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Impacts of the Brazilian Bio-Diesel Program on the World Soybean and Soybean Products Market: An Econometric Simulation Approach

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To develop a low-income region, the Brazilian Government will start a bio-diesel program in 2008. The government will provide castor beans, palm oil, sunflowers, cotton, peanuts, and soybean as the raw materials for bio-diesel production. Because of their favorable production costs and production levels, soybean have certain advantages over other crops in the production of bio-diesel. Our study is the first to evaluate the impact the Brazilian bio-diesel program will have on the domestic soybean and soybean products markets, by applying a newly developed world soybean and soybean products model. Our simulation suggests moderate impacts on the world soybean and soybean products markets.

Key words : Brazil, bio-diesel, soybean, soybean oil, and soybean meal.

1. Introduction

In 2008, the Brazilian government will promote a bio-diesel[1)] program to develop a low-income region and to deal with environmental and energy problems. The government began to research bio-diesel production from vegetable oils in the 1970s. In 1983, the government planned the National Program for Energy from Vegetable Oils (OVEG) project to test the use of bio-diesel and fuel mixtures in vehicles. However, the government strongly promoted the Brazilian National Alcohol Program (PROALCOOL),[2)] rather than a bio-diesel program at that time, so a national bio-diesel program didn't materialize.

In Brazil, the economic gap between the Southeast and Northeast regions has been a crucial problem. The southeast region is responsible for 55.2% of total GDP, and the Northeast is responsible for only 33.7%. The per capita income of the Southeast region is about three times higher than that of the Northeast (IBGE [6]). To increase job opportunities and income levels, especially in the Northeast regions, the government is promoting bio-diesel production and the use of raw materials to enhance this production. In January 2005, Law No. 11,047 determined that 2% of bio-diesel in diesel oil (B2) would be mandated nationwide from 2008, and 5% of bio-diesel oil (B5) would be mandated nationwide from 2013.

The Northeast region is the main producer of castor beans, with 97% of total domestic production. Bahia State (Northeast region) is responsible for 87% of total production (Ministry of Agriculture, Livestock and Supply [13]). The castor bean is a labor-intensive crop that is resistant to dry conditions. It is common in much of the Northeast and is cultivated mostly by small farmers. Palm oil adapts well to the humid, tropical conditions of the Bahia coast. At present, Para State (North region) is responsible for 81% of production, while Bahia State contributes 19% of total production (Ministry of Agriculture, Livestock and Supply [13]).

The government has approved the use of

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castor beans, palm oil, sunflowers, cotton, peanuts and soybean, as the raw materials for bio-diesel production.[3] Taking into account the production costs, production potential, profitability and production amount, soybean has an overwhelming advantage over other crops as a source for the production of bio-diesel.[4] Therefore, we focus on bio-diesel production from soybean in this study.

At present, several reports and studies have noted the bio-diesel program and soybean markets. Koizumi [8] investigated the Brazilian bio-diesel program and industry. Frondel and Peters [5] investigated the environmental and economic implications of the support of rapeseed-based bio-diesel. The USDA [19] assessed the effects biofuel production from soybean oil had on agriculture. Moraes [17] analyzed acreage response for soybeans in Brazil by assessing model specifications. Meyers, Helmar, and Devadoss [12] outlined the structure and components of the world soybean sector model on a linear equation basis. Koizumi and Yanagishima [10] examined the relationship between Brazilian sugar and the ethanol market using econometric models. Koizumi and Ohga [9] examined the impacts the Chinese ethanol program would have on the international corn market, using an econometric model. However, none of these studies dealt with how the Brazilian bio-diesel program would impact the domestic and world soybean and soybean products markets, using an econometric model. Meyers, Helmar, and Devadoss [12] adopted a model system in which crush volume depended on the *crushing margin* for some countries in linear equations. However, the model activity using the *crushing margin* can be unstable in non-linear equations, because the margin can be negative in most cases. To solve the instability problem, we adopt a new equation; each soybean crush depends on the domestic soybean price, the soybean oil price and soybean meal price in this model. On these points, this model is different from other econometric models. In this study, we hypothesized that the Brazilian bio-diesel program would impact not only on the domestic soybean and soybean products markets but also on world markets. Our study is the first to evaluate the impact the Brazilian bio-diesel program would have on domestic soybean and soybean products markets, using a world soybean and soybean products model. The next section is an explanation of the world soybean and products markets model we applied in evaluating the Brazilian bio-diesel program. In the third section, we discuss baseline projection figures, and in the fourth section, the market impacts. The last section summarizes our conclusion.

2. The World Soybean and Soybean Products Model

1) Overview of the world soybean and soybean products model

The world soybean and soybean products model was developed to analyze how the Brazilian bio-diesel program affects not only soybean globally, but also the world soybean products market. An econometric model has been developed as a dynamic partial equilibrium model that extends to the world soybean and soybean products markets. The world soybean and soybean products model consists of seven major soybean-trading countries and regions: Brazil, the US, Argentina, China, the EU25, Japan, and the Rest of the World. These six countries and regions accounted for 89.2% of world soybean production, 88.9% of world soybean exports, 83.8% of world soybean consumption, 85.8% of total oil production, 91.6% of total oil exports, 68.0% of total oil consumption, 85.3% of total meal production, 89.1% of total meal exports, and 70.9% of total meal consumption in 2006/07 (USDA-FAS [4]).

In the model, bio-diesel consumption in each country is derived exogenously. Soybean markets in each country consist of production, crush, consumption, export, import, and ending stocks activities. Soybean oil and soybean meal markets in each country consist of production, consumption, export, import, and ending stocks activities. The fundamental structure of our model is illustrated in the following chart (Figure 1).

2) Model structures

Each country and region's soybean and soybean products market is described by equations for production, crush, per capita consumption, imports, exports, and ending stocks. Soybean and soybean products data is derived from USDA-FAS[4]. Appendix 3 shows the evaluation of each parameter. Our model

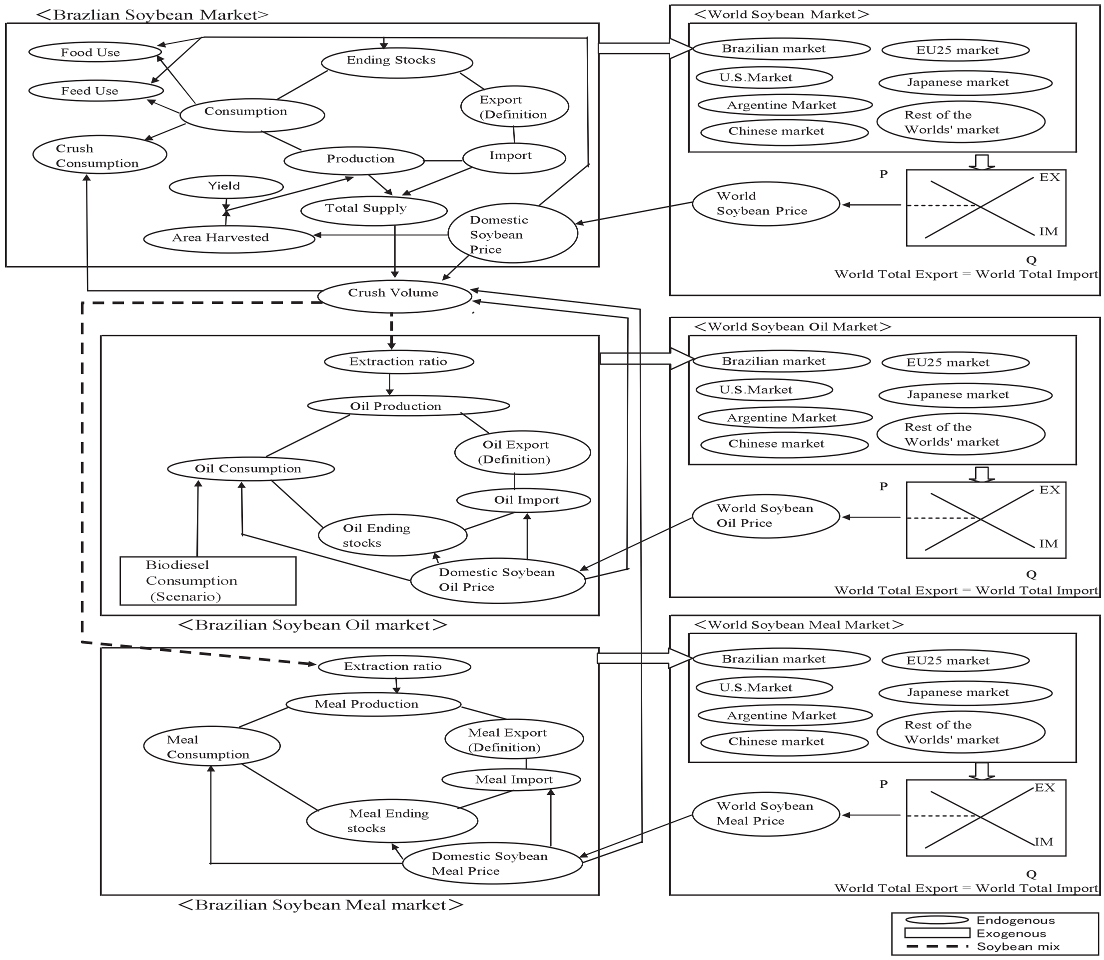

Figure 1. World soybean and soybean products model

is a policy simulation model, and we deem each equation to be necessary, and the magnitude of each parameter to be reasonable for building this model. Sign conditions of each parameter are reasonable. Although their t-values and coefficients of determination and their level of significance are not high, we provide Appendix 3 to enable the reader to better understand the model structure. Although we could get each constant term in evaluating each parameter, we didn't use their constant terms for building this model. Instead of a statistically estimated constant term, we applied a calibrated constant term[5] to improve the reality for model projection activity.

