# EFFECTS OF BIOFUEL POLICIES ON WORLD FOOD INSECURITY

## -- A CGE ANALYSIS

A Dissertation

by

JIAMIN LU

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

December 2011

Major Subject: Agricultural Economics

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Approved by:

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| Co-Chairs of Committee, | Henry L. Bryant |
| | James W. Richardson |
| Committee Members, | Joe L. Outlaw |
| | David A. Bessler |
| | Michael T. Longnecker |
| Head of Department, | John P. Nichols |

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# ABSTRACT

Effects of Biofuel Policies on World Food Insecurity
-- A CGE Analysis. (December 2011)

Jiamin Lu, B.S., Lingnan University

Co-Chairs of Advisory Committee: Dr. Henry L. Bryant
Dr. James W. Richardson

The food vs. fuel debate has heated up since the 2008 global food crisis when major crop prices dramatically increased. Heavily subsidized biofuel production was blamed for diverting food crops from food production and diverting resources from food and feed production, triggering a food crisis globally and leading to increases in the world food insecure population. Few studies have quantified the effects of biofuel policies on world food prices and world food insecurity. This study added the Brazil and China's biofuel sectors to an existing global trade CGE model, and applies the measurement of food insecurity as developed by FAO. Alternative scenarios were simulated to analyze the effect of U.S., Brazil, and China's biofuel policies on world food insecurity. Results are examined with focus on (1) effects on domestic biofuel productions, (2) change in food commodity productions and trade, (3) change in land use and land rents, and (4) change in regional undernourished populations.

Results indicated that biofuel expansion is not cost competitive to traditional fossil fuel. Without any policy incentives, huge expansion of biofuel production is not likely under current technology. The conventional biofuel mandates in U.S., Brazil and

China lead to increases in world food insecurity, while the advanced biofuel mandate in U.S. has the opposite effect. Subsidies to biofuels production help to lessen the increase in world food insecurity that is caused by increases in conventional biofuel production. Additionally, the effects from U.S. biofuel policies are smaller but more widespread than the effects from Brazil or China’s biofuel policies. Overall, the long term effects of biofuel production expansion on world food insecurity are much smaller than expected.

# ACKNOWLEDGEMENTS

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# NOMENCLATURE

| | |
|---|---|
| CES | Constant Elasticity of Substitution |
| CET | Constant Elasticity of Transformation |
| CGE | Computable General Equilibrium |
| FAO | Food and Agricultural Organization of the United Nations |
| FIP | Food Insecure Population |
| GTAP | Global Trade Analysis Project |
| MDG | Millennium Development Goal |
| RFS | U.S. Renewable Fuel Standard |
| SAM | Social Accounting Matrix |

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# CHAPTER I

# INTRODUCTION

Recent sharp increase in food and energy prices has raised serious concern in many countries. Major internationally traded crops have experienced price jumps over the last few years (Figure 1). The prices of maize and wheat have more than doubled, and the rice price has reached unprecedented levels since 2003. The prices of other food products, such as dairy, meat, and poultry have also increased significantly (FAO 2008a, von Braun et al. 2008). Moreover, these high agricultural prices do not appear likely to return to their 2000–2003 levels, and fluctuations may even become higher (von Braun et al. 2008). One key factor of these price hikes was the great increase in energy prices. The oil price has climbed to all-time high of more than 140 US dollars per barrel in early 2008 (von Braun et al. 2008). Although the price has dropped back to previous level afterwards, concern for food and energy insecurity still remains. The increase in oil price has affected food markets not only by increasing food production costs, but also by encouraging biofuel production which diverts food commodities from food and feed use and diverts land from food production.

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This dissertation follows the style of *American Journal of Agricultural Economics.*

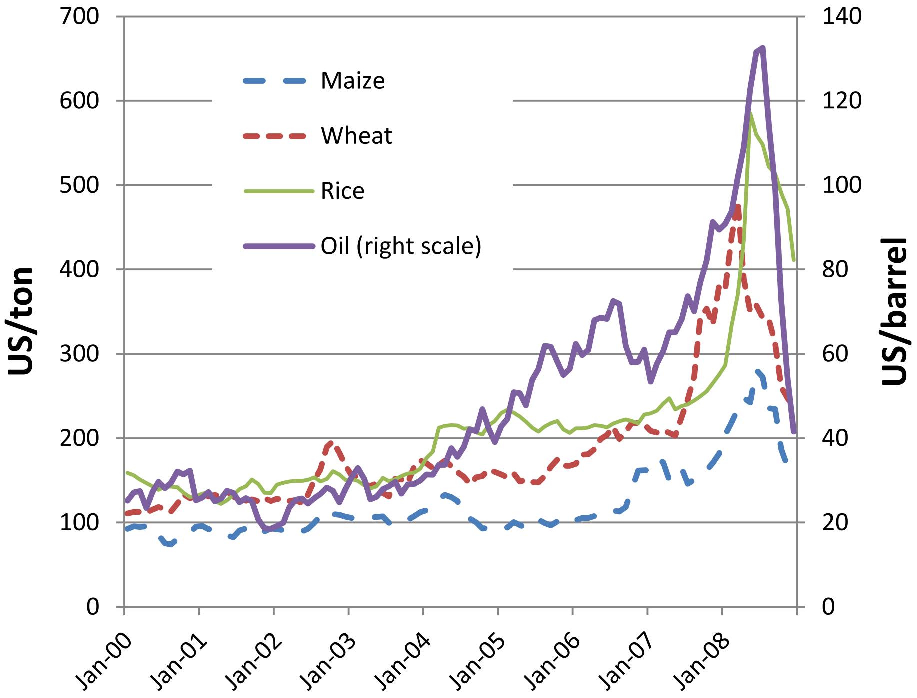

Figure 1. World Commodity Prices

Source: FAO (2008b), IMF (2008), USDA-ERS (2010)

Such food versus fuel issue has been widely debated on a global scale. It has been argued that such dramatic increase in world food prices was because of the heavily subsidized biofuel. On the other hand, the increase in food prices has threatened world food security. From 2005 to 2009, the number of undernourished people in developing countries increased by over 150 million (FAOSTAT 2010).

However, few studies have quantified the effects of biofuel production on world food prices and world food insecurity.  Also, many other factors have contributed to the soaring food prices and booming food insecurity, in an interactive way. In this study, a computable general equilibrium (CGE) model is employed to address this issue.

### *Objectives of the Study*

The domestic production of biofuel is directly affected and guided by renewable fuel policies. The main purpose of this study is to analyze the effect of selected biofuel policies on biofuel production and world hunger using a computable general equilibrium (CGE) model. The objectives of this study are summarized as follows:

a) Expand the current computable general equilibrium (CGE) model to include Chinese grain-base ethanol and Brazilian sugarcane-base ethanol production activities;
b) Analyze current world food insecurity situation with simulation results, and identify some common characteristics of current food-insecure regions;
c) Quantify the long term effects of renewable fuel policies from U.S., Brazil, and China on world agricultural commodities prices, production and trade;
d) Examine changes in domestic land use and rents under different renewable fuel policies;
e) Examine the change in world food supply and estimate the world undernourished population in alternative policy scenarios;
f) Study the effect of alternative policy scenarios of renewable fuel mandates on world hunger.

# CHAPTER II

# BACKGROUND AND LITERATURE REVIEW

## *Current World Food Insecurity*

Food insecurity has been a concern for years all over the world, for hunger is the leading threat to global health, killing more people than AIDS, Malaria, and tuberculosis combined (FAO 2006). According to the Food and Agricultural Organization of the United Nations (FAO) the food insecure population has concentrated in several regions for decades, including Asia and Pacific, Sub-Saharan Africa, and Latin America. Most countries in these regions are characterized as net food importers with low income and huge populations. World organizations such as the International Monetary Fund (IMF) and the United Nations (UN) have worked on various programs and strategies to relieve world hunger. In the World Food Summit in 1996, the Millennium Development Goal (MDG) was set, aiming to halve the number of chronically undernourished people by 2015. Since then, there has been a significant decrease in the food insecure population around the world (United Nations (UN) 2008). In general, countries that succeeded in reducing hunger were characterized by rapid economic growth, specifically in their agricultural sectors (United Nations (UN) 2008). However, the MDG is at risk, facing increasing prices in energy and crops, and severe climate change (United Nations (UN) 2008). One of the major drivers of food prices could be the current biofuel production expansion.

World hunger has increased rapidly during the recent years, especially after the global food crisis in 2008. FAO estimates that 1.02 billion people are undernourished worldwide in 2009. Asia and the Pacific is the most food-insecure region, followed by Sub-Saharan Africa, and Latin America and the Caribbean (Table 1).

Table 1. Estimated World Undernourished Population in 2009

| **Region** | **Undernourished population (millions)** |
|---|---:|
| Asia and the Pacific | 642 |
| Sub-Saharan Africa | 265 |
| Latin America and the Caribbean | 53 |
| Near East and North Africa | 42 |
| Developed countries | 15 |
| **Total** | **1,017** |

Source: FAOSTAT (2010)

World Bank has pointed out in a 1986 report that “the major sources of transitory food insecurity are variations in international food prices, foreign exchange earnings, domestic food production and household incomes(World Bank 1986).” FAO also pointed out the recent increase in world hunger is not only because of the short term declines in yield, but also as a result of soaring domestic food prices, lower incomes due to the global economic crisis (FAO 2009). According to FAO (2009), between early 2006 and 2008, the average world price for rice rose by 217%, wheat by 136%, maize by 125% and soybeans by 107% (FAO 2009). Various factors have contributed to such drastic increase in food prices, both in long term and short term.

**Population Growth**

Uncontrolled population growth in the recent decades, especially in the poor countries, has driven up the world food demand and contributed to the increase in hunger. However, evidence shows that world food production has continued to grow faster than population since the 1960s (Figure 2). The net food production per capita grows fastest in the developing countries, but declines for almost 10% in the Sub-Saharan Africa. Yet, overall, food production per capita is increasing, which means food accessibility, rather than availability, is the main reason for the increase in world hunger. In order to reduce world hunger, besides expanding world food production, it is more important to reduce and stabilize world food prices, and to improve income inequality among and within regions (Ahmed et al. 2007, Fan and Rosegrant 2008, Leathers and Foster 2004, 2009).

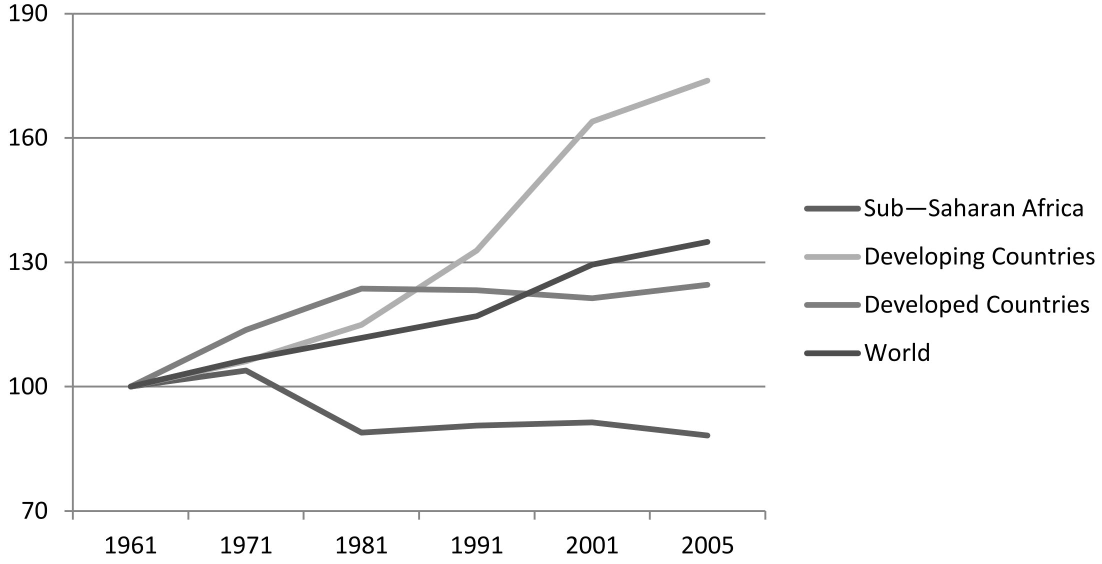

Figure 2. Index of Net Food Production per Capita, Selected Areas and Years (1961=100)

Source: Leathers and Foster (2009)

## Extreme Weather Events and Climate Change

Severe weather events over the world have disrupted agricultural production (Conceicao and Mendoza 2009, FAO 2008a, Horridge et al. 2005). Prolonged drought in Australia has drastically cut the world rice production in 2008. Recent floods in China, drought in Russia also cut world wheat production substantially. Such sharp reductions in food production have lead to severe short-term shocks in the food market, greatly increasing food prices. The food prices were reduced afterwards, but they never go down to the 2005 level (Leathers and Foster 2009, Zhang et al. 2010). Moreover, although there is no conclusive evidence that the occurrence of these extreme weather events were caused by global climate change and will persist, scientists have linked these event to the La Nina phenomenon, and suggested that such changes in climatic variability are likely to occur in the future. Such short-term shocks in the agricultural market could be more frequent in the future (Conceicao and Mendoza 2009).

### Energy Crisis

The world crude oil price has increased from a 2002 price of US$35. The most dramatic increase occurred during 2007 to 2008, from US$63 to US$147 per barrel (International Energy Agency (IEA) 2010). As a result, the cost of food production, including cost of fertilizer, has significantly increased. On the other hand, the energy crisis has encouraged countries like the U.S., to actively develop alternative energy – biofuels. The development of biofuels, especially heavily subsidized grain based ethanol is widely believed to have diverted resources from food production and increased food prices (Mitchell 2008, United Nations (UN) 2008, von Braun 2007, 2008). Moreover, poor people who were already living at a subsistence level have been paying much more for energy, and have been less able to afford enough food.

### Speculative and Policy-related Influences on Food Price Volatility

International grain markets became more volatile since trade liberalization was increased in the developing countries (FAO 2003a). Increasing commodity speculation played an important role in the food crisis. Speculative and investment activities largely influenced the commodity futures prices during 2006-2008 (Gilbert 2008). Recent export bans and restrictions further pushed up the world food prices, and encouraged commodity speculation. Among 60 low-income countries surveyed by the FAO in 2008, around one-quarter had some form of export restriction in place on food-related agricultural products. India, Vietnam, China and 11 other countries have limited or banned rice exports. India banned non-Basmati rice exports in November 2007 and Basmati rice exports in April 2008 (Mitra and Josling 2009).

## Biofuel Production

The most accused factor is the heavily subsidized biofuel production from grains and oilseeds in the U.S. and EU (Mitchell 2008). The aggressive expansion of biofuel has affected world food prices via different ways. Crops are shifted to biofuel production from food production. Land and other resources have directed to biofuel production, which leads to sharply increase in food production cost and food supply. Recent export bans on grains and speculative activity were due to rising food prices which were caused by heavily subsidized biofuel production according to the same analyst (Mitchell 2008).

### *Current Biofuel Production*

Current biofuel production is concentrated in the U.S., Brazil and E.U. (Table 2). U.S. produces ethanol mainly from field corn, which is grown to feed livestock, while Brazil uses mainly sugarcane. European countries largely use biomass to produce biodiesel. With billions of dollars of subsidies in developed countries, the biofuel industry is expanded at unprecedented speed worldwide. Between 2000 and 2007, the number of ethanol plants more than doubled and the production capacity tripled in the United States. According to the Renewable Fuels Association, there were a total of 110 ethanol plants in the United States in early 2007, and 76 more were under construction.

It was estimated that by the end of 2008, the United States ethanol production capacity reached 11.4 billion gallons per year (Renewable Fuels Association (RFA) 2008, Runge and Senauer 2007) There is also growing interests in biofuels in many developing countries, such as China, Thailand and India (Table 2), which have huge number of undernourished people (Zhang et al. 2009).

Table 2. Annual World Ethanol Production (in million gallons)

| **Country** | **2007** | **2008** | **2009** |
|---|---:|---:|---:|
| USA | 6,499 | 9,000 | 10,600 |
| Brazil | 5,019 | 6,472 | 6,578 |
| European Union | 570 | 734 | 1,040 |
| China | 486 | 502 | 542 |
| Canada | 211 | 238 | 291 |
| Thailand | 79 | 90 | 435 |
| Colombia | 75 | 79 | 83 |
| India | 53 | 66 | 92 |
| Australia | 26 | 26 | 57 |
| Other | 78 | 128 | 247 |
| **Total** | **13,096** | **17,335** | **19,535** |

Source: adopted from RFA (2011)

Global expansion of biofuel industry has pushed up demand for related crops, such as corns and soybeans. Furthermore, in the long run, it could threaten the food supplies by diverting land and other productive resources away from food crops. Many of the crops currently used for biofuel production require high quality agricultural land and significant inputs of fertilizer, pesticides and water (Energy Information

Administration (EIA) 2008). If better profit margins persist due to high energy prices and heavy subsidies, crops for biofuel production will be grown on the best lands, leaving cereals and subsistence crops to the low quality lands, thus reducing food supply (Gurgel et al. 2007, United Nations Energy (UN-Energy) 2007).

Because biofuel production affects world food security in complex ways through world trade, a computable general equilibrium (CGE) model is appropriate to evaluate the impact. A CGE model can derive a market equilibrium that takes into account all the factors and indirect effects that affect outcomes. CGE models have been widely used in policy analysis, as they are useful in estimating the effect of changes in one part of the economy on the rest (Hertel 1999). With a well defined CGE model, it can be easily estimated how an economy may react to changes in policy, technology or other external factors (Shoven and Whalley 1992).

