A new dilemma for Brazilian agribusiness: improve logistics or face regulatory demands from biotechnology?

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Abstract

This paper provides a soybean trade assessment of strict documentation requirements on traded shipments from Brazil. The aim of this paper is to analyze the impacts of segregating different grains in Brazil's transport logistics and storage, especially genetically modified (GM) grains according to the guidelines of the Cartagena Protocol on Biosafety (CPB) as well as developments in competitiveness in international markets. Adoption of biotechnology in the production of maize, soybeans and cotton has grown rapidly and it has occurred in parallel with a expansion of transaction cost in the regulation of the main procedures (segregation costs and identity preservation process). The growth in exports of Brazilian agricultural commodities has generated many positive effects, but at the same time has revealed the country's logistical weaknesses. In view of the inefficient transport and storage systems, the compliance with Cartagena Protocol demands related to traceability and identity preservation possibly will harm the Brazilian competitiveness. To incorporate aspects related to the segmentation of differentiated grains, such as the cost of tests to identify the differentiated grains, the development of a model formulated as a Mixed Complementarity Problem (MCP) is proposed. The results show that the cost of transport increases the number of tests along the path and also increased the segregated storage. Therefore it implies a reduction of sales, especially oriented to foreign market and, thus a decrease in production. The system once implemented could cause a reduction in the total of Brazilian soybeans trade. In one of the scenarios proposed it was reduced by 3.9%, a total loss of US$1.60 billion (tests and storage expenses and international trade reductions). However, it is observed that transport logistics are affected by the requirements of the Cartagena Protocol. Thus, more rigid is the identification process, the greater will be the impact on sales. The demands to indentify GM affect the diffusion of technology. For special purposes and differentiated grains, bilateral contracts could be a solution.

Key words: partial equilibrium model, agricultural biotechnology, logistics.

Resumo

O objetivo deste trabalho é analisar o efeito da segregação dos grãos diferenciados na logística de transporte e armazenagem do Brasil, especialmente os grãos geneticamente modificados (GMs), a partir das diretrizes do Protocolo de Cartagena de Biossegurança (PCB), bem como os desdobramentos na competitividade no mercado internacional. A adoção da biotecnologia na produção de milho, soja e algodão têm crescido rapidamente e ocorreu simultaneamente com o aumento dos de custos de transação na regulação dos principais procedimentos (custos de segregação e processo de preservação de identidade). O crescimento das exportações de commodities agrícolas brasileiras tem gerado impactos positivos, ao mesmo tempo em que revela uma série de fragilidades logísticas do país. Tendo em vista tais fragilidades, as demandas relacionadas à rastreabilidade e preservação de identidade para o cumprimento do

Protocolo de Cartagena podem prejudicar a competitividade brasileira no mercado internacional. Para incorporar aspectos relacionados à segregação de grãos diferenciados, tais como o custo dos testes para identificar os eventos transgênicos e armazenagem segregada, é proposto um modelo de equilíbrio espacial sob a forma de um Problema de Complementaridade Mista (PCM) que se adapta a esta classe de grãos geneticamente modificados (GM). Os resultados mostraram que com um maior número de testes ao longo das rotas e a demanda por armazenagem segregada, maior é o aumento do custo de transporte. Isto implica em queda da produção e na redução dos fluxos comerciais, especialmente com o mercado externo. O sistema de segregação, uma vez implementado, pode causar uma redução do volume comercializado de soja em 3,9% implicando em perdas na ordem de US$1,60 bilhões dólares (testes para eventos transgênicos, despesas de armazenagem dedicada e redução no comércio internacional). Observa-se que a logística para esta classe de produtos é afetada pelas exigências do Protocolo de Cartagena. Quanto mais rígido o processo de identificação, maior é o impacto na comercialização, além disso as exigências para a identificação de grãos GM afeta a difusão da tecnologia. Para mercados de produtos diferenciados, os contratos bilaterais podem ser uma solução.
Palavras-chave: modelo de equilíbrio parcial, biotecnologia agrícola, logística.

JEL: Q13, C61

INTRODUCTION

The globalization impacts in the Brazilian economy have resulted in some important changes in a number of diverse economic sectors, increasing the mobility of capital and transforming the traditional productive structures. In this period, Brazil has begun an important player in this integrated and competitive economic environment, where a true revolution has occurred to develop new technologies and to change the standard of grain demand in the world. This has affected the Brazilian agribusiness, forcing them to change the main strategies and apply new procedures and technologies to anticipate the negative impacts.

The large growth taxes in Brazilian agricultural commodities exports has generated many positive effects, but at the same time has revealed the country's logistical weaknesses. These weaknesses - the precarious highway conditions, the lack and inefficiency of railroad capacity and the extent and disorganization of the bureaucratic system - have consequently increased truck traffic at the main ports, showing an inability to meet deadlines for deliveries overseas.

The expansion of agriculture was stimulated by the new geographical distribution of the productive sectors and it was not accompanied by an expansion of the transport sector. The exploitation of potential grain production depends on establishing an efficient transport system. Thus, it is necessary to provide and integrate intermodal transport routes (roadways, railways, waterways) - linking the production areas, consumer centers and the international market - in order to increase the competitiveness of the products.

In Brazilian case, the transport of grains is confronted by the problem of the structure of its roads, generating product losses and an increase in freight price. In Brazil, the freight is one of the components that weigh most heavily on the final cost of the grains due to the lack of waterways, the insufficient railroads and precarious roadway conditions.

The transport of homogeneous and standardized products is important to guarantee economies of scale and to improve the logistic system. However, a growth in the demand for differentiated grains has been observed specially in grains with higher protein content, grains with superior industrial performance, grains with neutraceutic properties and grains certified as non-genetically modified products.

