Developments in the World Soybean Market: a Partial Equilibrium Trade Model

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Resumo

Esta pesquisa estudou o mercado mundial de soja. Aplicando teoria de equilíbrio parcial de comércio em combinação com teoria de bem-estar, os efeitos da liberação do comércio internacional, a expansão de biocombustível nos Estados Unidos da América (EUA), o crescimento da demanda da China e a melhoria na infra-estrutura brasileira foram estudados. Os resultados indicam que: i) a mudança total de bem-estar é pequena, no entanto mudanças de bem-estar entre agentes pode ser enorme; ii) o fim de políticas distorcivas geram melhoria no bem-estar total; iii) a redução da produção nos EUA é compensada pelo Brasil e Argentina; iv) o crescimento chinês gera ganhos para produtores e perdas para consumidores, sendo que a demanda chinesa é atendida principalmente pelo Brasil e Argentina; v) a melhoria da infra-estrutura no Brasil produz uma ampliação de bem-estar para consumidores ao redor do mundo, enquanto os produtores são perdedores, exceto no Brasil onde eles são os grandes beneficiários.

Palavras-chave: mercado mundial de soja; modelo de equilíbrio parcial de comércio; análise de bem-estar.

Abstract

This research studies the world soybean market. Applying partial equilibrium trade theory in combination with welfare analysis the effects of trade liberalization, US biofuel expansion, Chinese demand increase, and an improvement of the Brazilian infrastructure are determined. The research's results indicate that: i) the total welfare changes are relatively small for all countries but that welfare changes for producers, consumers and government can be large; ii) the end of the distorting policies improves welfare in the world; iii) the reduction in soybean production because of the increase in biofuel production in the United States is compensated by Brazilian and Argentinean producers; iv) the Chinese demand growth delivers gains for producers and losses for consumers, Chinese demand is met mainly by Brazil and Argentina; v) an improvement in the efficiency of the Brazilian infrastructure leads to an increase in consumers' welfare around the world while the producers lose, except in Brazil where they are the biggest beneficiaries.

Key words: world soybean market; partial equilibrium trade model; welfare analysis.

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* This text is preliminary article version and has not been revised yet. It was adapted especially to a presentation at Federal Senate on September, 2008.

1 Introduction

The soybean market is a mature market, with a world production in 2005 of 214.4 million tons and a trade of 33.3 billion dollars, according to the Food and Agriculture Organization (FAO, 2007). The main producers in 2005 were the United States (US), Brazil, Argentina and China, with 39%, 25%, 18% and 8% of the total production, respectively. US, Brazil and Argentina were the main exporters with 40%, 35% and 15% of the total export, respectively (FAO, 2007), while the main soybean importers in season 2004/2005 were China, European Union (EU) and Japan, with 35%, 25%, and 8% of the total import, respectively (Lovatelli, 2005).

Production decisions or changes in public policy are reflected almost instantaneously in the prices at the Chicago Board of Trade that is the most important soybean market in the world. Besides, it is to be expected that soybean demand will increase in the next years. The world population is expected to grow about 15.5% or 1.00 billion people until 2020, according to the U.S. Census Bureau. Moreover, Lovatelli (2005) points the following causes for a possible increase in soybean demand till 2020: i) The world will have an estimated economic growth of 3% per year up to 2020. So countries will require much more protein of vegetable origin; ii) There is a trend to substitute animal for vegetable components in feed; iii) The reduction or removal of trade barriers, mainly on meat and processed soybean products, in the US, EU and Japan will increase soybean demand for both feeding pork, cattle and poultry and producing oil; iv) Biofuel, using soybean, is becoming an option to replace petroleum that is becoming exhausted and consequently expensive.

On the supply side, some expected policy changes in the US, Argentina or China may lead to important consequences for these producer countries. The end of the US soybean producer subsidy or the removal of the Argentinean export tax, for example, will have probably important consequences for the world soybean market.

Interventionist agricultural policy has a long tradition in the US. It was first introduced for most agricultural products in the programs carried out by New Deal Legislation as an answer to the crisis of the 1930's. However, soybean is an exceptional case. This commodity had not received any significant subsidy until the beginning of 2000s. Orden and Diaz-Bonilla (2006) point out that direct payment were extended to oilseeds only in 2002. Although, the US seemed to have respected the limit of aggregate measurement of support in that period, Coelho (2002) highlights that in 2001 soybean producers received US$ 3.8 billion of support. Therefore, a possible reduction in subsidy levels, as it has been demanded by developing countries, may alter market conditions in the near future. The agricultural sector in Argentina, in turn, has suffered strongly from discriminating export policies. According to the Argentinean Producer Federation (AFA, 2004), the agricultural sector has been faced multiple exchange rates, export taxes and other taxes for more than 50 years. One of the most affected sectors is the soybean industry. In January 2007, the Argentinean Government (MEP, 2007) increased the export tax to 27.5%, and, in November, 2007, to 35%.

China applies an *ad valorem* import tariff of 3% on soybeans. Considering that this country is an important importer, the import tariff removal is expected to have a strong influence on this market. Finally, to complete this soybean overview, internal transport costs in Brazil can also be one of the elements that affects the international soybean price. Many production areas are located far from the nearest harbors leading to high transport costs that hamper exports.

Given its importance, it is common to find in the literature demand analyses for soybean. Vandenborre (1966), for instance, using a simultaneous equation model estimated soybean demand for a group of selected countries. Bateman & Stennis (1978) used the elasticity concept to do world price simulations as a result of US production changes. Haniotis et al. (1988) argued that soybean prices react strongly on changes in domestic export capacity, but minimally to other exogenous shocks. Piggott and Wohlgenant (2002), in turn, derived the soybean demand elasticity for the case of joint production. Finally, Babula et al. (2006), using a fully restricted cointegrated vector error correction model, estimated the own-price elasticity demand for US soybean, that differs from the values found normally in literature. According to these authors, this happened because their estimate is more long run than comparable literature estimates.

On the other hand, as far as it is known no studies showing the supply response in the US, Brazil, China or Argentina simultaneously to changes in soybean policies are available. In this sense, there is a lack of this kind of specific analyses in the literature. As a matter of fact, a partial equilibrium trade model is developed and welfare analysis is applied in this research.

At international level some issues play an important role in the present soybean market debate. As a consequence, some possible scenarios to be studied arise. First, agricultural trade liberalization is pointed out as one condition *sine quo non* to improve efficiency and welfare in the world. Second, biofuel production is equally taking a pivotal position because a change of soybean area into maize area in the US may lead to considerable change in production, prices and trade in coming years. Third, China's economic growth starts to call special attention not only because of the dimension of the Chinese demand but also by the important effects that this may cause for the international soybean trade. Last but not least, excessive infrastructure costs in some producer countries, especially in Brazil, hamper their ability to market soybean effectively. So, some reduction in these costs may also affect significantly the soybean market.