## ***Literature Review***

### **CGE Analysis**

Computable General Equilibrium (CGE) models are a series of models used in economic analysis. A typical CGE model assumes the selected base year economy represent a perfect competitive equilibrium. At this equilibrium, consumers maximize utilities by choosing consumption and producers maximize profits by choosing production levels and input quantities. Consumers are endowed with primary factors and earn payments, and the primary factors are totally exhausted in production activities. The structure of a standard CGE model is described in various literatures. (Ginsburgh and Keyzer 1997, Hertel 1999, McDonald et al. 2005, Shoven and Whalley 1992).

### *A Standard CGE Model*

Following the Walrasian general equilibrium structures, a standard CGE model is built up with equations representing economy wide activities.

Producers

In each region r and for each sector *i* or *j*, a representative firm chooses a level of output *y*, quantities of primary factors k and intermediate inputs *x* from other sectors *j* to maximize profits subject to the constraint of its production technology. The firm's problem is then:

$$\max_{y_{ri}, x_{rji}, k_{rfi}} \pi_{ri} = p_{ri} y_{ri} - C_{ri}\left(p_{ri}, w_{rf}, y_{ri}\right)$$

$$\text{Such that} \qquad y_{ri} = \varphi_{ri}(x_{rji}, k_{rfi})$$

where π and C denote the profit and cost functions respectively; and p and w are the prices of goods and factors respectively. The production technology usually is assumed to be a constant elasticity of substitution (CES) technology with constant return to scale (CRTS), which helps to simplify the problem.

Households

Each household is endowed with factors of production. At the equilibrium, a representative household *i* in region *r* chooses consumption and saving to maximize utility subject to a budget constraint given by the level of income *M*. The household's problem becomes:

$$\max_{d_{ri}, s_r} W_{ri}(d_{ri}, s_r)$$

$$\text{Such that } M_r = \sum_f w_{rf} K_{rf} = p_{rs} s_r + \sum_i p_{ri} d_{ri}$$

where $s$ is saving, $d$ is the final demand for commodities; $K$ is the aggregate factor endowment of representative agent in region $r$. $W$ is usually modeled as a constant elasticity of substitution (CES) utility function for simplicity.

### Government

Government is modeled to collect taxes from firms, households and commodities and makes transfer payments to households, where the expenditure consists of commodity demand and is assumed to be fixed in real terms. Government income is totally exhausted.

### Trade

Bilateral trade is allowed in an open economy. Usually, goods and services are traded with the Armington assumptions (Armington 1969). It means that domestic good and foreign goods are imperfect substitutes, which will be described by the Armington elasticities of substitution.  Domestic output is distributed between the domestic market and exports, usually with a constant elasticity of transformation (CET) function for simplicity. On the other hand, domestic consumption consists of domestic goods and imports with a CET function for simplicity. Also, transportation cost is added to trade and financed by domestic production. That is, the imports of region $r$ are equal to the exports from all other region $rr$ into region $r$ plus transportation cost.

### Model Closure

A number of closure rules are specified, which place aggregate constraints on the economic activities. Usually it includes several equations, that is, demand equals supply in all input and output markets, total government revenue equals total government expenditures, total imports equals total exports, and total savings equals total investments.

Database

The database used in CGE models is usually a social accounting matrix (SAM). A social accounting matrix (SAM) is a comprehensive square matrix that represents the flows of funds among accounts of production activities, commodities, primary factors and economic institutions in an economy in a period of time (Gehlhar et al. 1997, McDonald et al. 2005, Shoven and Whalley 1992). The circular payment flow of an economy depicted in Figure 3 is represented in a SAM, where the expenditures are listed in columns and receipts are listed in rows. And the corresponding row and column totals are equal for maintaining account balances in the economy.

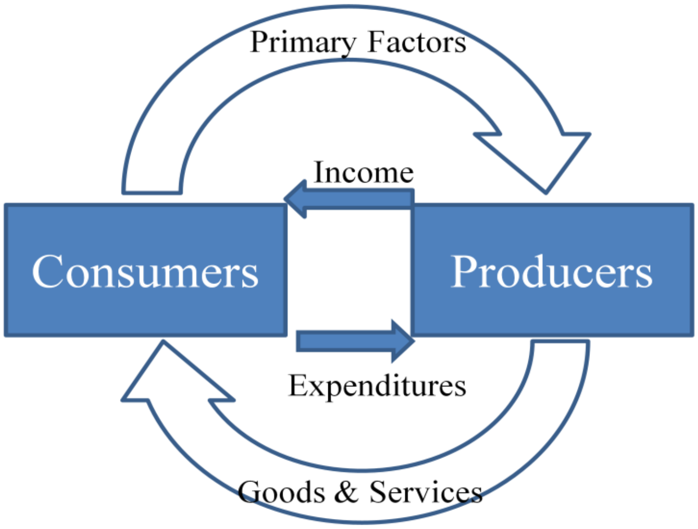

Figure 3. Circular Flow of the Economy

Calibration

All parameters and functions need to be calibrated until the bench-mark equilibrium is re-produced.

After setting up the model, policy or economic structural disturbances can be added to the model, and a counterfactual equilibrium can be simulated. Through comparing to the base equilibrium, researchers can examine the consequences of the disturbances.

### *Advantages and Limitations of CGE Models*

There are several advantages of the CGE models (Bautista et al. 2001, Devarajan and Robinson 2002, Wing 2004). Firstly, CGE allow the policy or structural disturbances to affect not only a particular sector but also every other related sectors or markets in the model. All inter-relationships among sectors and all interactions among markets in the economy are taken into account. This makes the CGE models a useful tool and framework for analyzing policies with widespread effects. Secondly, CGE models are explicitly structural and do not encounter the identification problem. Thirdly, CGE models can work with different disaggregated levels to facilitate different focus.

There are also some limitations with the CGE models (Bautista et al. 2001, Devarajan and Robinson 2002, Hertel 1999, Ianchovichina and McDougall 2000). Firstly, CGE models rely on the neo-classical assumptions of perfect competition. They assume the SAM represents a bench-mark perfect equilibrium which is not realistic. Secondly, static CGE models cannot take into account of the long-term technological improvement or any structural changes in the economy. However, the equilibrium simulated represents a long-term equilibrium state, which should take lengthy economic adjustments to reach, and short term variations are not accounted for. Thirdly, CGE models are not forecasting models, and the path and mechanism to achieve the counterfactual equilibrium is unknown, which makes it difficult to explain of what happens inside.

### *CGE Studies in Economic Issues*

Although there are some limitations, the CGE models are widely used in economic analysis. The first CGE model was presented by Johansen in 1960 (Johansen 1960), using an input-output data analysis. Since then, more and more CGE models were developed and used in economic analysis. CGE models have been popular in analyzing a wide range of issues such as environmental policy, trade policy, resource management, development economics, structural change, climate change policy and energy policy (Stenberg and Siriwardana 2005).

### *CGE Studies in Biofuel-related Issues*

Most of these studies have employed the Global Trade Analysis Project (GTAP) database, from which a SAM can be easily derived. The most current version of the GTAP data is the GTAP7, which was published in 2008 and was based on the input-output and trade data in 2004 (Gehlhar et al. 1997). However, the worldwide biofuel production was still very limited in 2004. Therefore, there is not any biofuel sectors represented in the GTAP7 database. The bio-energy component needs to be added when studying the biofuel-related issues (Kretschmer and Peterson 2010).

Major current CGE models with bio-energy components include the MIT EPPA model (Gurgel et al. 2007, Reilly and Paltsev 2007)), DART, GREEN, USAGE (Dixon et al. 2007), WorldScan (Boeters et al. 2008, WorldScan 1999), IFPRI IMPACT (von Braun et al. 2008), GTAP-E (Benson et al. 2008, Nijkamp et al. 2005) and the augmented version of GTAP (Hertel et al. 2008). These models are widely used in energy policy analysis with various emphasis, including land use, greenhouse gas (GHG) emissions, climate change and environmental issues, and thus have rather aggregated food sectors. Kretschmer and Peterson (2010) gave a nice review and comparison of the approaches adopted to add the bio energy component to the CGE model (Kretschmer and Peterson 2010). These approaches were classified into three broad categories, and the advantages and disadvantages in these approaches were summarized (Kretschmer and Peterson 2010).They concluded that the most promising approach is to calibrate the model to a SAM that disaggregates bioenergy activities in separate sector(Kretschmer and Peterson 2010).

Additionally, when studying the bio-energy issues, it was pointed out that the price effects on commodities found in some of the PE studies are usually higher due to the spillover effects could be captured in the CGE studies (Gerber et al. 2008). Also most of the CGE models have rather aggregated agricultural commodity sectors, so that the price effects are underestimated by averaging price change including the agricultural commodities that are not directly affected by biofuel production.

The CGE model used in this study follows Hertel’s guideline of CGE modeling in the Global Trade Analysis Project (GTAP) (Hertel 1997, Hertel 1999)). And some modeling issues pointed out in Hertel's another study were improved, such as the heterogenous land specification. McDonald and Theirfelder (2004) gave a detailed technical description of a global CGE model which was calibrated from the Social Accounting Matrix representation of the GTAP database (McDonald and Thierfelder 2004).

## Food Insecurity

One of the most frequently cited definitions of food security was proposed by the Food and Agricultural Organization of the United Nations (FAO): "*Food security exists when all people at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life*" (FAO 1996). Conceptually, food security is viewed in terms of four components – availability, access, utilization, and vulnerability. Each of these components captures different but overlapping dimensions of the phenomenon (Migotto et al. 2005).

Migotto et al (2005) have identified five general types of indicators for food insecurity, and three of them are commonly used in economic analysis (Migotto et al. 2005). One is *undernourishment*, which is measured by per capita dietary food energy supply. Based on the income or consumption distribution, aggregate food supply is distributed across households. The portion of distribution lying below a minimum energy requirement level is estimated as the undernourished (FAO 2003b). Another type of indicators is labeled as *food intake*, which measures the amount of food actually consumed at the individual or household level. Such indicators are usually obtained directly from household food consumption surveys (Smith et al. 2006). The last one is termed as *access-to-food*, which is proxied by wealth status, measured by total consumption, expenditures or income (Migotto et al. 2005).

Additionally, food security can be considered from global, national, household or individual level (FAO 2003a). Before the World Trade Organization (WTO) was established, food security was considered to be embedded in the national-household level. As more and more countries became trade liberalized, and actively involved in and influenced by the world economy, food security inevitably became a global issue (Chowdhury 2008).

## Empirical Studies on Food Insecurity

Extensive researches have been devoted to the study of the effect of trade liberalization, prices rise, food aid, and domestic policy reforms on food insecurity in the developing countries.

Between 1999 and 2002, FAO undertook a series of 23 country case studies to evaluate the impact of the WTO Agreement on Agriculture (AoA) on agricultural trade and food security in developing countries. In the period from 2002 to 2006, FAO further conducted case studies for 15 countries on the more broadly experience with trade-related reforms and food security. The study mainly included low-income countries that were likely to be at greater risk of food insecurity (FAO 2006). To evaluate the impact of trade and policy reforms, the researchers examined thoroughly the national level macroeconomic data obtained for the periods studied (FAO 2006). The study found globalization had affected the selected countries in various aspects. In general, trade liberalization helped to increase farmers' income and reduce income gaps.

Many studies also examined the impact of food aid program (Del Ninno et al. 2005, Gupta et al. 2003, Hoddinott et al. 2003), and found that food aid was not as effective as expected. Hoddinott et al. (2003) argued that the role of food aid should be to provide insurance for disasters that are not covered by insurance. Gupta et al. (2003) showed that the amount of food aid was insufficient to mitigate consumption of the poor. After examined the food aid experience in various countries from South Asia and Sub-Saharan Africa, Del Ninno et al. (2005) claimed that food aid should be spent on food insecure household directly, rather than on support building of production and market enhancing infrastructure, which has adverse price effect on producers.

Recently, the impact of recent world food price hikes on food insecurity and possible ways to solve the problem have been discussed (Benson et al. 2008, Dawe 2008, Shapouri and Rosen 2008, Wiggins and Levy 2008). Shapouri and Rosen (2008) found that, highly import-dependent or highly food-insecure countries can experience increase in food insecurity for decline in import capacity due to price increase. Lovendal and Jakobsen (2007) studied the case of Trinidad and Tobago and concluded that low income groups were mostly affected by higher food prices (Lovendal and Jakobsen 2007). Wiggins and Levy (2008) called for prompt assistance for countries facing hit by both food and energy crisis and for low income households. Dawe (2008) found that specific commodity policies in selected Asian countries did help to stabilize domestic prices and alleviate the increase in food insecurity. Benson et al. (2008) also argued that the impact of food crisis in the developing countries can be reduced or even avoided if policymakers have sufficient information, and design and implement policies accordingly.

Studies discussed above mostly generated conclusions by comparing the macro economic data before and after policy implementations.

## CGE Studies on Food Insecurity

As international food markets become more interrelated due to increasing globalization, more and more studies adopted the CGE models to analyze the effect of trade policies, trade reforms, food aid program, and rising food prices on world or regional food insecurity.

Adelman and Berck (1990) used a Korea CGE model, to evaluate several policies on food security subjected to random fluctuations in world prices and domestic food productivities. They disaggregated consumers into eight socioeconomic classes distinguished by ownership and access to factors of production and by whether they are net suppliers of demanders of food. Within each class, they further disaggregated households by income level (Adelman and Berck 1990). Results show that poverty-reducing development can effectively reduce food insecurity.

Based on Adelman and Berck's work, Bach and Matthews (1999) used RunAid, a global CGE model to evaluate different development aid strategies in alleviating food insecurity in developing countries. The RunAid model they developed was based on the Global Trade Analysis Project (GTAP) framework and modified with a development aid account, which allowed shocks of aid flows. They also utilized the FAO data on calories provided by different food groups and mapped it to the RunAid model to estimate average per caput daily calorie intake, so as to measure the nutritional status by the proportion and number of people with inadequate access to food (Bach and Matthews 1999). They found that without structural change in the economy, food aid's effort to alleviate hunger is only marginal. They also claimed that development assistance should be placed on agricultural investment and particularly investment in food grain production (Bach and Matthews 1999).

Ghosh and Whalley (2003) adopted a multi-sector multi-household CGE model and studied the rice price control in Vietnam. They found that welfare was enhanced with the rice price control as it can reduce the domestic adjustment costs in the face of volatile world prices (Ghosh and Whalley 2004).

Shane and Roe (2006) added to the GTAP model the feature of changing in shape of income distribution estimated by parameterized Gamma distribution, which allows a precise estimate of the food insecure population. And then they used the model to project number of Food Insecure population in three proposed scenarios, and found that shocks in productivity growth can have significant reduction in food insecure population (Shane and Roe 2006).

Inspired by recent world food and energy crisis, researchers have discussed the impact of increased prices on domestic food insecurity and poverty level. Diao et al (2008) constructed a CGE model for Morocco to assess the effect of rising world food prices. The results show that while poor consumers were hurt, social welfare loss was modest, and benefits to agricultural producers, especially small farmers were large.

Import subsidies can temporarily stabilize domestic prices, but the benefits to consumers are at the expense of producers (Diao et al. 2008).

The CGE models help to evaluate policies theoretically, rather than empirically examining the effects *ex post.* And the results found in the CGE models match the results from empirical studies.

**Studies on Biofuel and Food Prices**

The most widely discussed reason for recent high food prices is expanded use of crops to produce biofuel (Leathers and Foster 2009). Recent discussion mainly focuses on the impact of biofuel production expansion, which is believed to increase the level and volatility in food prices and lead to more serious global food insecurity.

Von Braun (2007) used IFPRI's International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT), a CGE model, to simulate future price levels due to biofuel expansion. Various scenarios suggested that biofuel industry expansion cause food prices to increase significantly, but it is not completely responsible for the imbalances in the world food situation (von Braun 2007). Runge and Senauer (2007) projected that the number of undernourished would rise by over 16 million for every percentage increase in the real price of staple foods due to factors such as expanding biofuel production. The number of food insecure would increase to 1.2 billion by 2025, if the expansion of biofuel industry persists (Runge and Senauer 2007).

Mitchell (2008) examined how world prices changed in food commodities since 2002, including maize, wheat, rice, soybeans, etc. He argued that, it was the biofuel production that led to the substantial decrease in global wheat and maize stocks, and the tripled oilseed prices. Otherwise, the effect due to other factors could be moderate. It was estimated that higher energy and fertilizer prices only increased crop production costs by about 15-20 percents in the U.S. and lesser percentage in countries with less intensive production practices (Mitchell 2008). Droughts in Australia only reduced global grain exports by about 4 percent and other exporters would normally have been able to offset this loss. The decline of the dollar has contributed about 20 percent to the rise in dollar food prices (Mitchell 2008).

However, some other studies argued that effects of biofuel on food prices may be overstated or not necessarily hurt the food insecure people. A report from the UN-Energy argued that the effect of expansion of biofuel production on food security could be negative or positive, depending on whether a country or household is a net buyer or seller of energy services and food products (United Nations Energy (UN-Energy) 2007). Zezza et al (2008) used household survey data to analyze the impact of increased food prices, found that net food sellers gained while net food buyers lost (Zezza et al. 2008). On the other hand, the UN report pointed out that current analyses are under way to quantify the impact of expanded biofuel production on global commodity prices, and in turn, the poor and food insecure (United Nations Energy (UN-Energy) 2007). Naylor et al (2007) gave a summary of current studies that predicted agricultural price changes in alternative biofuel production scenarios. They noted that most of those studies did not provide projections from the international market to certain countries (Naylor et al. 2007).

## Food Insecurity Measurement

As mentioned earlier, food insecurity has various aspects, therefore the measurement of food security is challenging. Economic measurement of food insecurity usually relates to income distribution, which determined the population's capacity of acquiring food (FAO 2003c, Migotto et al. 2005).

