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Cartagena protocol, biosafety and grain segregation: The effects on the soybean logistics in Brazil

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This article reviews the main effects of segregation of differentiated soybeans on the Brazilian logistics of transport and storage from the simulation of scenarios considering the resolutions taken by the Cartagena Protocol on Biosafety (CPB). To achieve this goal is used a partial equilibrium model formulated as a Mixed Complementarity Problem that allows assessing changes in terms of production, consumption and trade considering alternate scenarios. This spatial equilibrium model allows the impact analysis of the Cartagena Protocol on the different routes of commercialization of Brazilian soybeans. As a main conclusion, it is observed that the logistics of transport and storage in Brazil is affected by the requirements of the Cartagena Protocol on Biosafety. Therefore, the more rigid the identification process, the greater the impact on exports.

Keywords: Mixed complementarity problem, Partial equilibrium models, Grain sector and Logistics.

Introduction

This paper emphasizes the complexity of the issues involving the Brazilian agribusiness in discussing the conditions for deployment of identity preservation systems (IPS) of grains - especially the cultivation of soybeans - that meet the requirements arising from the diffusion of genetically modified cultivars in Brazil. The difficulty lies not only in differential impacts and costs of deploying these systems in distinct regions producing/exporting grain in the country, but also on the realization of the limitations caused by the inertia created by the process of commoditization of exports and the fragility of the transport and storage infrastructure.

As a result of the advancement of technical and organizational changes, the Brazilian food processing industry has undergone a restructuring process, with the main determinants the foreign competition and changes in consumer profile (BELIK, 1994). Similarly, Ramos (2007) points out that agricultural producers in Brazil are increasingly subject to demands and perceptions of the retail market. This is because the new "dimensions of consumption of goods" of the population, in particular with the social and environmental demands, lead the industry to adopt new standards of production, further segmenting the market and, thus, providing opportunities for new agribusiness.

The possibility of choice between GM, conventional products and various other specialties of agricultural products is not guaranteed at this current stage of organization and coordination of the agrofooding system (PESSANHA and WILKINSON, 2003). Ensuring choice requires new information and traceability rules, which

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may be voluntarily established by the initiative of the distinct actors in the chains or can be regulated through legislation implemented by governments. Such initiatives, involving preservation of the grain and food products identity, require the segregation of production of seeds and grains, and their traceability through all stages of production, transportation, processing and marketing in the food chain.

In this direction, the objective of this article is to analyze the effects of segregation of differentiated soybeans on the logistics of transport and storage of the country from the simulation of scenarios considering the resolutions taken by the Cartagena Protocol on Biosafety (CPB).

Finally, section 2 describes the requirements of the Cartagena Protocol on Biosafety and Article 18 on handling, transport, use and identification of shipments containing Living Modified Organisms (LMOs), and the Brazilian position at meetings of the CPB. Section 3 presents the model adopted – Mixed Complementarity Problem (MCP), to consider the issue of Genetically Modified (GM) soybean and the construction of the scenarios used. Section 4 presents the main results obtained from the partial equilibrium model in the form of a MCP and the impacts from the imposition of CPB in Brazilian trade flows. In the end, Section 5 presents the conclusions and contributions of the research.

International trade in LMOs: rules, norms and standards

Over the past decades, the modernization of the techniques of genetic manipulation promoted an expansion of the use of biotechnology, which includes a variety of technologies capable to introduce and enhance the characteristics of living organisms, enabling the generation of new products, processes and services. This new technological standard intends to replacement of a capital and fossil fuel intensive technologies, starting the search for new bio-based technologies.

This new paradigm is based on the ideas of genetics and information technology revolution, whose operational matrix creates a new economic era (RIFKIN, 1999). The possibilities opened up by biotechnology bring out new products and processes that influence the economic system. The biotechnological innovations are embedded in a context of risk and benefits, which conditions the emergence of institutional changes - to deal with issues of risk and regulation, intrinsic to this new segment - and restructuring of the markets - to explore these new resources that reduce costs. This is because such innovations dealing with the manipulation of living organisms to produce goods and services (JUMA, 1999; KALAITZANDONAKES, 1999; CONKO and SMITH, 1999).

The use of biotechnology in agriculture and medicine has been one of the most controversial current topics. This is due in large part by the clash between some social actors about the benefits and real or potential risks that the resulting products of agricultural biotechnology can cause to the environment. On the one hand, there are those who argue that the cultivation of GM crops reduce the use of pesticides, reducing agricultural production costs, which would imply a drop in prices of food and help fight hunger and malnutrition. On the other hand, there are those who maintain the position that the cultivation of GM crops can damage human health and biodiversity.

Regardless of the position regarding the LMOs, two points deserve emphasis. The first is related to the economic implications, particularly in developing countries. This is because the diversity of bio-security and authorization systems related to the labeling, identity preservation, segregation and traceability are aspects that could further complicate more the international trade of genetically modified crops and affect trade of agricultural commodities.

The second aspect is that, if in one side, developed countries have established their regulation to deal with agricultural biotechnology based on their national strategies and priorities, on the other side, developing countries are doing so in circumstances less flexible. As Zarilli (2005), instead of enjoying the freedom to assess the risks and benefits that agricultural biotechnology can bring and act in this sense, developing countries increasingly are driven on the demands of their trading partners to define their policies.

There is no consensus on how is the best way to regulate GMOs crops. In the last 15 years of production of genetically modified (GM) on a commercial scale, the global debate on the regulation was marked by disagreements between two major players in the world market for agricultural commodities: United States and European Union (SILVEIRA, 2010b).

In the United States, regulation of GMOs is made from a pre-existing structure, which analyzes the Biosafety of food products in general. This gives them experience to even consider the desirability or otherwise in participate in multilateral organizations. It involves three agencies: Food and Drug Administration (FDA), Environmental Protection Agency (EPA) and United States Department of Agriculture (USDA). When there is a launching of a new product, it's only verified if the criterion of "substantial equivalence", can be applied. Thus, in the United States, there is no specific regulation for LMOs (MCGARITY and HANSEN, 2001).