To carry out this research, the following objectives are formulated: i) Collecting data on soybean demand, supply, trade and prices for the main supplying and demanding countries; ii) Assessing the usefulness of spatial equilibrium theory in association with welfare theory to analyze production and demand in the US, Brazil, Argentina, China in combination with the rest of the world; iii) Building a trade model for calculating the welfare changes and effects of policy changes. Analyzed scenarios are: trade liberalization, biofuel expansion in the US, Chinese demand growth, and Brazilian infrastructure improvement.

Section 2 constructs a data set that serves as an input for the trade model. In Section 3 an empirical model describing the soybean market is built using spatial equilibrium trade theory in association with welfare analysis. Section 4 performs simulations with the developed model. Finally, in the last section, our main findings, conclusions, possible critiques on own analysis and suggestions for further research are given.

2 Data

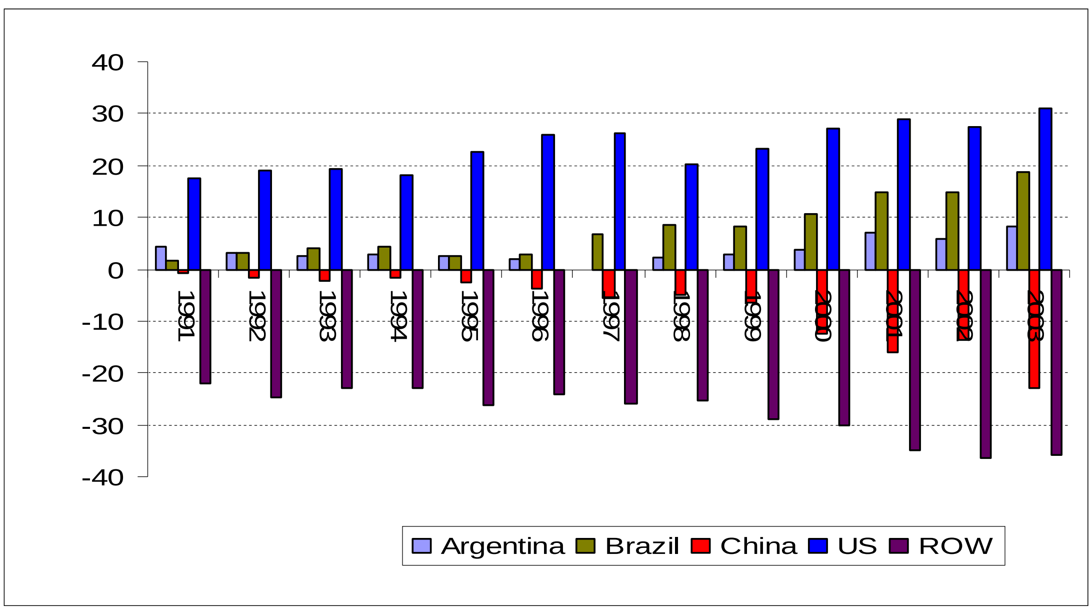
In this section a dataset, which serves as an input for the trade model built in Section 3, is constructed. The best available data are collected and an explanation of choices is given. Section 2.1 describes the calculation of the border prices. Next, Section 2.2 presents the soybean use. Then, Section 2.3 describes the calculation of the producer prices. Finally, Section 2.4 indicates how the elasticities were chosen.

2.1 Border Price

Trade data are extracted from the statistical database of the Food Agriculture Organization official site (FAOSTAT) for Brazil, Argentina, China, the US and the rest of the world (ROW). This dataset contains information on both export and import quantities and export and import values over the period 1991-2003 and it is used to obtain border prices. To construct the data about the ROW, the difference between world data and the four-country aggregates are taken. The quantity of soybean trade is given in Figure 2.1.

Figure 2.1: Quantity of soybean traded

Million tons

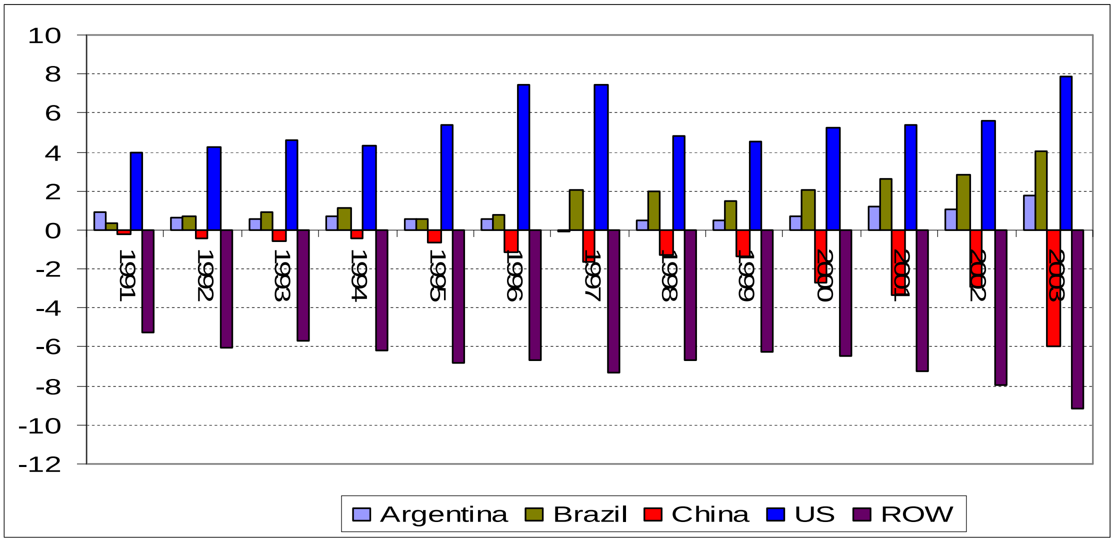


Source: FAO (2007), own elaboration

The same principle used to determine the trade quantity is used to find out the trade value. This information is given in Figure 2.2.