Segregation of different products causes an increase in the storage costs which affects directly the logistical system (SCHLECHT et. al, 2004). In order to keep the grains apart, a larger number of compartments are required in the storage units or it is necessary to implant smaller silos to be able to have segregated storage.

Wilson and Dahl (2002) developed a model to evaluate the costs and potential risks associated with a commercialization system for genetically modified (GM) grains. The model gives the additional system costs at each stage of the commercialization chain, incorporating the risk of different variables, using a stochastic optimization to manage this risk. Included among the primary sources of risk are: the issue of whether the producer will "tell the truth" or not, precision of tests, and accidental contamination that could occur in different localities (farm, storerooms, transport equipment and transportation at ports, due to a number of factors (such as inadequate cleanliness).

Nowadays the consumer market is more concerned about the quality of commodities. For this reason, significant changes have been occurred, especially in reference to biotechnology and biosafety. One of the main challenges faced by the transport and storage sector is to be able to separate categories of grains in order to gain economic advantages.

A complex standard of competition have been created to achieve low costs, although necessary, is not longer a primary condition. Therefore, it is necessary to consider the following criteria: quality, certification, good agricultural practices and product tracking systems (CONCEIÇÃO e BARROS, 2006). Thus, an important protocol has been established that defines conducts regarding the commercialization and transport of products which may have biotechnologically modified – The Cartagena Protocol on Biosafety (CPB).

Considering the inefficient transport and storage logistics in Brazil, the issue arises how this new situation of a differentiated grain market will impact the Brazilian competitiveness in the international agricultural market? One of the hypotheses considers that an raise in the demand by final consumers, increases the capacity to offer differentiated products and the efficiency of logistic system, reducing the costs and increasing the competitiveness. Therefore, the restructuring of the transportation and storage of grains will play a fundamental role in the performance of the national economy.

The objective of the proposal is to analyze the effect of segmenting differentiated grains - in particular, genetically modified grains as a result of directives issued by the Cartagena Protocol on Biosafety - on the logistics of the Brazilian transport system, as well as the implications of the competitiveness of Brazilian grain in the international market.

To incorporate aspects related to the segregation of differentiated grains, such as the cost of tests to identify the differentiated grains and segregated storage, a spatial equilibrium approach is formulated as Mixed Complementarity Problem (MCP). This approach allows the incorporation of tariffs, tax quotas and subsidies with more ease to the model. The use of the MCP was proposed by Thore (1992), Rutheford (1995) and Bishop, Nicholson and Pratt (2001) and is already being used by Alvim (2003) and Alvim and Waquil (2004).

THE CARTAGENA PROTOCOL

The Cartagena Protocol on Biosafety (CPB) originates from the Convention on Biological Diversity, which came into effect in 1993 and is today the principal international instrument for the discussion of issues on biodiversity (CBD, 2000). In its second meeting in 1995, the Conference of Parties established a working group for the development of a protocol on biosafety, with the purpose of examining the transboundary movement of any living modified organism (LMO) that may effect the sustainable use of biodiversity. Thus emerged the Cartagena Protocol on Biosafety, approved in 2000 (CBD, 2000). The CPB was started in 2003 and by October 2010, had been ratified by 160 countries (MACKENZIE, et al., 2003).

Brazil played an important role in the history and evolution of the CPB, for two reasons in particular. The first, for having hosted the Earth Summit in 1992 which led to the Biodiversity

Convention - of which the Protocol was a component - and second for its active participation and the important contributions during the negotiations.

The main objective of the Protocol is to help ensure an adequate level of protection in the transfer, handling and safe use of living modified organisms (LMOs) resulting from modern biotechnology that may have adverse effects on the conservation and sustainable use of biological diversity. It also considers the risks to human health, specifically focusing on transboundary movements (CBD, 2000). According to Slater (2008), the CPB applies to transboundary movements of LMOs intended for intentional introduction into the environment, use in a confined area (such as research), food, feed and processing, but does not apply to LMOs with pharmaceutical purposes.

The First Conference of the Parties (COP/MOP1) was held in 2004, in which Brazil took part in the Like-Minded Group – the group of countries, which defended the right to refuse imports of genetically modified (GM) products and to hold companies legally responsible in the event of damages, by demanding compensation. Moreover, they also favored mandatory labeling of Genetically Modified Organisms (GMOs). The group was formed largely by developing countries and the European Union. In contrast, the Miami Group, formed by the United States, Argentina, Canada, Australia, Chile and Uruguay, and dominated by the major world exporters, had a more liberal attitude towards the identification of GMOs, and was opposed to making the holding companies accountable for damages caused by such products (LIMA, 2006).

The choice to identify products as "may contain" or "contains" GMOs is a key point for exporting countries. This is because such a decision can incur extra costs and can unpredictably increase the costs of logistics. For Vieira Filho, et al. (2006), however, there is no clear evidence that the expression "contains" guarantees corresponding benefits for the parties involved (producers, intermediaries and consumers), or, for that matter, for the fulfillment of the goals of Protocol.[1]

In subsequent years, in which detailed discussions on how to deal more specifically with the implementation of the CPB, the Brazilian position moved towards that of the exporting countries.