In Europe, new structures were created for the regulation of genetically modified foods. They do not use the principle of substantial equivalence but the "precautionary principle", which recognizes the possibility that GMOs present risks to health and the environment. These risks require then the creation of a own regulation to the LMOs. The adoption of the "precautionary principle", expresses a cautious stance of European society, while scientific studies show no more reliable results (MCGARITY and HANSEN, 2001).

The regulation about GMOs has been, in theory, designed under the rules of the Convention on Biological Diversity (CBD) through the Cartagena Protocol on Biosafety (CPB) and the World Trade Organization (WTO), which is based on standards and guidelines of Codex Alimentarius to deal with the issues of food safety. The theory to practice, there is a distance covered by the complexity of the formation of multilateral protocols where consensus is the rule. The space for collective action results in that the constitution of the CPB, with respect to its specific provisions about the LMOs, go through various impasses.

The Cartagena Protocol on Biosafety (CPB) has its origin in the Convention on Biological Diversity, which entered into force in 1993 and is now the main international instrument for the discussion of issues on biodiversity (CBD, 2000). At its second meeting in 1995, the Conference of Parties of the convention established a working group that should develop a protocol on Biosafety, paying attention to the transboundary movement of any Living Modified Organism (LMO) that may have effects on the sustainable use of biodiversity. Thus emerged the Cartagena Protocol on Biosafety, approved in 2000 (CBD, 2000). The CPB came into force in 2003 and until October 2010, 160 countries have ratified the Protocol (MACKENZIE et al., 2003).

One aspect that has generated the most discussion is the identification of exported cargo containing LMOs. The discussions on the identification requirements, in the framework of PCB, are described in Article 18.2.a and were focused on the choice of expression that should be used to accompany the shipment of LMOs. Members of the Protocol agreed to consider two options: "May contain" – for shipments in which the events are not precisely identified, an alternative that can be easily operated by the inclusion in the loading, of a list of probable events (in this case, the impacts on trade flows would be much reduced); "Contains" – which requires additional measures, where the identity of GMOs contained in shipments must be determined by an Identity Preservation System (IPS)-based in tests, including a list of present events.

The identification will continue to be made with the "May contain" until 2014, when then the matter will be reconsidered. As Vieira Filho, Borges and Silveira (2006), when it's interfered in the contractual and export decisions grain export chain, the statement "contains" opens the door to demands that aims to generalize the demands of the identity preservation systems based on tests, with undesirable impacts in trade configuration – incentive to verticalization on producers countries and stimulus to grain production in countries less efficient in an agricultural point of view.

Another negative influence regarding the increased demands related to the change in cross-border trade of LMOs is about the process of diffusion of new technologies for agriculture, especially those resulting from agricultural biotechnology. Once these technologies can contribute sharply to the implementation of new management techniques, which greatly reduce the impact of agricultural practices on the environment, these positive outbreaks can be minimized (VIEIRA FILHO, BORGES and SILVEIRA, 2006).

With respect to CPB, Brazil has played an important role in its history and evolution, in particular for two main reasons: the first, for having hosted the Earth Summit in 1992, which gave rise to the Biodiversity Convention, which has the Protocol as part of it. The second, by the active participation and the important contributions during the negotiations (SIMÕES, 2008).

As Lima (2006), Brazil has a peculiar position among the members of the CPB. This is because, besides being a country of rich biodiversity, also ranks third in the list of the largest exporters of agricultural products in the world, which imposes negotiates the rules of the Protocol with balance and objectivity. Despite the claims of authors such as Zarilli (2005) that developing countries have established regulatory principles less defined than developed countries, this criticism does not apply to the Brazilian case, which is marked by ambiguity due to the fact of being a large exporter of agricultural products; a residual importer - wheat, barley and a few non-tropical products (SILVEIRA, 2010), and holder of high biodiversity and of centers of cultivars' origin (such as Peru, Colombia, Mexico, Costa Rica, Turkey, China and others) . Thus, the delay for the definition of Biosafety policy in Brazil is due less of lack of training in the area and more due the conflicts that still exist between different social actors who participate in direct and indirect regulatory process (BORGES, SILVEIRA and OLIVEIRA, 2009).

Methodology

In order to quantify the potential impacts of the costs of implementing the Cartagena Protocol on Biosafety (CPB) for Brazil, with a focus on organizing the logistics of transport and storage in Brazil, uses a partial equilibrium model formulated as a Mixed Complementarity Problem (MCP). The partial equilibrium model is analyzed the direct effects of any trade policy on a given market. Such approach allows a very detailed assessment of the studied sector. As Alvim (2003), this approach aims to solve the problems of trade between different spatially separated regions, which present distinct supply, demand and tradeflows. These models are also known as spatial equilibrium models.

The most frequent use of partial equilibrium models with endogenous prices has been observed in problems related to competition of interregional markets (YAVUZ et al., 1996). They also have been employed to simulate the impact of trade policies in different markets (McCARL and SPREEN, 2001). Moreover, it is important to note that the theoretical framework of this model can be expanded, including exporting and importing regions, multimodal transport and multi-commodity. And yet, they can be used to simulate the impact occurred in the markets through the application of trade policies, such as: quotes, subsidies, tariffs, among others (OLIVEIRA, 2004).

This study comprises an analysis of the impact of CPB in the Brazilian soybean market. The choice of this method provides a detailed assessment of the effects of the implementation of the CPB in the Brazilian trade, and also has the advantage of allowing the incorporation of tariffs, quotes, tariffs and subsidies more easily.

The partial equilibrium model can be presented as a Mixed Complementarity Problem (MCP). The use of MCP was proposed by Thore (1992), Rutherford (1995) and Bishop et al. (2001) and already used by Alvim (2003) and Alvim and Waquil (2004). A complementarity problem consists of a system of simultaneous equations (linear or nonlinear), which are described as inequalities, from the functions of supply and demand. The MCP is equivalent to the *Kuhn-Tucker* conditions, which are necessary and sufficient to achieve the most of the *Net Social Payoff*; (NSP), which in turn means reaching the equilibrium in all markets and all regions (BISHOP et al. 2001).