Figure 2.2: Value of soybean traded

Billion US$

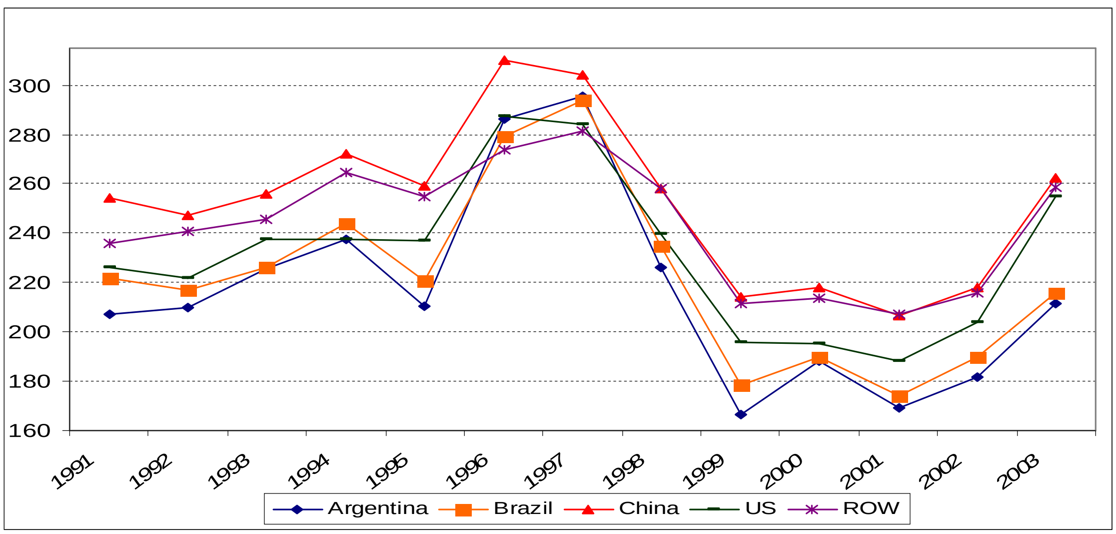


Source: FAO (2007), own elaboration

The ratio between export value and export quantity and between import value and import quantity will be used as a proxy for the Free On Board price (FOB) and for the Cost Insurance and Freight price (CIF), respectively. As consequence, for Argentina, Brazil and the US FOB prices are calculated, and for China and the ROW, CIF prices are calculated. Figure 2.3 depicts the border prices for the studied period.

Figure 2.3: Border Prices

US$/ton



Source: FAO (2007), own calculations

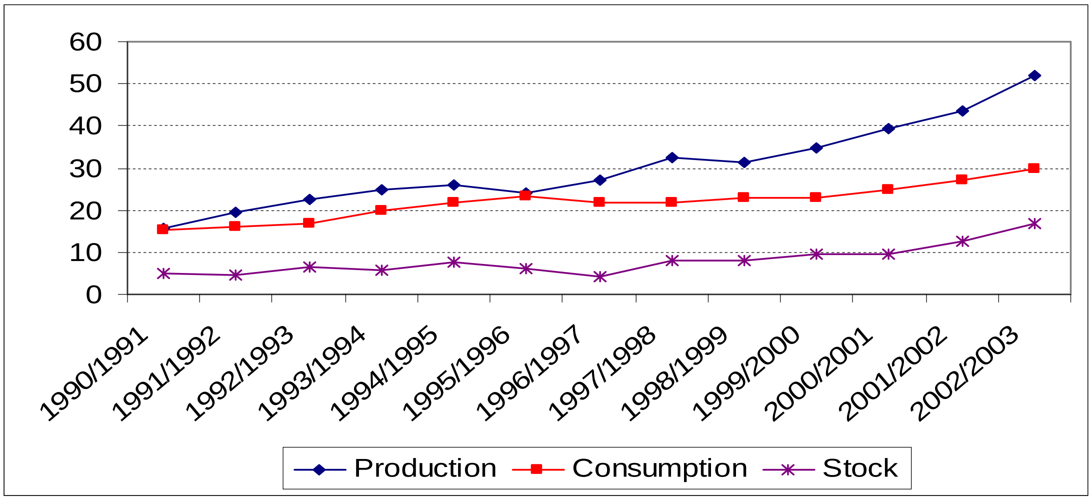
2.2 Soybean use

Stock, supply, demand and trade, measured in 1000 tons, are from the Foreign Agricultural Service database of the US Department of Agriculture. The trade data presented in Section 2.1 is yearly based while trade data of this section are season based. The used dataset contains complete information from the season 1990/1991 to the season 2002/2003 for the US, Brazil, Argentina, China and ROW (Figure 2.4

presents a soybean use's example for Brazil). For this reason, this source was chosen to depicts soybean use. Some important remarks rise from the evolution of soybean use in this period: Brazil and Argentina have increased their production significantly; the soybean consumption in China rocketed; production has increased in the US at lower rates and its consumption has maintained a slow growth; the ROW has had a growth in consumption at a lower rate than China and has maintained low production through the period.

Figure 2.4: Soybean Use in Brazil

Million tons



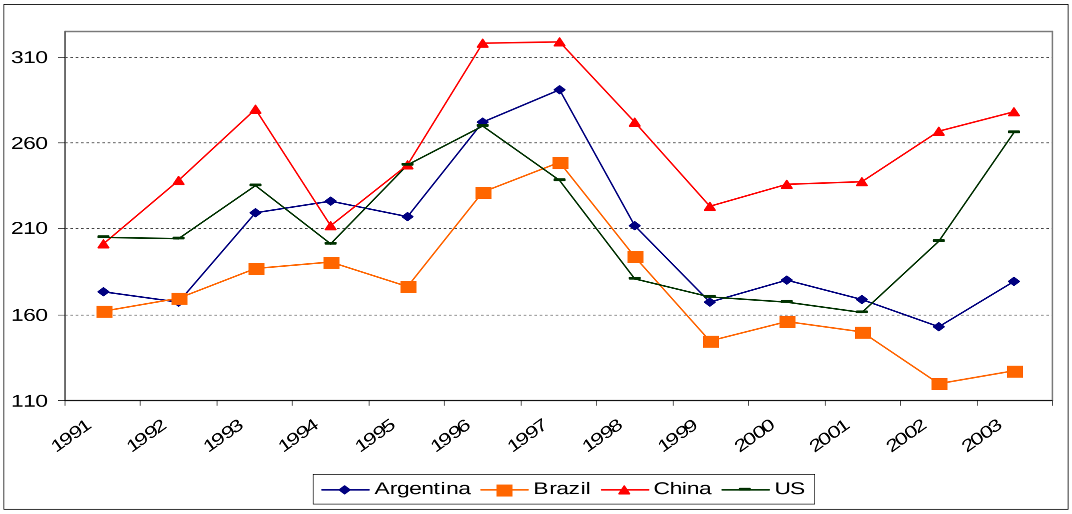
Source: USDA (2007), own elaboration

2.3 Producer Price

Producer prices (local currency per ton) are collected from FAOSTAT for the period 1990-2003. To standardize these prices into US$ per ton (see Figure 2.5), the exchange rate from the World Development data base was used.

Figure 2.5: Producer Price

US$/ton



Source: FAO (2007), own calculations

2.4 Elasticities

Piggott et al. (2001) mention several authors that estimated price elasticities for demand and supply between 1970's and 2000's. Finding the best estimate is beyond the scope of this research. For the purpose of this work, a source that provided values for all analyzed countries in the research was tried. Similarly to Dizioumenko (2002), it was not possible to find in the literature all elasticities needed. Therefore, it was decided to use the meal demand elasticities estimated by Meilke and Swindinsky (1998), except for the demand elasticity for the US. For this case, it was chosen to use the elasticity estimated in another study by Piggott and Wohlgenant (2002) because this data are better since they were specifically calculated for total demand for US soybean. The price elasticity of demand of Meilke and Swindinsky (1998) for the US was -0.12. It seems less adequate when compared to the estimates for the other countries.

Babula et al. (2006) also estimated the own-price elasticity of demand for US soybean. The value found /-0.90/ is much larger than /-0.38/ calculated by Piggott and Wohlgenant (2002). The authors argue that this happened because their estimate is more long run compared to others estimates available in the literature.