Area harvested and yield equations determined soybean production. The area harvested depends on the lagged domestic soybean price and alternative crop prices as follows:[6]

$$\begin{aligned}\log AH_{r,t} = &(1{+}a1)^{*} \log AH_{r,t-1}\\ &+a2^{*} \log^{*}(DS_{r,t-1}/DS_{r,t-2})\\ &+a3^{*} \log(DC_{r,t-1}/DC_{r,t-2})\\ &+a4^{*} \log(DR_{r,t-1}/DR_{r,t-2})\end{aligned}$$

where AH is the area of soybean harvested, $a1$-$a4$ are the parameters, DS is the domestic price of soybean, DC is the domestic price of corn, DR is the domestic price of rice, r is the country, and t is the time index. It is assumed that soybean yield depends on the technological growth ratio as follows:

$$YH_{r,t} = YH_{r,t-1}{}^{*}(1+a5)$$

where YH is soybean yield, and $a5$ is the parameter. Soybean production is explained as follows:

$$QPS_{r,t} = AH_{r,t} * YH_{r,t}$$

where *QPS* is the production of soybean. Per capita soybean consumption for food use depends on the domestic soybean price and income.

$$\log PQCS_{r,t} = (1+a6) * \log PQCS_{r,t-1} + a7 * \log(DS_{r,t}/DS_{r,t-1}) + a8 * \log(VV_{r,t}/VV_{r,t-1})$$

where *PQCS* is per capita soybean consumption for food use, $a6$-$a8$ are the parameters, and *VV* is the per capita income. Total soybean consumption for food use is calculated by multiplying the per capita other consumption by the country's population :

$$QCSF_{r,t} = PQCS_{r,t} * NN_{r,t}$$

where *QCSF* is soybean consumption for food and *NN* is population. Soybean consumption for feed[7] depends on the domestic soybean price and corn price.

$$\log QCSE_{r,t} = (1+a9) * \log QCSE_{r,t-1} + a10 * \log(DS_{r,t}/DS_{r,t-1}) + a11 * \log(DC_{r,t}/DC_{r,t-1}) + a12 * \log(LBP_{r,t}/LBP_{r,t-1})$$

where *QCSE* is the feed consumption of soybean, *LBP* is domestic livestock production and $a9$-$a12$ are the parameters. Total soybean consumption is the sum of food consumption, feed consumption,[8] and soybean crush.

$$QCS_{r,t} = QCSF_{r,t} + QCSE_{r,t} + CR_{r,t}$$

where *QCS* is the total consumption of soybeans and *CR* is soybean crush. For a net soybean exporting country, exports are the exportable domestic market balance deficit after domestic consumption has been satisfied.

$$EXS_{r,t} = IMS_{r,t} + QPS_{r,t} - QCS_{r,t} - (STS_{r,t} - STS_{r,t-1})$$

where *EXS* is the soybean export, *IMS* is the soybean import and *STS* is the soybean ending stocks. For other countries and regions, soybean exports depend on the world soybean price as follows:

$$\log EXS_{r,t} = (1+a13) * \log EXS_{r,t-1} + a14 * \log(WPS_{r,t}/WPS_{r,t-1})$$

where *EXS* is the soybean export, $a13$-$a14$ are the parameters, and *WPS* is the world soybean price. Soybean imports in a net importing country are the exportable domestic market balance deficit remaining after domestic consumption has been satisfied.

$$IMS_{r,t} = EXS_{r,t} + QCS_{r,t} - QPS_{r,t} + STS_{r,t} - STS_{r,t-1}$$

For other countries, soybean imports depend on the import price of soybean as follows:

$$\log IMS_{r,t} = (1+a15) * \log IMS_{r,t-1} + a16 * \log(MS_{r,t}/MS_{r,t-1})$$

where *MS* is the import price of soybean, and $a15$-$a16$ are the parameters. Soybean ending stocks are related to the level of production or consumption and domestic soybean prices in a net soybean-exporting country as follows:

$$\log STS_{r,t} = (1+a17) * \log STS_{r,t-1} + a18 * \log(QPS_{r,t}/QPS_{r,t-1}) + a19 * \log(QCS_{r,t}/QCS_{r,t-1}) + a20 * \log(DS_{r,t}/DS_{r,t-1})$$

where $a17$-$a20$ are the parameters.

Soybean crush depends on the domestic soybean price, the soybean oil price, the soybean meal price, and the world crude oil price as follows:

$$\log CR_{r,t} = (1+a21) * \log CR_{r,t-1} + a22 * \log * (DS_{r,t}/DS_{r,t-1}) + a23 * \log(DO_{r,t}/DO_{r,t-1}) + a24 * \log(DM_{r,t}/DM_{r,t-1}) + a25 * \log(WCO_{r,t}/WCO_{r,t-1})$$

where *DO* is the domestic soybean oil price, *DM* is the domestic soybean meal price, *WCO* is the world crude oil price,[9] and $a21$-$a25$ are the parameters. It is assumed that the soybean oil extraction ratio depends on the technological growth ratio as follows:

$$EXT_{r,t} = EXT_{r,t-1} * (1+a26)$$

where *EXT* is the soybean oil extraction ratio, and $a26$ is the parameter. Soybean oil production is explained as follows:

$$QPO_{r,t} = CR_{r,t} * (1+EXT_{r,t})$$

where *QPO* is soybean oil production. Per capita soybean oil consumption for food uses depends on the domestic soybean oil price, rapeseed price, peanut oil price, and income.

$$\log PQO_{r,t} = (1+a27)^* \log PQO_{r,t-1} + a28^* \log(DO_{r,t}/DO_{r,t-1}) + a29^* \log(RP_{r,t}/RP_{r,t-1}) + a30^* \log(PP_{r,t}/PP_{r,t-1}) + a31^* \log(VV_{r,t}/VV_{r,t-1})$$

where *PQO* is the per capita soybean oil consumption for food use, *RP* is the rapeseed price, *PP* is the peanut price, *VV* is the per capita income, and $a27$-$a31$ are the parameters. Total soybean oil consumption for food use is calculated by multiplying the per capita other consumption by the country's population:

$$QOF_{r,t} = PQO_{r,t}^* NN_{r,t}$$

where *QOF* is soybean oil consumption for food, and *NN* is population. Soybean oil consumption for industry depends on the domestic price of soybean oil.

$$\log QOI_{r,t} = (1+a32)^* \log QOI_{r,t-1} + a33^* \log(DO_{r,t}/DO_{r,t-1})$$

where *QOI* is the soybean oil consumption for industry and $a32$-$a33$ are the parameters. Total soybean oil consumption is the sum of food consumption and industry consumption.

$$QCO_{r,t} = QOF_{r,t} + QOI_{r,t}$$

where *QCO* is the consumption of soybean oil. For a net soybean oil exporting country, exports are the exportable domestic market balance deficit after domestic consumption has been satisfied.

$$EXO_{r,t} = IMO_{r,t} + QPO_{r,t} - QCO_{r,t} - (STO_{r,t} - STO_{r,t-1})$$

where *EXO* is the soybean oil export, *IMO* is the soybean oil import, and *STO* is the soybean oil ending stocks. For other countries and regions, soybean oil exports depend on the world soybean oil price as follows:

$$\log EXO_{r,t} = (1+a34)^* \log EXO_{r,t-1} + a35^* \log(WPO_{r,t}/WPO_{r,t-1})$$

where *EXO* is the soybean oil export, $a34$-$a35$ are the parameters, and *WPO* is the world soybean oil price. Soybean oil imports in a net importing country are the exportable domestic market balance deficit remaining after domestic consumption has been satisfied.

$$IMO_{r,t} = EXO_{r,t} + QCO_{r,t} - QPO_{r,t} + STO_{r,t} - STO_{r,t-1}$$

For other countries, soybean oil imports depend on the import price of soybean oil as follows:

$$\log IMO_{r,t} = (1+a36)^* \log IMO_{r,t-1} + a37^* \log(MO_{r,t}/MO_{r,t-1})$$

where *MO* is the import price of soybean oil, and $a36$-$a37$ are the parameters. Soybean oil ending stocks are related to the level of production or consumption and domestic soybean oil prices as follows:

$$\log STO_{r,t} = (1+a38)^* \log STO_{r,t-1} + a39^* \log(QPO_{r,t}/QPO_{r,t-1}) + a40^* \log(QCO_{r,t}/QCO_{r,t-1}) + a41^* \log(DO_{r,t}/DO_{r,t-1})$$

where $a38$-$a41$ are the parameters.

It is assumed that the soybean meal extraction ratio depends on the technological growth ratio as follows:

$$EXM_{r,t} = EXM_{r,t-1}^* (1+a42)$$

where *EXM* is the soybean meal extraction ratio, and $a42$ is the parameter. Soybean meal production is explained as follows:

$$QPM_{r,t} = CR_{r,t}^* (1+EXM_{r,t})$$

where *QPM* is soybean meal production. Soybean meal consumption for feed use depends on the domestic soybean meal price, corn price, broiler production, pork production, and income.

$$\log QME_{r,t} = (1+a43)^* \log QME_{r,t-1} + a44^* \log(DM_{r,t}/DM_{r,t-1}) + a45^* \log(DC_{r,t}/DC_{r,t-1}) + a46^* \log(LBP_{r,t}/LBP_{r,t-1}) + a47^* \log(LPP_{r,t}/LPP_{r,t-1}) + a48^* \log(VV_{r,t}/VV_{r,t-1})$$

where *QME* is soybean meal consumption for feed use, *LBP* is domestic broiler production, *LPP* is domestic pork production, *VV* is the per capita income and $a43$-$a48$ are the parameters. Soybean meal consumption for industry depends on the domestic soybean meal price.

$$\log QMI_{r,t} = (1+a49)^* \log QMI_{r,t-1} + a50^* \log(DM_{r,t}/DM_{r,t-1})$$

where *QMI* is the soybean meal consumption for industry and $a49$-$a50$ are the parameters. Per capita soybean meal consumption for food depends on the domestic soybean meal price.

$$\log PQMF_{r,t} = (1+a51)*\log PQMF_{r,t-1} + a52*\log(DM_{r,t}/DM_{r,t-1})$$

where $PQMF$ is the soybean meal consumption for food and $a51$-$a52$ are the parameters. Total soybean meal consumption for food is calculated by multiplying the per capita consumption for food by the country's population:

$$QMF_{r,t} = PQMF_{r,t} * NN_{r,t}$$

where QMF is the soybean meal consumption for food. Total soybean meal consumption is the sum of feed use, industrial use, and feed use.