The MCP proposed to analyze the Brazilian soy market is as follows:

Indexes:

$i =$ supply regions ($i = 1,...,9$)

$j =$ domestic demand regions ($j = 1,...,3$)

$k =$ international demand regions ($k = 1,...,3$)

$r =$ transport routes ($r = 1,...,15$)

Variables:

$p_i =$ supply price

$p_j =$ domestic demand price

$p_k =$ international demand price

$z_i =$ quantity supplied

$y_j =$ quantity consumed by domestic demand

$y_k =$ quantity consumed by international demand

$x_{..} =$ quantity transacted

Parameters

$t_{ij} =$ cost of transport

$\varphi_i =$ shadow price associated with the supply region i

$\lambda_j =$ shadow price associated with the domestic demand region j

$\mu_k =$ shadow price associated with the international demand region k

$$0 \le \varphi_i \perp \sum_j^J x_{ij} + \sum_k^K x_{ik} \le z_i \qquad (1)$$

$$0 \le \lambda_j \perp y_j \le \sum_i^I x_{ij} \qquad (2)$$

$$0 \le \mu_k \perp y_k \le \sum_i^I x_{ik} \qquad (3)$$

$$0 \le x_{ij} \perp p_i + t_{ij} \ge p_j \quad \forall_{i,j} \qquad (4)$$

$$0 \le x_{ik} \perp p_i + t_{ik} \ge p_k \quad \forall_{i,k} \qquad (5)$$

The symbol "□" means that at least one adjacent inequalities must be satisfied as a strict equality. This is nothing more than a formality of complementarity that we saw earlier, when presenting the Kuhn-Tucker conditions. Equations
(4) and (5) are thus presented to facilitate the inclusion of the fee or ad valorem rate brought
about by the cost of the test for identification of transgenic events.
The inclusion of ad-valorem tariff was based on
the work of Bishop et al. (2001). Given the zero profit condition (5), the inclusion of a parameter tax_{ik}, which represents a rate or ad valorem rate, is given by an incorporation on the model in the equation (5).
This is because, in this study, the rate has implications only in the flows intended for the international market. Modifying the condition of zero profit, as follows, we have:

$$(p_i + t_{ik}) \cdot (1 + tax_{ik}) \ge p_k \quad \forall_{i,k} \qquad (6)$$

In this case, the rate is a result of the imposition of performing tests for identification and quantification of GMOs events, plus the cost of segregated storage on the flows to the international market, since the CPB imposes measures on transboundary movements.

When equilibrium is attained, the existence of trade flows between producing regions and international demand, the price of the product at the supply region, plus the cost of transportation, after the imposition of segregation and LMO testing, must be equal to the price on international demand. Otherwise, if there is no trade flow, this means that the price of international demand in the region is less than the price offered in the region added to the costs of transportation and testing.

In the model, were initially identified and selected regions of supply and demand for soy. The selected states make up the Southeast, Midwest and South regions. It was studied the behavior of the last years of the variables: soybean production, average yield, acreage, exports and processing capacity (plant). The choice of the states that made up the model was based on the expression of these regions in participation of the variables analyzed. The aim was to characterize the dynamics of these regions, which have highlighted national expression and great potential for expansion based on the agricultural frontier.

For example, the State of Mato Grosso was selected because of high rates of production and productivity in recent years, besides being an important region of the agricultural frontier. Whereas the states of Parana and Rio Grande do Sul were selected because of the tradition in the cultivation of soy and high rates of production. The State of São Paulo was characterized as a major consumer of soybean grain destined for processing.

To characterize the regions of excess supply and demand, we started with the following premise: if the production of soybeans is greater than the amount processed, this region is characterized as a region of excess supply, otherwise, this region is characterized as a region of excess demand. For the state of Mato Grosso and Paraná were identified two different micro regions, relative to both production and processing, due to regional heterogeneity that implies different flow trades and use of different transport routes.

The data that make up the model (production, consumption, trade prices of domestic and international markets, price Elasticities of supply and demand, freight rates of different transport modes, costs of testing LMOs) were based on the year 2009. Data of production were collected from the Brazilian Institute of Geography and Statistics (IBGE) and the United States Department of Agriculture (USDA). The consumption data were based on the Brazilian Association of Vegetable Oil Industries (ABIOVE) and soybean prices for the domestic and international markets were based on the consultancy Safras & Mercado (2010) and USDA (2010), respectively. The data of price elasticities of supply and demand were based on studies developed by Fuller et al. (2001 and 2003) and FAPRI (2010).

There are two methods of analysis of LMO: one, accomplished by a DNA analysis and other, through the analysis of proteins. In the first case, the technique used is the PCR (*Polymerase Chain Reaction*), quantitative or qualitative. In the analysis of proteins, it can be used the ELISA (*Enzyme-linked immunosorbent assay*) or simple tape test, which is found in only one event at a time (OLIVEIRA, 2011).

According to this same study, the unit cost is U.S. $ 3.00 for tests of tape and U.S. $ 300.00 for the PCR. At each 40 tons, two samples are taken, which requires two tapes, giving a total cost of U.S. $ 6.00. In the case of PCR is considered the performance of three tests for each 3,000 tons, making a total of U.S. $ 900.00, including one

PCR at the time of shipment, one PCR at the export port and one PCR in the ship. Segregate storage costs are of the main companies exporting non-GM soy. Costs in transshipment warehouses are U.S. $ 13.00/tonne and the storage in export ports, on average, U.S. $ 10.00/tonne (OLIVEIRA, 2011).

This way, the estimated costs of testing and storage was developed aiming to use the term "contains", i.e., which includes both the identification and quantification of GM soy. This consideration was made, since the choice of the term "may contain" would almost no change the marketing costs and would have minimum consequences in the logistics structure (HUANG et al., 2008, BORGES et al. 2006b; KALAITZANDONAKES, 2004; GRUÈRE and ROSEGRANT, 2008; SIMÕES, 2008).