The Piggott and Wohlgenant's (2002) price elasticity of demand (-0.38) seems to be more in line with values for other countries estimated by Meilke and Swindinsky (1998). Additionally, it is not available long run estimates for the other countries. Therefore, it is not reasonable to use the elasticity of Babula et. al (2006) for this case.

European Union's elasticities is used as proxies for ROW elasticities, since the ROW elasticities are not available. For the supply elasticities, Meilke and Swindinsky (1998)'s data for Argentina, Brazil and China, and Meyers et al. (1998) for the US and ROW are used, because these are the available data. Meilke and Swindinsky (1998) and Meyers et al. (1998) outcomes may be found in Piggott and Wohlgenant (2001). The chosen elasticities of soybean demand and supply can be seen in Table 2.1.

Table 2.1: Elasticities of soybean demand and supply

	Argentina	Brazil	China	US	ROW
Demand	-0.30	-0.30	-0.20	-0.38	-0.50
Supply	0.25	0.55	0.28	0.30	0.22

Source: Meilke and Swindinsky (1998), Meyers et al. (1998) and Piggott and Wohlgenant (2002)

Data on soybean use and border and producer prices, in US dollars, will be used jointly with the elasticities of demand and supply to construct demand and supply curves for the four countries and the ROW.

3 Empirical Model

In this section, an empirical model that represents the world soybean market is presented. The first section describes the model. Next, Section 5.2 explains the model calibration. Finally, Section 3 presents the welfare analysis that is used in this research.

3.1 Model

Mas-Colell et al. (1995) apply quasilinear functional forms for supply and demand functions to analyse welfare changes in a partial equilibrium model. Following them and also due to lack of data, supply and demand functions will be assumed linear.

$$Q_i^S = \alpha_{0i} + \alpha_{1i} * PS_i \qquad (3.1)$$

$$Q_i^D = \beta_{0i} + \beta_{1i} * PD_i \qquad (3.2)$$

$$PS_i = P_i(P^W, S_i, t_i^e, t_i^i, T_{d\,i}^{\ e}) \qquad (3.3)$$

$$PD_i = P_i(P^W, S_i, t_i^e, t_i^i, T_{d\,i}^{\ e}) \qquad (3.4)$$

$$X_i = Q_i^S - Q_i^D + \Delta St_i \qquad (3.5)$$

$$\sum_{i=1}^{M} X_i = 0 \qquad (3.6)$$

Where:

α, β – parameters	i – index for countries and ROW (i =1,…, M)
Q_i^D – demand in country i	Q_i^S – supply in country i
PS_i – supply price in country i	PD_i – demand price in country i
X_i – total trade country i	ΔSt_i – stock change in country i
S_i – deficiency payment in country i	t_i^e – export tax in country i
t_i^i – tariff in country i	$T_{d\,i}^e$ – domestic transport costs country i

Q_i^D, Q_i^S, PS_i, PD_i, X_i are endogenous variables while St_i, S_i, t_i^e, t_i^i, $T_{d\,i}^e$ are exogenous variables. Stock change for each country was maintained at its initial level. The international transport costs (T_i^W) and exchange rate are parameters in this model. Exchange rate varies only if currency simulation is performed.

Each country applies a deficiency payment, an export tax, or an import tariff. Brazil does not apply any of these policy instruments, but it has high internal transport costs. In this way, the prices in country i (PS_i and PD_i) will be always a function of the world price (P^W), considering international transport costs (T_i^W), and of only one of these items: deficiency payment, export tax, import tariff, or domestic transport costs. Due to the assumption that ROW does not apply any policy instrument and also because domestic transport costs is disregarded, ROW prices stand for the P^W (vide appendix I).

Some additional considerations/assumptions have been made:

i) Argentina applies an export tax. Internal transport costs in Argentina are not relevant and the country has no program to support the soybean sector.

ii) Brazil does not apply an export tax. The Brazilian domestic transport costs are much higher than in other competing countries. The country does not have a subsidy program to support the soybean sector.

iii) Domestic transport costs in China are not considered. Chinese government has pushed some programs to reduce these costs recently. China applies an import tariff.
iv) It is taken in consideration in the model that the US supports its producers by means of a deficiency payment. In the reality, US policy is much more complex.
v) The domestic transport costs in importing countries are not considered. We are supposing that consumption is close to the harbor. The import tariff for the rest of the world is zero.
vi) Difference between CIF prices (in importing countries) and FOB (in exporting countries) is taken as proxy for international transport costs (T_i^W).

Careful counting shows that the model has as many endogenous variables as equations. As a consequence, the model can be solved because the system of equations is exactly identified. The relationship between the different prices is presented in Appendix I. Lastly, model written in GAMS solves simultaneously the block of equations using the policy instruments as exogenous variables. The GAMS model is long and cannot be put in an appendix in this article because of space limitation. However, it can found in Távora (2008).

3.2 Calibration

The parameters in the model are calibrated using 2003 data. Parameters of the supply and demand functions are calibrated so that the model depicts exactly supply, demand and prices in the base year. The price elasticities of supply (ε^S_i) and demand (ε^D_i) are those defined in the Section 2.4. Calibration takes place according to the following steps:

$\varepsilon^S_i = (\partial Q_i^S / \partial PS) * (PS_i / Q_i^S)$	(3.7)
$Q_i^S = \alpha_{0i} + \alpha_{1i} * PS_i$	equation (3.1)
$(\partial Q_i^S / \partial PS) = \alpha_{1i}$	first order derivative of equation (3.1)
$\alpha_{1i} = \varepsilon^S_i * \overline{Q_i^S} \;/\; \overline{PS_i}\;,\ \forall\ i$	(3.8)
$\alpha_{0i} = \overline{Q_i^S} - \alpha_{1i} * \overline{PS_i}\;,\ \forall\ i$	(3.9)

Parameters β_{0i}, β_{1i} for demand (see equation 3.2) are derived in the same way as the parameters for supply function, see equations 3.8 and 3.9.

$\beta_{1i} = \varepsilon^D_i * \overline{Q_i^D} \;/\; \overline{PD_i}\;,\ \forall\ i$	(3.10)
$\beta_{0i} = \overline{Q_i^D} - \beta_{1i} * \overline{PD_i}\;,\ \forall\ i$	(3.11)

Thus, supply and demand equations were calibrated according to the method described in this section. Simulations consider the price relationships established in Appendix I. Besides, the data for 2003 were adjusted so that the total export was equal to the total import. The residual difference in initial trade was added to rest of the world because, in our opinion, this causes less damage to the whole analyses. The soybean stock change for each country was maintained fixed at its initial level during the simulations. The calibrated parameters can be found in Table 3.1.

