ SEAB-PR), these products together occupy 4.3 of the 5.2 million ha of area used for summer crops of 1997/98. Due to the objective of identifying the competitiveness between crops, some other products were included in the model according to the area: cotton, coffee and cassava.

The division of the State in zones is based on the Regional Nucleus of SEAB-PR. The nuclei are located in the following cities, with their areas of influence: Apucarana, Campo Mourão, Cascavel, Cornélio Procópio, Curitiba, Francisco Beltrão, Guarapuava, Irati, Ivaiporã, Jacarezinho, Londrina, Maringá, Paranaguá, Pato Branco, Ponta Grossa, Toledo, Umuarama e União da Vitória.

Models proposed are, synthetically, models of linear programming, which will make viable the identification of a future agriculture production prognosis, between the products selected, within the zoning proposed. This is basic information for further identification of inter-regional flows.

The modeling to estimate the production consisted in optimizing the profits of rural activity. The model was based on the occupation of the fertile area, aiming at maximizing the producers profit . So, the production profit/ha of each product refers to the difference between producers' income (R$/ha), which is the lowest price received by the producer in the 90's multiplied by productivity, and the variable cost (R$/ha) of the 1999/ 2000 crops.

The model, then, aimed at maximizing the total production profit of the products selected (cotton, coffee, cassava, corn, and soya bean), conditioned by restrictions: (8) that the group of crops occupy a maximum area, per zone, referring to the maximum occupation obtained in the past 20 years; (9) that the products occupy the minimum area, per zone, eventually, to meet the consumption of industrial units located in the area or even for animal consumption, such area identified in the last 20 years; (10) that there must be maximum availability of funds for the planters, which is the operational cost per ha in zone i, weighted by the crops respective area; (11) that the quantities of hectares occupied be non-negative, to satisfy the condition of non-negativity of the model. The model has the following mathematical formulation:

$$Max \quad LT = \sum_{p=1}^{5} \sum_{i=1}^{20} \pi_i^p \cdot Y_i^p \tag{7}$$

subject to restrictions

$$\sum_{p=1}^{5} \sum_{i=1}^{20} A_i^p \leq AMAX_i, \qquad \text{for all } i,p \tag{8}$$

$$A_i^p \geq AMIN_i^p, \qquad \text{for all } i,p \tag{9}$$

$$\sum_{p=1}^{5} \sum_{i=1}^{20} COp_i^p \leq K_i \qquad \text{for all } i,p \tag{10}$$

$$Y_i^p \geq 0 \qquad \text{for all } i,p \tag{11}$$

being:

LT = total agriculture production profit to be maximized, between all the zones;

π_i^p = Profit per hectare, per product p and per zone i;

Y_i^p = Occupied area (in ha), per product p and per zone i;

$AMAX_i$ = Maximum total occupied area per group of crops, per zone i;

$AMIN_i$ = Minimum total occupied area per group of crops, per zone i;

COp_{ii}^p = Operational cost of product p in zone i;

K_i = Availability of funds in zone i;

In the case of some nuclei, the maximum area occupied by the crops was established, valid for coffee and cotton, considering that these crops have already experienced a golden period, which signals to a maximum occupation, and for cassava, which is expanding, and which may in the future stabilize in a lower profitability.

The data related to agriculture production in the State of Paraná were obtained with SEAB-PR.

The prices used were those presented in the study by Monteiro (1999). For modeling effects associated with the crops occupied area, when income and variable costs, and operational activities will be considered, the value used refers to the lowest price achieved in the 90's, considering the decreasing tendency verified in the prices recently, according to what is shown in Table 1. In this last aspect, despite the higher market price instability of some products, the worst performance was used as the parameter as referential of inferior potential limit for stabilizing prices.

Table 1. Price evolution and the minimum market price in the 90's for the selected products from Brazilian agriculture.