Reutlinger and Selowsky (1976) tried to assess the number of undernourished in the developing countries, with reference to income distribution. Following their framework (Reutlinger 1976), Timmer (1999) proposed a calorie-income relationship, which links calorie intake to income distribution related to the Engel relationship (Timmer 1999). Shapouri and Rosen (1999), Senauer and Sur (2001) and Runge et al. (2003) estimated the number of food insecure people in a similar way. The underlying assumption is that, income distribution data can be used to project calorie consumption for various income levels. The authors used regression analysis to estimate a calorie-income Engel curve, with data from FAO on daily calorie available per capita by country, and data from the World Bank on average GDP per capita and the distribution of income by quintile. As a result, daily calorie intake was represented as a function of income and the number of undernourished was estimated (Runge et al. 2003, Senauer and Sur 2001, Shapouri and Rosen 1999).

## FAO Methods of Measuring Food Insecurity

Another popular methanol of measuring food insecurity is developed by FAO (2003b). Comparing to the methods discussed above, the FAO method provides a systematic and consistent way to measure food insecurity in any aggregate level.

Different from household surveys, this approach is widely used to perform an aggregate measure of malnourished problem within regions or countries. The method is based on the food balance sheets (FBS) data, which are published annually by FAO on a country by country basis. The FBS basically records the quantities of food supplied and utilized within the country in one year. According to the total available food quantities, the daily calorie intake per capita can be estimated (FAO 2003b). In this study, the FAO method is incorporated to the CGE model to measure regional food insecurity. The following discussion follows the description of the FAO measurement of food insecurity (FAO 2003a).

### *Basic Methodological Framework*

Defined by FAO, this measure is attempting to capture those whose food consumption level is insufficient for body weight maintenance and work performance. It focuses on the phenomenon of hunger rather than under nutrition. In this case, the measurement is based on a probability distribution framework. Given the distribution of dietary energy consumption $f(x)$, the percentage of undernourished people is estimated as the proportion of population below the minimum per capita dietary energy requirement $r_L$ (Figure 4). $r_L$ is derived by aggregating the estimated sex-age-specific minimum dietary energy requirements, using the relative proportion of the population in the corresponding sex-age group as weights. The estimates are made on a country-by-country basis and are reported periodically by FAO.

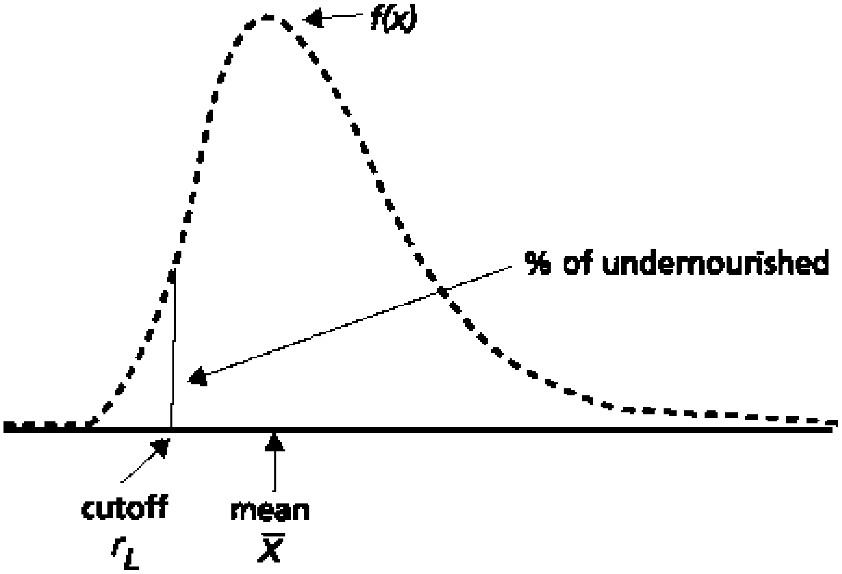

Figure 4. Calculation of Food Insecurity

*Estimation of the Distribution of Food Calorie Consumption*

The distribution *f(x)* is estimated based on household surveys, which collect data on the quantities of food product consumed by individuals in a representative sample of households in the population (Migotto et al. 2005). However, the methodology and concepts applied in the surveys are not sufficiently precise to provide an accurate and reliable estimate of the distribution. A theoretical distribution was chosen and is estimated by FAO (FAO 2003b).

As the frequency distribution depicted by the data from the food surveys is generally uni-modal, a specific group of theoretical distributions were considered for application. At first, the Beta distribution was chosen, as it enabled fixing the lower and upper limits of the range as determined by the physiological lower and upper limits of intake in individuals. However, researchers found this distribution was appropriate only when dealing with the true intake of individuals. In most of the surveys, the data refer to the food available to, or acquired by, the household and thus include household wastage, food fed to pets, etc. In 1987, the two-parameter log-normal distribution was chosen (FAO 2003b). Because the short lower tail and long upper tail can better reflect the richer and more affluent households, who are more likely to have wastages, food fed to pets, etc (FAO 2003b).

The log-normal distribution can be specified by two parameters, i.e., the coefficient of variations *CV(x)*, and the mean ($\bar{x}$). Given these two parameters, the mean and variance of the corresponding normal distribution can be determined as follows:

$$\sigma^2 = \ln\left(CV^2(\mathrm{x}) + 1\right)$$

and

$$\mu = \ln\bar{x} - \sigma^2/2$$

*Estimation of CV(x)*

The CV(x) is estimated as

$$CV(x) = \sqrt{CV^2(x|v) + CV^2(x|r)}$$

where *CV(x|v)* is variation owing to household per capita income *(v)*, and *CV(x|r)* is the variation owing to energy requirement *(r)*. These tow variance measures can be added up because

$$CV^2(x|v) = \frac{\sigma^2(x|v)}{\mu^2(x|v)}$$

$$CV^2(x|r) = \frac{\sigma^2(x|r)}{\mu^2(x|r)}$$

and

$$\mu(x|v) = \mu(x|r) = \mu(x)$$

$$Var(x) = Var(x|v) + Var(x|r)$$

This leads to

$$CV^2(x) = \frac{\sigma^2(x)}{\mu^2(x)} = \frac{\sigma^2(x|v) + \sigma^2(x|r)}{\mu^2(x)}$$

A detailed procedure of estimation is documented in FAO (2003b). Because the inequality of income distribution for a number of developing countries varied little over last three decades, and the inequality in the distribution of household per capita food consumption is much smaller than the inequality in the distribution of household income, *CV(x)* is assumed to be constant.

### *Estimation of the Mean* $\bar{\boldsymbol{x}}$

The mean $\bar{x}$ represented by the per capita dietary energy supply refers to the energy available for human consumption, expressed in kilocalories (kcal) per person. It is derived from the food balance sheets (FBS) compiled every year by FAO on the basis of data on the production and trade of food commodities. The total dietary energy supply is obtained by aggregating the food component of all commodities after being converted into energy values (FAOSTAT 2010).

### *Lowest Energy Requirement Level ($R_L$)*

Energy requirement is different for each individual. The most influential factors are age, sex, body weight, and activity level. The $R_L$ for a country is derived by aggregating the minimum sex-age-specific energy requirement with information on the composition of the population (FAO 2003b).

The sex-age-specific energy requirement is derived in two procedures. For adults and adolescents, the energy requirements are calculated with the basal metabolic rate (BMR). For the children below age ten, the energy requirements are expressed as fixed amounts of energy per kilogram of body weights. The lower limits of the requirements for each sex-age group were derived with the lowest acceptable body weight and lowest acceptable activity allowance (FAO 2003b). $R_L$ is around 2,000 kcal per day for each country, and is updated by FAO periodically as the composition of population changes over time.

### *Strength and Weakness*

The main strength of the FAO estimates is that the distribution of household per capita dietary energy consumption is directly linked to the dietary energy supply derived from the food balance sheet. The food balance sheets database, which practically covers all countries of the world, is regularly revised and updated. As a result, the database is a readily available source of information for the assessment and monitoring of the prevalence of undernourishment at the global, regional and country levels (FAO 2003b). It provided a mechanism for assessing the effect of short-term changes in aggregate food availability as well as its components (production, import, etc.) on the prevalence of undernourishment (FAO 2003b).

It was pointed out that there are several weaknesses that affect the validity of the estimates. First, the log-normal distribution of per capita dietary energy consumption is proposed rather than empirically estimated. Second, the derivation of the parameters is crucial to the estimates. It was shown that the results are very sensitive to the cutoff point and the mean, especially when the mean is low and close to the cutoff point, as the distance of these two parameters determines the proportion of the population undernourished. In this case, the percentage is practically insensitive to the CV. Sensitivity to the CV tends to increase as the mean increases to higher levels. Also, it was discussed that errors in the estimation of the CV are of less consequence to the result as compared with errors in the cutoff point and the mean. Nevertheless, to have a precise estimate, we need all three elements to be sufficiently accurate.

# CHAPTER III

# BIOFUEL INDUSTRY IN U.S., BRAZIL AND CHINA

## *U.S. Biofuel Industry*

The United States biofuel production began to shoot up in 2000 (Figure 5), and the U.S. became the world's largest producer of ethanol fuel since 2005. In 2009, the U.S. produced 10.6 billion gallons of ethanol fuel, and together with Brazil, both countries accounted for 89% of the world's production in that year.

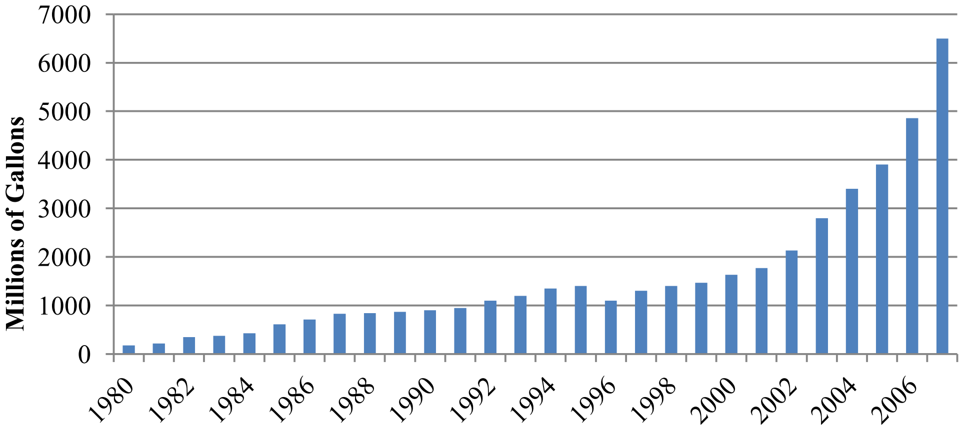

Figure 5. Historic U.S. Biofuel Productions (1980-2007)

Source: RFA (2007a, 2008)

According to the Renewable Fuels Association (RFA), there are about 139 ethanol bio-refineries in operation, and another 62 under construction (Renewable Fuels Association (RFA) 2008). When the construction is completed as expected in 2011, it will bring the U.S. ethanol production a total capacity of 14.46 billion gallons per year. As current biofuel in the U.S. is produced mainly using corn as feedstock, the refineries are concentrated in the Midwest, where the Corn Belt is (Figure 6).

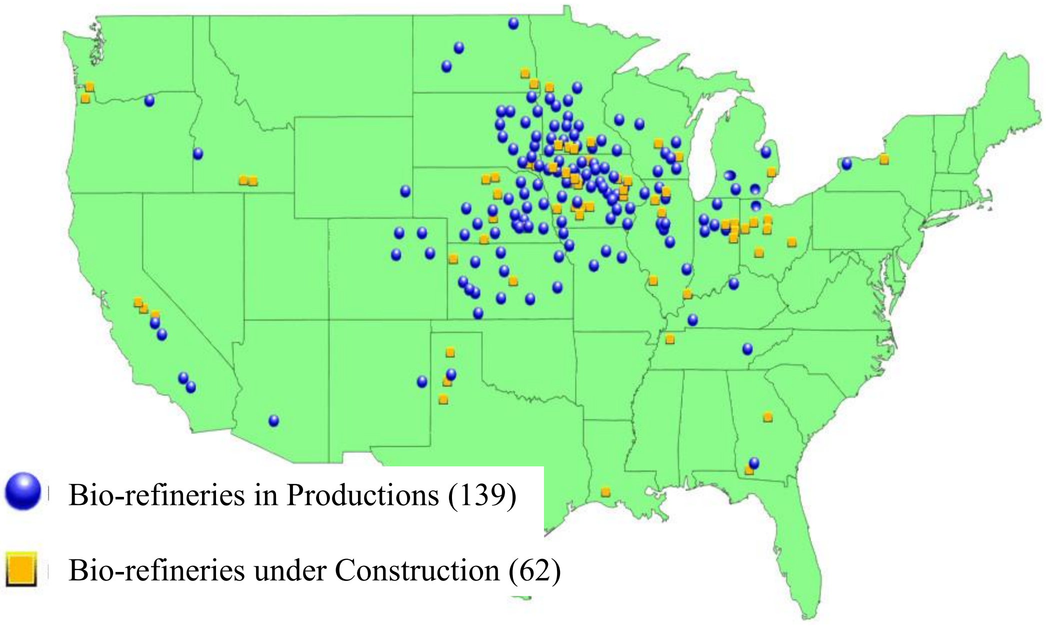

Figure 6. U.S. Ethanol Bio-refinery Locations

Source: RFA (2008)

## Production Technologies

There are two types of ethanol that will be consumed in the U.S., conventional ethanol and cellulosic ethanol. Conventional ethanol is mainly produced from food crops, while advanced ethanol is mainly produced from non-food crops and crop residue. The following discussion is adopted from the Renewable Fuels Association (Renewable Fuels Association (RFA) 2007b).

### *Conventional Ethanol Production*

Conventional Ethanol is produced with feedstock of high sugar and starch content through fermentation. Common feedstocks include sugarcane, corn and wheat, mainly food crops. There are two types of fermentation processes in conventional ethanol production – dry milling and wet milling.

In the dry milling process, the feedstock is firstly ground into flour and then cooked and fermented (Figure 7). Co-products in this process include dried distillers grains with soluble (DDGS) and carbon dioxide.

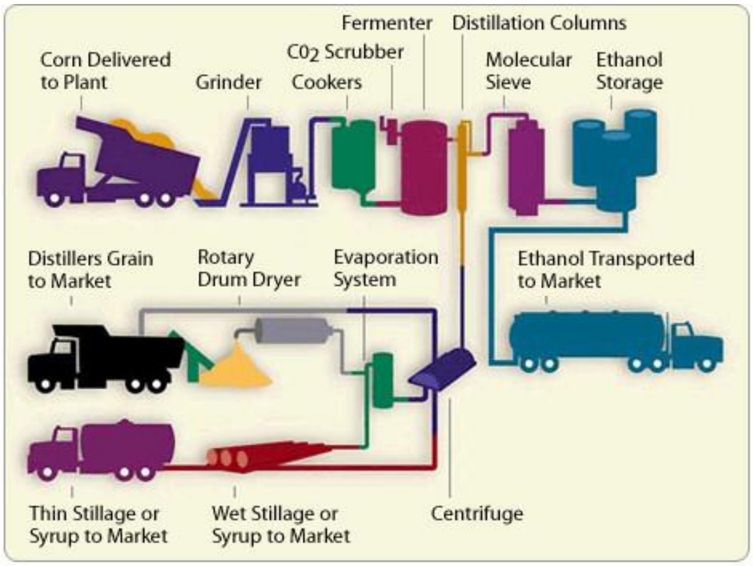

Figure 7. Dry Milling Process in Ethanol Production

Source: RFA (2007b)

In the wet milling process, the feedstock is initially steeped to separate the grain into its various parts, which then go through different process to various final products (Figure 8). Co-products in this process include corn oil, wet feed, gluten meal, and high fructose corn syrup.

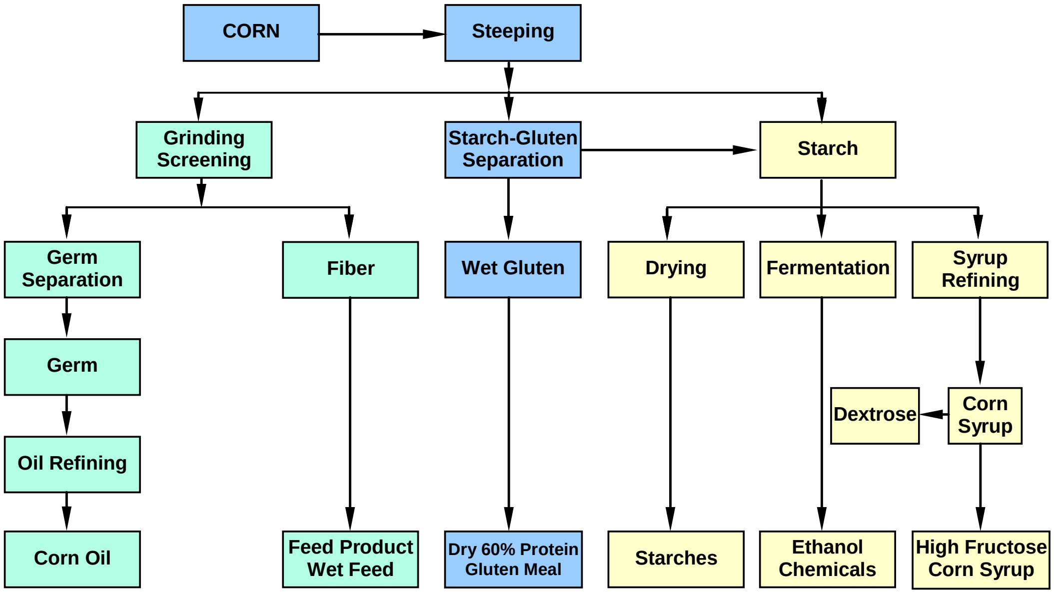

Figure 8. Wet Milling Process in Ethanol Production

Source: RFA (2007b)

*Cellulosic Ethanol Production*

Cellulosic Ethanol is produced from lignocelluloses, which can be found in wood, grasses or the non-edible parts of plants. Lignocelluloses are hard to break down and covert into sugar for ethanol production. Two different processes can be used.