Then, in 2005, during the Second Conference of the Parties to the Protocol (COP/MOP2) Brazil strongly defended the position and the option for the term "may contain" claiming that this alternative, along with the information available on the Biosafety Clearing House (BCH)[2], would

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[1] As for handling, transport, packaging and identification, Article 18 states that:

In order to avoid adverse effects on the conservation and sustainable use of biological diversity, taking also into account risks to human health, each Party shall take necessary measures to require that living modified organisms that are subject to intentional transboundary movement within the scope of this Protocol are handled, packaged and transported under conditions of safety, taking into consideration relevant international rules and standards. 2. Each Party shall take measures to require that documentation accompanying: (a) Living modified organisms that are intended for direct use as food or feed, or for processing, clearly identifies that they "may contain" living modified organisms and are not intended for intentional introduction into the environment, as well as a contact point for further information. The Conference of the Parties serving [...] shall take a decision on the detailed requirements for this purpose, including specification of their identity and any unique identification, no later than two years after the date of entry into force of this Protocol; ; (b) Living modified organisms that are destined for contained use clearly identifies them as living modified organisms; and specifies any requirements for the safe handling, storage, transport and use, the contact point for further information, including the name and address of the individual and institution to whom the living modified organisms are consigned; and ; (c) Living modified organisms that are intended for intentional introduction into the environment of the Party of import and any other living modified organisms within the scope of the Protocol, clearly identifies them as living modified organisms; specifies the identity and relevant traits and/or characteristics, any requirements for the safe handling, storage, transport and use, the contact point for further information and, as appropriate, the name and address of the importer and exporter; and contains a declaration that the movement is in conformity with the requirements of this Protocol applicable to the exporter. 3. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall consider the need for and modalities of developing standards with regard to identification, handling, packaging and transport practices, in consultation with other relevant international bodies. (CDB, 2000: 14).

[2] Through the Advance Informed Agreement, the CPB allows importing countries to approve the import of LMOs to be released into the environment and can make a risk assessment. Moreover, countries exchange information and experience concerning conditions of cultivation, movement and development of LMOs into their territories via the Biosafety Clearing House (BCH). Based on information from the BCH and the EIA, the importers may approve or not approve the import of LMOs, although the CPB ensures the restriction or denial of import based only on potential unknown risk (precautionary principle) (Simoes, 2008).

ensure the biosafety level that the Protocol aims to achieve, thus avoiding unnecessary costs of testing and strict segregation that would be required by the word "contains" (CIB, 2006).

At the COP/MOP 3, held in 2006, Brazil once again changed its position. Thus it was decided that both options should be accepted in commercial transactions. It was established that the expression "contains" should be employed in cases where the identity of the LMOs contained in the shipment is likely to be determined by Identity Preservation Systems (IPS) and the expression "may contain" would be used when there is loss of identity during the commercialization of commodities. Such labeling options should be revised according to the experiences of countries at the COP/MOP 5 in 2010, although the final decision on the term to be used will not be made until 2012 (SIMÕES, 2008).

According to Vieira Filho et al. (2006), when it interferes in the contractual decisions in the export chain of grains, the term "contains" promotes vertical integration in producer countries and stimulates production in countries less efficient in agricultural terms, resulting in adverse impacts.

Another negative influence, when it comes to increased demands related to the change in transboundary trade in LMOs, can be found in the process of diffusion of new agricultural technologies, especially agricultural biotechnology, which can contribute significantly to the deployment of management techniques, dramatically reducing the impact of agricultural practices in agriculture (VIEIRA FILHO et al., 2006).

MATERIAL AND METHODS

In order to predict the impacts and quantify the potential effects of the implementation of the Cartagena Protocol on logistics organization of transport and storage in Brazil, a spatial equilibrium model formulated as a Mixed Complementarity Problem (MCP) for the transfer of soy has been developed.

The optimization model described in this section uses a formulation presented in the form of a Mixed Complementarity Problem (MCP), as proposed by Thore (1992), Rutherford (1995) and Bishop, Nicholson and Pratt (2001) and already used by Alvim (2003) and Alvim and Waquil (2004).

A nonlinear complementarity problem consists of a system of simultaneous (linear or nonlinear) equations that are written as inequalities, from the functions of supply and demand. Here, the MCP is equivalent to the Kuhn-Tucker conditions which are necessary and sufficient to achieve a maximum peak value of the Net Social Payoff[3] (NSP) function, which in turn implies in achieving equilibrium in all markets and all regions[4]. Also, the MCP has the advantage of allowing the incorporation of tariffs, quotas and subsidies more easily to the model.

Samuelson (1952) showed that market equilibrium is obtained by maximizing the NSP function by the sum of the surplus of producers and consumers minus the transportation cost between producers and consumers regions. Takayama and Judge (1964) expand the Samuelson's approach become possible an operational programming analyze using linear supply and demand functions.

The Lagrange multipliers in Kuhn-Tucker conditions can be interpreted as shadow prices in competitive markets. The Lagrange multiplier indicates the maximum that the consumer might

[3]Samuelson's formulation shows that the problem of maximising "net social payoff" (the sum of consumers' and producers' surpluses in each region less transportation costs) subject to regional commodity balance equations generates a set of optimality conditions that define an equilibrium in each regional market. We hasten to point out that Samuelson warned of the problems associated with using his result to make inferences about welfare. Hence his term "net social payoff", which explicitly excludes a reference to welfare. The literature would seem to suggest, however, that Samuelson's cautionary note was almost immediately ignored. See his 1952 paper for further details

[4] For a nonlinear programming problem where the objective function which is differentiable and concave, with restrictions linear (differentiable and convex), the results are a maximum global, since the optimal point satisfy the Kuhn-Tucker conditions.

be willing to pay for some additional supply of the good. In addition, the Lagrange multiplier associated sets the minimum price that the producer might be willing to accept for an additional unit of the good.