Table 3.1: Supply and Demand Equations Parameters

Countries	Supply Equation		Demand Equation	
	Intercept (tons)	First order derivative	Intercept (tons)	First order derivative
Argentina	26,625	49.306	32,240	-41.333
Brazil	23,400	225.197	38,543	-41.179
China	11,887	16.629	42,348	-25.388
US	52,507	84.598	65,583	-70.82
ROW	13,859	15.152	78,073	-100.87

3.3 Total welfare function

For the purpose of this research, it is assumed that consumers, producers and the government in all selected countries value money equally. As a consequence, the sum of the changes in consumer surplus, producer surplus and government budget is a measure for the total welfare change in a country caused by implementing a policy instrument. In this way, total welfare change can be represented by a so-called Pigouvian welfare function:

$$\Delta W = \Delta PS + \Delta CS + \Delta B \tag{3.12}$$

Where:

ΔW : total welfare change $\quad$ ΔPS : producer surplus change

ΔCS : consumer surplus change $\quad$ ΔB : government budget change

Gardebroek and Peerlings (2006) underline that this calculation is not fully correct because: i) utility can only be experienced by consumers and not by producers or the government; ii) the consumer surplus is a partial measure because it only considers the change in the utility of consumption of the product for which a change took place. It does not take into in account utility changes in other markets and it ignores the income effect of price changes; iii) the changes in producer surplus and budget costs are approximations of these effects, only acceptable if analyzed changes are either small or the product has a small share in total production or consumption.

To compute the total welfare change, in the general case, it is formally necessary to calculate the integral under the supply curve (producer surplus change) and demand curve (consumer surplus change) and the change in government budget as follows. Demand is from all demanders, which include industrial demanders (companies, traders, stock house) while supply is constituted by all producers. Instead of using the change in consumer surplus the change in profit of demanders of soybean could have been used. Both calculations would give the same result.

$$\Delta CS = \int_{P1}^{P2} Q_i^D dp \qquad \Delta PS = \int_{P1}^{P2} Q_i^S dp \qquad \Delta B \tag{3.13}$$

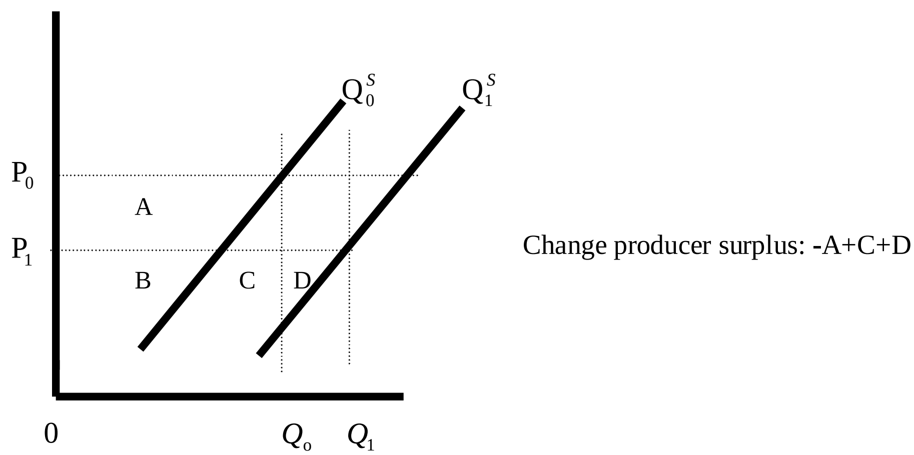
Where:

ΔPS :	producer surplus change	ΔCS :	consumer surplus change
ΔB :	government budget change	Q_i^D :	demand in country i
Q_i^S :	supply in country i	Pi:	output prices

The welfare effects of a positive supply shock using a linear supply are given in Figure 3.1:

$$Q_0^S = \alpha_1 P + \alpha_2 \qquad (3.14)$$
$$Q_1^S = \alpha_1 P + \alpha_2 + s \qquad (3.15)$$

Figure 3.1: Welfare effect of a positive supply shock



To get the profit with (3.17) and without the shock (3.16) the integrals of the functions with (3.15) and without (3.14) the supply shock are taken:

$$\Pi_0 = \int_0^{P0} Q_0^S \, dp = (\alpha_1 P_0^2)/2 + \alpha_2 P_0 + c \qquad (3.16)$$

$$\Pi_1 = \int_0^{P1} Q_1^S \, dp = (\alpha_1 P_1^2)/2 + \alpha_2 P_1 + sP_1 + c \qquad (3.17)$$

$\Pi_1 = \Pi_0 + \Delta PS$ or $\Delta PS = \Pi_1 - \Pi_0$

Where:

α_1, α_2:	parameters	s:	supply shock		
Q_i:	supplied quantity	P_i:	price	c:	constant

For a demand shock a similar procedure applies.

4 Simulations and results

In this section, simulations are done using the empirical model described in the previous section. Section 4.1 describes the scenarios. Next, Section 4.2 presents the impact on prices, supply, demand, trade, and the welfare effects of the scenarios.

4.1 Policy Scenarios

The base scenario reproduces the world soybean market in 2003 and provides the base for comparison of different scenarios. The for alternative scenarios are presented as follows.

S1: Trade liberalization. The main responsibility of the WTO is standardizing rules and promoting free trade between nations. In this context, the elimination of the US deficiency payment and the Chinese import tariff represent steps in this direction. The Argentinean export tax makes the country worse off and hampers the economic development in the country. In this sense, it is reasonable to think that this policy will be reconsidered. S1 simulates the **elimination of all these policies together.**

S2: Biofuel. In this scenario it is assumed that the US has **a reduction of 15% of its soybean production** as a consequence of a change in crop area allocated to soybeans. The reason behind a reduction in the American soybean supply is the possibility of transforming soybean area into corn area in order to increase biofuel production with corn. With the increase of the world oil price, American producers started to substitute soybean area into corn area in order to produce biofuel with corn. In April 2008, the oil price reached US$ 135 per barrel. This can increase further the trend of soybean area reduction for coming years. At the moment, the forecast for season 2007/2008 of soybean area shows a reduction of 15% while the corn area shows an increase of 19% according to Ministry of Agriculture, Livestock and Food Supply (MAPA) in Brazil that used data from USDA. This research does not consider the effects of the competition between sub-product of corn used to biofuel production with soybean products.

S3: Chinese demand growth. The Chinese population is still growing and the protein need in Europe and Japan has been filled in part by soybean products consumption. Here an increase of **15% China's soybean demand is simulated**. Moreover, China tends, on the one hand, to have a smaller share of production in the coming years because it is substituting soybean for other food crops. And, on the other hand, it also tends to demand more soybeans because the country imports the product, processes it, and exports feed and oil to neighbor countries. Both effects may contribute to a possible Chinese demand expansion.

S4: Brazilian Infrastructure Improvement. It was assumed that internal transport costs are not important, except in Brazil that has high internal transport costs. Although Brazil is an important soybean producer and exporter, it loses competitiveness in the market because its internal transport costs are very high. Recently, the Federal government has launched the Growth Acceleration Program (PAC) that aims to reach a sustainable Gross Domestic Product (GDP) growth and its acceleration towards 5% per year. In the sphere of this program, a group of measures intends to improve the

Brazilian infrastructure and to correct some deficiencies in the logistic area. As a consequence, it is expected that the Brazilian internal transport costs can be reduced in the coming years and that the producers will receive a better income. In S4 **a reduction of 15% in the Brazilian domestic transport costs** is simulated.