One process is cellulosysis, in which the biomass is initially pretreated to liberate cellulose (Figure 9). After pretreatment, the biomass will go through a chemical or enzymatic hydrolysis process to break the cellulose molecules into sugar. Finally, the sugar is fermented into ethanol, then distillated into pure ethanol.

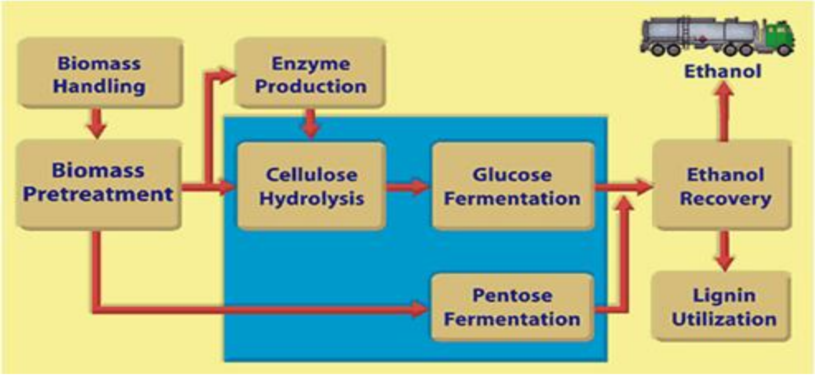

Figure 9. Cellulosic Ethanol Production Process (Cellulolysis)

Source: RFA (2007b)

The other process is gasification, which transform the biomass into carbon monoxide and hydrogen. Then the gases can be converted to ethanol by fermentation or chemical catalysis. Finally the ethanol is distillated into pure ethanol.

However, currently there is no substantial production of cellulosic ethanol and the production costs are likely to be high.

**Feedstocks**

Corn, wheat and sorghum are the most popular feedstock for conventional ethanol production, while corn stover, switch grass, miscanthus, woodchips and the byproducts of lawn and tree maintenance are some of the more popular cellulosic materials for ethanol production. Cellulosic feedstocks are not only more abundant and cheaper than the conventional feedstock, but also much more favored over conventional feedstock, when concerning land use, energy balances and carbon intensity (Fargione et al. 2008, Searchinger et al. 2008). However, under current production technology in the

U.S., conventional ethanol from grain is commercially viable, while cellulosic ethanol from biomass is not. In this study, we only focus on corn, corn stove which are widely grown in the U.S., and switch grass, which is believed to have good potential in the U.S.(Mapemba et al. 2007, Pimental and Patzek 2005).

### *Corn*

Over 240 million dry tons of corn is produced each year in the U.S. (Atchison and Hettenhaus 2004). Currently, almost all ethanol in the United States is made from corn grain. During 2006 to 2009, the increase in the use of corn for ethanol nearly doubles the production each year (U.S. Department of Agriculture (USDA) 2009). The U.S. Department of Agriculture (USDA) estimated that, in 2008, the total use of corn for ethanol has accounted for 30% of the U.S. corn production (Shapouri and Gallagher 2005). It was concerned that the rapid expansion of the corn-growing sector has caused an unprecedented demand shock to the world agricultural system. The price of corn increases by about 75% from 2006 to 2007, and the higher price of corn has consequently increased the price of all other grains worldwide. In the future, corn may no longer be the main feedstock for U.S. ethanol production if biomass becomes commercialized as alternative. A report by the U.S. DOE and USDA (2006) suggests that, by the middle of the 21st century, the United States should be able to produce 1,300 million US tons of biomass feedstock per year, enough to displace approximately 30% of its current petroleum consumption (USDA 2006).

### *Corn Stover*

Corn stover is a byproduct of corn grain production. Half of the corn crop yield is corn stover, but it is generally left in the field after harvest. For every ton of corn that is produced, about 1 dry ton of stover remains on the field. The main component of corn stover is cellulose, so it can be collected and used as a biomass source for cellulosic ethanol production(Perlack and Turhollow 2003). Corn stover is now largely unutilized crop in the U.S. as less than 5% of corn stover production is generally used (Hettenhaus and Wooley 2000). However, corn stover use in biofuel production largely depends on the corn production, and a certain percentage of corn stover must be left on the ground to prevent soil erosion. There exists a limit to the cellulosic biofuel production using corn stover, which makes the switch grass another favored biomass candidate.

### *Switch Grass*

Switch grass (*Panicum virgatum*) is a summer perennial grass that is native to North America. It is a natural component of the tall-grass prairie which covered must of the Great Plains, but which also was also found on the prairie soils in the Black Belt of Alabama and Mississippi (U.S. Department of Agriculture (USDA) 2008). There are two main types of switch grass: upland types, which usually grow 5 to 6 feet tall and are adapted to well drained soils, and low land types, that grow up to 12 feet tall and which are typically found on heavy soils in bottomland sites (U.S. Department of Agriculture (USDA) 2008). Switch grass is self-seeding, resistant to many plant diseases and pests, and tolerant to poor soils, flooding, and drought (McLaughlin and Adams Kszos 2005). Switch grass is also known for its rapid growth, high yields with low applications of fertilizer and other chemicals. It can be grown in most parts of the U.S.(McLaughlin and Adams Kszos 2005) Particularly, it is grown to cover the land under the Conservation Reserve Program (CRP), which pays producers for not growing crops on land. The switch grass can help to improves soil quality and prevents erosion, enhance water quality, and increase wildlife habitat (U.S. Department of Agriculture (USDA) 2008). If switch grass for biofuel production could become economically viable, it can lower the cost of the CRP while increasing ecological sustainability (Kszos et al. 2002, McDonald et al. 2006, McLaughlin and Adams Kszos 2005).

## U.S Biofuel Policies

Various policies have been implemented to promote the domestic production and consumption of biofuel, including biofuel mandates and tax credits.

### *Renewable Fuel Standards*

The Renewable Fuel Standard (RFS1) program was first established under the Energy Policy Act of 2005. It called for a mandate of 7.5 billion gallons of biofuel to be used annually by 2012. RFS1 called for increasing use over time. The RFS requirement increased by about 23% from 2008 to 2009, from 9 billion to 11.1 billion gallons. According to the Environmental Protection Agency (EPA), the 2009 RFS set a mandatory renewable fuel blending ratio of 10.21% in gasoline, which was increased from 7.76% in 2008.

In May 2009, the EPA released an expanded RFS program (RFS2) as required under the Energy Independence and Security Act (EISA) of 2007. The program was expanded to increase the volume of renewable fuel required to be blended into transportation fuel from 9 billion gallons in 2008 to 36 billion gallons by 2022. In addition, it has established new definitions and volume standards for cellulosic ethanol, biodiesel, and advanced biofuel separately. Furthermore, the new requirements also include new criteria for both renewable fuels and for the feedstock used to produce them, including lifecycle greenhouse gas (GHG) emission thresholds. These thresholds were set to ensure that each category of renewable fuel emits fewer GHG than the petroleum fuel it replaces. The RFS2 has set the schedule for both Conventional Biofuel and Advanced Biofuel (Figure 10). In 2022, the consumption of total renewable fuel will reach 36 billion gallons, with a maximum of 15 billion gallons of conventional biofuel and a maximum of 21 billion gallons of advanced biofuel.

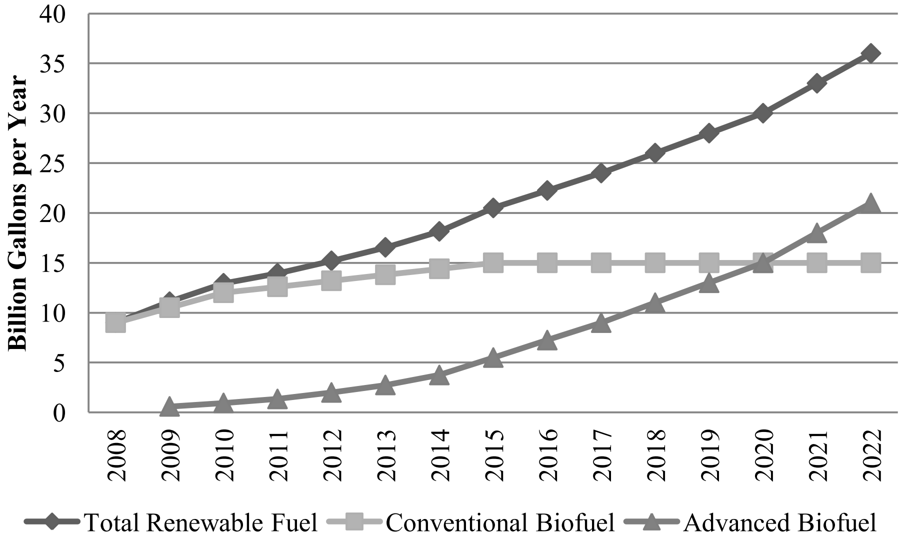

Figure 10. Renewable Fuel Standard (RFS2) Schedule (2007)
Source: U.S. Congress (2007)

### *Tax Credits*

Other than the volume mandate, U.S. has also subsidized consumption. Under the Volumetric Ethanol Excise Tax Credits (VEETCs), an ethanol blender can receive a tax credit for pure ethanol blended into gasoline. As of January 1, 2009, the original tax credit of 51 cents per gallon on pure ethanol (5.1 cents per gallon for E10, and 42 cents per gallon on E85) was reduced to 45 cents per gallon. The tax credit was intended to end in the end of 2010. However, recently a bill was introduced to extend VEETCs at 45 cents per gallon for five years. Other than VEETCs, various other incentives for different renewable fuels can be found in Alternative Fuels and Vehicles Data Center (AFDC) of Department of Energy, such as grants, loans, income tax credits, and producer tax credits.

## ***Brazilian Sugarcane Ethanol Industry***

Brazil is one of the world's most efficient producers of biofuel feedstock – sugarcane, which makes it the world's second largest producer, yet the most cost effective, of fuel ethanol. During 1970 to 2004, ethanol has substituted about 61 billion gallons of gasoline in domestic use (OECD/IEA 2006). Since 2000, Brazil's ethanol production has continued increasing, and the increase is especially steep in recent years (Figure 11).

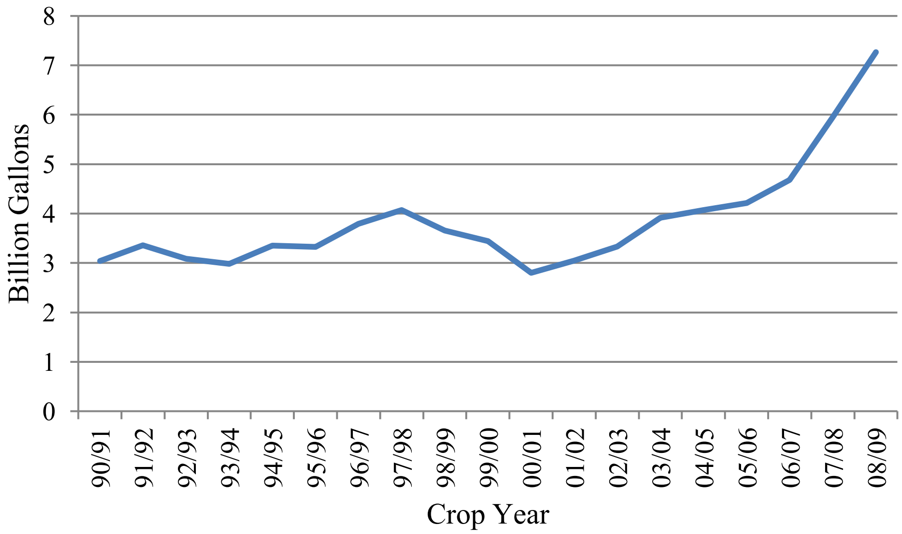

Figure 11. Annual Brazilian Sugarcane Ethanol Production (1990-2008)
Source: EPE (2010)

According to UNICA (2007, 2008), Brazil's production of ethanol has reached 6.9 billion gallons in 2008, with 1.2 billion gallons exported (União da Indústria de Cana-de-Açúcar (UNICA) 2007, 2008). It is expected the number will be increased to 17.2 billion gallons in 2020 (Table 3).

Table 3. Ethanol and sugar output, domestic demand and export

| 2008[a] | Output | Domestic Demand | | | Export |
|---|---|---|---|---|---|
| **Ethanol (billion gallons)** | 6.9 | 5.7 | (82%) | 1.2 | (18%) |
| **Sugar (million tons)** | 29.7 | 10.8 | (36.4%) | 18.9 | (63.6%) |
| **2020[b]** | Output | Domestic Demand | | | Export |
| **Ethanol (billion gallons)** | 17.2 | 13.1 | (76.0%) | 4.1 | (24.0%) |
| **Sugar (million tons)** | 45.0 | 12.1 | (26.9%) | 32.9 | (73.1%) |

Source: [a]UNICA (2008)
[b]UNICA (2007)

Brazil has a specific energy profile (Figure 12). The main energy sources are biomass, oil and hydro electricity. Biomass and oil account for almost 70% of domestic energy consumption.

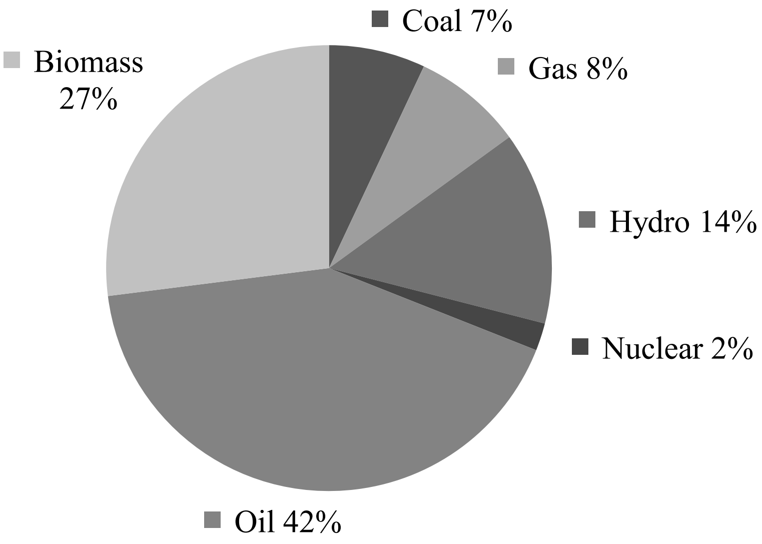

Figure 12. Brazil's Energy Profile 2002

Source: Goldemberg et al. (2002), IAEA (2006)

Increase in ethanol use domestically did help Brazil to reduce its energy dependence. Since when the government started the ProAlcool program to promote sugarcane ethanol, petroleum imports have gradually decreased (Figure 13). Moreover, during this time period, new oil fields were found and domestic oil production increased. As a result, Brazil achieved self-sufficiency in crude oil in 2006. And Brazil is also considered as a hub for energy integration in South America; especially with regards to the production and use of ethanol (OECD/IEA 2006).

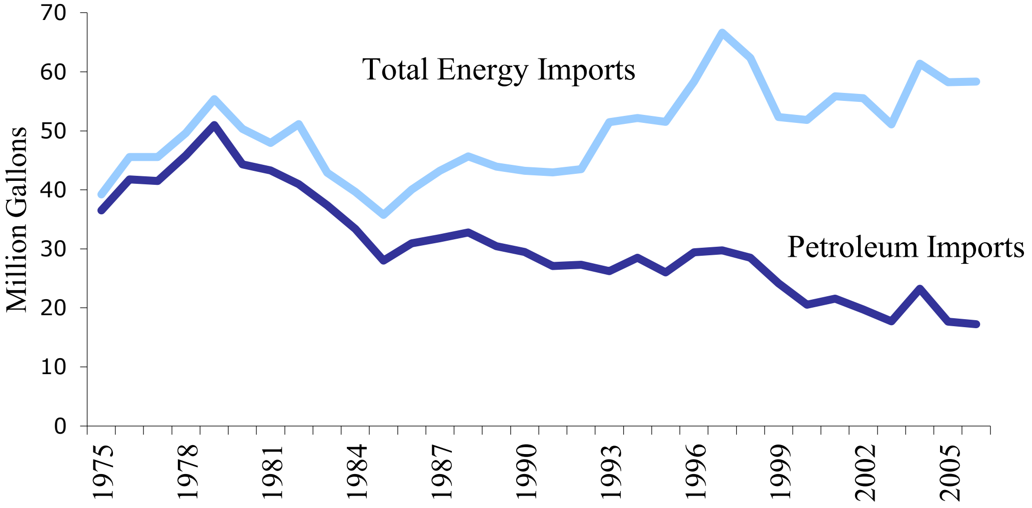

Figure 13. Historic Brazilian Energy Imports

Source: UNICA (2008)

## Ethanol Use

In Brazil, ethanol is used in two forms – anhydrous ethanol and hydrous ethanol. Anhydrous ethanol contains no water, and is suitable for blending with gasoline. Hydrous ethanol contains 95 % ethanol and 5% water, and is used directly as a fuel. Brazil's ethanol is basically used in transportation and exports (Jank 2008).