$$QCM_{r,t} = QME_{r,t} + QMI_{r,t} + QMF_{r,t}$$

where QCM is the total consumption of soybean meal. For a net soybean meal-exporting country, exports are the exportable domestic market balance deficit after domestic consumption has been satisfied.

$$EXM_{r,t} = IMM_{r,t} + QPM_{r,t} - QCM_{r,t} - (STM_{r,t} - STM_{r,t-1})$$

where EXM is the soybean meal export, IMM is the soybean meal import, and STM is the soybean meal ending stocks. For other countries and regions, soybean meal exports depend on the world soybean meal price as follows:

$$\log EXM_{r,t} = (1+a53)*\log EXM_{r,t-1} + a54*\log(WPM_{r,t}/WPM_{r,t-1})$$

where WPM is the world soybean meal price, and $a52$-$a53$ are the parameters. Soybean meal imports in a net importing country are the exportable domestic market balance deficit remaining after domestic consumption has been satisfied.

$$IMM_{r,t} = EXM_{r,t} + QCM_{r,t} - QPM_{r,t} + STM_{r,t} - STM_{r,t-1}$$

For other countries, soybean meal imports depend on the import price of soybean meal as follows:

$$\log IMM_{r,t} = (1+a55)*\log IMM_{r,t-1} + a56*\log(MM_{r,t}/MM_{r,t-1})$$

where MM is the import price of soybean meal, and $a55$-$a56$ are the parameters. Soybean meal ending stocks are related to the level of production or consumption and domestic meal prices as follows:

$$\log STM_{r,t} = (1+a57)*\log STM_{r,t-1} + a58*\log(QPM_{r,t}/QPM_{r,t-1}) + a59*\log(QCM_{r,t}/QCM_{r,t-1}) + a60*\log(DM_{r,t}/DM_{r,t-1})$$

where $a57$-$a60$ are the parameters.

3) World market equilibrium and price linkage

For each simulation year, the model determines gross exports and imports for each country. A world soybean market equilibrium price is then obtained from the following equilibrium conditions through the use of the Gauss-Seidel algorithm. World soybean price refers to the world soybean market clearing price.

$$\Sigma EXS_{r,t} = \Sigma IMS_{r,t}$$

where EXS is soybean export, IMS is soybean import, r is each country and region, and t is the time index. World soybean oil price refers to the world soybean oil market clearing price.

$$\Sigma EXO_{r,t} = \Sigma IMO_{r,t}$$

where EXO is soybean oil export, IMO is soybean oil import. World soybean meal price refers to the world soybean meal market clearing price.

$$\Sigma EXM_{r,t} = \Sigma IMM_{r,t}$$

where EXM is soybean meal export, and IMM is soybean meal import.

The domestic soybean and soybean products producer prices and import prices are linked to the world soybean and soybean products price through constant price transmission elasticity as follows:

$$\log DS_{r,t} = a61*\log(WPS_{r,t}/WPS_{r,t-1})$$
$$\log DO_{r,t} = a62*\log(WPO_{r,t}/WPO_{r,t-1})$$
$$\log DM_{r,t} = a63*\log(WPM_{r,t}/WPM_{r,t-1})$$
$$MS_{r,t} = (WPS_t)*(1+TSS_{r,t})$$
$$MO_{r,t} = (WPO_t)*(1+TSO_{r,t})$$
$$MM_{r,t} = (WPM_t)*(1+TSM_{r,t})$$

where $a61$-$a63$ are the parameters, and where TSS is the *ad valorem* tariff ratio for soybean, TSO is the *ad valorem* tariff rate for soybean oil, and *TSM* is the *ad valorem* tariff rate for soybean meal. For China, Japan, and the EU25, each import price means each domestic price.

3. Projections

1) Assumptions

Our baseline projection is based on a series of assumptions about the general economy, agricultural policies, and technological changes in the exporting and importing countries during the projection period. The exogenous assumption regarding projected consumption for gasoline in Brazil was taken from *International Energy Outlook 2006* [1]. Another exogenous assumption, the projected world crude oil price, was derived from the US Department of Energy's *Annual Energy Outlook 2007* [21]. In this USDE high world oil price case scenario, the world crude oil price is expected to increase at a rate of 3.6 % per year from 2006 to 2015. The exogenous corn and rice price, poultry and pork production were taken from FAPRI [2], OECD-FAO [11] and USDA [20]. Population data for all countries were taken from official United Nations population estimates (medium variant) (United Nations [18]). Per capita real GDPs were also treated as exogenous variables and their growth rate assumptions were based on OECD and USDA economic forecasts. [10]

We also assumed that current agricultural polices will continue in all countries throughout the projection period. Following the general adopted procedures, we assumed normal weather and historical rates of technological innovation. New WTO agricultural agreements were not taken into account in the model. Market access was frozen at levels prevailing in the year 2006. Regional free trade areas were assumed not to expand.

It is assumed the Brazilian Government will start the B2 program from 2008, and the B5 program from 2013. Castor bean and palm oil are the main raw products for the production of bio-diesel. The government emphasized castor bean and palm oil as raw materials for bio-diesel and didn't mention bio-diesel production from soybean. In the baseline scenario, soybean will not be used for bio-diesel production as a raw material in the Brazilian bio-diesel program. [11] In the US, 348 million gallons of bio-diesel will be derived from soybean oil in 2015 (FAPRI [2]). In the EU25, 5.2 million tons of rapeseed is used for bio-diesel production, and 1.4 million tons of soybean oil is used for bio-diesel production (USDA-FAS [3]). It is assumed this volume will be used for bio-diesel production to the year 2015.

2) Projected world soybean and soybean products market to the years 2015/16

World soybean consumption and production were projected to increase by 2.2% per annum from 2006/07 to 2015/16. World soybean exports and imports are projected to increase by 2.6% per annum during this period. The world soybean price is projected to increase steadily from 6.05 US dollars/bushel in 2006/07 to 6.71 US dollars/bushel in 2015/16. Brazilian soybean production is projected to increase by 4.5% per annum during this period. Brazil has abundant areas, especially the Middle West and North, to expand soybean production. Brazilian area harvested for soybean is projected to increase by 3.9% per annum. In the US, it is assumed that growers will shift from soybean to corn, because more favorable returns from corn production will result from the expansion of corn-based bio-ethanol production. US soybean production is projected to increase by 0.1% per annum. As a result, Brazil is projected to be the world largest producer of soybean from 2013/14.

US soybean exports are projected to decrease by 4.3% per annum. Brazilian soybean exports are projected to increase by 7.0% per annum. Brazil is expected to be the biggest soybean exporter, occupying a dominant share (58.4%) of world soybean exports in 2015/16. Argentine soybean exports are projected to increase by 4.6% per annum. As for soybean import and consumption, the country that contributes most to this increase in world soybean import and consumption is China.

World soybean crush volume is projected to increase by 2.3% per annum from 2006/07 to 2015/16. World soybean oil consumption and production were projected to increase by 2.2 % per annum. China contributes the most to this increase in world soybean oil consumption. World soybean oil exports are projected to increase by 3.9% per annum and world soybean oil imports are projected to increase by 4.3% per annum during this period. The world soybean oil price is projected to increase steadily from 27.21 US cents/lb in 2006/07 to 33.84 US cents/lb in 2015/16.

World soybean meal consumption and production were projected to increase by 2.2% per annum from 2006/07 to 2015/16. China contributes most to this increase in world soybean meal consumption. Global soybean meal exports and imports are projected to increase by 2.6% per annum during this period. The world soybean meal price is projected to increase steadily from 189.59 US dollars/ton in 2006/07 to 228.99 US dollars/ton in 2015/16.[12)]

4. Impact of the Brazilian Bio-Diesel Program on Global Soybean and Soybean Products Markets

1) Alternative scenario

The Brazilian Government will start its B2 program from 2008 and its B5 program from 2013. As raw materials for bio-diesel production, the government has chosen castor beans, palm oil, sunflower oil, cotton oil, peanut oil, and soybean oil. Those oils other than soybean oil don't have much production potential (Koizumi [8]). Taking into account the production costs, production potential, profitability and production amount, soybean have an overwhelming advantage over other crops as a source for the production of bio-diesel.[4)]

Brazilian diesel consumption for automobile use increased from 18,266 thousand kl in 1990 to 28,599 thousand kl in 2003/04 (Ministerio de Minas e Energia [16]). We estimated projected Brazilian diesel consumption from projected gasoline consumption data. We applied projected gasoline consumption to diesel consumption data, because we could not get projected diesel consumption data in Brazil. Based on these data, we estimated projected Brazilian diesel consumption to be 33,139 thousand tons in 2008/09 and 39,494 thousand tons in 2015/16 (Table 1). Projected Brazilian bio-diesel consumption is 676 thousand tons in 2008/09 and 2,079 thousand tons in 2015/16 (Table 1).

In September 2005, the Ministry of Agriculture, Livestock, and Food Supply gave the following breakdown of bio-diesel production in Brazil: North area 9%; Northeast area 14%; Midwest, South, and Southeast regions 77% (Ministry of Agriculture, Livestock and Food Supply [13]). The Midwest, South, and Southeast are the main soybean production areas. In the 2005 breakdown, the government implied that soybean were the main raw material for bio-diesel production.

In the baseline scenario, castor beans and palm oil are the main raw materials for producing bio-diesel. As alternative scenarios to this study, we assumed that soybean would be the main raw material for bio-diesel production in Brazil. For Scenario 1, we assumed that soybean would be used for 50% of the raw material for bio-diesel production;[13)] the other crops used for bio-diesel production are castor beans, palm oil, sunflower oil, cotton oil, and peanut oil. For Scenario 2, we assumed that soybean would be used for 89.1% of the raw material for bio-diesel production,[14)] with the other crops making up the balance.