The MCP for Brazilian soybeans is given below:

Indexes:

$i = \text{supply regions } (i = 1, \ldots, 9)$

$j = \text{domestic demand regions } (j = 1, \ldots, 3)$

$k = \text{international demand regions } (k = 1, \ldots, 3)$

$r = \text{transportation route } (r = 1, \ldots, 15)$

Variables:

$q_i^s = \text{quantity produced}$

$q_j^d = \text{quantity consumed by domestic demand}$

$q_k^l = \text{quantity consumed by international demand}$

$p_i^s = \text{supply price}$

$p_j^d = \text{domestic demand price}$

$p_k^l = \text{international demand price}$

$X_{\_} = \text{quantity transported}$

Parameters:

$t_{\_} = \text{transportation cost}$

$\varphi_i = \text{shadow prices associated with supply region}$

$\lambda_j = \text{shadow prices associated with domestic demand region}$

$\mu_k = \text{shadow prices associated with internation demand region}$

$$0 \leq \varphi_i \perp \sum_j^J X_{i,j} + \sum_k^K X_{i,k} \leq q_i^s \qquad (1)$$ [5]

[5] In the MCP the coefficients and elasticities are included in constraints 1, 2 and 3, replacing the quantities produced and consumed by the following expressions:

$q_i^s = a_i \cdot \varphi_i^{b_i}$

$q_j^d = c_j \cdot \lambda_j^{-d_j}$

$q_k^l = e_k \cdot \mu_k^{-f_k}$

$$0 \leq \lambda_j \perp q_j^d \leq \sum_i^I X_{i,j} \qquad (2)$$

$$0 \leq \mu_k \perp q_k^l \leq \sum_i^I X_{i,k} \qquad (3)$$

$$0 \leq X_{i,j} \perp p_i^s + t_{i,j} \geq p_j^d \quad \forall_{i,j} \qquad (4)$$

$$0 \leq X_{i,k} \perp p_i^s + t_{i,k} \geq p_k^l \quad \forall_{i,k} \qquad (5)$$

Where the "⊥" symbol is understood as at least one of the adjacent inequalities must be satisfied as a strict equality. This is nothing more than a formal statement of the complementary slackness result that we saw earlier when presenting the Kuhn-Tucker conditions.

Consider the zero profit condition (5), if we had a parameter called $tax_{i,k}$ denoting our asymmetric ad-valorem tariff or tax rate, then it would be a simple matter to incorporate it into the model by modifying the zero profit condition as follows:

$$\left(p_i^s + t_{i,k}\right) \cdot \left(1 + tax_{i,k}\right) \geq p_k^l \quad \forall_{i,k}$$

In this case the tax is equal to the costs of test to identify transgenic/GMO events plus segregated storage costs.

Initially, the supply and demand regions of soybeans were identified in the model. The selected states include the South-east, Central-west and the North. The behavior of a number of variables in previous years was analyzed, including: soybeans production, average return, cultivated area, exports and installed capacity of processing (industrial plant). The states used in the model were chosen with the aim of characterizing the dynamics of these regions and the potential for expansion based on agricultural frontiers.

In order to characterize the regions with excess supply and demand, the following argument was applied: if the production of soybeans is greater than the quantity processed, the region will be characterized as a region of excess supply. Where the contrary is true, the region will be characterized as a region of excess demand. Different microregions[6] were identified in the state of Mato Grosso and Paraná, both in terms of production and processing.

The processing of information for the MCP, developed for the transfer of soy in Brazil, was done utilizing the computer program *General Algebraic Modeling System* – GAMS - (BROOKE et al., 1995).

The model´s data (production, consumption, commercialization prices of the national and international market and freight from different models) were based on the year 2009. The production data were taken from the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística, IBGE*) and the United States Department of Agriculture (USDA). The consumption data were based on the Brazilian Association of Vegetable Oil Industries *(Associação Brasileira de Indústrias de Óleos Vegetais, ABIOVE),* and the price of soy for the national and international markets were based on data from SAFRAS & Mercado (2010) and USDA (2010). The data on price elasticity of supply and demand were based on studies undertake by Fuller *et al*. (2003 and 2000) and FAPRI (2010).

[6] Microregions: consist in a grouping of cities with similar characteristics as agricultural production, industrial and economics activities.

There are two methods to analyze LMO´s: by analyzing DNA or proteins. In the case of DNA analysis, PCR (*Polymerase Chain Reaction)* is utilized, either quantitatively or qualitatively. For the analysis of proteins, the simple or strip ELISA (*Enzyme-linked immunosorbent assay*) test can be employed, which detect just one event at a time.

The costs of the tests were covered by interviews with laboratories and kit suppliers. The unit cost was US$3.00 for the strip tests and US$300.00 for PCR.

For each 40 tons, 2 samples are used, requiring 2 test strips, giving a total cost of US$6 for every 40 tons. In the case of PCR, 3 analyses for every 3000 tons were carried out, giving a total cost of US$900.00 for every 3000 tons. In this case, 1 PCR test in the moment of shipment, 1 PCR test on export port and 1 PCR test in the ship.

The costs of the segregated storage were covered by interviews with leading companies in this non-GMO marketing. The costs in the transshipment points are on average US$ 13.00/ton and in the export port are US$ 10.00/ton.

Road and rail transportation costs in the model were estimated using linear equations based on the distances between the points of shipment and those of reception (origin/destination). The behavior of the transport costs (response variable) was analyzed using a multiple linear regression model, utilizing the database of freights in 2009, based on data from the Information System for Freights (*Sistema de Informação de Fretes, SIFRECA*), all over Brazil, in accordance with the distance and the different months of the year. For the water transport model the data on actual freights were utilized.

The hypothesis of the existence of differentiated behavior for freights with distances up to 500km (explanatory variables) was utilized for road transportation. For road transportation the following function is given:

$$Y = \beta X + \varepsilon$$

$$Y = \beta_0 + \beta_1 \delta X + \beta_2 (1 - \delta) X + \varepsilon$$

where,

$$\delta = \begin{cases} 1 \text{ if distance } \geq 500 \\ 0 \text{ if distance } < 500 \end{cases}$$

and,

$Y = \text{freightin US\$/ton}$

$X = \text{distance in km}$

$\beta = \text{regression coefficient}$

$\delta = \text{binary variable}$

$\varepsilon = \text{random error}$

The linear cost model was implemented into the statistical program SAS (2006). For rail transport, the equations were developed in the same way as for road transport with the reference distance being 700 km.