### *Flex-fuel Vehicles*

Before the introduction of flex-fuel vehicles, ethanol vehicles could only use hydrous ethanol, that is, without addition of gasoline. In 2003, car manufacturers, beginning with Volkswagen introduced the Flex-fuel Vehicles (FFVs), which can run on any mixture of a gasoline-ethanol blend and hydrous ethanol. This protects domestic consumers from any fuel shortages (International Energy Agency (IEA) 2004). Production of FFVs continued to rise (Figure 14). Today 70% of the cars sold in Brazil are FFVs (an estimate of 2.5 million in 2009), which cost no more than conventional cars (Grad 2006). As a result, ethanol accounts for 40% of Brazil's transportation fuel. Brazil's FFV fleet is the only one in the world that can use 100% of either ethanol or gasoline (OECD/IEA 2006). Pure gasoline is no longer sold in Brazil (Hira and de Oliveira 2009, Pereira Jr et al. 2008). And until 2006, most of the domestic gasoline-anhydrous ethanol sole was E25 blend, while E5 and E10 are most common blends in other countries (OECD/IEA 2006).

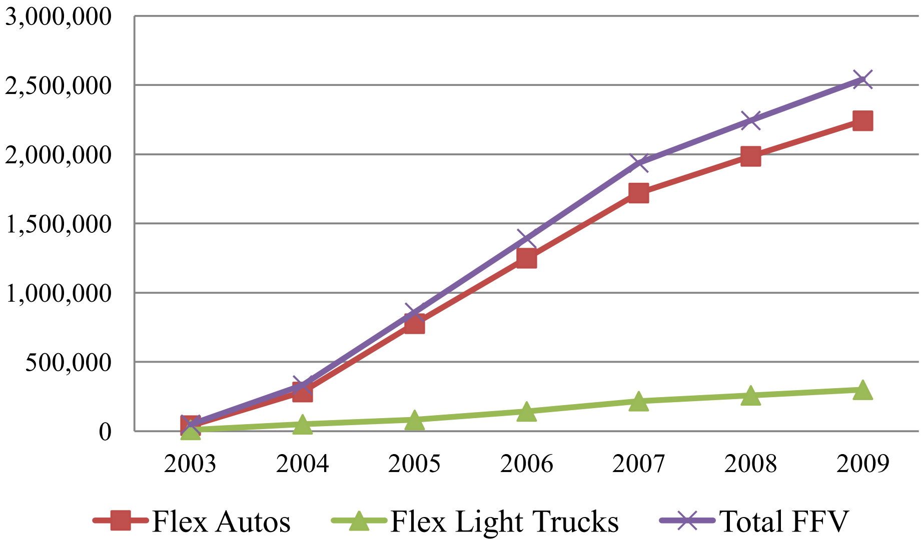

Figure 14. Historic Brazilian Flex-fuel Vehicles Production

*Export*

Brazil is the largest exporter of ethanol in the world, and is currently exporting ethanol to the US, India, Venezuela, Nigeria, China, South Korea and Europe (Table 4). Brazil’s ethanol production was 6.9 billion gallons in 2008, more than a third of the global production, of which 1.2 billion gallons were exported (União da Indústria de Cana-de-Açúcar (UNICA) 2010). Brazil has a 50% market share of global ethanol exports. Export to Japan is After Japan authorized the substitution of up to 3% of gasoline with ethanol to help meet its Kyoto Treaty commitments Brazil is also negotiating with Japan to export ethanol to it. Japan is a very attractive export market for Brazilian ethanol as it must import all of its consumption (OECD/IEA, 2006).

Table 4. Brazilian ethanol exports by selected countries and regions (millions of gallons)

| **Country/Region** | **2007** | **%** | **2006** | **%** | **2005** | **%** |
|---|---:|---:|---:|---:|---:|---:|
| United States | 246.43 | 26% | 469.60 | 52% | 71.59 | 11% |
| Caribbean | 240.50 | 26% | 140.17 | 16% | 146.41 | 21% |
| European Union | 265.30 | 28% | 155.17 | 17% | 140.22 | 21% |
| Japan | 96.17 | 10% | 59.55 | 7% | 83.33 | 12% |
| Republic of Korea | 17.62 | | 24.38 | | 57.16 | |
| India | 0.00 | | 2.66 | | 108.52 | 16% |
| **Total** | **866.02** | | **851.53** | | **607.23** | |

Source: Lamers et al. (2011)

## Production Process

Sugarcane ethanol is produced as co-product with sugar from sugarcane. The ethanol refineries, usually located near the sugarcane production areas, are centered in the state of Sao Paulo, but are expanding to other states and areas. The availability of cheap resources and cheap labor makes sugarcane the most competent biofuel feedstock in Brazil (Grad 2006). Due to improved techniques in agricultural management, sugarcane production costs have further gone down as a result of increasing yields during recent years (Almeida et al. 2007). The world’s most cost competitive bioethanol is produced using the first generation technology, which is mature and economically feasible. The production process is done through a very integrated process chain, including milling, electricity generation, fermentation, distillation and dehydration of ethanol (Coelho et al. 2006, Sanchez and Cardona 2008).

### *Milling and Refining*

Once harvested, the sugarcane is transported to the plant, washed, chopped, and shredded. The juice called garapa, which contains 10 – 15% sucrose, is extracted and collected. The fiber residue called bagasse is saved for electricity generation.

The cane juice is then filtered and treated by chemicals and pasteurized. The juice is filtered once again, producing vinasse, a fluid rich in organic compounds. After evaporation, the syrup is precipitated by crystallization, producing a mixture of clear crystals surrounded by molasses. The sugar crystals are separated from the molasses by a centrifuge, then washed by addition of steam, and dried by airflow. Upon cooling, sugar crystallizes out of the syrup. From this point, the sugar refining process continues to produce different types of sugar, and the molasses continue a separate process to produce ethanol (Goettemoeller and Goettemoeller 2007, Solomon 2010) .

### *Fermentation, Distillation and Dehydration*

The molasses are sterilized to be free of impurities, and ready to be fermented. In the fermentation process sugars are transformed into ethanol by addition of yeast. Fermentation time varies from four to twelve hours. The yeast is recovered from the wine through a centrifuge. Making use of the different boiling points the alcohol in the fermented wine is separated from the main resting solid components. The remaining product is further distillated to hydrous ethanol, which by national specification can contain up to 4.9% of water by volume. This hydrous ethanol is the fuel used by ethanol-only or flex vehicles in the country (Goettemoeller and Goettemoeller 2007).

Further dehydration is done to produce anhydrous ethanol, which is used for blending with pure gasoline to obtain the country's E25 mandatory blend (Pereira Jr et al. 2008). The dehydration process increases the cost of anhydrous ethanol, as in 2007 the average producer price difference between the two was around 14% for São Paulo State. This production price difference, though small, contributes to the competitiveness of the hydrous ethanol (E100) used in Brazil, about double in quantity of anhydrous ethanol in 2008/2009 crop year (Goettemoeller and Goettemoeller 2007).

### *Electricity Generation from Bagasse*

Bagasse is the by-product of sugarcane crushing with low moisture content as mentioned above. It is burned for electricity generation, allowing the plant to be self-sufficient in energy and to generate electricity for the local power grid. The amount of bagasse produced is generally equivalent to about 25-30% (by-weight) of the sugarcane (Taheripour et al. 2010). It is used as fuel for cogeneration systems, ensuring energy supply self sufficiency (thermal, mechanical and electric) in almost all existing sugarcane mills (Mejean and Hope 2010).

Since the early days bagasse was burned in the plant to provide only the energy required for the industrial part of the process. Today, the Brazilian best practice uses high-pressure boilers that increase energy recovery, allowing most sugar-ethanol plants to be energetically self-sufficient and even sell surplus electricity to utilities. According to analysis from Frost and Sullivan, Brazil's sugarcane bagasse used for power generation can increase from 3.0 GW in 2007, to 12.2 GW in 2014. The analysis also found that sugarcane bagasse cogeneration accounts for 3% of the total Brazilian energy matrix. The energy is especially valuable to utilities, because it is produced mainly in the dry season when hydroelectric dams are running low (Crago et al. 2010, Goldemberg et al. 2004b).

## Production Costs Reductions

Since the PROALCOOL program, the ethanol production costs in Brazil have been sharply reduced, and sugarcane ethanol became the most cost competitive biofuel in today's world (Crago et al. 2010). The program provided a lot of subsidies and incentives for the biofuel industry to grow. Ethanol production costs were close to 2.38 US/gallon in the initial stages of the Program in 1980, reduced to around $1 US/gallon in 2004. Detailed analysis of such cost reduction process can be found in van den Wall Bake (2004). A downward sloping historical cost curve was identified, which was mentioned as the experience curve in various studies (Coelho et al. 2006, Goldemberg et al. 2004a, van den Wall Bake et al. 2009). Basically, such cost reductions are due to technological improvements in both of the ethanol production and sugarcane production.

### *Sugarcane Production Cost Reduction*

Feedstock cost accounts for 60% - 70% of the final cost of ethanol production in Brazil. Thus, most of the cost reductions over years have been achieved in the agricultural phase – sugarcane production. Agricultural yield growth and the amount of the sucrose increased in the plant have played a very important role in the cost reductions. Since the beginning of 1970s, yields have grown about 33% in Sao Paulo State with the development of new species and the improvement of agricultural practices (van den Wall Bake et al. 2009, Wang 2006).

The development of sugarcane varieties aimed at increasing the sugar content in the sugarcane, developing disease resistant species, adapting to different soils and extending the crushing season (Martinelli and Filoso 2008, União da Indústria de Cana-de-Açúcar (UNICA) 2008).

Introduction of machinery for soil preparation, conservation and harvesting also helped in improving sugarcane agriculture. It was estimated that mechanized harvesting has allowed a significant cost reduction per ton of sugarcane (Jolly 2006). Gains in productivity and cost reductions have also been achieved with the introduction of operations research techniques in agricultural management and the use of satellite images for identifying varieties in planting and application rates for herbicides and fertilizers (Braunbeck et al. 2005, Martinelli and Filoso 2008).

### *Ethanol Production Technological Progress*

In the same time, ethanol production technology has advanced, especially in the fermentation process. Sugarcane is much more effectively fermented and greatly reduced the ethanol production cost. The main technological progresses are summarized in Table 5.

Table 5. Main technological improvements in the industrial process of ethanol production

| Process step | Actions | Average and best practice results |
|---|---|---|
| **Juice extraction** | Increase in crushing capacity<br>Reduction of energy requirements<br>Increase in yield of juice extraction | Extraction yield up to 97.5% (average yield around 96%) |
| **Fermentation** | Microbiological control<br>Yeast selection based on genetics and better yeast selection<br>Large scale continuous fermentation, better engineering and better control of process | Fermentation yield up from 83% to 91.2% (best practice 93%)<br>Production time down from 14.5 to 8.5 hours (best practice 5.0 hours)<br>Wine content up from 7.5% to 9.0% (best practice 11.0%)<br>Reduction of about 8% on ethanol costs owing to continuous fermentation and microbiological control |
| **Ethanol distillation** | Improvements in process control | Average yield up from 96% in the early 1990s to up to 99.5% (result also influenced by higher ethanol wine content) |
| **Sugarcane washing** | General improvements | Reduction in water consumption<br>Reduction in sugar losses (2% down to just 0.2% in some cases) |
| **Industry in general** | Instrumentation and automation | Impact on juice extraction, evaporation and fermentation, crystallization and steam generation |

Source: IAEA (2006), Pereira Jr et al. (2008)

## Social Impacts and Benefits

Ethanol production, including the agricultural and industrial segments, supports about 1.5 million jobs in Brazil, with a relatively low index of seasonal work (International Atomic Energy Agency (IAEA) 2006). The number of harvest workers was reduced in the past decades owing to the increase mechanization. Besides, the ethanol production also helped in reducing of atmospheric emission of sulphur oxides (SO), carbon monoxide (CO), particulates and volatile organic compounds (VOCs) from vehicles (La Rovere et al. 2011, Schaffel and La Rovere 2010). The World Resources Institute (WRI) estimates that Brazil's development of ethanol not only has saved US$100 billion on its oil imports, but also has reduced its carbon dioxide emissions by about 574 million tons since 1975, which is equivalent to ten per cent of the country's emissions during that period (Almeida et al. 2007, OECD/IEA 2006, Schaffel and La Rovere 2010).

## Brazilian Sugarcane Ethanol Policies

Biofuel could not be commercially viable without significant government support. Brazilian government initiated the Pró-Álcool program in 1975, creating the conditions for large-scale development of the sugar and ethanol industry (Grad 2006, Soccol et al. 2005, Sorda et al. 2010, Wang 2006). The program has the basic components as follows:

> (a) The state-owned oil producer and distributor of transportation fuels (Petrobras) had the obligation to purchase a guaranteed amount of ethanol;
>
> (b) The agribusiness sector received incentives (in the form of low-interest loans) to develop the ethanol production infrastructure;
>
> (c) Ethanol was sold at the pump for 59 per cent of the price of gasoline, to make it attractive for consumers.

Following the second major oil shock, in 1979, a more ambitious and comprehensive program was implemented. A series of tax and policy incentives was introduced to promote the development of new plants and the use of purely ethanol-fuelled vehicles (Almeida et al. 2007, FAO 2008c, Moreira and Goldemberg 1999).

Since the late 1980s, Brazil began to deregulate the fuel supply system. By 1990 alcohol replaced one half of the gasoline that would be otherwise consumed in the country (Moreira and Goldemberg, 1999). In 1990, the planning and implementation of the industry's production, distribution and sales activities were gradually transferred to the private sector. The use of hydrated ethanol as fuel diminished drastically. In 1993 a mandate blending requirement was introduced, specifying that 22 percent of anhydrous ethanol must be added to all petrol distributed at retail petrol stations (FAO 2008b).

Since 2000, Brazil has continued liberalizing the industry. Ethanol exports increased as a result of high oil prices in the world market. The dynamics of the sugar and ethanol industry began to depend much more on market mechanisms, particularly in the international markets. The industry has made enormous investments, expanding production and modernizing technologies, one of which is the investment in the in flex-fuel vehicles (FFVs)(Schmitt et al. 2011).

The introduction of FFVs has brought significant structural changes to the industry (Giesecke et al. 2008, Schmitt et al. 2011). As FFV drivers can choose to consume pure gasoline or E20 blending of ethanol and gasoline, ethanol will be preferred when the ethanol-gasoline relative price is lower than 0.7(Almeida et al., 2007). Since 2001, the relative prices have been in the 0.55–0.70 range over 80% of time. Since 2003, every time the price relationship has been unfavorable to ethanol (around 10% of time in 2003-2007); government has been called on to intervene in the ethanol market (D'Agosto and Ribeiro 2009).

Currently, there are no restrictions or subsidies on Brazilian ethanol production; the only ethanol policy is the mandate gasoline blending ratio of 20-25 per cent (La Rovere et al. 2011, Lehtonen 2011). On the other hand, ethanol receives government incentives in form of tax exemptions:

> Excise tax is exempted since 2004. The total federal taxes charged over gasoline amount to US$0.26/liter compared to US$0.01/liter on ethanol;
>
> VATs charged over gasoline and over ethanol are different in different states.

### ***Chinese Biofuel Industry***

China is the world's third largest fuel ethanol producer after the United States and Brazil, and is expected to become a major player in the global biofuel market. In 2005, Fuel ethanol production in China was around 310 million gallons (International Energy Agency (IEA) 2010, Renewable Fuels Association (RFA) 2008). By 2008, the fuel ethanol production capacity has reached 650 million gallons (Li and Chan-Halbrendt 2009). Fuel ethanol is mainly used for blending gasoline. E10 blended gasoline (10% ethanol and 90% gasoline) is used in five provinces and 27 cities, which was accounted for nearly 20% of national gasoline consumption in 2005 (Asia-Pacific Economic Cooperation (APEC) 2008).

Until late 2006, nearly 80% of the fuel ethanol in China is made from maize; the rest is made from other feedstock including wheat, cassava, and sugarcane. However, concerns about food insecurity have led the industry to turn to non-grain feedstock, such as sweet sorghum and sweet potato, which were viewed as transitional feedstock in the long term (Asia-Pacific Economic Cooperation (APEC) 2008). The Chinese government has restricted production of ethanol from maize since the end of 2006 (U.S. Department of Agriculture Foreign Agricultural Service (USDA-FAS) 2007). However, Chinese government will strategically promote biofuel in the coming years for the following reasons.

### Population Growth

Population growth is certainly an important factor, especially the increase in urban population. China currently has 1.33 billion of population, which is expected to grow at 0.5% annually in the coming years (UN Department of Economic and Social Affairs 2011). China, as one of the most populous countries, will continue to face rapid increase in demand for energy. Alternative energy development can help to meet the exploding demand (Gan and Yu 2008, Ma et al. 2009).

### Energy Security

China's energy consumption is dominated by coal, following by oil, hydroelectric power, natural gas, and nuclear (Figure 15). However, coal mining is not renewable, thus, not sustainable in the future. While crude oil as the second major energy source, is accounted for 20 per cent in the energy matrix (Ma et al. 2010).

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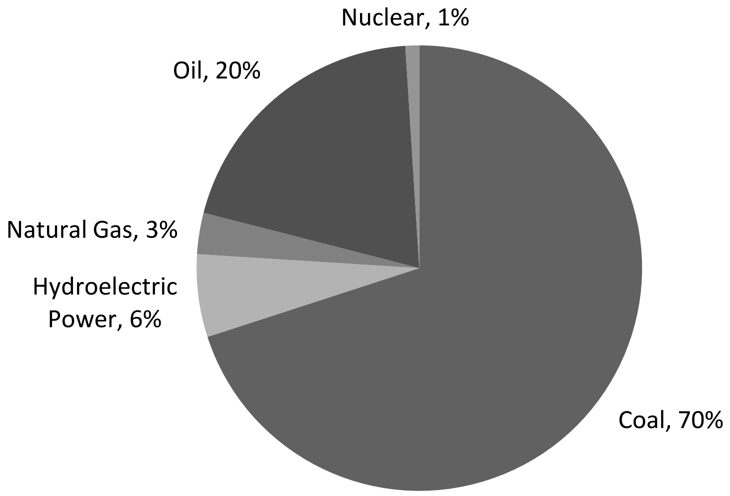


Figure 15. Chinese Energy Profile (2006)

Source: IEA (2010)

The demand for crude oil has continued to grow since when China began to open trade and experienced fast economic development in the 1980s (Anderson and Peng 1998). Since mid-1990s, Chinese's crude oil demand has outreached supply (Figure 16). The gap between domestic production and consumption is enlarging year by year (Anderson and Peng 1998). By 2009, half of Chinese domestic crude oil consumption has been imported. China is accounted for 40% of the growth in oil demand during 2005 to 2009 (International Energy Agency (IEA) 2010). The International Energy Agency (IEA) also projected that crude oil demand in China will more than double from 2004 to 2020 (International Energy Agency (IEA) 2004).