Three different scenarios are simulated: Scenario 1 is the control, in which there was no expenditure on testing for LMOs and segregated storage, the trade flows occurred only on the basis of transportation costs, i.e., without imposing CPB aiming the term "contains". Scenario 2, was proposed an intermediate scenario in which were evaluated for detection one transgenic event, event RR (*Roundup Ready*) tolerant to the herbicide glyphosate. The PCR test is considered at the time of shipment, at the export port and in the ship The number of tape tests varied according to the transportation route considered. At each change of mode of transport - which requires transshipment, since cargo mixing could occur – an additional tape test was performed. The segregated storage was also considered during the process. Based on these considerations, the ad-valorem rate was calculated at 40% in intermodal flows and 37% in unimodal flows. In Scenario 3 are evaluated two transgenic events, because, according to respondents in Group 1 and Group 3, the most tested event is RR, however, with the approval by CTNBio of other products, like Bayer's *LibertyLink* soybean and Monsanto's BtRR2 soybean, a crescent demand has occurring to evaluate more than one event. Thus, in this scenario, the ad valorem rate parameter was changed (48% to unimodal and 52% intermodal). As the intermodal transport requires transshipment, which requires further tape testing, costs for identification of transgenic events has increased, resulting in an ad valorem rate superior to unimodal routes. The pattern of sampling and collection points were the same as Scenario 2, the differential was only in the number of events tested, which increases labor costs.

The processing of information to the MCP developed for the movement of soybeans in Brazil was done using the computer program *General Algebraic Modeling System* - GAMS (Brooke et al., 1995).

Transport costs of road and rail modes in the model were estimated by linear equations based on the distances between the points of loading and receiving (source / destination). The behavior of modal cost (response variable) was analyzed using a multiple linear regression model. It was used a database of monthly freight practiced throughout Brazil in 2009, having as the source the data from Freight Information System (SIFRECA, 2010). For hydro modal, were used the freight rates on hydro routes in 2009 and SIFRECA was also a source. It was not performed a regression test, since the number of hydro routes considered in the model was only three.

Results and Discussion

According to Alvim (2003), mathematical programming models must be validated by the checking and consistency of the problem results. To Waquil and Cox (1995), validation requires an adjustment of the coefficients and the model structure. The model can be validated by checking how well the solution suggested by the model approximates the real situation. According to Thompson (1981) apud Waquil and Cox (1995), most of the spatial equilibrium models do not generate identical results to real data. In this study, the authors analyzed the evolution of international agricultural trade of the United States, indicating the different reasons why the models do not reproduce all the observed trade flows of agricultural *commodities*. Among them: products may not be perfectly homogeneous, some countries impose health restrictions on imports, and importers may diversify their purchases among several suppliers.

Thus, some differences between the results estimated by the model and observed data can occur without invalidating the model. In Table 1,
we can check the levels of supply and demand estimated by the model. The volumes carried in
2009 ("Observed Data") and the estimated data
from the model ("Scenarios 1, 2 and 3") are also presented.

Scenario 1 corresponds to the control group. In it, there was no expenditure on testing LMOs and segregated storage, trade flows occurred only on the basis of transportation costs. This scenario represents business transactions without the imposition of the CPB. With the focus of analyzing the impacts under the CPB through the article 18.2.a and considering the use of the term "contains", the costs of segregation tests were incurred in Scenario 2 and 3.

In Scenario 2, the identification and quantification of soy produced a negative impact of 3.98% in soybean production. International flows were the hardest hit, with losses of 1.25 million tons. Exports to Japan and Europe, which are the largest importers of non-GM soybeans, fell by 8.50% and 5.14% respectively.Scenario 2 gives evidence of competitiveness loss of Brazilian soybeans. Through the given parameters, it's possible to identify how the productive performance and consumption in the regions analyzed are modified when an international agreement is simulated. Due to drain the Brazilian production is necessary to carry a greater number of transfers, given the long distances to export ports, the loss of Brazilian competitiveness in relation to key competitors, the United States and Argentina, could be higher, since these countries have a higher logistic efficiency.

Regarding to the monetary losses, considering the cost of testing and storage (U.S. $ 1.1 billion) and the reduction of international trade (U.S. $ 482.8 million), losses reach U. S. $ 1.57 billion. This amount represents 13.8% of foreign exchange generated by exports of soybeans in Brazil in 2009, which amounted, according to the Ministry of Development, Industry and Foreign Trade from Brazil (MDIC), U.S. $ 11.41 billion.

Commercial losses in Scenario 3 were 1.49 million tons. Following the same trend observed in Scenario 2, the highest rates of reduction were observed in the states of Mato Grosso do Sul (6.54%) and Goiás (5.97%). In this scenario, commercial losses reached U.S. $ 2.01 billion, representing 17.6% of hard currency received by Brazilian exports of soybeans in 2009.

From the simulation of Scenarios 2 and 3, it is possible verify that the outbreaks of the CPB will have differentiated reflex in the main productive

Brazilian regions; the losses in Scenario 3, ranged from 3.05% to 6.54%. The impact of the measures of the CPB can vary considerably between Brazilian states that are soybean exporters. These differences occur because the conditions of the infrastructure of transportation and storage, logistics options available and capable of rapid adjustments to meet the segregated movement, the laboratory infrastructure and weight of grain exports to the state's trade balance.

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Table 1. Supply volumes, domestic demand and international demand, model estimates (Scenarios 1, 2 and 3) and Observed Data, 2009.