Products	Prices 90-98/80-89	Lowest price in the 90's
Cotton	**-48,89**	0,570 kg
Coffee	-50,58	0,675 kg
Cassava	-59,43	0,063 kg
Corn	-48,01	0,131 kg
Soya Bean	-52,45	0,214 kg

Source: Monteiro (1999)

The matter concerning production costs of the crops (R$/ha), refer to those made available by SEAB-PR. The variable costs were used as signal to the decisions of planting prevailing 2 months before hand. In the case of coffee, the average costs and productivity was calculated between the traditional and high density production systems, given the recent and good adoption of the system in the agriculture of Paraná. On the other hand, the operational costs were reference to the funds available for planting, as a mean value for the State, weighted by the respective occuppied areas in the last crops of the 90's.

2.3 Inter-zonal Flows Estimations

The inter-zonal flows are understood as the quantities of products transported between the area under study, based on the identification of supply and demand . The inter-zonal flow expectation is based on the re-grouping of the nuclei by SEAB in zones, having as a parameter the grouping of regions to identify more easily the important flows of the products at stake. Therefore, the zones and their respective areas of influence would represent the following re-grouping of the SEAB nuclei (Figure 1):

- Campo Mourão - Campo Mourão and Umuarama
- Cascavel - Cascavel and Toledo
- Pato Branco - Pato Branco and Francisco Beltrão
- Guarapuava
- Maringá - Maringá, Londrina, Cornélio Procópio, Jacarezinho, Paranavaí and Ivaiporã
- Paranaguá
- Ponta Grossa - Ponta Grossa, União da Vitória, Curitiba and Irati

For the flow expectations, a spatial interaction model was used, where merchandise surplus and deficits occurred between zones. In the present study a model of linear programming was used. Origin-destination matrices are estimated specified by products for the State of Paraná.

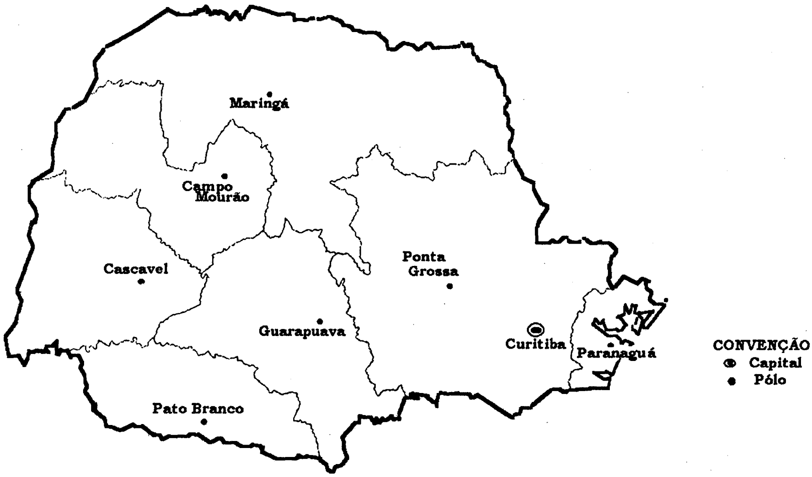

Figure 1 – Zoning of the State of Paraná used in the present study.

The model was specified as follows. Starting from exogenous variables production O_i^p and consumption D_j^p of grains, the objective function Z (12) was minimized, to obtain the product flows between the poles T_{ij}^p, which are the decision variables in this model.

$$Min \quad Z = \sum_{p=1}^{3} \sum_{i=1}^{7} \sum_{j=1}^{7} d_{ij} T_{ij}^p \tag{12}$$

subject to restrictions

$$\sum_{j=1}^{7} T_{ij}^p \leq O_i^p, \qquad \text{for all } i, j \tag{13}$$

$$\sum_{i=1}^{7} T_{ij}^p \geq D_j^p, \qquad \text{for all } i, j \tag{14}$$

$$T_{ij}^p \geq 0 \qquad \text{for all } i, j \tag{15}$$

being:
Z = distance function for flux allocation of soya bean, corn and soya meal;
d_{ij} = Road distances (in km) between the zones *i* e *j*, per unit of product;
O_i^p = Excess of supply of product *p* in zone *i*;
D_j^p = Excess demand of product *p* in zone *j*;
T_{ij}^p = Flow of product *p* with origin in *i* and destination in *j*.