RESULTS AND DISCUSSION

The MCP obtained for the movement of Brazilian soybeans underwent a process of verification and validation to determine its reliability and usefulness, and thus can generate future scenarios. The first step was developed to verify the resulting data, analyzing the flows generated between supply and demand for soybeans in the respective regions, with emphasis on the quantities sold and prices offered.

In Table 1 it can be verified that the amounts supplied and demanded in the model. The actual data and the estimated data from the model are compared. According to Thompson (1981) and Waquil (1995), small differences between the actual data and estimated values can occur, not invalidating the model.

Scenario 1 is the control; here there were no costs incurred with the tests and transfer takes place only on the basis of transportation costs. Costs of strip and PCR tests were added in scenario 2, the strip tests varied according to the quantity of tranfers made following the considered shipping route; upon each change in mode of transport a test was conducted. PCR tests were conducted in the storage before shipment, at the port of shipping for export and also on the ship.

Table 1. Model-Estimated (Scenario 1 and 2) and Actual Soybean Flows Quantities (thousand tons)

Supply	Scenario 2 (A)	Scenario 1 (B)	Actual data (C)	Deviation (A)/(B) (%)	Deviation (B)/(C) (%)
Total Mato Grosso	*12,930.86*	*13,488.97*	*13,131.20*	*-4.14*	*2.72*
Mato Grosso-North	6,926.46	7,222.44	7,071.38	-4.10	2.14
Mato Grosso-West	3,762.66	3,934.06	3,791.97	-4.36	3.75
Mato Grosso-Northeast	2,241.75	2,332.47	2,267.85	-3.89	2.85
Total Paraná	*6,411.85*	*6,692.37*	*6,525.53*	*-4.19*	*2.56*
Paraná-West	3,592.56	3,753.36	3,671.13	-4.28	2.24
Paraná-North	2,819.29	2,939.01	2,854.40	-4.07	2.96
Rio Grande do Sul	4,801.73	4,924.71	4,853.80	-2.50	1.46
Góias	2,789.88	2,931.11	2,820.39	-4.82	3.93
Minas Gerais	1,257.24	1,307.85	1,282.86	-3.87	1.95
Mato Grosso do Sul	1,016.82	1,073.39	1,065.86	-5.27	0.71
TOTAL SUPPLY	**29,208.39**	**30,418.40**	**29,679.64**	**-3.98**	**2.49**
Domestic Demand (D)					
São Paulo	2,046.03	2,023.36	2,028.85	1.12	-0.27
Paraná-Southeastern	1,234.74	1,221.38	1,225.04	1.09	-0.30
Mato Grosso-Southeastern	754.62	744.95	748.52	1.30	-0.48
Sub-total	*4,035.39*	*3,989.69*	*4,002.41*	*1.15*	*-0.32*
International Demand (E)					
China	15,521.95	16,232.66	17,000.00	-4.38	-4.51
EU-27	9,068.00	9,558.88	10,000.00	-5.14	-4.41
Japan	583.03	637.16	700.00	-8.50	-8.98
Sub-total	*25,172.98*	*26,428.70*	*27,700.00*	*-4.75*	*-4.59*
TOTAL DEMAND (D+E)	**29,208.37**	**30,418.39**	**31,702.41**	**-3.98**	**-4.05**

Source: Research data, 2010.

As the number of tests is increased along the route resulting from the change transportation mode, the greater the increase in transport cost. This leads to a reduction of production, also implying the reduction of sales, especially in foreign markets, reflecting a decrease in competitiveness of Brazilian soybeans. But the production destined for domestic demand increased. In the Scenario 2, the system for identification of the presence of GM events – specifying the events in soybean shipments – generates a negative impact of 4.75% on exportations of soybean. Especially Japan (8.50%) and Europe (5.14%), which are the largest importers of non-GM soybean, had the largest reductions in the market trades.

In a first analysis, the losses in absolute values of quantity soybean traded do not appear to be so expressive. But when we analyze the losses in millions of U.S. dollars, considering the tests and storage expenses (US$1.1 billion) and international trade reductions (US$501.0 million), losses amounts almost US$1.60 billion. This amount represents 13.8% of foreign exchange generated by exports of soybeans to Brazil in 2009.

Thus, it is observed that the logistics of transport are affected by the requirements of the Cartagena Protocol. Therefore, the more rigid the identification process, the greater the impact on sales. As a consequence, the competitiveness of Brazilian soybeans on the international market is compromised by weak logistics.

Scenario 2 gives evidence of Brazilian losses in soybean market. Through the parameters used, it is possible to identify how the performance of production and consumption in the regions analyzed change when an international agreement is simulated. To export the Brazilian production is necessary to do a greater number of transshipments, given the long distances to export ports, so the loss to Brazil's competitiveness relative to key competitors, the United States and Argentina, could be higher, since these countries have a more efficient logistics (the United States) and lower distances to export ports (Argentina).

Such vulnerabilities are represented by poor road conditions, low efficiency and lack of rail capacity, disorganization and excessive bureaucracy in the ports. This is all in addition to the inadequacy of the Brazilian transport network, dominated by road transport.

Chart 1 and 2 shows the main logistical routes used in Scenario 1 and 2, respectively. In the case of soy production in the West of Paraná State (PR-W) in Scenario 1, part of the production was destined for the local market of the State (in the Southeast (PR-SE) – agroindustrial region), and thus just road transport was used to reach that region. Another portion of the production from West of Paraná was destined for the Europe market, which was exported via the port of Paranaguá (state of Paraná). For this flow both road and rail routes were used, soybean from this producing region was transported by truck to the rail terminal in the city of Londrina (state of Paraná), and from there was transported by rail to the port of Paranaguá (R10).