Regions	Estimated			Observed (D)	Variation (B)/(A)	Variation (C)/(A)	Variation (A)/(D)
	Scenario 1 (A)	Scenario 2 (B)	Scenario 3 (C)				
Supply	(thousand tons)						
Total Mato	13,488.97	12,930.86	12,799.29	13,131.20	-4.14	-5.11	2.72
North MT	7,222.44	6,926.46	6,858.14	7,071.38	-4.10	-5.04	2.14
West MT	3,934.06	3,762.66	3,720.74	3,791.97	-4.36	-5.42	3.75
Northeast MT	2,332.47	2,241.75	2,220.40	2,267.85	-3.89	-4.80	2.85
Total Paraná	6,692.37	6,411.85	6,343.37	6,525.53	-4.19	-5.21	2.56
West PR	3,753.36	3,592.56	3,553.49	3,671.13	-4.28	-5.33	2.24
North PR	2,939.01	2,819.29	2,789.88	2,854.40	-4.07	-5.07	2.96
Rio Grande do	4,924.71	4,801.73	4,774.60	4,853.80	-2.50	-3.05	1.46
Goiás	2,931.11	2,789.88	2,755.98	2,820.39	-4.82	-5.97	3.93
Minas Gerais	1,307.85	1,257.24	1,246.51	1,282.86	-3.87	-4.69	1.95
Mato Grosso do	1,073.39	1,016.82	1,003.21	1,065.86	-5.27	-6.54	0.71
TOTAL SUPPLY	30,418.39	29,208.37	28,922.95	29,679.63	-3.98	-4.92	2.49
Domestic							
São Paulo	2,023.36	2,046.03	2,051.64	2,028.85	1.12	1.40	-0.27
Southeast PR	1,221.38	1,234.74	1,238.09	1,225.04	1.09	1.37	-0.30
Southeast MT	744.95	754.62	756.91	748.52	1.30	1.61	-0.48
Sub-total	3,989.69	4,035.39	4,046.64	4,002.41	1.15	1.43	-0.32
International							
China	16,232.66	15,521.95	15,353.48	17,000.00	-4.38	-5.42	-4.51
UE-27	9,558.88	9,068.00	8,952.40	10,000.00	-5.14	-6.34	-4.41
Japan	637.16	583.03	570.43	700.00	-8.50	-10.47	-8.98
Sub-total	26,428.70	25,172.98	24,876.31	27,700.00	-4.75	-5.87	-4.59
TOTAL DEMAND	30,418.39	29,208.37	28,922.95	31,702.41	-3.98	-4.92	-4.05

Source: Research Data, 2010.

losses reach U. S. $ 1.57 billion. This amount represents 13.8% of foreign exchange generated by exports of soybeans in Brazil in 2009, which amounted, according to the Ministry of Development, Industry and Foreign Trade (MDIC), U.S. $ 11.41 billion.

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From the simulation of Scenarios 2 and 3, it is possible verify that the outbreaks of the CPB will have differentiated reflex in the main productive Brazilian regions; the losses in Scenario 3, ranged from 3.05% to 6.54%. The impact of the measures of the CPB can vary considerably between Brazilian states that are soybean exporters. These differences occur because the conditions of the infrastructure of transportation and storage, logistics options available and capable of rapid adjustments to meet the segregated movement, the laboratory infrastructure and weight of grain exports to the state's trade balance.

Charts 1, 2 and 3 show the trade flows and logistics routes used for the movement of soybeans in Scenarios 1, 2 and 3, respectively. In Scenario 1, a portion of the production of soybeans in the West Paraná was destined for the local market, supplying the Southeast region of the state, using only the road (Route R2). Another portion of the production was directed to Europe, being exported through the port of Paranaguá (PR). For this flow, road and rail were used (intermodal route). Soybean was transported by truck to the rail terminal in the city of

Londrina (PR), and from there was transported by rail to the port of Paranaguá (Route R10).

The movement of this soy in this region in Scenario 2, in which there was an increase in logistics costs by the imposition of CPB, changed. The region now provides a greater volume of local markets and began to export soybean to China. Besides this modification, the route to the international market has changed (the intermodal route (R10), before used in Scenario 1, is no longer competitive). The export was done through the port of Paranagua via road (Route R9). Likewise occurred with the West of Mato Grosso. In Scenario 1, the production of this region was destined to Chinese and Japanese markets, using intermodal transport via port of Santarém (PA). Soybeans were transported by truck to the river port of city of Porto Velho (RO), and there followed by hydro way to the port of Santarém. In Scenario 2, there were changes in transacted volume and destination markets. The route used was the same (R15), but exports were destined for China with only a 4.4% reduction in total sales in the region.

In Scenario 3, the situation has worsened. Although no changes occur in the trade relations and the used routes, all flows destined for the international market have been reduced. An example is the State of Goiás, which, in Scenario 1, directed its production to the international market using the road-hydro-rail route to the Port of Santos. Soybeans following by truck to the hydro port of São Simão (GO), making the transfer to barges and being conducted through the hydro way to the rail terminal of Pederneiras (SP), and then following by rail to the Port of Santos (route R8). With the imposition of the CPB, this logistic option is no longer competitive, due the number of transfers performed, and the road route R4 started to be used for transportation. In addition, there was a reduction in trading volume, from around 907.7 to 704.3 thousand tons (22.4% reduction).

Another analysis that can be made is about the routes used. In Scenario 1, the exports were made via intermodal options, accounting for 86.9% of movements (26.4 million tons). In the Scenario 2 and 3, only 15.0% of soybeans destined for the international market is given by intermodal options (approximately 3.7 million tons). Only exports of the western region of Mato Grosso used intermodality as competitive option. The implementation of segregation measures have caused more than 77.0% of intermodal routes were no longer competitive due to the increased cost, and road transportation was prioritized and overloaded, i.e., the costs of implementing the CPB had a greater impact on the intermodal routes due to the greater number of tests required and the increased demand for segregated storage; these factors contributed to the increased cost of transport for unimodal routes that use only the road transportation for the movement of soybeans.

Thus, the logistics of transport and storage is affected by the requirements of the Cartagena Protocol on Biosafety. Therefore, the more rigid the identification process, the greater the impact on exports. As a consequence, the competitiveness of Brazilian soybeans on the international market is compromised by inefficient logistics in responding to the demands of the CPB at the same speed. Although the study aim to analyze the Brazilian trade flows, due the country has an unbalanced transportation matrix and logistics constraints, the costs for the adequacy of infrastructure in the face of rules and standards established by the CPB are higher when compared to key competitors, Argentina and the United States, that have better logistic conditions. The soybeans produced in Argentina travels shorter distances between production areas and export ports; the Americans prioritized hydro way - at a lower cost compared to other modes - to sell their production.