The data relative to corn and soya bean production refer to the results of the agriculture occupation model of the State, by regional SEAB nucleus. From the total production, it becomes necessary to consider some production proportions that don't reach the market, due to losses, reserves and seed production.

Therefore, the soya bean loss expectations calculated by EMBRAPA (Brazilian Enterprise of Agriculture and Animal Raising Research), by SEAB-PR, and by other technical studies, such as Monteiro (1990) for corn, were used.

Quantifying consumption is a much more complex process, since the production may be destined to human and industrial consumption, and for export. Therefore, information concerning grain use for animal feed production was used, according to the ANFAR (1993) suggestion, conversion rate of animal feed into carcass, available in Sugai *et al.* (1998), volumes of pork and poultry sales obtained at SEAB-PR, data from mowing industry, considering updated location and capacity, according to information provided by ABIOVE (Brazilian Vegetable Oil Industry Association), and for population evolution, the 0.82% a.a rate was used, estimated based on IPARDES (1999).

Once quantities produced and consumed were identified, by pole, the pre-conditions for product transportation are established. The zones with excess products provide them to the ones with product deficits.

These estimations of grain and soya meal flows are a first information to build up the tools for analysis of optimal modal allocation that minimizes the costs of transport in Paraná. The aggregation of others, such as costs of transport between regions, modal capacity and costs of transboarding, allows the investigation of optimal modal distribution that minimizes transportation costs in Paraná, which, at the same time, rationalizes the transport infrastructure in Paraná.

In the model for the identification of the transport cost, minimizing modal distribution considered the modals available, as well as their traffic capacity restrictions. Within the proposed model, the objective was to minimize the total costs with the product movement between the zones (16), taking into consideration the restrictions over the total being transported (17), and over the traffic capacities of the points with railway (18). The model stands as:

$$Min \quad Z = \sum_{i=1}^{n}\sum_{j=1}^{n}\left[\left(FR_{ij}.TR_{ij}\right)+\left(FF_{ij}.TF_{ij}\right)\right] \qquad (16)$$

subject to

$$TR_{ij} + TF_{ij} = T_{ij}, \qquad \text{for all } i,j \qquad (17)$$

$$TF_{ij} \leq C^{f}_{ij} \qquad \text{for all } i,j \qquad (18)$$

being:

Z = total transport cost function;

FR_{ij} = Road freight between zones i and j;

TR_{ij} = Quantity transported via road between zones i and j;

FF_{ij} = Railway freight between zones i and j;

TF_{ij} = Quantity transported via railway between zones i and j;

T_{ij} = Flow Volumes of the flow with origin in i and destination in j (matrices O/D estimated);

C^{f}_{ij} = Traffic capacity of products in the railways.

In the case of road freights, the data for various routes in the State available in the SIFRECA (Agricultural Cargo Freight Information Data Base System), from the Department of Economy, Administration and Rural Sociology of the College of Agriculture "Luiz de Queiroz" (University of São Paulo), were used for the transport of corn, soya bean and soya meal. The freight reflects the mean value at the moment of transportation (R$. t.km) in the period 1996-2000, by ranges of kilometers. The data used for railway freight refer to the values charged in March 2000, due to the recent process of modernization of the railroads.

As to the restriction over railway transport, this is reflected from: availability of road material, terminals' capacity and lanes' capacity. The restriction incorporated in the model of this study concerned the traffic capacity of the railway lanes, and the information was provided by the firms that operate with railway transport in the State, ALL (Latin America Logistics) and FERROPAR (Railroad Paraná). Restrictions associated with traffic capacity of the roads were not considered, since this is not considered in the Concession Plan.