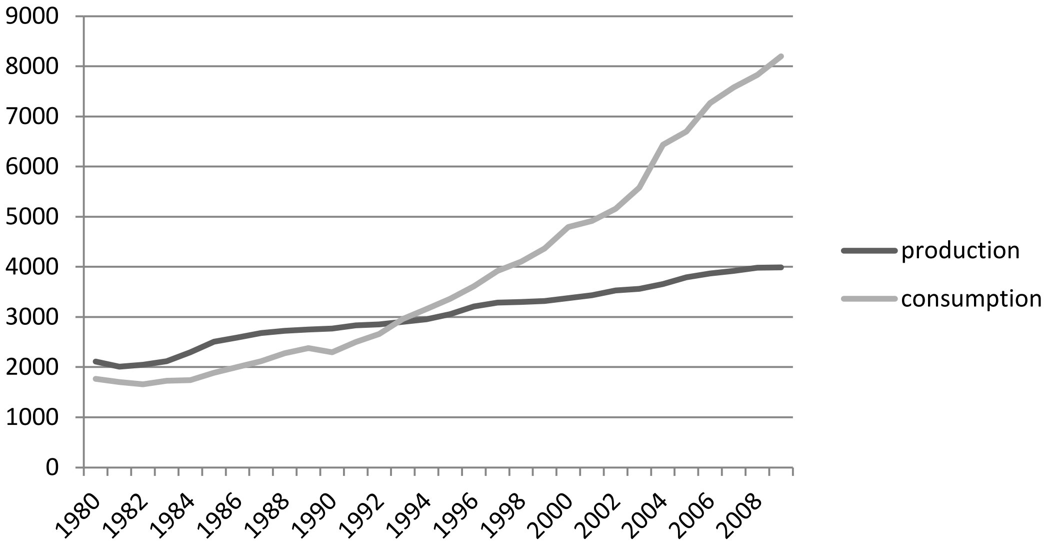


Figure 16. Crude Oil Productions and Consumptions in China (1980-2009)
Source: IEA (2010)

According to the Twelve Five-Year Plan (2010), Chinese economy will maintain an average annual growth of 7-8% in the coming years (The National Development and Reform Commission (NDRC) 2010). Fast urban development and expansion will continue. To fuel the emerging economy without heavily depending on foreign energy, and prepare for the shrinking coal mining, Chinese best strategy is to develop renewable fuels (Asian Development Bank (ADB) 2009).

## Motorization

Current biofuel production is mainly used in transportation sector. E10 blend is currently enforced in 6 provinces and expected to expand, and a higher blend will be introduce. But current production is far from enough to fulfill the mandate, given current aggressive motorization. Domestic car sales in China have dramatically increased from 2.2 million to 13.6 million during the last decades (Figure 17). And the growth rate is increasing year by year. It was anticipated that China could become the world's largest car market by 2020 (Ma et al. 2009).

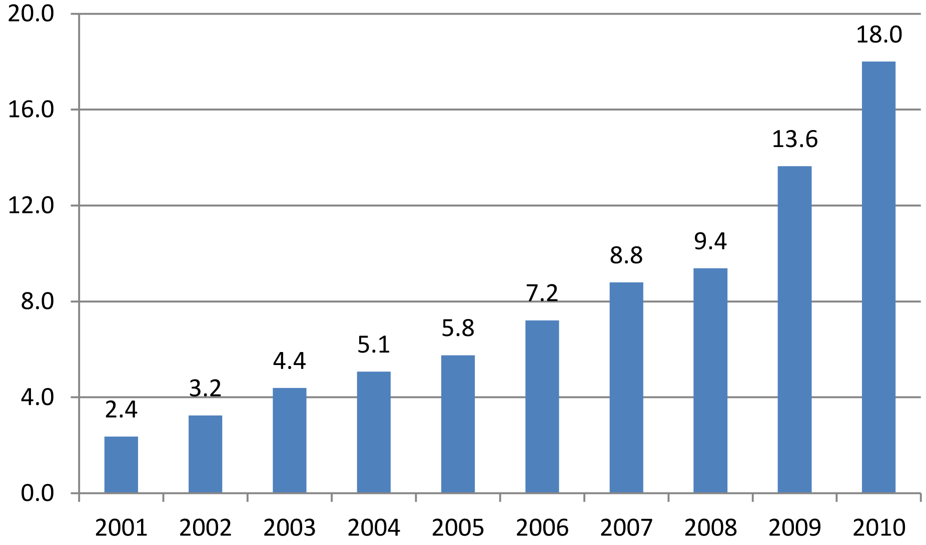


Figure 17. Chinese Domestic Automobile Sales, 2001-2010 (millions)
Source: NBSC (2001-2010)

## Environmental and Social Concern

Massive pollution from coal burning in China has raised global concern. A report by the World Wildlife Fund has estimated that the water pollution, air pollution and human loss have cost China an additional 262 billion dollars per year, or more than 7%

of GDP. The rapid increase in car ownership and use also brought much concern for increasing green house gas (GHG) emission (Fan et al. 2007, Yan and Crookes 2009a, Yan and Crookes 2009b). Alternative energy such as biofuel may solve this problem (Ou et al. 2010a, Ou et al. 2010b).

### Feedstocks

Currently, China mainly uses crops with high sugar content, to produce bioethanol via the first generation technology (Li and Chan-Halbrendt 2009). The use of biomass via the second generation technology is developing but far from mature, thus, not economically viable yet.

#### *Maize and Wheat*

Maize and wheat is currently the leading bioethanol feedstock in China. Although maize is widely planted all over China, the production is concentrated in the northeast region and the North China Plain, which accounted for about 70% of the total maize production (U.S. Department of Agriculture Foreign Agricultural Service (USDA-FAS) 2007). In 2006, maize contributed 90% of China's fuel ethanol feedstock (U.S. Department of Agriculture Foreign Agricultural Service (USDA-FAS) 2007). However, the maize used before 2006 was mainly China's reserve stock, which has been exhausted by 2006. When China started to use fresh maize, domestic maize price soared and concern for food insecurity was raised (U.S. Department of Agriculture Foreign Agricultural Service (USDA-FAS) 2007). However, in 2007, maize still accounted for 80% of China's fuel ethanol production, while wheat accounts for 15%. It is expected that maize and wheat are still the leading biofuel feedstock in China in the near future (Wang and Tian 2011, Zhang et al. 2009).

### *Sweet Sorghum*

For its high energy content, high photosynthesis efficiency and high biomass production capacity, sweet sorghum is considered as the most important feedstock to be used in bioethanol production in China in the future (Qiu et al. 2010). Sweet sorghum is a genotype of sorghum, which is rich in sugar and moisture. As sweet sorghum also has high tolerance to drought and water logging and can be planted on saline alkali soils, it is planted in almost every province in China. However, sweet sorghum production is currently very limited, mostly in northern China. In 2006, total production of sorghum amounted to 2,098 tons, most of which was used for alcohol production. Much sorghum farmland is gradually switched to planting sweet sorghum instead of sorghum. It is estimated that, if the sorghum-growing land used for cultivating sweet sorghum amounts to 20% in 2020, then there will produce 1.12 million ton (370 million gallons) of bioethanol (Ma et al. 2009, Wang and Tian 2011).

### *Cassava*

Cassava is considered as the second most important bioethanol feedstock. In 2008, a new cassava-based bioethanol plant was established in the Guangxi Province, with an annual production capacity of 200 thousand tons (66 million gallons). Because cassava also has high tolerance to drought and barren land, and high starch content, it is suitable to be a feedstock for bioethanol production. Currently, cassava is mainly used for starch and ethanol production in China. 90% of cassava in China is grown in the provinces of Guangxi and Guangdong; however, the amount produced is very small compared to other potential biofuel feedstock (Fan et al. 2007, Qiu et al. 2010). The first bioethanol production base using cassava went into operation in December 2007. In the same year, cassava accounted for 5% of China's fuel ethanol production (Yan et al. 2009). It is designed to produce 200,000 metric tons of biofuel annually out of about 1.5 million metric tons of cassava (Zhang et al. 2009).

#### *Sweet Potato*

Sweet potato is grown in most provinces in China, and is also considered as one of ideal feedstock for bioethanol. Starch content of sweet potato is around 20-30% which makes the feedstock have high biomass yield (Qiu et al. 2010, Zhang et al. 2009). However, production of sweet potato in China is very minor. We cannot have large bioethanol production using sweet potato.

#### *Sugarcane and Sugar Beet*

Sugarcane is another potential feedstock for bioethanol in China, which is primarily produced in southeast China. However, sugarcane production is very limited in China, only 99.8 billion tons in 2007. Moreover, China is a sugar importer and its sugar import has been rising and is projected to rise in the future. Given this situation, sugarcane is not considered as a leading biofuel feedstock currently (Chavez 2010).

### China's Renewable Fuel Policies

China's fuel ethanol industry was created in 2000 with strong government support, including subsidies and monetary payments (U.S. Department of Agriculture Foreign Agricultural Service (USDA-FAS) 2006). In early 2001, the first 5-year plan for bioethanol was announced. The Pilot Testing Program of Bioethanol Gasoline for Automobiles was issued by the National Development and Reform Commission (NDRC) and seven other ministries in early 2002 (U.S. Department of Agriculture Foreign Agricultural Service (USDA-FAS) 2007). It provided the following major policies:

> (i) The 5% consumption tax on all bioethanol under the E10 program was waived for all bioethanol plants.
>
> (ii) The value-added tax (normally 17%) on bioethanol production was refunded at the end of each year.
>
> (iii) All bioethanol plants received subsidized “old grain” (grains reserved in national stocks that are not suitable for human consumption) for feedstock. This subsidy was jointly provided by the central and local governments.
>
> (iv) The government offered a subsidy to ensure a minimum profit for the bioethanol plants. This meant that if, despite the other support mechanisms, any bioethanol plant were to record a loss in production and marketing, it would receive a subsidy equal to the gap between marketing revenues and production costs plus a reasonable profit that the firm could have obtained from an alternative investment. This subsidy is estimated for each plant at the end of each year.

The pilot testing program was expanded in 2004. Annual bioethanol use in automobiles was targeted at 1.02 MT (336 million gallons) in 2004 (Asian Development Bank (ADB) 2009).

Total subsidies to the ethanol producers were US$ 114 million in 2006. This amounts to US$ 73 per ton or about US$ 0.22 per gallon (Li and Chan-Halbrendt 2009). The subsidy level is expected to go up to US$ 616 million by 2020 or US$ 2 per gallon (Global Subsidy Initiative of the International Institute for Sustainable Development (IISD) 2008).

However, due to concerns on national food insecurity, government started to shift the support away from grain-based ethanol to non-grain-based ethanol and biodiesel production. Under the newly drafted 11th Five-Year Plan, "*a new subsidy will be granted to firms that develop a new production base of feedstock not currently produced in the existing cultivated land area*" (Asian Development Bank (ADB) 2009).

In June 2007, under the Renewable Energy Law guidelines, the NDRC formulated the Middle- and Long-Term Development Plan of Renewable Energy. This plan aims to increase annual bioethanol production to 4 MT (1.32 billion gallons) in 2010 and 10 MT (3.3 billion gallons) by 2020. According to the plan, E10 sales are to expand in more provinces in 2010, and E20 and E85 possibly will be introduced in 2020 (Asia-Pacific Economic Cooperation (APEC) 2008, Asian Development Bank (ADB) 2009).

On the other hand, ethanol use mandate is expanded gradually. In 2004, the government introduced the compulsory use of a 10% bioethanol blended gasoline (E10) in provinces of Helongjiang, Jilin, Liaoning, Henan, and Anhui. The government expands the E10 program to 27 cities in the provinces of Shandong, Jiangsu, Hebei, and Hubei in 2006 (Sang and Zhu 2011).

For the foreseeable future, the biofuel program in China will be determined by government policy rather than economics (U.S. Department of Agriculture Foreign Agricultural Service (USDA-FAS) 2006).

Major renewable policies in China are summarized in Table 6.

Table 6. Major laws, regulations and plans in relation to biofuel development

| | **Documents** | **Major Content** |
|---|---|---|
| **2001** | Standards on Denatured Fuel Ethanol (GB18350-2001) and Bioethanol Gasoline for Automobiles (GB19351-2001) | Establish national compulsory standards for the production of E 10 (gasoline mixed with 10% ethanol) |
| **2006** | Renewable Energy Law | Promote the development and utilization of renewable energies, optimize the energy structure, safeguard the energy safety and protect the environment |
| **2006** | Announcement regarding strengthening management of bioethanol projects and promoting healthy development of ethanol industry | Control market access and promote stringent project management; request the approval of the Central Government for any new ethanol plants |
| **2006** | Urgent announcement regarding development and management of maize processing projects | Restrain developing maize based ethanol and support the use of non-grain based feedstock such as cassava, sweet sorghum and cellulose materials |
| **2007** | Medium and Long-term Development plan for Renewable Energy in China | Set the target of biofuel production in 2010 and 2020 |
| **2007** | Guidance towards promoting healthy development of maize deep processing industry | Control expansion rate of maize deep processing industry; prioritize fodder production over other uses; promote coordinated development |
| **2008** | 11th Five Year Plan on Renewable Energy Development (2006-2010) | Set the development target of bioenergy till end of 2010 |

Source: adopted from Yang et al. (2009)

# CHAPTER IV

# METHODOLOGY

A two-step method will be used to study the effect of various biofuel policies. First, a base equilibrium for 2004 will be calibrated with the GTAP7 data. Then, a counterfactual equilibrium will be simulated with a global trade CGE model. Changes in household food consumption from 2004 base will be obtained. Secondly, using the FAO's method, changes in the percentage of world hunger will be calculated, and thus comes the number of undernourished people.

## ***Existing CGE Model***

The existing CGE model developed by (Bryant et al. 2010)is employed. Based on this model, two sectors, Brazil's Sugarcane Ethanol Production and Chinese Grain Ethanol Production, were added.

The existing model is based on the Global Trade Analysis Project (GTAP) data, the model is similar to that of McDonald et al. (2005) and McDonald et al. (2006)(McDonald et al. 2005, McDonald et al. 2006), but with more detailed representations of land use and agricultural and biofuel-related activities (Bryant et al., 2010). It is a global trade CGE model with 9 regions and 38 sectors, including 13 food sectors and 3 biofuel-related sectors for U.S., which is not seen in other similar models. Additionally, land is disaggregated using the agro-ecological zones (AEZs) definition. The following sections will highlight the model features. The detail description of the model can be found in the model documentation (Bryant et al., 2010).

**Data**

The primary data used to build up and calibrate the model is the GTAP database. The GTAP7 dataset contains flow of funds among 57 sectors within and between each of the 113 regions in 2004. It was converted to a social accounting matrix (SAM), which was used to calibrate parameters for the CGE model. Additionally, a supplementary GTAP database on land use was employed to better present land transformation in the agricultural sectors. The database records payments to the land in each of 18 separate agro-ecological zones (AEZs). Following the Koppen-style climate classification, the global endowments of land in the AEZs are illustrated in Figure 18.

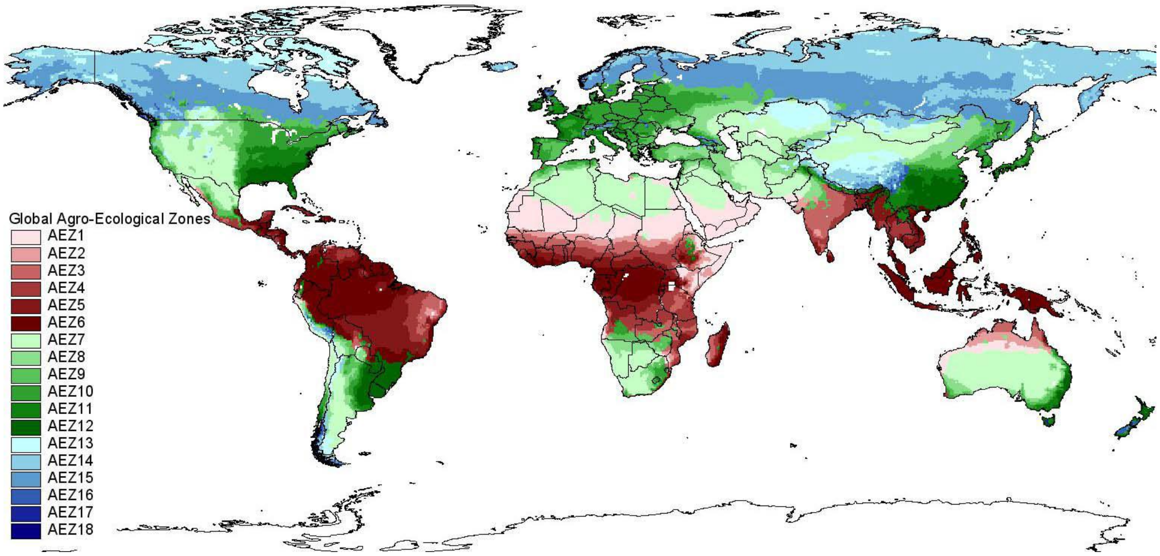


Figure 18. Global Endowments of Land in Agro-ecological Zones (AEZs)
Source: adopted from Bryant et al. (2010)

## Regions

The 9 regions in the model are aggregated from the 113 regions in the GTAP7 (Figure 19). The basis for the aggregation includes importance in agricultural and other trade, consistent treatment under trade policy, and geographical proximity. Regional aggregation was also chosen to reduce computational difficulties.