In Scenario 1, soybean consumption for bio-diesel use is predicted to grow from 1,579.5 thousand tons in 2008/09 to 4,854.6 thousand tons in 2015/16 (Table 2). Soybean oil consumption for bio-diesel use is predicted to increase from 309.3 thousand tons in 2008/09 to 1,018.3 thousand tons in 2015/16. In Scenario 2, soybean consumption for bio-diesel use is predicted to increase from 2,814.7 thousand tons in 2008/09 to 8,650.9 thousand tons in 2015/16. Soybean oil con-

Table 1. Bio-diesel consumption in Brazil

(Unit: 1,000 kl)

	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16
Diesel consumption for automobile use	28,599	28,599	29,734	30,869	32,004	33,139	34,273	35,408	36,225	37,043	37,860	38,677	39,494
Bio-diesel consumption		—	—	—	—	676	699	723	739	756	1,993	2,036	2,079
Bio-diesel program						←———— B2 Program				————→	←— B5 Program		——→

Note: Estimated from *Brazilian Energy Balance* [16] and *International Energy Outlook* [1].

sumption for bio-diesel use is predicted to rise from 551.1 tons in 2008/09 to 1,814.6 thousand tons in 2015/16.

2) **Impact on world soybean and soybean products markets**

As a result of Scenario 1 (soybeans will comprise 50% of the raw materials used for bio-diesel production), Brazilian soybean oil consumption is predicted to increase by 26.8% in 2015/16 (Table 3). Brazilian soybean oil production is predicted to increase by 1.6% and world soybean oil production is predicted to increase by 0.7% in 2015/16.

Although the higher world soybean oil price will stimulate major soybean oil-exporting countries, such as the US and Argentina, total world soybean oil exports are predicted to decrease by 3.3%, because Brazilian soybean oil exports are predicted to decrease by 23.1% in 2015/16 (Table 3). Chinese soybean oil imports are predicted to decrease by 9.5% and oil imports by the EU25 are predicted to decrease by 10.9% in 2015/16. Japanese oil imports are predicted to decrease by 38.1% in 2015/16. One featur of the Japanese soybean products market is that soybean products are domestically produced by crushing from imported soybean. Soybean product import is very minor in Japan. World soybean oil imports are predicted to decrease by 3.3% in 2015/16. As a result, the world soybean oil price is predicted to increase by 11.2% in 2015/16 (Table 6).

Brazilian soybean crush is predicted to increase by 1.6% in 2015/16 (Table 3). World total crush is predicted to increase by 0.6% in 2015/16. Brazilian soybean meal production is predicted to increase by 1.6% (Table 4). Its exports are predicted to increase by 2.7%, and the meal export of Argentina is predicted to increase by 1.7% in 2015/16. World soybean meal exports are predicted to increase by 1.6% in 2015/16. The lower world soybean meal price will increase imports by major meal-importing countries, including China, whose meal imports are predicted to increase by 11.9%. World meal imports are predicted to increase by 1.6% in 2015/16. As a result, the world soybean meal price is predicted to decrease by 3.3% in 2015/16.

Brazilian soybean consumption is predicted to increase by 1.4% in 2015/16 because of in-

Table 2. Soybean oil consumption for bio-diesel use (Scenario Projection)

	Unit	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16
Soybean oil consumption for bio-diesel use (Scenario 1)	1,000 ton	309.3	323.0	337.0	348.2	359.6	957.1	987.5	1,018.3
Soybean consumption for bio-diesel use (Scenario 1) : (1) = (2) *2.8026	1,000 ton	1,579.5	1,633.6	1,687.7	1,726.6	1,765.6	4,653.7	4,754.2	4,854.6
Soybean area harvested (Scenario 1) : (2) = (3) /0.6	1,000 ha	563.6	582.9	602.2	616.1	630.0	1,660.5	1,696.3	1,732.2
Bio-diesel consumption from soybean (Scenario 1) : (3) = (4) *0.5	1,000 kl	338.1	349.7	361.3	369.6	378.0	996.3	1,017.8	1,039.3
Soybean oil consumption for bio-diesel use (Scenario 2)	1,000 ton	551.1	575.6	600.5	620.5	640.8	1,705.6	1,759.7	1,814.6
Soybean consumption for bio-diesel use (Scenario 2) : (5) = (6) *2.8026	1,000 ton	2,814.7	2,911.0	3,007.4	3,076.8	3,146.2	8,293.0	8,472.0	8,650.9
Soybean area harvested (Scenario 2) : (6) = (7) /0.6	1,000 ha	1,004.3	1,038.7	1,073.1	1,097.9	1,122.6	2,959.0	3,022.9	3,086.8
Bio-diesel consumption from soybean (Scenario 2) : (7) = (4) *0.891	1,000 kl	602.6	623.2	643.9	658.7	673.6	1,775.4	1,813.7	1,852.1
Total bio-diesel consumption : (4)	1,000 kl	676.3	699.5	722.6	739.3	756.0	1,992.6	2,035.6	2,078.6

Note: 1) Estimated from *Brazilian Energy Balance* [16], *International Energy Outlook* [1] and *Biodiesel in Brazil* [13].
2) 2.8026 means soybean yield (t/ha) and 0.6 means bio-diesel extraction ratio from soybean (kl/ha) (*Biodiesel in Brazil* [13]).

Table 3. Impacts on world soybean oil markets (2015/16, Scenario 1/Baseline)

	World total	Brazil	USA	China	Argentina	Japan	EU25	Rest of the world
Consumption	0.7%	26.8%	−1.5%	−2.2%	−1.1%	−1.4%	−2.2%	−1.3%
Crush	0.6%	1.6%	0.7%	0.1%	1.7%	1.5%	1.6%	0.1%
Production	0.7%	1.6%	0.7%	0.1%	1.7%	1.5%	1.6%	0.1%
Export	−3.3%	−23.1%	13.9%	3.6%	1.9%	—	3.0%	1.5%
Import	−3.3%	−0.3%	−3.2%	−9.5%	—	−38.1%	−10.9%	−1.4%

creasing soybean oil consumption for bio-diesel use (Table 5). Brazilian soybean production is predicted to increase by 0.4% in 2015/16. World total soybean exports are predicted to decrease by 0.6% (Table 5). Chinese soybean imports are predicted to decrease by 0.9% in 2015/16. Japanese soybean imports are predicted to increase by 0.7% in 2015/16, because Japan will prefer soybean rather than relatively higher soybean oil. Global soybean imports are predicted to decrease by 0.6% in 2015/16. As a result, the world soybean price is predicted to increase by 9.0% in 2015/16 (Table 6).

As a result of Scenario 2 (soybeans will comprise 89.1% of the raw materials used for bio-diesel production), Brazilian soybean oil consumption is predicted to increase by 47.7% in 2015/16 (Table 7). Brazilian soybean oil production is predicted to increase by 2.8% in 2015/16. Although the higher world soybean oil price will stimulate the exports of major soybean oil-exporting countries, total world soybean oil exports are predicted to decrease by 5.9%, because Brazilian soybean oil exports are predicted to decrease by 41.1% in 2015/16 (Table 7). Chinese soybean oil imports are predicted to decrease by 16.8% and the oil imports of the EU 25 are predicted to decrease by 19.4% in 2015/16. Japanese soybean oil imports are predicted to decrease by 68.1% in 2015/16. Soybean products import is very minor in Japan. World soybean oil imports are predicted to decrease by 5.9% in 2015/16. As a result, the world soybean oil price is predicted to increase by 20.9% in 2015/16 (Table 10).

Brazilian soybean crush is predicted to increase by 2.8% in 2015/16 and the crush of other countries is predicted to increase (Table 7). Total world crush is predicted to increase by 1.1% in 2015/16. Brazilian soybean meal production is predicted to increase by 2.8% (Table 8). Its exports are predicted to increase by 4.9%, and meal exports from Argentina are predicted to increase by 3.0% in 2015/16. World soybean meal exports are predicted to increase by 2.9% in 2015/16. The lower world soybean meal price will increase imports by major meal-importing countries,

Table 4. Impacts on world soybean meal markets (2015/16, Scenario 1/Baseline)

	World total	Brazil	USA	China	Argentina	Japan	EU25	Rest of the world
Consumption	0.6%	0.3%	0.4%	0.5%	0.9%	1.1%	0.7%	0.9%
Production	0.6%	1.6%	0.7%	0.1%	1.7%	1.5%	1.6%	0.1%
Export	1.6%	2.7%	1.6%	−0.4%	1.7%	—	−0.6%	−0.7%
Import	1.6%	0.1%	0.4%	11.9%	—	0.3%	0.2%	1.7%

Table 5. Impacts on world soybean markets (2015/16, Scenario 1/Baseline)

	World total	Brazil	USA	China	Argentina	Japan	EU25	Rest of the world
Consumption	0.4%	1.4%	0.5%	0.1%	1.5%	0.8%	1.3%	0.1%
Production	0.4%	0.4%	0.1%	0.5%	0.5%	0.5%	0.6%	0.3%
Export	−0.6%	−0.1%	−0.9%	0.7%	−3.1%	—	3.7%	0.7%
Import	−0.6%	−1.2%	−0.2%	−0.9%	−0.2%	0.7%	1.2%	−1.6%

Table 6. Impacts on world soybean products price (2015/16)

	Scenario 1/Baseline
World soybean oil price (Crude Decatur)	11.2%
World soybean meal price (48% Protein Decatur)	−3.3%
World soybean price (No. 1 Yellow, Illinois processor)	9.0%

Note: Each percetage means (Scenario 1 (2015/16)/Baseline (2015/16) −1)*100.

of which China is predicted to increase its meal imports by 21.5%. World meal imports are predicted to increase by 2.9% in 2015/16. As a result, the world soybean meal price is predicted to decrease by 5.9% in 2015/16 (Table 10).