3 Results and Discussion

3.1 Production Estimations

Table 2 presents the results obtained with the model of agricultural occupation in the State of Paraná, referring to occupied area and production. From the total available area for products, about 10 million ha, there was no occupation of 2.5 million ha. Through the signal of the model, there is expressive increase in the area planted with cotton compared to what was observed in the 90's, however, the equivalent to half of the occupied area in the golden years of the crop. On the other hand, crops like coffee and corn tend to maintain the occupation last verified. In the case of coffee, the production may increase meaningfully if compared to today's production, considering the expansion of the high density coffee.

Table 2. Area (in ha) and respective production (in ton) of the selected crops resulting from the agricultural occupation model for the State of Paraná, by SEAB's Regional Nucleus

SEAB	Cotton		Coffee		Cassava		Corn	
Nucleus	Area	Production	Area	Prod.	Area	Prod.	Area	Prod.
Apucarana	269	545	8,020	241,168	1,000	23,483	136,051	100,978
Campo Mourão	14,740	30,792	9,966	24,770	27,000	570,942	78,310	2,562,162
Cascavel	56,980	123,932	364	916	30,000	871,200	177,500	1,635,906
Cornélio Procópio	111,063	256,000	13,430	42,908	1,000	18,404	54,100	682,273
Curitiba	0	0	0	0	896	10,842	110,090	93,027
Francisco Beltrão	0	0	0	0	22,000	594,880	237,800	626,968
Guarapuava	90	187	0	0	3,000	54,840	191,100	635,474
Irati	0	0	0	0	750	16,337	60,600	212,628
Ivaiporã	59,486	124,683	10,642	30,250	6,000	136,380	174,421	123,447
Jacarezinho	370	865	41,828	186,469	400	10,960	80,073	46,213
Londrina	35,084	86,658	14,865	36,323	4,500	94,275	43,623	1,060,847
Maringá	43,425	94,058	5,155	13,068	7,500	154,147	23,310	1,173,587
Paranaguá	0	0	0	0	2,100	44,041	392	0
Paranavaí	18,539	37,078	11,689	32,560	45,000	915,615	10,230	7,990
Pato Branco	0	0	0	0	5,100	102,000	108,460	970,936
Ponta Grossa	0	0	0	0	3,500	88,392	164,072	1,249,917
Toledo	9,285	19,284	4,886	18,689	30,000	805,380	90,570	2,558,327
Umuarama	15,114	29,351	21,162	66,502	45,000	1,052,550	29,960	407,825
União da Vitória	0	0	0	0	4,800	86,784	42,899	112,589
TOTALS	364,445	803,434	142,007	476,623	23,.546	5,651,453	1,813,561	6,432,200

Table 2. Area (in ha) and respective production (in ton) of the selected crops resulting from the agricultural occupation model for the State of Paraná, by SEAB's Regional Nucleus(continue)

SEAB Nucleus	Soya Bean	
	Area	Prod.
Apucarana	38,600	100,978
Campo Mourão	940,588	2,562,162
Cascavel	589,941	1,635,906
Cornélio Procópio	295,101	682,274
Curitiba	39,620	93,028
Francisco Beltrão	236,146	626,968
Guarapuava	231,671	635,474
Irati	77,123	212,628
Ivaiporã	48,774	123,447
Jacarezinho	19,344	46,213
Londrina	389,159	1,060,847
Maringá	424,137	1,173,587
Paranaguá		0
Paranavaí	3,410	7,990
Pato Branco	349,132	970,936
Ponta Grossa	443,705	1,249,917
Toledo	915,323	2,558,328
Umuarama	147,123	407,825
União da Vitória	41,454	112,589
TOTALS	5,230,351	14,261,095

Cassava tends to experience continuity in the recent expansion, being able to reach up to 239,000 ha of area.

In the case of corn, there is a recorded tendency for decrease in the State total production and pulverization of the crop, with no regional specialization. As a result, there can only be a mention to some regions that would produce between 150,000 and 240,000 ha: Cascavel, Francisco Beltrão, Guarapuava, Ivaiporã and Ponta Grossa. We have signaled to the increase in Pato Branco and Apucarana, where there are no historic records of cotton plantation.