4.2 Impact on price, production, demand, trade and welfare changes

This section presents the most important effects on price, production, demand, trade and welfare changes for the selected scenarios. Change in producer price (ΔPP), consumer price (ΔCP), supply (ΔSup), demand (ΔDem), and trade (Δtrade) are expressed in percentages relative to the base year. The computation of welfare changes compared to year base is based on methodology presented in Section 3.3.

4.2.1 Trade liberalization (S1)

The abolishment of the Chinese tariff, the Argentinean export tax and the US deficiency payment lead to a decrease in the producer prices in Brazil, the US, the ROW and China. Meanwhile an increase in the producer price occurs in Argentina (see Table 4.1).

Table 4.1: S1- Change in producer price, consumer price, supply, demand, and trade

	ΔPP	ΔCP	ΔSup	ΔDem	ΔTrade
ARGENTINA	16.2%	16.2%	4.1%	-4.9%	32.7%
BRAZIL	-1.4%	-0.8%	-0.8%	0.3%	-2.6%
CHINA	-6.4%	-6.4%	-1.8%	1.3%	3.5%
US	-4.8%	-0.7%	-1.4%	0.3%	-4.3%
ROW	-0.7%	-0.7%	-0.2%	0.3%	0.6%

In Argentina, consumers react to the price increase consuming fewer soybeans while producers react by producing more. As a consequence, the country increases its trade under this scenario. Consumers and producers in the other countries do exactly the opposite. The consumers increase demand while the producers reduce production. The net effect for other exporting countries is to export less and for importing countries is to import more.

As a result of the abolishment of the Argentinean export tax, soybean producers face an increase in their welfare. The Argentinean consumers are negatively affected because of the consumer price increase. In the same way, the government loses tax revenue. The society as a whole, however, gets better off since the total welfare effect is positive (see Table 4.2).

Table 4.2: S1 - Welfare Changes, US thousand dollars

	ΔPS	ΔCS	ΔB	ΔW
ARGENTINA	1,057,614	-706,535	-331,700	19,379
BRAZIL	-93,243	53,440	-	-39,804
CHINA	-291,246	632,190	-300,480	40,463
US	-953,209	85,665	825,110	-42,434
ROW	-31,962	93,860	-	61,897
WORLD	-312,047	158,619	192,930	39,502

In China, the abolishment of import tariff reduces the government budget. The producers are not protected any longer and face a reduction in producer surplus. Besides, the reduction of the world market price also has a negative effect for producers. The consumers, in turn, gain a lot with the liberalization and are able to compensate the whole loss of the government and producers. As a consequence, the total welfare effect is positive. In Brazil, the price fall improves the consumers' welfare and lowers producers' welfare while, in the ROW, the consumers are the gainers (US$ 93.9 million) and the producers are the losers (US$ -32.0 million).

Under this scenario the US producers lose part of their surplus due to the end of the assumed deficiency payment and due to the reduction of the price. The loss in producer surplus (US$ -953.2 million) is larger than the gain that the consumers (US$ 85.7 million) and the government (US$ 825.1 million) have with the price fall and the end of the subsidy, respectively. So, total welfare goes down (US$ -42.4 million). However, looking only at the effect of the abolishment of the producer subsidy (see Table 4.3), it is possible to check that it is profitable for the US society to abolish the support to soybean producers.

Table 4.3: Only the US producer subsidy abolishment: Welfare Changes, US thousand dollars

	ΔPS	ΔCS	ΔB	ΔW
ARGENTINA	42,754	-29,812	5,621	18,562
BRAZIL	73,573	-41,781	-	31,792
CHINA	24,729	-52,790	606	-27,455
US	-715,414	-66,965	825,110	42,731
ROW	25,079	-73,318	-	-48,239
WORLD	-549,279	-264,666	831,337	17,392

4.2.2 Biofuel Scenario (S2)

A US production shock (s = –12,915 thousand tons) that reduces 15% of the initial production leads to an increase in the producer prices in all countries (see Table 4.4).

Table 4.4: S2 - Change in producer price, consumer price, supply, demand, and trade

	ΔPP	ΔCP	ΔSup	ΔDem	ΔTrade
ARGENTINA	9.3%	9.3%	2.3%	-2.8%	18.7%
BRAZIL	15.4%	9.1%	8.5%	-2.7%	28.5%
CHINA	7.5%	7.5%	1.8%	-1.5%	-4.1%
US	7.4%	7.7%	-15.0%	-2.9%	-34.9%
ROW	7.6%	7.6%	1.7%	-3.8%	-6.8%

In all countries, consumers react to the increase in prices consuming fewer soybeans while producers react by producing more. A soybean area reduction or an unexpected shock in the production leads according to our hypothesis to an increase of the production in Brazil and, in consequence, the country increases its exports. Brazil has abundance of land and the largest price elasticity of supply. On the other hand, Argentina has a limited area to expand its production and soybean competes with wheat production in which the country has a huge comparative advantage. This results in a lower price elasticity of supply. China has increased food crop areas and has in oil and feed business its main focus. This also results in a relatively lower price elasticity of supply.

The impact on welfare of the biofuel scenario is negative for all consumers around the world while for the producers the impact is positive because the soybean price goes up (see Table 4.5).

Table 4.5: S2 - Welfare changes, US thousand dollars

	ΔPS	ΔCS	ΔB	ΔW
ARGENTINA	599,736	-408,403	82,053	273,386
BRAZIL	1,061,127	-572,531	-	488,596
CHINA	346,532	-727,565	7,444	-373,589
US	1,484,640	-916,781	123,848	691,707
ROW	350,757	-999,606	-	-648,849
WORLD	3,842,793	-3,624,886	213,344	431,251

All importers (China and ROW) face a reduction in their total welfare while the exporters (Argentina, Brazil, and the US) experience an increase in total welfare. Argentina exports more so the export tax revenue increases. China imports less, but the price level is higher. Consequently, the revenue from the import tariff is a bit higher as well. For the US the reduction in production lowers the budget expenditure on the deficiency payments. At world level, the total welfare effect is positive because the producer surplus change is very high due to price increase.

4.2.3 Chinese Demand Growth Scenario (S3)

A Chinese demand shock (s = +5,550 thousand tons) that reduces about 15% of initial demand leads to an increase in the producer prices in all countries (see Table 4.6).

Table 4.6: S3 - Change in producer price, consumer price, supply, demand, and trade

	ΔPP	ΔCP	ΔSup	ΔDem	ΔTrade
ARGENTINA	4.0%	4.0%	1.0%	-1.2%	8.0%
BRAZIL	6.6%	3.9%	1.4%	-1.2%	12.2%
CHINA	3.2%	3.2%	0.9%	15.1%	24.5%
US	3.2%	3.3%	0.9%	-1.3%	4.6%
ROW	3.3%	3.3%	0.7%	-1.6%	-2.9%

In all countries, consumers react to the increase in prices consuming fewer soybeans while producers react producing more. As a consequence, the export countries increase their exports. Due to the demand shock China has to import more soybeans under this scenario. Brazil, Argentina, and the US, in this order, fulfill the Chinese soybean need. It seems to be consistent with the information that was collected in field research in Brazil on December 2007, and with comments made on the previous scenario. The impact of a Chinese demand shock is negative for all consumers around the world while for the producers the impact is positive because the soybean price goes up (see Table 4.7).