Brazilian soybean consumption is predicted to increase by 2.4% in 2015/16 because of increasing soybean oil consumption for bio-diesel use (Table 9), while Brazilian soybean production is predicted to increase by 0.7% in 2015/16. World soybean exports are predicted to decrease by 1.1% (Table 9). Chinese soybean imports are predicted to decrease by 1.6%. Japanese soybean imports are predicted to increase by 1.2%, because Japan will prefer soybean rather than relatively higher soybean oil. World soybean imports are predicted to decrease by 1.1% in 2015/16. As a result, the world soybean price is predicted to increase by 16.9% in 2015/16 (Table 10).

5. Conclusion

The Brazilian Government will promote a bio-diesel program to develop low-income regions from 2008. The government will start its B2 program from 2008 and its B5 program from 2013. The government has approved the use of castor beans, palm oil, sunflowers, cotton, peanuts, and soybean as the raw ma-

Table 7. Impacts on world soybean oil markets (2015/16, Scenario 2/Baseline)

	World total	Brazil	USA	China	Argentina	Japan	EU25	Rest of the world
Consumption	1.3%	47.7%	−2.7%	−4.0%	−2.0%	−2.5%	−3.8%	−2.3%
Crush	1.1%	2.8%	1.2%	0.1%	3.0%	2.7%	2.9%	0.1%
Production	1.3%	2.8%	1.2%	0.1%	3.0%	2.7%	2.9%	0.1%
Export	−5.9%	−41.1%	24.7%	6.6%	3.5%	—	5.5%	2.6%
Import	−5.9%	−0.5%	−5.8%	−16.8%	—	−68.1%	−19.4%	−2.5%

Table 8. Impacts on world soybean meal markets (2015/16, Scenario 2/Baseline)

	World total	Brazil	USA	China	Argentina	Japan	EU25	Rest of the world
Consumption	1.1%	0.6%	0.6%	0.9%	1.6%	1.9%	1.3%	1.6%
Production	1.1%	2.8%	1.2%	0.2%	3.0%	2.7%	2.9%	0.1%
Export	2.9%	4.9%	2.8%	−0.6%	3.0%	—	−1.0%	−1.2%
Import	2.9%	0.1%	0.7%	21.5%	—	0.6%	0.4%	3.0%

Table 9. Impacts on world soybean markets (2015/16, Scenario 2/Baseline)

	World total	Brazil	USA	China	Argentina	Japan	EU25	Rest of the world
Consumption	0.7%	2.4%	0.9%	0.1%	2.8%	1.4%	2.3%	0.1%
Production	0.7%	0.7%	0.2%	0.9%	1.0%	0.9%	1.0%	0.6%
Export	−1.1%	−0.2%	−1.7%	1.4%	−5.6%	—	6.7%	1.4%
Import	−1.1%	−2.2%	−0.3%	−1.6%	−0.3%	1.2%	2.2%	−2.9%

Table 10. Impacts on world soybean products price (2015/16)

	Scenario 2/Baseline
World soybean oil price (Crude Decatur)	20.9%
World soybean meal price (48% Protein Decatur)	−5.9%
World soybean price (No. 1 Yellow, Illinois processor)	16.9%

Note: Each percetage means (Scenario 2(2016/15)/Baseline(2016/15) −1)*100.

terials for bio-diesel production. Taking into account the production costs, production potential, profitability and production amount, they clearly have an advantage over other crops as a source for the production of bio-diesel.

In this study, we hypothesized that the expansion of soybean production for the Brazilian bio-diesel program would impact not only the domestic soybean and soybean products markets but also world soybean and soybean products markets. As a result of expanded soybean use for the bio-diesel program from 2008, world soybean and soybean oil prices and the soybean oil trade are predicted to increase. Our estimate shows that the magnitude of world soybean and soybean oil price hikes will persist for years. On the other hand, higher soybean oil prices stimulate soybean crushing volume in major crushing countries and regions. As a result of increasing crushing volume, world meal production and exports are predicted to increase, and world soybean meal prices are predicted to decrease. The price diversification between soybean products is very interesting, and is the result of the diverse characteristics between soybean crush and soybean products.

As a result of our analysis using the econometric model, we concluded that the program is predicted to impact not only domestic soybean and soybean products but also world soybean and soybean products markets. This means soybean and soybean oil consumption for bio-diesel are competing with soybean and soybean oil consumption for food. In world soybean and soybean products markets, Chinese soybean oil and meal consumption have been expanding since the 1990s because of high economic growth. The increasing of Brazilian soybean production has contributed to meet the increasing soybean demand of China. The expansion of soybean use for the Brazilian bio-diesel program will result in decreasing exports and increasing world soybean price, which will impact the Chinese soybean market.

Although Brazilian soybean crushers and soybean growers are expected to receive material benefit from this program, it can impact soybean and soybean oil-importing countries' food security situation and food availability. Although the share of Japanese soybean imports from Brazil is relatively small (9.4%) (Ministry of Agriculture, Forestry and Fisheries of Japan [14]), imported soybean account for more than 90% of Japan's consumption of soybean (Ministry of Agriculture, Forestry and Fisheries of Japan [15]). This program will have an impact on Japanese soybean and soybean products markets to some extent. On the other hand, decreasing the soybean meal price will contribute to reducing feed cost for livestock sectors. It is expected that this reduction will be beneficial for livestock markets and increase livestock production.

It is assumed that Brazilian bio-diesel production will be concentrated on the Center and West regions, not the Northeast region. This program will benefit large agribusinesses in the Center and West region, but not small farmers in the Northeast region as a result of the expansion of soybean production for the Brazilian bio-diesel program. This is also different from the initial purpose of Brazil's bio-diesel program.

Because of its growing conditions, it is difficult to expand palm oil production beyond Para State. The expansion of palm oil in Para State can damage for tropical rain forests in the Amazon region. The extraction cost of glycerin is much higher than for other raw materials, because castor bean oil has strong viscosity. For this technical reason, the government of India recently suspended bio-diesel production from castor beans. As a result of these problems, it is estimated that bio-diesel production from castor beans and palm oil will have limitations to its expansion in future.

In light of these points, international technical and financial cooperation should be promoted to increase bio-diesel production, not from soybean but from *Jatropha curcus*.[15] The Brazilian research institutes are seeking means to develop bio-diesel production from *Jatropha curcas*. It can be produced in dry areas not only in the Northeast region but also other regions.

Increasing the use of *Jatropha curcas* for bio-diesel production will decrease the ratio of soybean used for bio-diesel production in Brazil. Technical and financial cooperation to increase *Jatropha curcas*-based bio-diesel production is crucial in addressing the needs of world soybean and soybean oil markets. The future direction of this study is how bio-diesel production from *Jatropha curcas* can contribute to development of the Northeast regions.

1) Bio-diesel is an alternative diesel oil, produced mainly from vegetable oils. It can contribute not only to a decrease in CO_2 levels and fossil-fuel dependency, but it can also diminish environmental problems. Bio-diesel is widely used in the EU, Malaysia, Indonesia, the US, and other countries and regions.
2) PROALCOOL is a national bio-ethanol program. This program was promoted to enhance the production of sugar cane-based bio-ethanol between 1975 and 1990. This program contributed to the expansion of Brazil's bio-fuel industry and markets.
3) The Brazilian government is also researching bio-diesel production from animal fat.
4) For further information concerning Brazil's bio-diesel program, please refer to Koizumi [8].
5) The coefficient of calibration obtained to correct each market activity of the first projection year (2007/08) is equivalent to updated estimated data (2007/08) published by USDA-FAS [4].
6) This model is a policy simulation model, reflecting time-series price changes. In building this model, we applied lagged variables. The main advantage of applying them is to prevent spurious regression, eliminating a trend.
7) Soybean can be used for breeding chickens and other birds. The amount of its consumption is very minor.
8) Seed use and waste are included in feed consumptions.
9) The world crude oil price is a crucial factor in the production cost of operating soybean-crushing facilities.
10) Please refer to Appendix 2, Table A2-1.
11) The purpose of this study is evaluating the impact the Brazilian bio-diesel program would have on domestic soybean and soybean products markets. To clarify the difference between using bio-diesel production from soybean and without soybean, we set soybean not to be used for bio-diesel production as a raw material in the baseline projection.
12) FAPRI [2] projected U. S. and World Agricultural Outlook. It covers world soybean and soybean products market. In FAPRI's baseline projection, world soybean production and consumption are predicted to increase by 1. 9% per annum from 2006/07 to 2016/17 and world soybean trade is predicted to increase by 2. 6% per annum during this period. World soybean crush is predicted to increase by 2. 1% per annum during this period. World soybean oil production and consumption are predicted to increase by 2. 3% per annum and world soybean oil trade is predicted to increase by 3. 3% per annum during this period. World soybean meal production and consumption are predicted to increase by 2. 1% per annum and world soybean meal trade is predicted to increase by 2. 3% per annum during this period. Because, FAPRI didn't publish model structures or parameters, it is difficult to compare the model from FAPRI and this model. When the projection results are compared, there are no great differences between them.
13) Interviewed from the Ministry of Agriculture, Livestock, and Food Supply of Brazil, November 2005 and June 2007.
14) In September 2005, the Ministry of Agriculture, Livestock, and Food Supply provided a breakdown of bio-diesel production as follows: North area 9%, Northeast area 14%; Midwest, South, and Southeast regions 77%. In the North area, soybeans account for 42. 8% of total crop production for bio-diesel (castor beans, palm oil, sunflowers, cotton, peanuts, and soybean) production. In the Northeast area, soybeans account for 81. 3% of total crop production; in the Midwest, South and Southeastregions, soybean account for 96% of total crop production. The use ratio for bio-diesel production, 89. 1%, is estimated from these regions' soybean production ratio (IBGE[7]): 3. 9% from North area, 11. 3% from Northeast area, and 73. 9% from the Midwest, South and Southeast regions. This information is derived from interviews with the Ministry of Agriculture, Livestock, and Food Supply of Brazil in November 2005 and June 2007.
15) *Jatropha curcas* belongs to the *Euphobiacae* family and is an important plant used for the production of oil, which is not suitable for food use. It is resistant to drought, can produce two years after planting, and has a production life of up to 50 years.

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Appendix 1.