As to soya bean, due to the high generalized productivity in the whole State , as shown by studies such as GEIPOT (1999), which estimate a future leap in the nowadays' 2.2 to 3.2 t/ha in Brazil, there was a significant indication of increase of production area of around 80%, enabling the State to produce 14 million tons of the product in 5.2 million ha. Although there has been a sign of decrease in the area occupied with soya bean in the Northern nucleus of the State, Apucarana, Jacarezinho and Paranavaí, where it would lose land to corn, coffee and cassava, respectively, the increase in area would be generalized, with emphasis on Campo Mourão and Toledo regions.

According to literature review, only to the market of the products of the soya bean complex, the prognostic is maintained and updated following up that viabilizes an analysis of the period under study.

The production obtained can be seen as a challenge to Paraná's agriculture. According to David & Nonnenberg (1997), the soya market analysis makes more sense when the soya complex (grain, oil and soya meal) is evaluated, since the composition of exports varies according to international values. The scenario formed for the future of the soya complex is the one of broad perspectives of closing in of international competitiveness due to the aspects emphasized by GEIPOT (1999), such as the maintenance of North American and European export encouragement policies, the appearance of new producers in the international scenario, and the deregulation of the world trade.

In the case of Brazilian production, the South, traditional producer, has lost participation in the national area of soya (80% in 1982 and 44.5% in the years 1990-95). Today's tendency recorded in the Brazilian regional production points to the growing in the Cerrado, Midnorth, and part of the States of Mato Grosso (Northwest) and Rondonia. This change can be credited to factors such as exhaustion of agricultural frontiers in the traditional areas and the investments in modes of transportation that have given viability to production spreading out in the "new" areas at a cost competitive with market prices.

However, the continuous gains in productivity and the changes in the international scenario may be events that give viability to the expansion indicated for the State, mainly if corn substitution is considered.

3.2 Estimated Matrices of Origin-Destination

Table 3 specifies the corn, soya bean and soya meal production and consumption prognosis, per zone, in the State of Paraná.

The global estimated movement for the products was of 10.4 million tons/year, with the exception of Paranaguá, all the poles present significant transportation demand, with emphasis to Cascavel, Campo Mourão, Ponta Grossa and Pato Branco (in this order). The region of Campo Mourão has shown up for the potential of generating cargo for all poles. Considering the cargo characteristic and the transportation demand, it is once more proved the demand for technical viability studies that investigate the construction of a railway to integrate the region, primordially to Maringá, due to geographic proximity, and, eventually to Cascavel, possibly constituting an important railway integration of MERCOSUL from Foz do Iguaçu to São Paulo. Martins (1998) had already identified this opportunity.

Table 3. Estimated production and consumption (in ton) of corn, soya bean, and soya meal in the State of Paraná for future scenarios

Zone	Corn		Soya Bean		Soya meal	
	Production	Consumption	Production	Consumption	Production	Consumption
Campo Mourão	256,423	101,614	2,661,137	403,200	316,512	28,650
Cascavel	459,155	716,437	3,753,839	871,920	684,457	263,195
Pato Branco	769,278	563,670	1,430,123	592,200	464,877	211,684
Guarapuava	136,568	110,330	568,749	327,600	257,166	36,762
Maringá	1,036,093	1,157,164	2,859,823	3,636,000	2,854,260	2,241,920
Paranaguá	16,775	8,676	0	3,886,555	395,640	4,309,433
Ponta Grossa	808,557	824,958	1,493,004	3,049,200	2,393,622	274,890
TOTALS	3,482,849	3,482,849	12,766,675	12,766,675	7,366,534	7,366,534

Source: research results

Table 4. Estimated matrices of origin-destination for corn in the State of Paraná for future scenarios