However, the impacts of CPB to Brazil not only depend on the level of demand for segregation, but also of compliance to the Protocol measures at the side of the main importers that should demand the same requirements for non-signatory countries, Argentina and the United States. This is because if the United States and Argentina do not have to follow the norms and standards provided by the CPB, Brazil could become even less competitive.

The studies from Simões (2008), Kimani and Gruer (2010) and Bouet, Gruer and Leroy (2010) found similar results to herein. For Simões (2008), considering the market for soybean grain, the implementation of the CPB by Brazil would adversely affect Brazilian exports, with a range from 0.1% to 3.5%. If Argentina and the United States adopted the same measures, the losses of the Brazilian currency would reach U.S. $ 329.00 million. To Kimani e Gruère (2010), the implementation of the CPB would imply loss of business, resulting in elevation of port costs and also significant increases in costs for producers.

The study of Bouët, Gruère and Leroy (2010), which aimed to evaluate the effects of implementation of CPB on developing countries signatories, reached similar results. They indicated that the requirements of the Protocol would have significant effects on the corn market, increasing international prices and decreasing quantities transacted worldwide. Global losses would reach U.S.$ 1.2 billion/year.

An additional assessment was made to Scenarios 2 and 3, through sensitivity analysis of two parameters used in the model: the price elasticity of supply and price elasticity of demand. Thus, some simulations are conducted to assess the international trade of Brazilian soybean (already considering the imposition of the CPB and its impact) from the positive and negative variation of these parameters. The parameter price elasticity of supply is associated with producing regions in Brazil and the parameter price elasticity of demand is associated with areas of domestic and international. According to Alvim (2003), the price elasticity of demand measures

Chart 1. Trade flow by transportation route for Scenario 1 (thousand tonnes)

Supply	Demand	Route										
		R1	**R2**	**R3**	**R5**	**R8**	**R9**	**R10**	**R13**	R14	**R15**	**Total**
PR-W	PR-SE		1,221.38									1,221.38
MT-N	MT-SE			744.95								744.95
GO	SP	2,023.36										2,023.36
RS	UE-27								4,924.71			4,924.71
PR-N	China						2,939.01					2,939.01
PR-W	UE-27							2,531.98				2,531.98
MT-N	China				6,477.50							6,477.50
MT-NE	UE-27				2,102.19							2,102.19
MT-NE	China				230.27							230.27
MT-W	China										3,296.90	3,296.90
MT-W	Japan										637.16	637.16
MS	China							1,073.39				1,073.39
GO	China					907.74						907.74
MG	China									1,307.85		1,307.85
Total		2,023.36	1,221.38	744.95	8,809.96	907.74	2,939.01	3,605.37	4,924.71	1,307.85	3,934.06	30,418.39

Scenario 1: no expenditure testing for LMOs.Road Route (unimodal): R1, R2, R3, R9. Intermodal route: R5, R8, R10, R13, R14, R15. Source: Research Data, 2010

the response of consumers to price changes, while the price elasticity of supply measures the reaction of producers to price changes. When there is a change in market prices, there may be changes in the consumed and produced volumes that are more or less intense, depending on the slopes of the curves of supply and demand of the evaluated product. In this study, price elasticities of supply and demand are different depending on the region and, therefore, certain changes in prices may mean more or less intense variations in each region.

When simulations are made regarding the behavior of price elasticity of supply, it must be considered that this variable may vary if there are technological changes in production and/or marketing, new alternatives in the production, among others. As for the price elasticity of demand, this may vary in the countries analyzed in relation to the base scenario, if there are changes in income, substitutes products, or simply the preference of consumers.

Thus, it was simulated for Scenario 2 a 50% increase in the price elasticities of supply and demand, C2S+50 and C2D+50, respectively, and a 50% decrease in the price elasticities of supply and demand,C2S-50 e C2D-50, respectively. Similarly for Scenario 3, C3S+50 and C3D+50, to positive variation in the price elasticities of supply and demand, and C3S-50 and C3D-50 for negative variation.

In the scenario with the imposition of the CPB to evaluate one transgenic event (Scenario 2), all trade flows show losses when the price elasticity of supply in the producing regions increases (CS+50) (Figure 1), that is, consumers respond negatively to this variation. This chart has a good approximation to the implications of the CPB, because, besides the observed increase in transportation costs for segregation (simulated in Scenario 2), other expenses can be generated with the adoption of the Protocol, involving additional costs of marketing and operationalization of a preserved identity system (PI), that can result in prices variations, leading to a decline in the total volume traded.In Scenario 2, the trades had totaled 29,208,370 tons, but with the CS+50 simulation framework the volume traded, rose to 29,150,000 tons (down 0.20%). The greatest loss was in the framework C2D+50, down 2.3%, in which the total volume fell to 28,573,050 tons (Chart 4).

The biggest gain in volume was observed in the simulation C2D-50, where the marketing of soybeans approached even Scenario 1 (without the imposition of tests), reaching 30,175,230 tons. In this configuration, Scenario 2 (C2D-50) managed to reduce the negative impacts of CPB.

In a context of negative variation of price elasticity of demand (CD-50), the gains were perceived for the regions of supply and international demand regions. This is because, if there are productivity gains and/or different prices
for soy-GM - for example varieties with high protein content - and these are reflected in the marketing prices, these regions positively internalize such variation, increasing the trading volumes between these regions. The domestic demand responded negatively, either as function of negative slope of the demand curve, or in terms of flows destined to international markets that respond best to this oscillation, which resulted in trade deviation to the regions of international demand. Sensitivity analysis for Scenario 3 (Figure 2) displays the same behavior observed in Scenario 2, with changes in the intensity of variations of the percentages that were higher, while in volume, were smaller. Analyzing the variations in consumption, the largest gains occurred in the simulation C3D-50, in which
international demand showed gains of 4.5%, demanding a volume of 25,994,620 tons.