Table 4.7: S3 - Welfare changes, US thousand dollars

	∆PS	∆CS	∆B	∆W
ARGENTINA	256,041	-176,917	34,194	113,318
BRAZIL	445,426	-247,969	-	197,457
CHINA	148,037	-1,906,440	95,106	-1,663,297
US	634,026	-397,296	-7,829	228,901
ROW	150,020	-434,300	-	-284,280
WORLD	1,633,551	-3,162,923	121,471	-1,407,900

Argentina and Brazil face a welfare increase because of their export expansion. The US budget expenditure increases because the country increases its production. However, the higher producer surplus supersedes the US consumer and government losses. In the ROW total welfare goes down due to the price increase. The total welfare in China is also reduced significantly due to the demand shock in the country. As consequence at world level the total welfare effect is negative.

4.2.4 Brazilian Infrastructure Improvement Scenario (S4)

A Brazilian domestic transport costs decrease of 15% leads to an increase in producer prices in Brazil and reduces the producer prices around the world, while consumer prices decrease around the world (see Table 4.8).

Table 4.8: S4 - Change in producer price, consumer price, supply, demand and trade

	∆PP	∆CP	∆Sup	∆Dem	∆Trade
ARGENTINA	-2.2%	-2.2%	-0.5%	0.6%	-4.3%
BRAZIL	6.9%	-2.1%	3.8%	0.6%	9.8%
CHINA	-1.7%	-1.7%	-0.5%	0.3%	1.0%
US	-1.7%	-1.8%	-0.5%	0.7%	-2.5%
ROW	-1.8%	-1.8%	-0.4%	0.9%	1.6%

The demand increases in all countries, varying from 0.3% in China to 0.9% in the ROW. Brazil expands its export 9.8% and the US and Argentina decrease their export with 2.5% and 4.3%, respectively. Both China and the ROW increase their import. A 15% internal transport costs reduction improves the consumers' situation in all countries. However, it hurts the producers around the world, except in Brazil. As a consequence all consumer surplus changes are positive while all producer surplus changes are negative, except for the Brazilian producers (US$ 465.9 million increase). Argentina exports less and the US produces less. So the Argentinean tax revenue is smaller as well as the American budget costs. China imports 1% more but as the border price falls 4.8%, the revenue from the import tariff also falls and the Chinese budget change is negative in US$ 2.0 million (see Table 4.9).

Table 4.9: S4 - Welfare changes, US thousand dollars

	∆PS	∆CS	∆B	∆W
ARGENTINA	-137,635	96,723	-17,851	-58,763
BRAZIL	465,939	135,539	-	601,479
CHINA	-79,637	170,936	-2,032	89,267
US	-340,945	217,304	4,241	-119,400
ROW	-80,817	238,237	-	157,420
WORLD	-173,094	858,739	-15,643	670,002

Brazil, China and the ROW face an increase in their total welfare while welfare decreases in the US and Argentina. However, for the latter countries it happens only because there are huge losses in producer surplus. For their consumers welfare increases. For the world, the total welfare change is positive (US$ 670.0 million) and reflects that less distortions increase total welfare.

Thus, an improvement in the Brazilian infrastructure produces clear benefits to the agricultural producers in the country and to the consumers around the world. The producers in other countries lose and Brazil displaces part of the Argentinean and American export.

5 Discussion and Conclusions

This research focused on: i)assessing the usefulness of a spatial equilibrium trade model in association with welfare analysis to study production, demand and trade in the US, Brazil, Argentina and China in combination with the rest of the world; and ii) calculating the welfare changes and effects of policy changes. The empirical model developed in Section 3 was used to analyze the effects of four scenarios created in Section 4. The main research results are presented as follows.

The first simulation – S1: Trade Liberalization – shows that liberalization including the abolishment of the Argentinean export tax leads to important prices changes around the world. In Argentina the producer price increases by 16.2% while in the US and China it decreases by 4.8% and 6.4%, respectively. In Brazil and the rest of the world the prices reduce 1.4% and 0.7%, respectively. For consumers, the prices go up with 16.2% in Argentina and reduce with less than 0.8% in other countries. As a consequence, Argentina increases its exports under this scenario. The net effect for other exporting and all importing countries is to export less and to import more, respectively.

Under S1, US saves US$ 825.1 million budget because of the elimination of deficiency payment and Argentina loses US$ 331.7 million budget with the abolishment of the export tariff. Even trading 3.5% more, China losses US$ 330.5 budget from its import tariff because the import price falls 6.4%. This scenario shows also a small positive welfare increase for the world as a whole. The main consequence is, however, a welfare redistribution amongst countries and agents within the countries. Consumers gain except in Argentina, where producers gain while consumers lose. Argentina as a whole gains because the export tax is a damaging measure for producers and overall welfare. Moreover, the elimination of the US domestic support has a positive impact on welfare for exporting countries. Thus, the abolishment of the US producer subsidies, Argentinean export tax and Chinese import tariff can be recommended as measures to improve the welfare of the world as a whole. Brandão and Lima (2002) affirm that 50% of the subsidized US soybean production is exported. The authors believe that the elimination of the US domestic support to soybeans will also imporve the world price. Last, they affirm that the US subsidy causes damage to Brazilian producers and exporters.

The second simulation – S2: Biofuel – implies a reduction of arable land used for soybean production in order to increase corn production. This is the way used for the US to produce more biofuel. The outcomes of this scenario show an increase in the producer and consumer prices in all countries. In China, the rest of the world and the US the producer prices increase with 7.5%, while the increase is 9.3% and 15.4% in Argentina and Brazil, respectively. The consumer prices increase about 9% in Argentina and Brazil, and 7.6% in the other countries. Brazil and Argentina increase their exports and importing countries import less in face of the price increase.

This scenario shows that, in terms of welfare, soybean exporters gain while the importers lose. The consumers around of the world are worse off and producers are better off because of the price increase. Under S2, US crops 15% soybean less and spends less US$ 123, 9 million budget even with producer price 7.4% greater. Argentina trades 18.7% more with price 9.3% greater, and collects more US$ 82.1 million budget. China trades 4.1% less but it collects more US$ 7.4 million budget because the import price is 7.4% greater. At world level, the total welfare change is positive, the increase in producer surplus is larger than the decrease in consumer surplus. Moreover, it can be observed that US producers are not hurt and that Brazilian and Argentinean producers compensate the fall in production of the US.

The third simulation – S3: Chinese demand growth analyzes a demand shock by an increase in soybean demand by China. The shock comes from Chinese population growth and from the fact that China exports feed and oil for neighbor countries. This scenario results in an increase in all prices around the word. In China, rest of the world and the US the producer price increase is almost the same (3.2%), while it is 4.0% and 6.6% in Argentina and Brazil, respectively. The consumer prices, in turn, increase between 3.2% and 4% around the world. Exporting countries expand their exports while the rest of the world reduces its imports. Furthermore, the Chinese demand growth is met mainly by Brazil and Argentina.