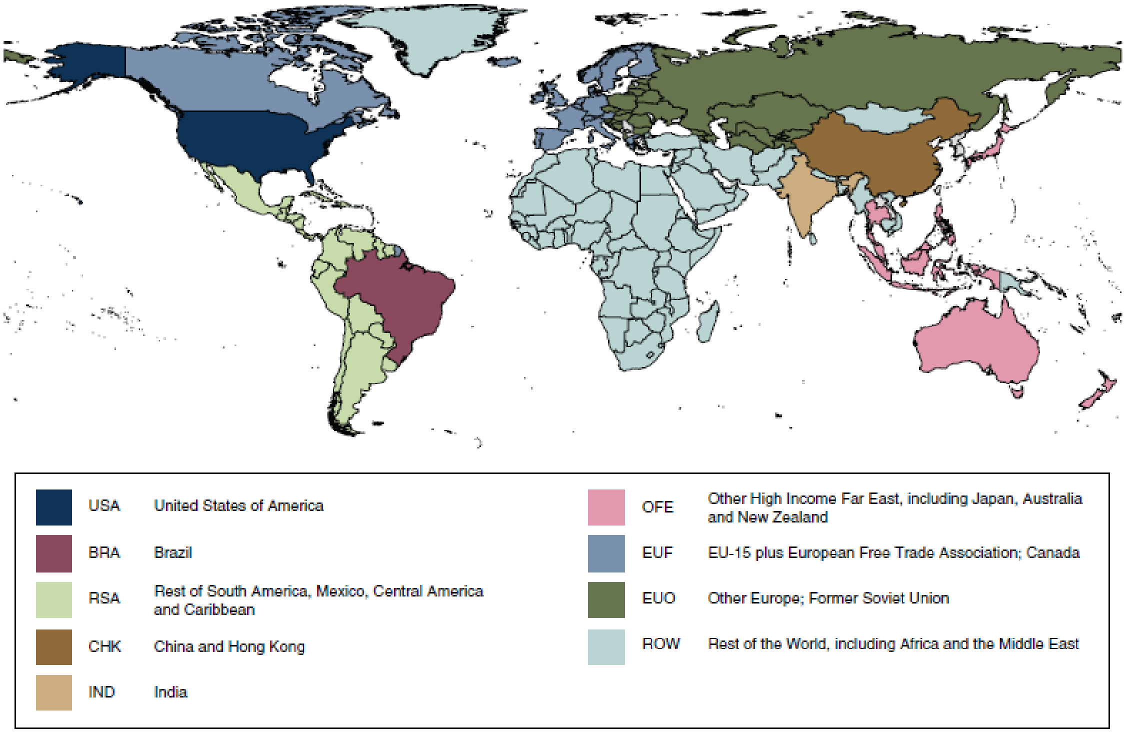


Figure 19. Map of CGE Regions

Source: adopted from Bryant et al. (2010)

## Sectors

The 35 common sectors are aggregated from the 57 sectors in GTAP7 (Table 7).

Table 7. Sectors Represented in the Model

| **GTAP7 Sectors** | | **New Sectors** |
|---|---|---|
| **Food Sectors** | | |
| **wht** | Wheat | US switch grass |
| **gro** | Other cereal grains | US grain ethanol |
| **v_f** | Fruits/Vegetables | US cellulosic ethanol |
| **osd** | Oil seeds | |
| **oap** | Other animals and products | |
| **sgr** | Processed sugar | |
| **ofb** | Other food and beverage products | |
| **cmt** | Meat products (corresponds to ctl) | |
| **omt** | Other meat products | |
| **vol** | Vegetable oils and fats | |
| **mil** | Dairy products | |
| **pcr** | Processed rice | |
| **fsh** | Fishing | |
| **Other Sectors** | | |
| **pdr** | Paddy rice | |
| **pfb** | Plant-based fibers | |
| **ocr** | Other crops | |
| **ctl** | Livestock (cattle, sheep, goats) | |
| **rmk** | Raw milk | |
| **c_b** | Sugar cane and beets | |
| **frs** | Forestry and logging | |
| **wol** | Wool and silk worm cocoons | |
| **coa** | Coal mining | |
| **oil** | Crude oil extraction | |
| **gas** | Natural gas extraction | |
| **omn** | Other mineral mining | |
| **clt** | Textiles and clothing products | |
| **wdp** | Wood and paper products | |
| **p_c** | Petroleum and coal products | |
| **crp** | Chemical rubber and plastic products | |
| **mfg** | Other manufactured products | |
| **ely** | Electricity | |
| **gdt** | Gas manufacturing and distribution | |
| **wtr** | Water | |
| **srv** | Services | |
| **trn** | Transportation | |

Additional 3 biofuel-related sectors are modeled separately. As presented in Table 7, the food sectors are highly disaggregated, thus it is more accurate to calculate the food-insecure population using the simulation results.

### Primary Factors

Each region is endowed with primary factors, including capital, labor, land and natural resources. Firms choose an optimal bundle to produce commodities. Except for lands, all primary factors are treated as homogeneous across sectors. Land endowments in each of the 18 AEZs are imperfect substitutes in producing commodities. The supply of land follows a nested constant elasticity of transformation (CET) function as in Figure 20. At first stage, land owners choose to supply land to forestry or agricultural land. At second stage, agricultural land is allocated between cropland and pastureland. At the final stage, livestock and dairy production activities compete for pastureland for each AEZ, and primary agricultural production activities compete for cropland for each AEZ.

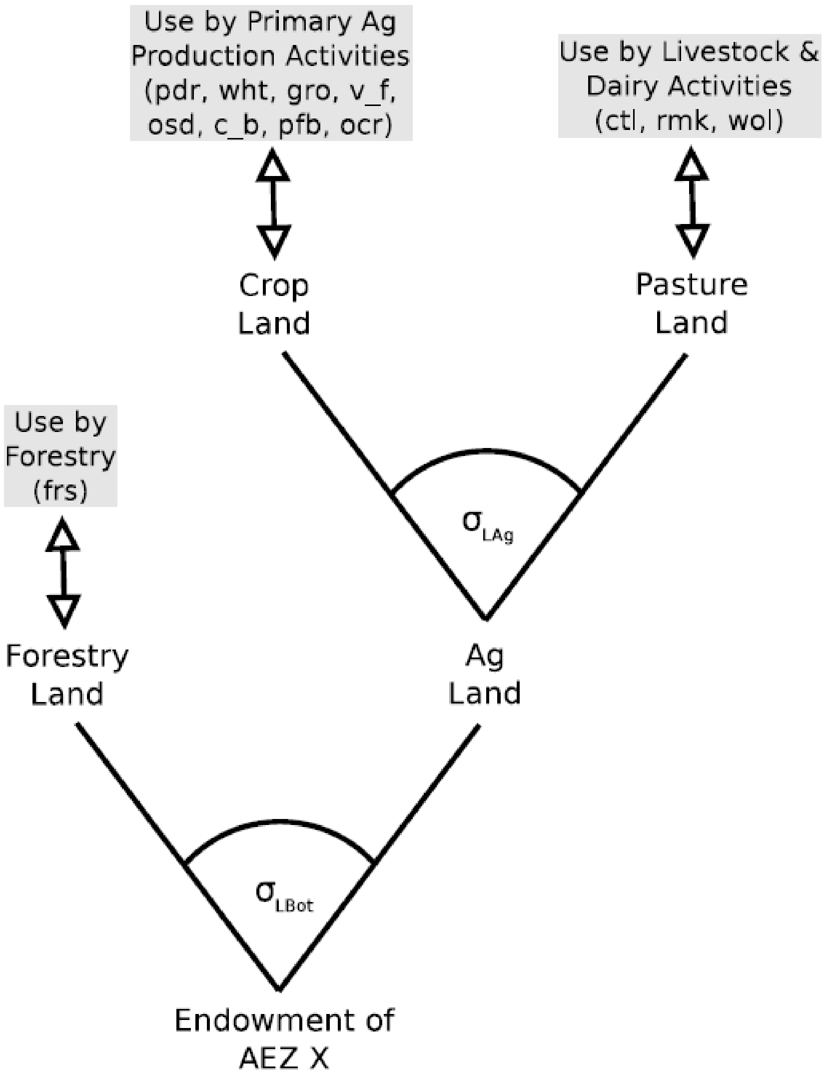


Figure 20. Land Transformation

### Production

Production is modeled with nested constant elasticity of substitution (CES) technology. A representative firm maximizes profit by choosing its production level, values-added inputs, land inputs and intermediate inputs, subject to its production technology constraint. A common production function is assumed. Parameters of the production function are calibrated using the GTAP7 data. And special cases, such as Leontief and Cobb-Douglas technologies are allowed. The nested structure of production is presented in Figure 21. This setup is applied to the productions of all standard commodities, Chinese grain ethanol and Brazilian sugarcane ethanol.

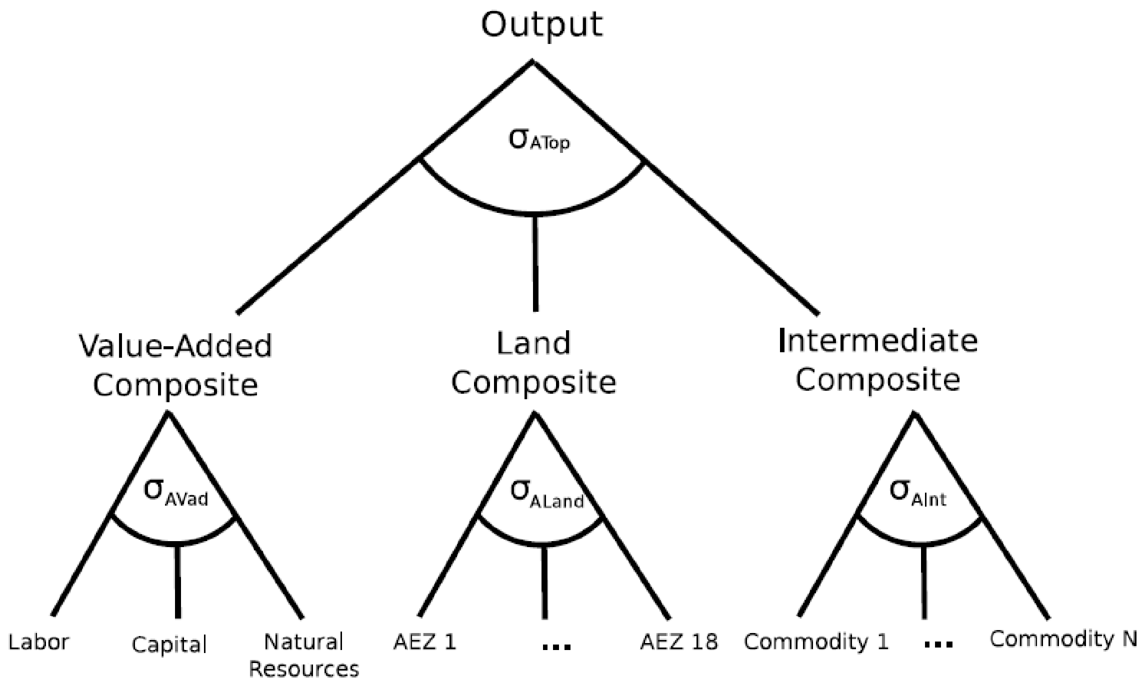


Figure 21. Nested CES Production for Standard Commodities

*U.S. Biofuel-related Sectors*

As mentioned earlier, the biofuel-related sectors are not represented in the GTAP dataset. Productions of U.S. switch grass, U.S. grain ethanol, and U.S. cellulosic ethanol activities are added to the model using nested CES production technology, which is similar to other standard production activities.

Corn stover is modeled as the by-product of cereal grain production in U.S., and a 30% collection rate is assumed (Figure 22).

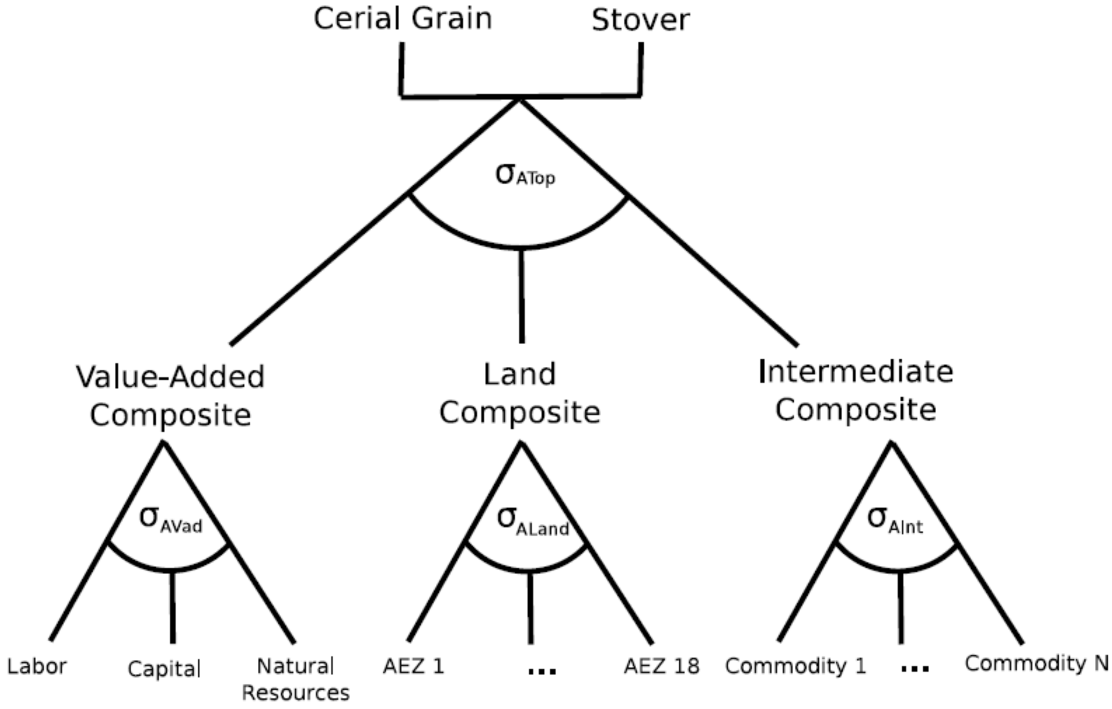


Figure 22. Corn Stover Nest

Corn stover and switch grass are used as intermediate inputs in cellulosic ethanol production in U.S.  Cereal Grain is used as intermediate input in grain ethanol production in U.S. and China. Sugarcane is used as intermediate inputs in sugarcane ethanol production in Brazil. In U.S., both of grain ethanol and cellulosic ethanol production contribute to the biofuel sector. In China and Brazil, only grain ethanol or sugarcane ethanol contributes to the biofuel sector. The Biofuel sector together with the Traditional Petroleum and Coal Products sector form the New Petroleum and Coal Products sector using a CET technology (Figure 23).

Cost of ethanol in U.S. is calculated as average cost of grain ethanol and cellulosic ethanol weighted by quantity. Final price of ethanol reflects government subsidies per gallon. The minimum production levels are specified reflecting government mandates.

All production functions of the U.S. biofuel-related sectors are calibrated with cost share and total cost information from a broad review of literature (Campiche 2009) (Bryant 2009). Detail cost breakdowns are presented in Table 8.