Table A1. Estimated parameters

Coefficient	Dependent variables	Explanatory variables	Brazil	USA	Argentina	China	Japan	EU25	Rest of the world
a1	Soybean area harvested	Growth ratio	0.0350	−0.0030	0.0180	0.0050	−0.0001	0.0130	0.0150
a2		Domestic price of soybean	0.3061〈*〉	0.1348〈 〉	0.1360〈 〉	0.1543〈 〉	0.1325〈 〉	0.1420〈 〉	0.1854〈 〉
a3		Domestic price of corn	−0.1003〈 〉	−0.0842〈 〉	−0.1429〈 〉	−0.1267〈 〉	—	—	0.1257〈 〉
a4		Domestic price of rice	0.2825〈*〉	—	—	—	—	—	—
a5	Soybean yield	Growth ratio	0.0310〈***〉	0.0128〈***〉	0.0276〈***〉	0.0191〈***〉	0.0165〈***〉	−0.0141〈**〉	0.0191〈***〉
a6	Per capita soybean consumption for food	Growth ratio	—	—	—	0.0150	0.0100	0.0100	0.0015
a7		Domestic price of corn	—	—	—	−0.0589〈 〉	−0.5473〈 〉	−0.1363〈 〉	−0.0586〈 〉
a8		Per capita income	—	—	—	0.5054〈 〉	0.1855〈*〉	0.0269〈*〉	0.1305〈*〉
a9	Soybean consumption for feed	Growth ratio	0.0100	0.0010	0.0010	0.0100	0.0100	0.0100	0.0001
a10		Domestic price of soybean	−0.1173〈**〉	−0.1830〈 〉	−0.1008〈*〉	−0.0253〈 〉	−0.2523〈 〉	−0.2717〈 〉	−0.0589〈 〉
a11		Domestic price of corn	—	0.0388〈 〉	0.0457〈 〉	—	—	—	—
a12		Domestic broiler production	0.0188〈 〉	0.0115〈 〉	—	0.0447〈 〉	0.0132〈 〉	0.0270〈 〉	—
a13	Soybean export	Growth ratio	—	—	—	0.0100	—	−0.0001	0.0001
a14		World soybean price	—	—	—	0.0857〈 〉	—	0.3397〈 〉	0.0857〈 〉
a15	Soybean import	Growth ratio	0.0100	0.0100	0.0001	—	—	—	—
a16		World soybean price	−0.1448〈 〉	−0.0215〈*〉	−0.0223〈 〉	—	—	—	—
a17	Soybean ending stocks	Growth ratio	0.0100	0.0100	0.0100	0.0100	0.0100	0.0010	0.0001
a18		Domestic soybean production	−0.1482〈***〉	0.4831〈 〉	−0.0316〈***〉	—	—	—	—
a19		Domestic soybean consumption	—	—	—	0.0165〈 〉	0.5445〈 〉	0.2213〈 〉	0.0652〈 〉
a20		Domestic soybean price	—	−0.4414〈*〉	0.2448〈*〉	−0.2498〈 〉	−0.2747〈 〉	−0.3286〈 〉	−0.4984〈*〉
a21	Soybean crush	Growth ratio	0.0150	0.0150	0.0180	0.0395	0.0010	0.0010	0.0150
a22		Domestic soybean price	−0.1126〈 〉	−0.1314〈 〉	−0.3711〈 〉	−0.2439〈 〉	−0.1365〈 〉	−0.1275〈 〉	−0.1462〈 〉
a23		Domestic soybean oil price	0.3706〈 〉	0.2393〈 〉	0.0657〈 〉	0.1017〈 〉	0.3115〈 〉	0.3268〈 〉	0.0818〈 〉
a24		Domestic soybean meal price	0.2858〈*〉	0.2133〈 〉	0.2815〈 〉	0.0338〈 〉	0.1875〈 〉	0.2190〈 〉	0.0539〈 〉
a25		World crude oil price	—	−0.0075〈 〉	—	—	—	—	—
a26	Soybean oil extraction ratio		0.0162〈***〉	0.0017〈***〉	0.0051〈***〉	0.0253〈***〉	0.0017〈***〉	−0.0007〈*〉	0.0025〈***〉
a27	Per capita soybean oil consumption for food	Growth ratio	−0.0100	−0.0130	0.0210	0.0180	0.0120	0.0150	0.0200
a28		Domestic soybean oil price	−0.1659〈 〉	−0.1457〈**〉	−0.1645〈*〉	−0.2139〈 〉	−0.1349〈 〉	−0.1446〈**〉	−0.1214〈*〉
a29		Domestic rapeseed price	0.1139〈 〉	0.0599〈 〉	0.1261〈***〉	0.1719〈 〉	0.0616〈 〉	0.2162〈*〉	0.1186〈***〉
a30		Domestic peanut oil price	0.1525〈*〉	0.0937〈**〉	—	—	—	—	—
a31		Per capita income	0.4177〈 〉	0.3598〈 〉	—	0.1566〈 〉	0.1354〈*〉	0.0320〈 〉	0.1566〈 〉
a32	Soybean oil consumption for industry	Growth ratio	—	—	0.0185	—	0.0010	—	0.0001
a33		Domestic soybean oil price	—	—	−0.1788〈 〉	—	−0.1227〈 〉	—	−0.1227〈 〉
a34	Soybean oil export	Growth ratio	—	—	—	0.0100	—	0.0010	0.0001
a35		World soybean oil price	—	—	—	0.3378〈 〉	—	0.2831〈 〉	0.1378〈 〉
a36	Soybean oil import	Growth ratio	0.0100	0.0100	—	—	—	—	—
a37		World soybean oil price	−0.0285〈 〉	−0.3786〈 〉	—	—	—	—	—
a38	Soybean oil ending stocks	Growth ratio	0.0100	0.0100	0.0010	0.0100	0.0010	0.0010	0.0001
a39		Soybean oil production	—	0.3715〈 〉	0.5605〈 〉	—	—	—	—
a40		Soybean oil consumption	—	—	—	0.2124〈 〉	0.5445〈 〉	0.1280〈 〉	0.4124〈 〉
a41		Domestic soybean price	−0.2263〈 〉	−0.2946〈 〉	−0.1402〈 〉	−0.2941〈 〉	−0.2747〈 〉	−0.2140〈*〉	−0.2941〈 〉
a42	Soybean meal extraction ratio		−0.0016〈***〉	−0.0004〈**〉	−0.0024〈***〉	−0.0022〈***〉	0.0008〈***〉	−0.0012〈**〉	−0.0022〈***〉
a43	Soybean meal consumption for feed	Growth ratio	0.0100	0.0120	0.0190	0.0190	0.0100	0.0150	0.0110
a44		Domestic soybean meal price	−0.1187〈 〉	−0.1051〈 〉	−0.2611〈 〉	−0.1585〈 〉	−0.1328〈 〉	−0.1106〈 〉	−0.2585〈 〉
a45		Domestic corn price	0.0636〈 〉	0.0106〈 〉	0.0887〈***〉	0.1723〈 〉	0.1045〈 〉	—	0.1723〈 〉
a46		Domestic broiler production	0.5499〈 〉	0.4152〈**〉	0.8178〈*〉	0.1378〈 〉	0.0741〈 〉	0.0430〈 〉	0.3780〈 〉
a47		Domestic pork production	—	—	—	0.1300〈 〉	—	—	0.3001〈 〉
a48		Per capita income	0.4057〈 〉	0.0293〈 〉	—	0.1241〈 〉	0.0086〈 〉	0.0410〈 〉	0.2411〈 〉
a49	Soybean meal consumption for industry	Growth ratio	—	—	—	0.0001	0.0130	0.0010	0.0001
a50		Domestic soybean meal price	—	—	—	−0.1490〈***〉	−0.1279〈 〉	−0.1151〈 〉	−0.1496〈 〉
a51	Per capita soybean meal consumption for food	Growth ratio	—	—	—	—	0.0130	—	0.0001
a52		Domestic soybean meal price	—	—	—	—	−0.2473〈 〉	—	−0.1279〈 〉
a53	Soybean meal export	Growth ratio	—	—	—	0.0010	—	0.0010	0.0100
a54		World soybean meal price	—	—	—	0.1041〈 〉	—	0.3678〈 〉	0.2041〈 〉
a55	Soybean meal import	Growth ratio	0.0100	0.0100	—	—	—	—	—
a56		World soybean meal price	−0.0310〈*〉	−0.1174〈 〉	—	—	—	—	—
a57	Soybean meal ending stocks	Growth ratio	0.0220	−0.0010	0.0200	—	−0.0010	−0.0010	0.0001
a58		Soybean meal production	0.1463〈*〉	0.2487〈 〉	0.2435〈 〉	—	—	—	—
a59		Soybean meal consumption	—	—	—	—	0.0753〈 〉	—	0.0753〈 〉
a60		Domestic soybean meal price	−0.1252〈 〉	−0.2966〈 〉	−0.1733〈 〉	—	−0.1884〈 〉	−0.3023〈 〉	−0.1884〈 〉
a61	Domestic price transmission elasticity	World soybean price	0.8196〈**〉	—	—	—	—	—	—
a62		World soybean oil price	0.7916〈**〉	—	—	—	—	—	—
a63		World soybean meal price	0.7918〈*〉	—	—	—	—	—	—
TSS	Import soybean price	Ad valorem tariff ratio	0.0000	0.0000	0.0000	0.0300	0.0000	0.0000	—
TSO	Import soybean oil price	Ad valorem tariff ratio	0.1000	0.0190	0.1000	0.0900	0.0920	0.0450	—
TSM	Import soybean meal price	Ad valorem tariff ratio	0.1000	0.1910	0.1000	0.0900	0.0420	0.0640	—

Note: 1) "—" means doesn't apply to the country or region.
2) 〈 〉 means level of significance. ***means 1%, **means 5% and *means 1%. It doesn't apply to the growth ratio (coefficient of calibration).
3) Sign conditions of each parameter are reasonable.
4) As for Japanese soybean oil tariff ratio, it is equivalent to ad valorem.