Finally, in the CPB enforcement scenarios other impacts may occur (positive or negative), according to the perception of the agents involved in soybeans marketing , about the benefits of soy-GM and the costs associated with segregation. Such perception may be reflected in the price level that will interfere in the volumes traded.

Conclusion

Since the economic opening, Brazilian agriculture has shown a good performance coming from the record crops, productivity gains and expansion of the agricultural frontier. The progress of agribusiness is being followed with synchrony by some segments of the economy, such as science & technology. On the other hand, the logistics sector has not reached the same level of development and has revealed several weaknesses, either due to the lack of infrastructure to transport the production, or by the inability to properly store the national harvest.

The logistics of transport and storage, until now, attempts to fit the movement of standardized products and in large volumes, should adapt quickly to meet growing demand for differentiated products, which must be segregated and will require adjustments in the current logistics system.

It was observed that the difficulty lies not only in differential impacts and costs of deploying these systems to the different producing regions in Brazil, but also on the realization of the difficulties originated by the process of commoditization of exports in the face of logistical weaknesses.

From the proposed model, with the rising costs of storage and transportation, there was a reduction in production that resulted in the decrease of marketing for the foreign market. The trade flows demanded the performing of tests along the chain, which resulted in a loss of competitiveness of Brazilian soybeans. In a certain way, the CPB also imposes an increase in the opportunity cost of adopting a new technology.

The obligation to implement processes that lead to an increase in fixed costs, without direct connection with the fulfillment of the objectives of the Protocol, should be seen as a new component in the process of creating technical barriers to trade, with negative effects on agricultural producers in exporting countries and on the consumers of importing countries.

The rigidity of certain importers about very strict thresholds for adventitious presence of unapproved events (less than 1%) cannot be an argument for the imposition of processes that require the qualitative and quantitative evidence for the events already approved. The Cartagena Protocol on Biosafety (CPB) must fulfill its primary function: to promote the release of information, and not to encourage, on behalf of Biosafety, the imposition of barriers to commodities trade or shifting the burden of consumer preferences for differentiated products to farmers.

Today, Brazil faces the challenge of reducing its deficit in the storage and transport capacity, a process based on increasing operational efficiency, and also taking advantage of economies of scale and scope. The imposition of identity preservation systems on a large scale would not only mean to divert resources from agribusiness to follow the growth rate of Brazil, but also would create uncertainty as to the type of investment that should be done.

Another issue to be considered and analyzed in future studies is about the supplementary agreement, with stricter rules on liability and reparation for damage resulting from transboundary movements of LMOs during transboundary movements. Brazil has yielded to the proposal for an insurance to cover any environmental damage caused by exporters of LMOs through financial compensation, but this brings another factor of increase in marketing costs.

The CPB, like other agreements that involve the regulation of trade flow, interferes with the trade dynamic and in the conditions of free trade of agricultural commodities. The argument based on conservation of biodiversity should also take into account the implications and economic impacts caused by the imposition of regulatory measures, under the penalty of creating trade

Chart 2. Trade flow by transportation route for Scenario 2 (thousand tonnes).

Supply	Demand	Route							
		R1	R2	R3	R4	R9	R11	R15	Total
PR-W	PR-SE		1,234.74						1,234.74
MT-N	MT-SE			754.62					754.62
GO	SP	2,046.03							2,046.03
RS	UE-27						4,801.73		4,801.73
PR-N	China					2,819.29			2,819.29
PR-W	China					2,357.82			2,357.82
MT-N	China				3,083.21				3,083.21
MT-N	UE-27				2,505.60				2,505.60
MT-N	Japan				583.03				583.03
MT-NE	China				2,241.75				2,241.75
MT-W	China							3,762.66	3,762,66
MS	UE-27					1,016.82			1,016.82
MG	China				1,257.24				1,257.24
GO	UE-27				743.85				743.85
Total		2,046.03	1,234.74	754.62	10,414.68	6,193.93	4,801.73	3,762.66	29,208.39

Scenario 2: includes the cost of the tests for one event and segregation. Ad-valorem rate: road routes: 37%, intermodal routes: 40%.Road Route (unimodal): R1, R2, R3, R4, R9, R11. Intermodal route: R15. Source: Research Data, 2010.

Chart 3. Trade flow by transportation route for Scenario 3 (thousand tonnes).

Supply	Demand	Route							
		R1	R2	R3	R4	R9	R11	R15	Total
PR-W	PR-SE		1,238.09						1,238.09
MT-N	MT-SE			756.91					756.91
GO	SP	2,051.64							2,051.64
RS	UE-27						4,774.60		4,774.60
PR-N	China					2,789.88			2,789.88
PR-W	China					2,315.40			2,315.40
MT-N	China				3,060.54				3,060.54
MT-N	UE-27				2,470.25				2,470.25
MT-N	Japan				570.43				570.43
MT-NE	China				2,220.40				2,220.40
MT-W	China							3,720.74	3,720.74
MS	UE-27					1,003.21			1,003.21
MG	China				1,246.51				1,246.51
GO	UE-27				704.34				704.34
Total		2,051.64	1,238.09	756.91	10,272.47	6,108.49	4,774.6	3,720.74	28,922.94

Scenario 3: includes the cost of the tests for two events and segregation. Ad-valorem rate: road routes: 48%, intermodal routes: 52%.
Road Route (unimodal): R1, R2, R3, R4, R9, R11. Intermodal route: R15. Source: Research Data, 2010.

Chart 4. Volumes of soybean marketing obtained from the changes in price elasticities of supply and demand, Scenarios 2 and 3.(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
Variables	Scenario 3	C3S+50	C3S-50	C3D+50	C3D-50
Supply	28,922.95	28,830.18	29,107.07	28,178.25	29,997.69
Domestic Demand	4,046.64	4,039.00	4,061.83	4,115.41	4,003.07
International Demand	24,876.31	24,791.17	25,045.23	24,062.84	25,994.62

Source: Research Data, 2010.