	Campo Mourão	Cascavel	Pato Branco	Guara-Puava	Maringá	Paranaguá	Ponta Grossa	ORIGIN
Campo Mourão	0	33,738	0	0	121,071	0	0	154,809
Cascavel	0	0	0	0	0	0	0	0
Pato Branco	0	205,608	0	0	0	0	0	205,608
Guarapuava	0	17,936	0	0	0	0	8,302	26,238
Maringá	0	0	0	0	0	0	0	0
Paranaguá	0	0	0	0	0	0	8,099	8,099
Ponta Grossa	0	0	0	0	0	0	0	0
DESTINATION	0	257,282	0	0	121,071	0	16,401	

Source: Results of research

Table 5. Estimated matrices of origin-destination for soya bean in the State of Paraná for future scenarios

	Campo Mourão	Cascavel	Pato Branco	Guara- puava	Maringá	Paranaguá	Ponta Grossa	ORIGIN
Campo Mourão	0	0	0	0	776,177	0	1,481,760	2,257,937
Cascavel	0	0	0	0	0	2,881,919	0	2,881,919
Pato Branco	0	0	0	0	0	763,487	74,436	837,923
Guarapuava	0	0	0	0	0	241,149	0	241,149
Maringá	0	0	0	0	0	0	0	0
Paranaguá	0	0	0	0	0	0	0	0
Ponta Grossa	0	0	0	0	0	0	0	0
DESTINATION	0	0	0	0	776,177	3,886,555	1,556,196	

Source: research results

Table 6. Estimated matrices of origin-destination for soya meal in the State of Paraná for future scenarios

	Campo Mourão	Cascavel	Pato Branco	Guara-puava	Maringá	Parana-Guá	Ponta Grossa	ORIGIN
Campo Mourão	0	0	0	36,762	0	251,100	0	287,862
Cascavel	0	0	0	0	0	263,195	0	263,195
Pato Branco	0	0	0	0	0	253,193	0	253,193
Guarapuava	0	0	0	0	0	257,166	0	257,166
Maringá	0	0	0	0	0	612,340	0	612,340
Paranaguá	0	0	0	0	0	0	0	0
Ponta Grossa	0	0	0	0	0	2,118,732	0	2,118,732
DESTINATION	0	0	0	36,762	0	3,755,726		

Source: research results

Concerning estimated flows, the configuration confirms itself towards the Oriental part of the State. The cargo originated in Cascavel is primordially destined to Paranaguá and Ponta Grossa; from Pato Branco and Guarapuava, soya and soya meal are destined to Paranaguá and Ponta Grossa, and the corn to Cascavel; the important flow originated in the region of Maringá has as destination the Paranaguá harbor; the same occurs with the cargoes originated in Ponta Grossa. The resulting matrices are attached.

In the case of corn (Table 4), the main flows occur in shorter distances: Pato Branco – Cascavel and Campo Mourão – Maringá. As to soya, the distances surpass 400 Km, being the main flows originated in Cascavel and Campo Mourão and destined to Ponta Grossa and Paranaguá (Table 5). As for soya meal, according to what is shown in Table 6, the main point of origin is the North of the State (Maringá), where the local production is spread out in other Brazilian States, and in second place in Ponta Grossa, mainly for soya milling industry concentration). The main destination is the Paranaguá harbor.

3.3 Optimal Modal Distribution

The model signaled to the predominance of the road modal in the transport of the grain originated in the State of Paraná. The road modal is responsible for 60% of the cargo, while the railway modal for only 40%. This result is explained by the fact that there is no railway connection between all pairs of poles.

Therefore, the cargo originated in Maringá and Ponta Grossa and destined to Paranaguá would have exclusive railway transport. Only because of problems of traffic restriction, the same does not occur to the products originated in Cascavel, which fills the capacity of railway transportation and then uses road transport.

There is an under-loading in the railway transportation on the Maringá-Ponta Grossa-Paranaguá way. Notwithstanding, as this way receives important flows coming from Midwest Brazilian States, which could happen through railway or inter-modal traffic, such under-loading could be filled.

The evaluation of viability of inter-modal transportation was also performed. Inter-modal freight was the result of the adding the sub-way modal freight and the transloading cost of R$ 2.50. The verification took place at the pairs Campo Mourão-Paranaguá, road-railway with transloading in Maringá, and Pato Branco-Paranaguá, road-railway with transboarding in Guarapuava.