But in the Scenario 2, with increasing test and storage costs, this region reduced the volume and began to supply the Chinese market. Besides this change, the route to the international market has changed using just road transport (R9).

Similarly happened with West of Mato Grosso (MT-W). In scenario 1 the production from this region was destined to Chinese and Japanese markets using intermodal transportation via Port of Itacoatiara (Amazonas State). The soy was transported by truck to the waterway Port in the city of Porto Velho (Rondônia State), and from there was transported by waterway to the port of Itacoatiara. In scenario 2 there have been changes in trading volumes and market destination. The route used was the same (R15) but the market destination was only to China and a 4.3% reduction of sales.

As earlier mentioned, the flows destined to foreign markets were the most affected. This is due to the fact that intermodal transport, which involves a larger number of transshipments, dominated, and consequently a greater number of tests were performed, leading to increased transport costs. Also, the greater cost is the segregated storage, since the farm until shipping and landing locations. Moreover, the PCR costs are incurred in the port of export as the greater the number of events identified, the greater the impact.

Chart 1. Soybean Flows Quantities by Route in Scenario 1 (thousand tons)

Supply	Demand	Route[7]									
		R1	***R2***	***R3***	***R5***	***R8***	***R9***	***R10***	***R13***	***R14***	***R15***
PR-W	PR-SE		1,221.38								
MT-N	MT-SE			744.95							
GO	SP	2,023.36									
RS	EU-27								4,924.71		
PR-N	China						2,939.01				
PR-W	EU-27							2,531.98			
MT-N	China				6,477.50						
MT-NE	EU-27				2,102.19						
MT-NE	China				230.27						
MT-W	China										3,296.90
MT-W	Japan										637.16
MS	China							1,073.39			
GO	China					907.74					
MG	China									1,307.85	

Scenario 1: not include cost of tests. Highway route (unimodal): R1, R2, R3, R9, R11. Intermodal route: R5, R8, R10, R13, R14, R15. Source: Research data, 2010.

Chart 2. Soybean Flows Quantities by Route in Scenario 2 (thousand tons)

Supply	Demand	*Route*						
		R1	***R2***	***R3***	***R4***	***R9***	***R11***	***R15***
PR-W	PR-SE		1,234.74					
MT-N	MT-SE			754.62				
GO	SP	2,046.03						
RS	EU-27						4,801.73	
PR-N	China					2,819.29		
PR-W	China					2,357.82		
MT-N	China				3,083.21			
MT-N	EU-27				2,505.60			
MT-N	Japan				583.03			
MT-NE	China				2,241.75			
MT-W	China							3,762.66
MS	EU-27					1,016.82		
MG	China				1,257.24			
GO	EU-27				743.85			

Scenario 2: include Strip Test and PCR for International Flows. Ad-valorem tariff: highway route (unimodal) – 37% and intermodal route – 40%.
Highway route (unimodal): R1, R2, R3, R4, R9, R11. Intermodal route: R15. Source: Research data, 2010.

[7] Descriptions of routes and supply and demand regions are in Appendix A.

The studies of Simões (2008), Kimani and Gruère (2010) e Bouët, Gruère and Leroy (2010) reached similar conclusions to those presented here. For Simões (2008), considering the soybean market, the implementation of the CPB by Brazil would negatively affect Brazilian exports, ranging from 0.1% to 3.5%. If Argentina and the United States take the same measures of segregation, the Brazilian losses would reach US$329.00 million. To Kimani and Gruère (2010), the implementation of the CPB would mean trade losses. Implementing a stricter requirement, whereby all consignments must be labeled “does contain” would lead to consumer price increases and significant additional costs for public agencies that would likely be borne by traders, without benefits for regulators. It would also create potential hurdles for future GM crops in Kenya. The study by Bouët, Gruère and Leroy (2010), which aimed to evaluate the trade diversion, price, and welfare effects of implementing the “does contain” rule on the maize sector in all significant trading countries.

The results show that information requirements would have a significant effect on the world market for maize. But they would have even greater effects on trade, creating significant trade distortion, diverting exports from their original destination. The measure would also lead to significant negative welfare effects, for all members of the Protocol and non-member that produce GM maize. While producers in non-GM Protocol member countries may benefit from increased protection, consumers and producers in selected countries will have to proportionally pay a much heftier price for such measure. This results call for governments affected Protocol member countries to reconsider their support for this new regulation that is bound to have no environmental benefits but significant and lasting economic costs.

An additional assessment was made for Scenario 2 (already considering the imposition of the CPB), through sensitivity analysis of two parameters in the inputs of the model: price elasticity of supply and price elasticity of demand. According to Alvim (2003), the price elasticity of demand measures consumers reaction to changes in price, while the price elasticity of supply measures the reaction of sellers to price changes. When there is a change in market prices, there may be changes in volumes consumed and produced that are more or less intense, depending on the slopes of the curves. In this study, price elasticities of supply and demand are different according to region considered.

The simulations of the price elasticity of supply behavior consider that this variable may have variations if there are technological changes in production and/or marketing, new alternatives in the production. As for the price elasticity of demand, this may be altered if there are changes in income, substitute products or simply consumer preferences.