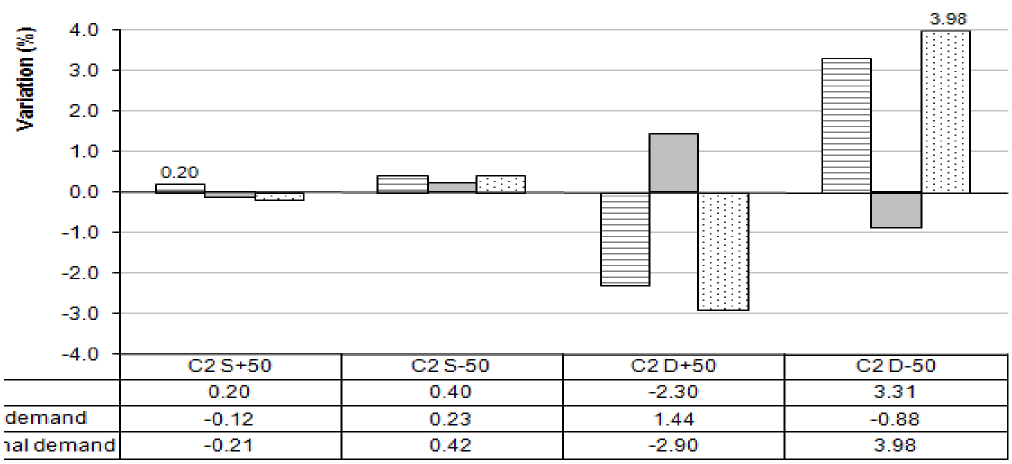

Figure 1. Sensitivity analysis of the marketing of soybeans for Scenario 2, for changes in price elasticities of supply and demand.Source: Research Data, 2010.

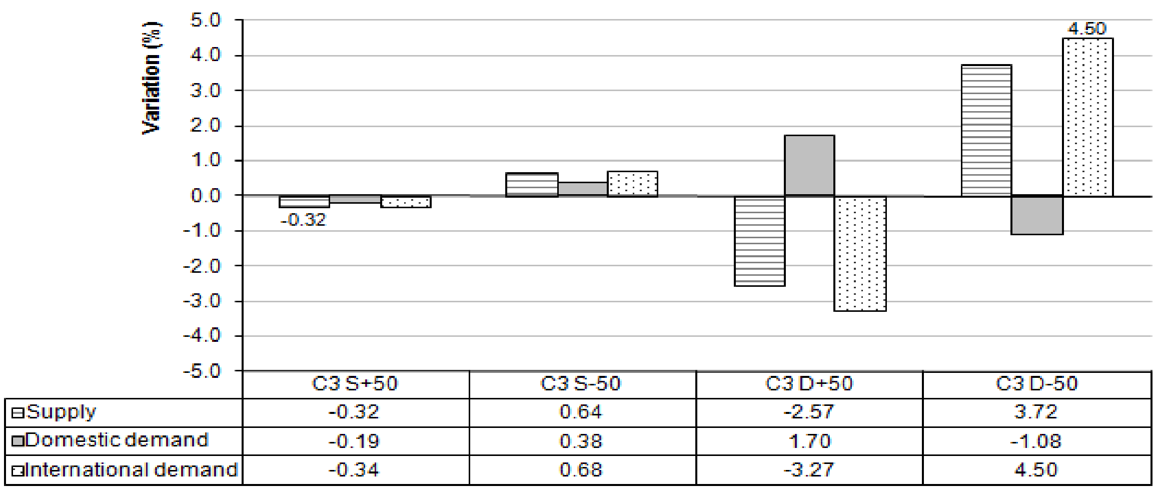

Figure 2. Sensitivity analysis of the marketing of soybeans for Scenario 3, for changes in price elasticities of supply and demand.Source: Research Data, 2010.

Chart 5. Description of the regions of supply and demand 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
MG	Minas Gerais State	Supply Region
SP	São Paulo State	Domestic Demand Region
GO	Goias State	Supply Region
MS	Mato Grosso do Sul State	Supply Region
MT-N	North of Mato Grosso do Sul State	Supply Region
MT-W	West of Mato Grosso do Sul State	Supply Region
MT-SE	Southeast of Mato Grosso do Sul State	Domestic Demand Region
MT-NE	Northeast of Mato Grosso do Sul State	Supply Region
Europe	European Union (EU 27): Germany, Austria, Belgium, Bulgaria, Cyprus, Denmark, Slovakia, Slovenia, Spain, Estonia, Finland, France, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, United Kingdom, Czech Republic, Romania and Sweden.	International Demand Region
China		International Demand Region
Japan		International Demand Region

Chart 6. Description of the routes considered in the Model

Route	Description		
	Destination	Transport Modals	Transshipment Points
R1	SP demand	Road	
R2	PR-SE demand	Road	
R3	MT-SE demand	Road	
R4	Port of Santos	Road	
R5	Port of Santos	Road and rail	Rail terminal of Alto Araguaia
R6	Port of Santos	Road and rail	Rail terminal of Campo Grande
R7	Port of Santos	Road and rail	Rail terminal of Goiânia
R8	Port of Santos	Road-hydro-rail	Hydroport of São Simão and Rail terminal of Pederneiras
R9	Port of Paranaguá	Road	
R10	Port of Paranaguá	Road and rail	Rail terminal of Londrina
R11	Port of Rio Grande	Road	
R12	Port of Rio Grande	Road and rail	Rail terminal of Cruz Alta
R13	Port of Rio Grande	Road and hydro	Hydroport of Estrela
R14	Port of Vitória	Road and rail	Rail terminal of Araguari
R15	Port of Santarem	Road and hydro	Hydroport of Porto Velho

deviations and adversely affect the competitiveness of agribusiness. An important contribution to try to equate these deviations is the implementation of bilateral agreements and/or prediction of mechanisms for the reduction of rates imposed by importing countries, in an attempt to reduce the negative impacts of CPB.

Either way, it is essential that investments in agricultural infrastructure envisage a differentiated grain agriculture for the biotechnology itself shows positive effects for consumers and to the countries whose talent manifests itself in the competitiveness of agribusiness.

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