Appendix 2. Baseline Projection

Table A2-1. Exogenous variables

	Unit	Source	2006/07	2015/16 (Projection)
World crude oil price	US$/barrel	High oil price, U.S. Department of Energy, Annual Energy Outlook 2007 (2007)	51.9	72.6
Domestic corn price, Brazil	2006/07=1	OECD-FAO (2007)	1.0	1.5
Domestic rice price, Brazil	2006/07=1	OECD-FAO (2007)	1.9	2.6
Rapeseed price	US$/MT	FAPRI (2007)	832.0	851.0
Peanut oil price	US$/MT	FAPRI (2007)	1,059.0	1,190.0
Broiler production, Brazil	Thousand metric tons	FAPRI (2007)	9,280.0	11,073.0
Domestic corn price, USA	US$/ton	No. 2 Yelow Corn, US f.o.b. Gulf port	140.4	139.5
Broiler production, USA	Million lbs	USDA (2007)	35,462.0	38,960.0
Broiler production, Argentina	Thousand metric tons	FAPRI (2007)	1,210.0	1,541.0
Broiler production, China	Thousand metric tons	FAPRI (2007)	10,350.0	13,180.0
Pork production, China	Thousand metric tons	FAPRI (2007)	5,300.0	62,651.0
Broiler production, Japan	Thousand metric tons	FAPRI (2007)	1,195.0	1,061.0
Broiler production, EU25	Thousand metric tons	FAPRI (2007)	7,245.0	8,018.0
Per capita income, Brazil	2006/07=1.0	OECD (2007)	1.0	1.4
Per capita income, USA	2006/07=1.0	USDA (2007)	1.0	1.3
Per capita income, Argentina	2006/07=1.0	OECD (2007)	1.0	1.4
Per capita income, China	2006/07=1.0	OECD (2007)	1.0	2.0
Per capita income, Japan	2006/07=1.0	OECD (2007)	1.0	1.1
Per capita income, EU25	2006/07=1.0	USDA (2007)	1.0	1.2

Note: Per capita income means per capita real GDP.

Table A2-2. Projected soybean and soybean products prices

	Unit	Source	2006/07	2015/16 (Projection)
World soybean price	US$/Bushel	No. 1 Yellow, Illinois processor	6.1	6.7
World soybean oil price	US cents/lb	Crude Decatur	27.2	33.8
World soybean meal price	US$/ton	48% Protein Decatur	189.6	228.9
Domestic soybean price, Brazil	R$/ton, Deflated	CONAB/GEPAV/GEAME, FNP (2006)	582.6	635.6
Domestic soybean oil price, Brazil	R$/ton, Deflated	CONAB/GEPAV/GEAME, FNP (2006)	1,644.5	1,956.5
Domestic soybean meal price, Brazil	R$/ton, Deflated	CONAB/GEPAV/GEAME, FNP (2006)	486.2	570.3

Table A2-3. Soybean production

(thousand metric tons)

	2000/01	2006/07	2011/12	2015/16	Growth rate (2006/07-2015/16)
World	175, 771. 0	227, 096. 7	255, 222. 5	280, 733. 2	2. 2%
Brazil	39, 500. 0	59, 000. 0	76, 872. 4	91, 833. 8	4. 5%
USA	75, 055. 0	81, 615. 0	82, 109. 6	82, 148. 5	0. 1%
China	15, 400. 0	16, 050. 0	17, 306. 9	18, 384. 0	1. 4%
Argentina	27, 800. 0	44, 666. 7	51, 217. 1	58, 206. 3	2. 7%
Japan	235. 0	225. 3	238. 1	245. 0	0. 8%
EU25	1, 258. 0	1, 155. 0	1, 240. 8	1, 289. 3	1. 1%

Source: USDA-FAS[4], PS & D (2000/01, 2006/07), Authors' projections (2011/12, 2015/16).
Note: 1) However, we projected annual projection from 2006/07-2015/16, we show mid-term and final terms' projection briefly in this study.
2) As for Table A2-4, A2-5 and A2-6, sources and note are the same as this table.

Table A2-4. Soybean import

(thousand metric tons)

	2000/01	2006/07	2011/12	2015/16	Growth rate (2006/07-2015/16)
World	53, 152. 0	69, 463. 3	81, 242. 5	90, 199. 1	2. 6%
Brazil	733. 0	64. 7	67. 4	69. 9	0. 8%
USA	97. 0	103. 3	108. 5	112. 8	0. 9%
China	13, 245. 0	30, 939. 0	39, 994. 3	48, 090. 2	4. 5%
Argentina	420. 0	928. 0	916. 9	916. 7	−0. 1%
Japan	4, 767. 0	4, 069. 0	4, 307. 5	4, 477. 1	1. 0%
EU25	17, 602. 0	14, 652. 0	15, 493. 9	16, 080. 8	0. 9%

Table A2-5. Soybean export

(thousand metric tons)

	2000/01	2006/07	2011/12	2015/16	Growth rate (2006/07-2015/16)
World	53, 866. 0	69, 941. 3	81, 242. 6	90, 199. 3	2. 6%
Brazil	15, 469. 0	26, 866. 3	40, 873. 1	52, 671. 6	7. 0%
USA	27, 103. 0	28, 188. 0	23, 026. 7	18, 128. 4	−4. 3%
China	208. 0	398. 0	420. 3	438. 4	1. 0%
Argentina	7, 414. 0	7, 783. 0	10, 179. 5	12, 198. 3	4. 6%
Japan	0. 0	0. 0	0. 0	0. 0	—
EU25	22. 0	46. 3	48. 3	49. 4	0. 6%

Table A2-6. Soybean consumption

(thousand metric tons)

	2000/01	2006/07	2011/12	2015/16	Growth rate (2006/07-2015/16)
World	171, 764. 0	225, 241. 7	254, 561. 4	280, 044. 6	2. 2%
Brazil	24, 734. 0	31, 906. 7	35, 923. 4	39, 089. 5	2. 1%
USA	49, 203. 0	52, 949. 3	59, 059. 9	64, 002. 2	1. 9%
China	26, 697. 0	47, 130. 0	56, 857. 0	66, 013. 1	3. 4%
Argentina	18, 336. 0	36, 295. 0	41, 594. 9	46, 532. 8	2. 5%
Japan	5, 075. 0	4, 275. 0	4, 541. 7	4, 717. 9	1. 0%
EU25	18, 546. 0	15, 716. 7	16, 685. 3	17, 319. 9	1. 0%

Table A2-7. Soybean crush

(thousand metric tons)

	2000/01	2006/07	2011/12	2015/16	Growth rate (2006/07-2015/16)
World	146, 623. 0	194, 290. 3	221, 366. 0	244, 913. 6	2. 3%
Brazil	22, 742. 0	28, 961. 7	32, 861. 1	35, 928. 0	2. 2%
USA	44, 625. 0	48, 069. 3	54, 198. 1	59, 151. 5	2. 1%
China	18, 900. 0	36, 966. 7	45, 190. 1	53, 019. 0	3. 7%
Argentina	17, 300. 0	34, 762. 0	40, 072. 7	45, 019. 7	2. 6%
Japan	3, 775. 0	2, 890. 0	3, 056. 9	3, 163. 6	0. 9%
EU25	16, 728. 0	14, 254. 7	15, 166. 9	15, 749. 3	1. 0%

Source: USDA-FAS[4], PS & D (2000/01, 2006/07), Authors' projections (2011/12, 2015/16).
Note: 1) However, we projected annual projection from 2006/07-2015/16, we show mid-term and final terms' projection briefly in this study.
2) As for Table A2-8, A2-9 and A2-10, sources and note are the same as this table.

Table A2-8. Soybean oil production

(thousand metric tons)

	2000/01	2006/07	2011/12	2015/16	Growth rate (2006/07-2015/16)
World	26, 762. 0	35, 971. 7	40, 559. 0	44, 523. 3	2. 2%
Brazil	4, 333. 0	5, 560. 0	6, 626. 8	7, 536. 2	3. 1%
USA	8, 355. 0	9, 184. 3	9, 931. 7	10, 481. 7	1. 3%
China	3, 240. 0	6, 605. 7	7, 776. 1	8, 852. 7	3. 0%
Argentina	3, 240. 0	6, 466. 7	7, 651. 2	8, 774. 6	3. 1%
Japan	675. 0	527. 7	562. 5	585. 8	1. 1%
EU25	2, 984. 0	2, 548. 0	2, 699. 7	2, 794. 0	0. 9%

Table A2-9. Soybean oil import

(thousand metric tons)

	2000/01	2006/07	2011/12	2015/16	Growth rate (2006/07-2015/16)
World	6, 996. 0	9, 648. 0	12, 549. 8	14, 720. 1	4. 3%
Brazil	69. 0	14. 0	14. 7	15. 2	0. 8%
USA	33. 0	15. 0	15. 4	15. 9	0. 6%
China	355. 0	1, 688. 7	1, 879. 0	2, 013. 1	1. 8%
Argentina	0. 0	0. 0	0. 0	0. 0	—
Japan	3. 0	61. 7	49. 9	46. 5	−2. 8%
EU25	29. 0	895. 3	962. 0	1, 048. 7	1. 6%

Table A2-10. Soybean oil export

(thousand metric tons)

	2000/01	2006/07	2011/12	2015/16	Growth rate (2006/07-2015/16)
World	7, 179. 0	10, 081. 0	12, 550. 0	14, 720. 3	3. 9%
Brazil	1, 533. 0	2, 327. 0	3, 106. 2	3, 816. 0	5. 1%
USA	636. 0	605. 3	1, 155. 6	1, 531. 9	9. 7%
China	53. 0	90. 0	98. 5	105. 0	1. 6%
Argentina	3, 215. 0	5, 935. 3	7, 041. 1	8, 103. 5	3. 2%
Japan	0. 0	0. 0	0. 0	0. 0	—
EU25	889. 0	256. 7	266. 9	273. 4	0. 6%

Table A2-11. Soybean oil consumption

(thousand metric tons)

	2000/01	2006/07	2011/12	2015/16	Growth rate (2006/07-2015/16)
World	26, 396. 0	36, 117. 7	40, 521. 7	44, 497. 0	2. 2%
Brazil	2, 952. 0	3, 298. 0	3, 532. 2	3, 733. 5	1. 2%
USA	7, 401. 0	8, 520. 7	8, 772. 9	8, 953. 8	0. 5%
China	3, 542. 0	8, 213. 3	9, 553. 3	10, 758. 5	2. 7%
Argentina	247. 0	536. 7	604. 2	664. 4	2. 2%
Japan	700. 0	586. 0	612. 4	632. 4	0. 8%
EU25	2, 137. 0	3, 187. 0	3, 394. 7	3, 570. 0	1. 1%

Source: FAS, USDA, PS & D (2000/01, 2006/07), Authors' projections (2011/12, 2015/16).
Note: 1) However, we projected annual projection from 2006/07-2015/16, we show mid-term and final terms' projection briefly in this study.
2) As for Table A2-12, A2-13 and A2-14, sources and note are the same as this table.