Simulations for Scenario 2 were C2S+50 (supply) e C2D+50 (demand), for a positive variation of 50% in the price-elasticities (supply and demand). To negative variation of 50% in the price-elasticities (supply and demand): C2S-50 and C2D-50. In C2D+50, the price-elasticity of demand was more negative. For example, for São Paulo the price-elasticity of demand was -0.10 and in the Scenario 2 C2D+50 was equal -0.15. In C2D-50, the price-elasticity of demand was less negative. For example, for São Paulo the price-elasticity of demand was -0.10 and in the Scenario 2 C2D-50 was equal -0.05.

In the scenario with the imposition of the CPB for testing of transgenic event (Scenario 2), the trades had totaled 29,208.370 tons, but the simulation of the C2S +50 the volume traded down 0.20%, to 29.150,00 tons. The greatest loss was within C2D+50 (down 2.3%) (Chart 3).

Chart 3. Volume of soybeans trading resulting from variation in price-elasticities of supply and demand, Scenario 2.

(thousand tons)

Variables	Scenario 2	C2S+50	C2S-50	C2D+50	C2D-50
Supply	29.208,37	29.150,00	29.323,98	28.537,05	30.175,23
Domestic demand	4.035,39	4.030,67	4.044,75	4.093,31	3.999,76
International demand	25.172,98	25.119,33	25.279,23	24.443,74	26.175,47

Source: Research data, 2010

The biggest gain in volume was observed in the simulation C2D-50, where the marketing of soybeans came even Scenario 1 (without the imposition of tests), reaching 30,175.23 tons. In this configuration, Scenario 2 C2D-50 was able to reduce the negative impacts of CPB.

In a context of positive variation of the price-elasticity of supply (C2S+50), all trade flow reduces (Chart 3 and Figure 1). Consumers respond negatively to this change. This frame has a good approximation to the implications of the CPB, because, besides the increase in transportation costs for segregation (simulated in Scenario 2), other expenses may occur with the adoption of the Protocol, involving additional costs of marketing and operation of a Identity Preserved system (IP), which can result in price changes, leading to a fall in total volumes traded.

In a context of negative variation of the price elasticity of demand (C2D-50), the gains were realized by supply regions and international demand regions. This is because, if there are productivity gains and/or different prices for GM soybean - for example varieties with high protein - and these are reflected in the prices, these regions internalize such a positive change, increasing the volumes traded between these regions. The domestic demand respond negatively, either in terms of slope of the demand curve, either in terms of flows to the international market that best respond to such oscillations, which resulted in trade redirection to the international demand regions (Figure 1).

	C2 S+50	C2 S-50	C2 D+50	C2 D-50
Supply	-0,20	0,40	-2,30	3,31
Domestic demand	-0,12	0,23	1,44	-0,88
International demand	-0,21	0,42	-2,90	3,98

Figure 1. Sensitivity analysis of soybean trading for Scenario 2, variations in the price-elasticities of supply and demand.

Source: Research data, 2010

CONCLUSIONS

Using the MCP model proposed for the transfer of Brazilian soy, it was possible to verify the effects of the implementation of the Cartagena Protocol. The study assessed the main routes used in moving the production of soybean directed to the domestic market and for exportation, and considered the performance of strip tests and PCR (Polymerase Chain Reaction) testing (used to identify the presence of GM events) along the route.

With segregated storage and tests to identify the GMO´s throughout the exportation routes, there is an increase of the cost of transport. This causes a reduction in production, resulting in a fall in commercialization, especially of the external market that demanded the largest number of tests, reflecting a decrease in competitiveness of Brazilian soy. The CPB also imposed an increase in the opportunity cost by adopting a new technology.

In this research the implementation of the Cartagena Protocol by Brazil would negatively affect Brazilian exports by 4.75%, this variation results in losses in the international trade of US$501.0 million in 2009. Different variation among importing countries was observed, Japan exports to decrease by 8.5%, to Europe by 5.1% and to China by 4.4%.

The impact of the Protocol will differ significantly even among exporter countries. These differences will reflect logistical conditions, the infrastructure for identification testing, and the share of exports in total production. Cost differences among exporter countries may affect their competitiveness and cause trade diversion.

Thus, transport and storage logistics that up to now are not yet adequate for the transport of standardized products must be adapted in order to meet the demand for differentiated products.

The requirement to implement processes which involve a rise in fixed costs with no direct connection to compliance with the Protocol's Biosafety objectives should be seen as another component of the process to create technical barriers to trade, with negative effects on the agricultural producers in exporting countries and on the consumers in the countries which import Brazil's production.

At the present time, Brazil faces the challenge of reducing its deficit in storage and transportation capacity, a process which is being based on increased efficiency from agility and taking advantage of scale economies and scope. The imposition of identity conservation systems on a large scale would not only mean diverting the resources necessary to accompany the Brazil's agricultural production growth rate, but also create uncertainties as to the type of investment that should be made.

The idealizers of the CPB imagined this agreement as being "self-fulfilling", i.e. that the CPB would be able to impose their rules, even for non-members countries, by power of the member-countries importers of commodities. Such argument does not consider the strategy of the bilateral agreements, which may lead the member-countries to reduce their requirements and the possible economic impacts resulting from the application of the CPB.

Put another way, the CPB, like other agreements involving the regulation of trade flows, trade and interfere with the dynamics conditions of free trade of agricultural commodities. The argument based on biodiversity preservation must also take into account the economic impacts caused by the imposition of regulatory measures, under the penalty to create trade diversion and adversely affect the competitiveness of agribusiness. An important contribution to try to solve these diversions is the implementation of bilateral contracts and/or provide mechanisms to reduce tariffs imposed by importing countries in an attempt to reduce the negative impacts of CPB.