The inter-modal freight, in such conditions, was not competitive. However, it is worth remembering that large contracts, the consolidation of firms specialized in logistic, and the effectiveness of the multi-modal operator can, indeed, alter this scenario, since the transportation of soya between Campo Mourão and Paranaguá is already made under such conditions and traded by COAMO (Agricultural Cooperative Mourãoense).

4 Conclusions

According to what it was possible to draw from this study, the zones located in the western part of the State are those that should cause the biggest worries about transportation planning in Paraná, at least in respect to agricultural and agro-industrialized products transport. The results signaled to the continuity of the importance of Cascavel and Campo Mourão regions to the production and distribution of grains that are destined, mainly, to Ponta Grossa and the Harbor of Paranaguá. This is a real situation and it tends to persist in the long run.

On the other hand, these are not all the points of origin of products destined to Ponta Grossa and the Harbor of Paranaguá. Opening the perspective of the inquiries, an important parcel of the production from Mato Grosso do Sul and Paraguay would use the same corridor, independent of other alternatives.

However, what is observed in today's transportation infrastructure is that the State area has not adequately contemplated the via planning. With respect to the roads, the Integration Ring, the State road development plan, which has given concession of most of the network, does not predict the integration of these regions by highways up to 2020. This data added to the potential flow identified in the study, the cost of transportation may be increased inhibiting the predicted growth in grain and soya meal trading.

The railway, a modal alternative, may not be the way out for the problem. Firstly, because there are no routes to unite Campo Mourão to Maringá or to Cascavel, what has been shown as strategically important for the MERCOSUL corridor. Secondly, this region is isolated in terms of railway transportation. As to Cascavel, the existing railway, FERROESTE, is already operating near to its limits, since there is traffic strangling in the section Guarapuava-Ponta Grossa.

At the same time, the country is undergoing through a moment of elevation of infrastructure investment levels distributed in several States. Their results will have some impact over the transportation flow in the transportation infrastructure of Paraná, such as the doubling of Regis Bittencourt highway, São Paulo-Curitiba, and of the BR-101, Curitiba-Florianopolis section, the FERRONORTE railway, the conclusion of the Tiete-Paraná Hydroway and the operating of agricultural commodities in bulk in the Harbor of Sepetiba (RJ).

It is configured, this way, a strong tendency in the sense of agricultural cargo detour in the State. The operationalization of the Tiete-Paraná Hydroway, the Harbors of Itaqui and Sepetiba, and the FERRONORTE tend to detour Brazilian Midwestern cargo that were once exported through Paranaguá or traded with State agro-industrials. On the other hand, the charging of road fee in Paraná roads and a continuity of competitive grow of the Harbor of São Francisco (SC) may detour from Paranaguá cargo originated within the own State through the road routes in Southwest Paraná.

So, it stands as strategically priority that:

1) The plan for doubling the State's roads, expressed in the Integration Ring Program, be reviewed such that improvements of traffic conditions of the occidental State roads be added, with emphasis on the regions of Campo Mourão and Cascavel;

2) New railway investments be encouraged in the State as a form of reducing the product transportation costs, creating competitive strengths for the state production, avoiding the evasion of part of it to other harbors, mainly to the Harbor of São Francisco, the geographically nearest competitor, and that this be also a form of standing up to other States investments, achieving, this way, the attraction/maintenance of cargo originated in other States. Furthermore, the need for developing the railway link with the harbor is becoming too obvious;

3) The Harbor of Paranaguá goes firmly on in the modernizing follow up, with consequent reduction of harbor operation costs, which is the most viable way to reduce the contrary impacts of the road fee and the tendency of increase of other costs associated with road transportation;

4) The development of firms in the agro-industrial logistic field can provide viability to an increase of return cargo, which implies the reduction of freight and storage costs and structures, to avoid the peaks of concentrated demand in some months of the year.

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