In this scenario all exporting countries have an increase in total welfare while importing countries experience a negative welfare effect. The lion's share of gains and losses goes to the producers and consumers, respectively. Under S3, US spends more US$ 7.8 million budget because the producers supply about 1% more with producer price 3.3% greater. Argentina and China collect US$ 34.2 million and USS 95.1 million budget, respectively. They trade more with higher trading prices. Total welfare in China is reduced significantly due to the demand shock. This affects the world welfare change that is negative.

The last scenario – S4: Brazilian Infrastructure Improvement analyzes a reduction of the Brazilian domestic transport costs of 15%. As a result producer prices in Brazil increase (6.9%) and reduce in the other countries. with 1.7% to 2.2%. Consumer prices also decrease with 1.7% and 2.2%. Brazil expands its export by 9.8%, and the US and Argentina decrease their exports by 2.5% and 4.3%, respectively. Both China and the rest of the world increase their imports.

Under this scenario the consumers' welfare is improved in all countries. However, the producers' welfare goes down around the world, except in Brazil. Brazil, China and the rest of the world face an increase in their total welfare while total welfare decreases in the US and Argentina. For the latter countries the decreases in producer welfare are larger than the increases in consumer welfare. Under S5, US crops 0.5% less with prices 1.7% smaller. So, the country saves US$ 4.2 million budget. Argentina trades 4.3% less with trading prices 2.2% smaller. It collects US$ 17.9 million budget less. China trades 1% more with importing prices 1.7% smaller. Therefore, it collects US$ 2.0 million budget less. Finally, the total world welfare change is also positive.

The results found are in line with findings from the literature. Hart and Beghin (2006) quote a study by Schnepf et. al (2001) that affirms that the Brazilian infrastructure hampers Brazil's ability to market agricultural commodities. Hart and Beghin (2006) also mention Fuller and others' study (2000) that affirms that transport improvements could lead to an increase in Brazilian's soybean prices in a range of US$ 11 to US$ 22 a ton. A Brazilian transport improvement favors more welfare of consumers, except in Brazil where the producers gain most. All countries improve their total welfare, except the other main exporters Argentina and the US.

As a general conclusion, it can be said that the total welfare changes are relatively small for all countries in the chosen scenarios. However, welfare changes for individual agents can be large. This makes the topic so important in the political arena. Our results are also in line with Anderson and Martin (2006). They show that removing all agricultural tariffs and subsidies can lead for developing countries to a decrease of 2% in their welfare. This is divided into -3% and 1% in their welfare for export subsidies and domestic support removal, respectively. Hertel and Keeney (2006) explain that many developing countries depend crucially on cheap food imports and that the elimination of support in developed countries will hurt them.

The partial equilibrium trade model used in this research is a simplification of the very complex world soybean market. For example, in reality there are many products such as beans, food, oil and feed. The main critiques on our analyses are threefold. The reliability of data comes first. Not a single consistent data set exists, so two data sources had to be used. Moreover, yearly data had to be used in place of a more detailed length of time. Besides, elasticities were taken from the literature instead of estimated being estimated.

Secondly, the simplification of the US, Argentinean, Brazilian and Chinese policies as well as the Brazilian domestic transport costs are an important issue to be considered when interpreting the results. In reality policies are much more complex. For instance, the American soybean policy is much more complex than the simplified one that was used in this research. Moreover, the Argentinean export tax is based on an official price fixed by the government that may be different of the actual price. Finally, for Brazil average domestic transport costs were taken. In practice, each region in the country has different transport costs.

Thirdly, the scenarios are not always completely realistic. For example, the abolishment of the Argentinean export tax cannot be considered only for soybean. To be more realistic for all products the export tax should be abolished. Otherwise, the producers may reduce wheat area in favor of soybean. Another example is that the US support payment does not change when the price alters.

Notwithstanding these limitations it can be concluded that the model developed is a useful tool for analyzing the world soybean market. It provides important insights for policy makers that are consistent with expert opinions and economic theory. For coming studies, the estimation of the price elasticities of supply and demand and cross price elasticities could improve the its. Flexible functional forms could replace the linear functional forms used here. A more detailed data set, for example with data on production costs, could also increase the quality of the analysis.

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Appendix I – Price relationships

In this section, linking prices in the exporting country with prices in the importing country for all involved agents, the relationships between the different prices in the model are defined.

The export price is the producer price plus internal transport costs from producer to the exporting harbor. This price does not include the export tax.

$$P^e = P_p^e + T_d^e$$

The free on board price (FOB) is the export price plus the export tax:

$$P^{fob} = P^e * (1 + t^e)$$

The fob price plus transport costs between exporting and importing country gives the import price of the importing country:

$$P^{cif} = P^{fob} + T_i^W$$

The cost insurance and freight price (CIF) price of the importing country is the import price plus the tariff:

$$P^i = P^{cif}(1 + t^i)$$

Assuming demand is largest close to the importing harbor, the producer price in the importing country is equal between the cif price minus the transport costs in the importing country:

$$P_p^i = P^i - T_d^i$$

It is important to highlight that CIF and FOB are border prices.

Where:

P^e	export price (including export tax)
P_p^e	producer price in exporting country
T_d^e	domestic transport costs in exporting country
P^{fob}	fob price (includes the export tax)
t^e, t^i	export tax and tariff (importing country)
P^{cif}	CIF import price (excludes tariff)
T_i^W	transport costs from exporting to importing country
P^i	import price net of tariff
T_d^i	domestic transport costs in importing country

Applying these relationships and additional assumptions (Section 3.1), after some steps, the following simplified equations are built:

Argentina

$$PS_{ARG} = PD_{ARG} = P_{ARG}^{fob} / (1 + t_{ARG}^{e})$$

Brazil

$$PS_{BRA} = P_{BRA}^{fob} - T_{dBRA}^{e} \qquad PD_{BRA} = P_{BRA}^{fob}$$

United States

$$PS_{US} = P_{US}^{fob} + S_{US} \qquad PD_{US} = P_{US}^{fob}$$

Rest of the World

$$P_{ROW}^{cif} = P_{BR}^{fob} + T_{BR/ROW}^{W} \qquad P_{ROW}^{cif} = P_{ARG}^{fob} + T_{ARG/ROW}^{W} \qquad P_{ROW}^{cif} = P_{US}^{fob} + T_{US/ROW}^{W}$$

$$PS_{ROW} = PD_{ROW} = P_{ROW}^{cif}$$

China

$$P_{CHN}^{cif} = P_{ARG}^{fob} + T_{ARG/CHN}^{W} \qquad P_{CHN}^{cif} = P_{BR}^{fob} + T_{BR/CHN}^{W} \qquad P_{CHN}^{cif} = P_{US}^{fob} + T_{US/CHN}^{W}$$

$$PS_{CHN} = PD_{CHN} = P_{CHN}^{cif} * (1 + t_{CHN}^{i})$$