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APPENDIX A

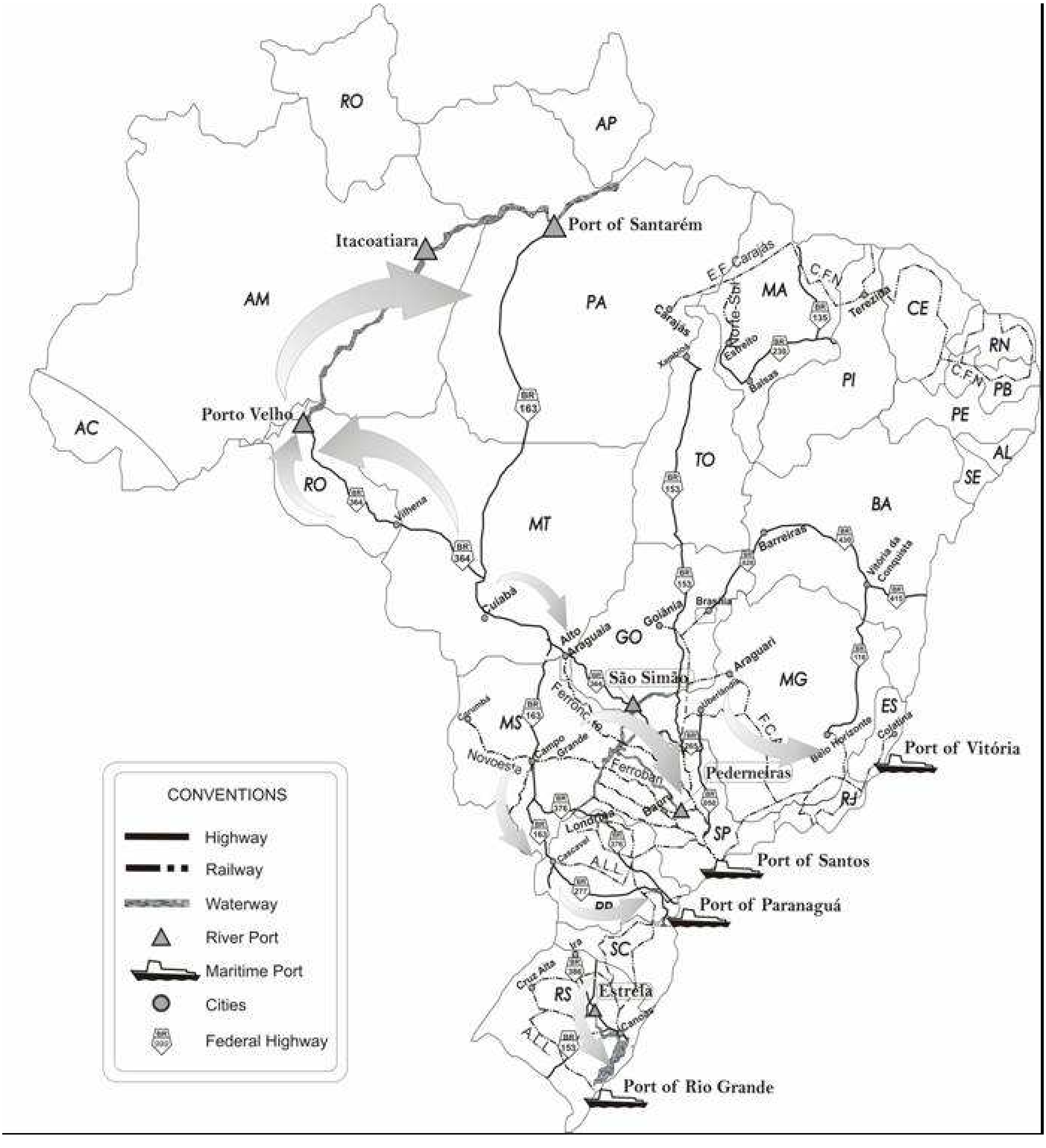
Chart 4. Description of Routes considered in the Model

Route	Description		
	Destination	Mode of Transport	Transshipments Points
R1	SP Demanda	roadway	-
R2	PR-SE Demand	roadway	-
R3	MT-SE Demand	roadway	-
R4	Port of Santos	roadway	-
R5	Port of Santos	roadway and railway	by Alto Araguaia (MT) train station
R6	Port of Santos	roadway and railway	by Campo Grande (MS) train station
R7	Port of Santos	roadway and railway	by Goiânia (GO) train station
R8	Port of Santos	road, water and railway	by São Simão (GO) waterway Port and Pederneiras (SP) train station
R9	Port of Paranaguá	roadway	-
R10	Port of Paranaguá	roadway and railway	by Londrina (PR) train station
R11	Port of Rio Grande	roadway	-
R12	Port of Rio Grande	roadway and railway	by Cruz Alta (RS) train station
R13	Port of Rio Grande	roadway and waterway	by Estrela (RS) waterway Port
R14	Port of Vitória	roadway and railway	by Araguari (MG) train station
R15	Port of Itacoatiara	roadway and waterway	by Porto Velho (RO) waterway Port

Chart 5. Description of Supply and Demand Regions considered in the Model

Regions	Description	Classification
PR-N	North of Paraná State	supply region
PR-W	West of Paraná State	supply region
PR-SE	Southeast of Paraná State	domestic demand region
RS	Rio Grande do Sul State	supply region
MT-N	North of Mato Grosso State	supply region
MT-NE	Northeast of Mato Grosso State	supply region
MT-W	West of Mato Grosso State	supply region
MT-SE	Southeast of Mato Grosso State	domestic demand region
MS	Mato Grosso do Sul State	supply region
GO	Góias State	supply region
MG	Minas Gerais State	supply region
SP	São Paulo State	domestic demand region
EU-27	Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxemburg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the United Kingdom	international demand
China		international demand
Japan		international demand

Figure 2. Map of Transhipments, Ports and Routes considered in the Model



Source: Created by the author using data from Brazilian Institute of Geography and Statistics (IBGE, 2010).