Table A2-12. Soybean meal production

(thousand metric tons)

	2000/01	2006/07	2011/12	2015/16	Growth rate (2006/07-2015/16)
World	116, 166. 0	152, 973. 0	172, 989. 6	190, 037. 4	2. 2%
Brazil	17, 725. 0	22, 425. 7	25, 379. 5	27, 677. 4	2. 1%
USA	35, 730. 0	38, 025. 3	43, 013. 5	47, 067. 7	2. 2%
China	15, 050. 0	29, 273. 7	33, 654. 1	37, 593. 0	2. 5%
Argentina	13, 718. 0	27, 296. 7	31, 240. 8	34, 895. 8	2. 5%
Japan	2, 927. 0	2, 249. 7	2, 401. 3	2, 503. 2	1. 1%
EU25	13, 175. 0	11, 219. 7	11, 929. 1	12, 381. 4	1. 0%

Table A2-13. Soybean meal import

(thousand metric tons)

	2000/01	2006/07	2011/12	2015/16	Growth rate (2006/07-2015/16)
World	36, 058. 0	52, 515. 7	61, 801. 7	68, 073. 8	2. 6%
Brazil	184. 0	215. 0	225. 3	234. 1	0. 9%
USA	46. 0	142. 7	148. 0	152. 8	0. 7%
China	100. 0	562. 3	2, 292. 5	3, 411. 7	19. 8%
Argentina	0. 0	0. 0	0. 0	0. 0	—
Japan	611. 0	1, 625. 3	1, 534. 6	1, 499. 1	−0. 8%
EU25	17, 712. 0	22, 894. 7	24, 043. 8	25, 320. 5	1. 0%

Table A2-14. Soybean meal export

(thousand metric tons)

	2000/01	2006/07	2011/12	2015/16	Growth rate (2006/07-2015/16)
World	36, 549. 0	53, 375. 0	61, 801. 8	68, 074. 0	2. 6%
Brazil	10, 673. 0	12, 401. 3	13, 534. 4	14, 112. 4	1. 3%
USA	7, 335. 0	7, 503. 7	10, 392. 3	12, 183. 5	5. 0%
China	155. 0	452. 3	459. 9	464. 9	0. 3%
Argentina	14, 043. 0	26, 546. 3	30, 488. 3	34, 034. 0	2. 5%
Japan	0. 0	0. 0	0. 0	0. 0	—
EU25	253. 0	632. 7	647. 9	657. 7	0. 4%

Table A2-15. Soybean meal consumption

(thousand metric tons)

	2000/01	2006/07	2011/12	2015/16	Growth rate (2006/07-2015/16)
World	116, 169. 0	153, 144. 3	172, 942. 1	189, 970. 5	2. 2%
Brazil	7, 063. 0	10, 225. 0	12, 033. 9	13, 763. 5	3. 0%
USA	28, 359. 0	30, 625. 7	32, 770. 7	35, 037. 0	1. 4%
China	14, 995. 0	29, 383. 7	35, 486. 6	40, 539. 7	3. 3%
Argentina	325. 0	599. 0	724. 2	825. 1	3. 3%
Japan	3, 559. 0	3, 886. 3	3, 937. 2	4, 002. 9	0. 3%
EU25	30, 711. 0	33, 474. 7	35, 334. 5	37, 048. 6	1. 0%

Source: FAS, USDA, PS & D (2000/01, 2006/07), Authors' projections (2011/12, 2015/16).
Note: However, we projected annual projection from 2006/07-2015/16, we show mid-term and final terms' projection briefly in this study.

Appendix 3. Major Estimated Equations

Soybean area harvested in Brazil

$$\log AH_{r,t} = 8.839240 + (1+0.0350) * \log AH_{r,t-1} + 0.3061 * \log^{*} (DS_{r,t-1}/DS_{r,t-2})$$
$$(48.3151)\langle *** \rangle \qquad (2.3386)\langle * \rangle$$
$$+ (-0.1003) * \log (DC_{r,t-1}/DC_{r,t-2}) + 0.2825 * \log^{*} (DR_{r,t-1}/DR_{r,t-2})$$
$$(-0.6764)\langle \ \rangle \qquad (2.2282)\langle * \rangle$$
$$R^2 = 0.973573,\ \bar{R}_2 = 0.955956,\ n = 11 \text{ (from 1994 to 2004)},\ DW = 1.781354$$

Soybean crush in China

$$\log CR_{r,t} = 4.5584 + (1+0.0395) * \log CR_{r,t-1} - 0.2439 * \log{}^{*} (DS_{r,t}/DS_{r,t-1})$$
$$(17.4447)\langle *** \rangle \qquad (-0.153031)\langle \ \rangle$$
$$+0.101701 * \log (DO_{r,t}/DO_{r,t-1}) + 0.0338 * \log (DM_{r,t}/DM_{r,t-1})$$
$$(0.9286)\langle \ \rangle \qquad (0.4883)\langle \ \rangle$$
$$R^2 = 0.960104,\ \bar{R}^2 = 0.949465,\ n = 20 \text{ (from 1988 to 2007)},\ DW = 1.122382$$

Soybean crush in Argentina

$$\log CR_{r,t} = 8.3918 + (1+0.0180) * \log CR_{r,t-1} - 0.3711 * \log{}^{*} (DS_{r,t}/DS_{r,t-1})$$
$$(38.0402)\langle *** \rangle \qquad (-0.4111)\langle \ \rangle$$
$$+0.0657 * \log (DO_{r,t}/DO_{r,t-1}) + 0.2815 * \log (DM_{r,t}/DM_{r,t-1})$$
$$(0.1254)\langle \ \rangle \qquad (0.4892)\langle \ \rangle$$
$$R^2 = 0.9907,\ \bar{R}^2 = 0.9815,\ n = 9 \text{ (from 1999 to 2007)},\ DW = 2.5625$$

Soybean oil consumption for food in Brazil

$$\log PQO_{r,t} = 2.403924 + (1-0.0100) * \log PQO_{r,t-1} + (-0.165952) * \log (DO_{r,t}/DO_{r,t-1})$$
$$(10.4392)\langle *** \rangle \qquad (-1.2413)\langle \ \rangle$$
$$+0.1139 * \log (RP_{r,t}/RP_{r,t-1}) + 0.1525 * \log (PP_{r,t}/PP_{r,t-1})$$
$$(1.2395)\langle \ \rangle \qquad (1.7346)\langle * \rangle$$
$$+0.417671 * \log (VV_{r,t}/VV_{r,t-1})$$
$$(1.4598)\langle \ \rangle$$
$$R^2 = 0.9167,\ \bar{R}^2 = 0.8542,\ n = 15 \text{ (from 1990 to 2004)},\ DW = 1.9821$$

Soybean meal consumption for feed in USA

$$\log QME_{r,t} = 9.1769 + (1+0.0120) * \log QME_{r,t-1} + (-0.1051) * \log(DM_{r,t}/DM_{r,t-1})$$
(50.6386)⟨***⟩ (−0.4727)⟨ ⟩

$$+0.0106 * \log(DC_{r,t}/DC_{r,t-1}) + 0.4152 * \log(LBP_{r,t}/LBP_{r,t-1})$$
(0.8109)⟨ ⟩ (2.5706)⟨**⟩

$$+0.0293 * \log(VV_{r,t}/VV_{r,t-1})$$
(0.0726)⟨ ⟩

$R^2 = 0.9815$, $\bar{R}^2 = 0.9757$, $n = 22$ (from 1983 to 2004), $DW = 2.2486$

Per capita soybean consumption for food in China

$$\log PQCS_{r,t} = 1.5805 + (1+0.0150) * \log PQCS_{r,t-1} + (-0.0589) * \log(DS_{r,t}/DS_{r,t-1})$$
(2.4299)⟨**⟩ (−0.5268)⟨ ⟩

$$+0.5054 * \log(VV_{r,t}/VV_{r,t-1})$$
(0.9507)⟨ ⟩

$R^2 = 0.7053$, $\bar{R}^2 = 0.6372$, $n = 17$ (from 1988 to 2004), $DW = 1.2729$

Soybean export in China

$$\log EXS_{r,t} = 2.2263 + (1+0.0010) * \log EXS_{r,t-1} + (0.0857) * \log(WPS_{r,t}/WPS_{r,t-1})$$
(5.2908)⟨***⟩ (0.4508)⟨ ⟩

$R^2 = 0.8911$, $\bar{R}^2 = 0.8639$, $n = 11$ (from 1996 to 2006), $DW = 2.8625$

Soybean ending stocks in USA

$$\log STS_{r,t} = 9.3735 + (1+0.0100) * \log STS_{r,t-1} + (0.4831) * \log(QPS_{r,t}/QPS_{r,t-1})$$
(31.9622)⟨***⟩ (0.9562)⟨ ⟩

$$-0.4414 * \log(DS_{r,t}/DS_{r,t-1})$$
(−2.1503)⟨*⟩

$R^2 = 0.8586$, $\bar{R}^2 = 0.8114$, $n = 13$ (from 1987 to 1999), $DW = 2.728$

Note: 1) The figures under each elasticity are t-value, except for coefficient of calibration.
2) ⟨ ⟩ means level of siginificant. *** means 1%, ** means 5% and * means 10%.