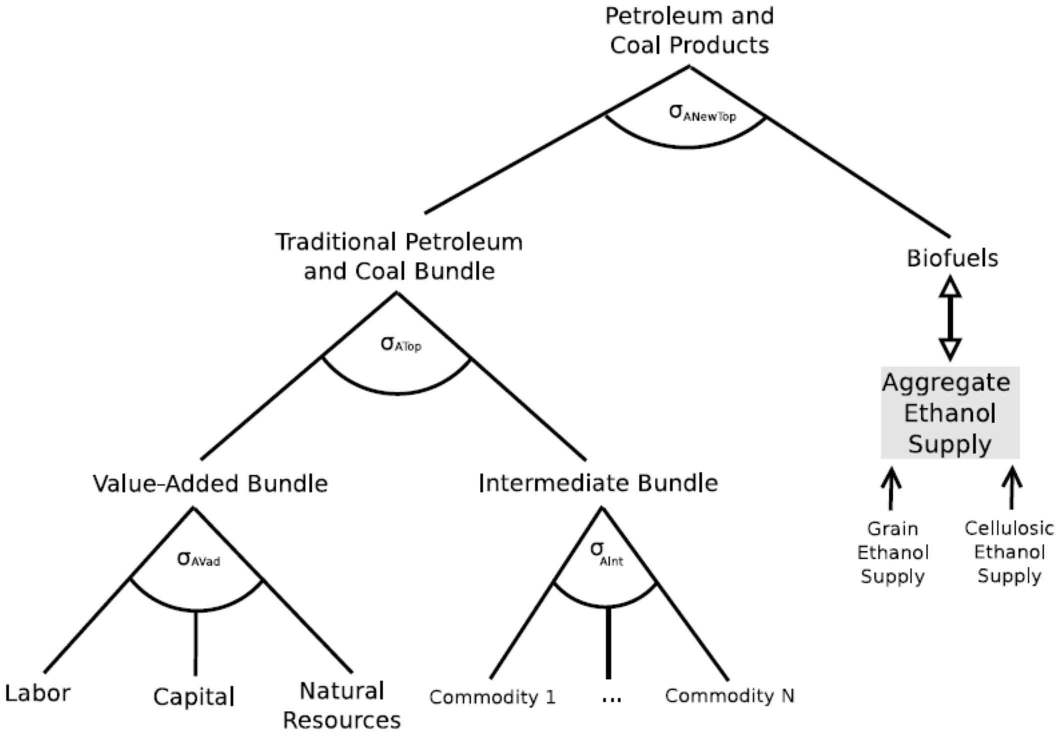


Figure 23. New Petroleum and Coal Products Nest

Table 8. U.S. Ethanol-related Production Costs Breakdown

| | **Grain Ethanol ($/gal)** | **Cellulosic Ethanol ($/gal)** | **Switch grass ($/ton)** |
|---|---|---|---|
| Capital | 0.21 | 0.52 | 9.99 |
| Labor | 0.11 | 0.25 | 10.41 |
| Biomass | | 0.77 | |
| AEZ7 | | | 0.22 |
| AEZ8 | | | 8.84 |
| AEZ9 | | | 8.84 |
| AEZ10 | | | 1.11 |
| AEZ11 | | | 1.11 |
| AEZ12 | | | 1.99 |
| Other cereal grains | 0.47 | | |
| Other crops | | | 1.03 |
| Other mineral mining | | | 0.46 |
| Textiles and clothing products | | | 0.46 |
| Wood and paper products | | | 0.05 |
| Petroleum and coal products | 0.08 | 0.02 | 1.37 |
| Chemical rubber and plastic products | 0.09 | 0.29 | |
| Other manufactured products | | | 19.52 |
| Electricity | 0.07 | 0.02 | |
| Gas manufacturing and distribution | 0.05 | | |
| Water | 0.01 | 0.01 | |
| Transportation | 0.12 | 0.2 | |
| **Total** | **1.21** | **2.08** | **65.40** |

Source: adopted from Bryant et al. (2010)
Note: See Figure 18 for definitions.

## Households

A single representative household is model with nested CES utility function for each region, which is illustrated in Figure 24. The household is endowed with primary factors of production, and receive payments to the primary factors. The primary factors include capital, labor, land and natural resources, which are fully mobile across sectors, but immobile across regions. The household maximizes utilities by choosing optimal saving and commodities consumptions, subject to a budget constraint.

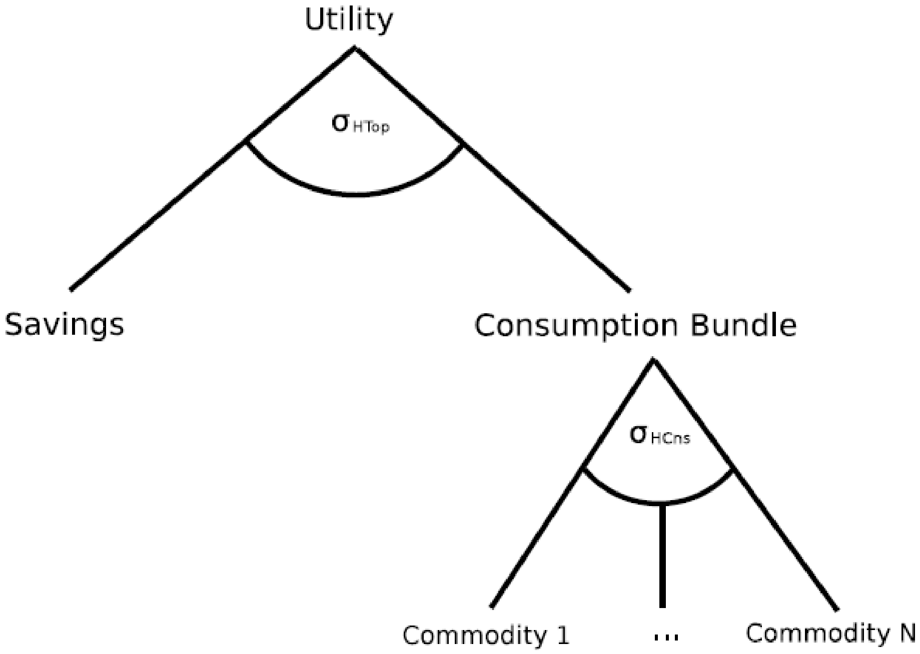


Figure 24. Nested CES Household Utility

### Government

Government within each region is modeled to collect *ad valorem* taxes, including sales tax, import and export taxes, and factors taxes on production activities. Government uses the tax revenue to purchase goods and make transfer payments to households within the region. And all government income is exhausted.

### Trade

Armington trade is assumed in the model, where domestically produced and imported goods are imperfect substitutes (Armington gton, 1969). For each commodity, domestic output is allocated between export and domestic use according to a nested constant elasticity of transformation (Fawcett and Sands)(CET) function (Figure 25). For each commodity, a composite bundle, which consists of domestic produced and imported goods by a nested CET function, is allocated among end users. All the trade elasticities are specified exogenous.

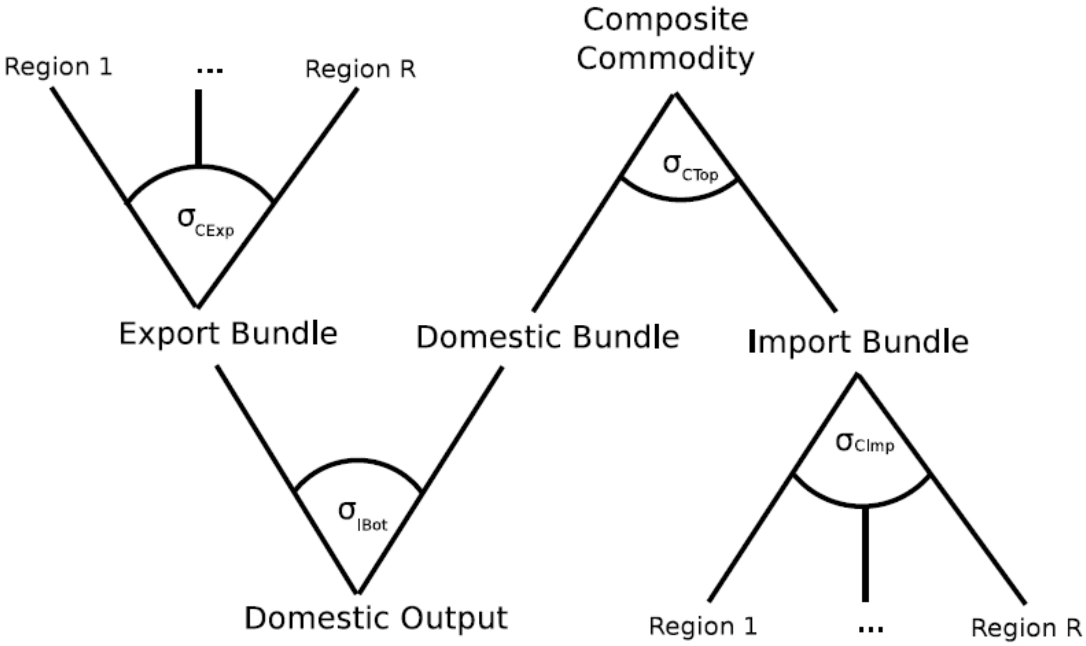


Figure 25. Trade System

## Model Closure

Primary factors are fully employed in each region. Government spending is flexible to exhaust revenue within each region. Exchange rates are flexible. Saving rate is fixed for the representative household in each region.

### *Adding Biofuel Sectors for Brazil and China*

Similar to the U.S. biofuel sectors, the Brazilian Sugarcane Ethanol Production and Chinese Grain Ethanol Production sectors are incorporated using the method and same nest structure, except they only have one type of biofuel. The production functions of both types of bioethanol are calibrated using the cost share and total cost information from other studies. Thereafter, they are incorporated to the new petroleum and coal products sector by a CES function. And prices and quantities will be linked by adding equations. Policy instruments will be imposed too.

### Brazil's Sugarcane Ethanol Production Cost

Although ethanol production is concentrated in the Sao Paulo area, production cost varies in different plants. It is difficult to come up with a single cost structure, especially when exchange rate frustrated a lot in recent years.

Recent studies of Brazil's ethanol production mainly focus of the energy input-output ratios, and the greenhouse gas (GHG) balance involved in production and consumption. Very few literatures discussed the economic cost of Brazil's ethanol production after it became cost competitive to fossil fuel, and detailed breakdowns of production cost in recent years are not easily found in literature. Production costs breakdowns found in studies are not very detailed, which only include categories of investment costs, operation costs and other costs (van den Wall Bake et al. 2009). Relatively more detailed estimates of costs were only found in Outlaw (2007) and Henniges and Zeddies (2004). Outlaw (2007) estimated the detailed cost of ethanol production, according to the expert manager of Alcohol for Dedini and the CEO of Chaves consultant firm. Henniges and Zeddies (2004) estimated the cost breakdown of ethanol production in Brazil according to an expert consulted (Henniges and Zeddies 2004). The average of these two estimates is used to calibrate the production function (Table 9). In addition, feedstock cost is updated to 2004 producer price. The producer price for Brazilian sugarcane in 2004 was estimated as $ 9.76 US/ton (FAO 2009). The conversion factor, 20.88 gallons of ethanol per ton of sugarcane is calculated as the average estimates from various literatures (Henniges and Zeddies 2004, International Energy Agency (IEA) 2004, Outlaw et al. 2007, Shapouri and Gallagher 2005, União da Indústria de Cana-de-Açúcar (UNICA) 2008, USDA 2006). Thus the feedstock cost in 2004 is estimated at $0.47 US/gallon of ethanol, about 45% of the total cost. We did not differentiate the dehydrated ethanol and hydrated ethanol, as the cost difference is very subtle when weighted by production quantity. The total cost of sugarcane ethanol in 2004 is $1.05 US/gallon. Detail cost breakdown is stated in Table 9. In 2004, 3,989 million gallons of Brazilian sugarcane ethanol was produced (Renewable Fuels Association (RFA) 2008).

Table 9. Brazilian Sugarcane Ethanol Production Cost Breakdown

| | **Outlaw (2007)** | **Henniges (2004)** | **$/gal** | **Share** |
|---|---|---|---|---|
| Feedstock (Sugarcane) | 0.91 | 0.323 | 0.467 | 0.444 |
| Labor | 0.10 | 0.023 | 0.062 | 0.058 |
| Capital | 0.32 | 0.062 | 0.191 | 0.181 |
| Water | 0.10 | 0 | 0.050 | 0.047 |
| Other manufactured products | 0.36 | 0.25 | 0.273 | 0.259 |
| Service | 0 | 0.022 | 0.011 | 0.010 |
| **Total** | **1.80** | **0.6795** | **1.053** | **1** |

## Chinese Grain Ethanol Production Cost

As the technology to produce first generation biofuel from other feedstocks is not mature, and second generation biofuel is not commercially viable currently, information of the detail cost breakdowns is very limited. And related cost studies are rarely found in the literature, only the grain-based ethanol is incorporated in the CGE model in this study. Production cost shares are obtained from Li and Chan-Halbrendt (Li and Chan-Halbrendt 2009). Similarly, cost of corn is updated to the 2004 base year producer price reported by FAO at $189.69 US/ton. Conversion factor is 92.8 gallons per ton of corn, which is the average industry level estimated by the China National Chemical Information Center (China National Chemical Information Center (CNCIC) 2008).

The total cost of grain-base ethanol is $2.36 US/gallon, which is the highest of all biofuels in the model. Detail cost breakdown is stated in Table 10.

Table 10. Chinese Grain Ethanol Production Cost Breakdown

| | **$/gal** | **Share** |
|---|---|---|
| Capital | 0.180 | 0.076 |
| Labor | 0.013 | 0.006 |
| | | |
| Feedstock (Corn) | 2.044 | 0.865 |
| Petroleum and coal products | 0.108 | 0.046 |
| Other manufactured products | 0.017 | 0.007 |
| **Total** | **2.362** | **1** |

## Adding New Sectors to the Model

With the above cost information, a SAM table was constructed adjusted by tax rates for Brazil and China separately. The tax rates were obtained from the GTAP SAM data. The constructed SAM data shows total quantities of each input used in producing ethanol in Brazil and China with unit price assumption. This constructed SAMs represent the biofuels production activity in Brazil and China in 2004, respectively.

Both of the Brazilian sugarcane ethanol production and Chinese grain ethanol production feature with a constant elasticity of substitution (CES) technology with two hierarchy nests, and is built in a bottom-up manner (Figure 26 and Figure 27). The bottom nests include the value-added input nest and the intermediate input nest. The value-added nest represents the substitution between labor and capital, while the intermediate nest represents the substitution among all the intermediate inputs. The top nest represents the substitution between the composite value-added bundle and the intermediate input bundle.

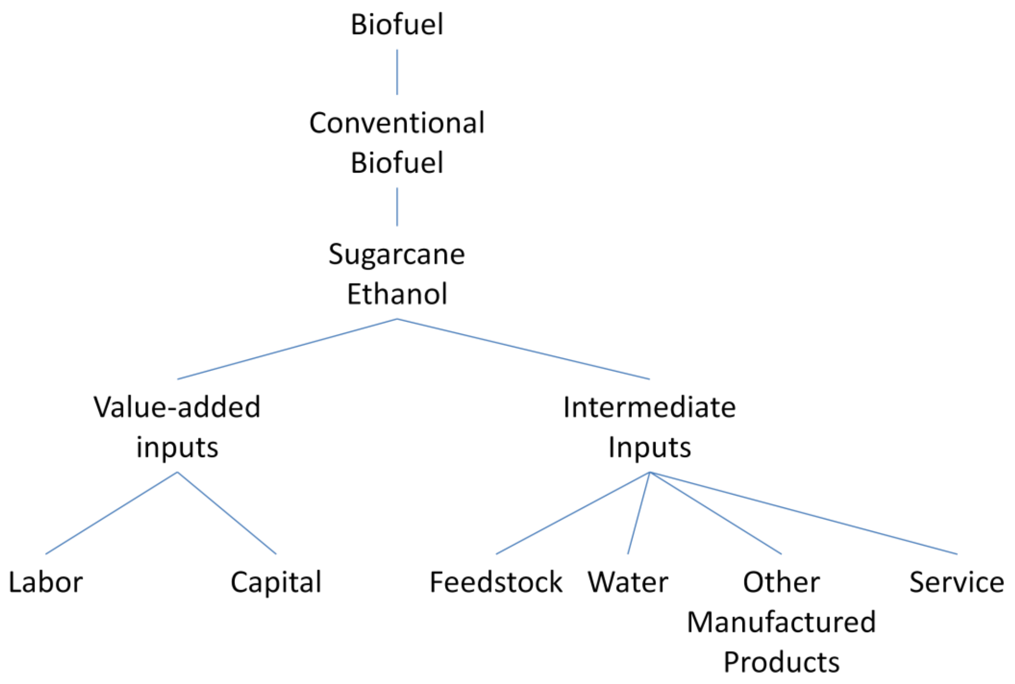


Figure 26. CES Production Structure for Brazil

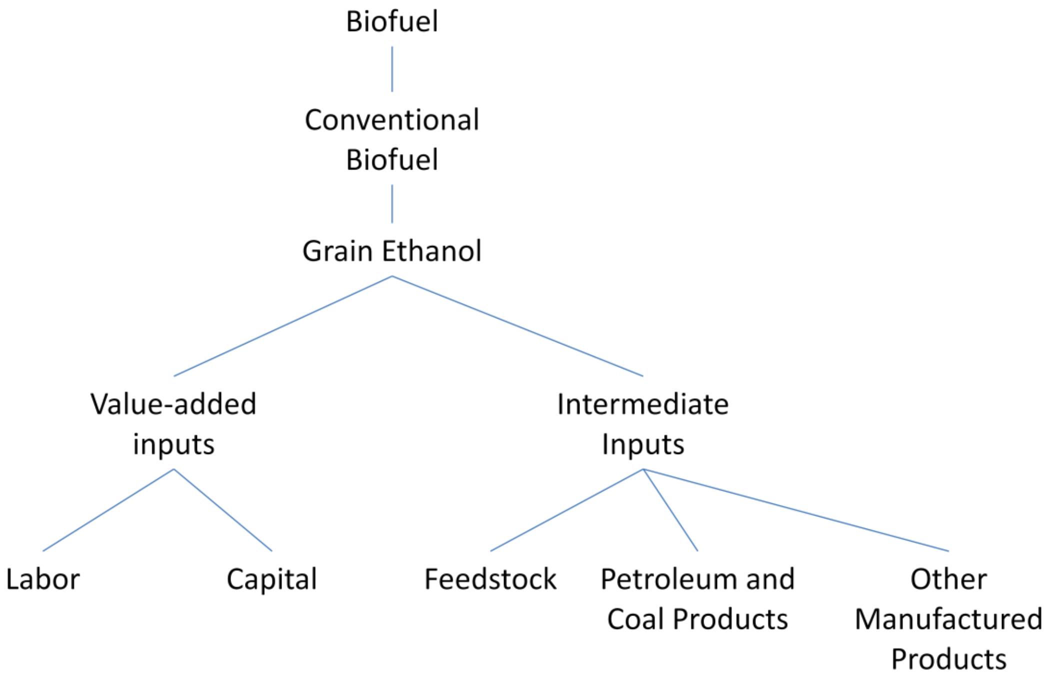


Figure 27. CES Production Structure for China

The production functions are then calibrated to the constructed SAM data. After calibration, the Brazilian sugarcane ethanol sector and the Chinese grain ethanol sector are incorporated to the existing CGE model by specifying equations as follows.

As there is only one type of biofuel in Brazil and China, for the ease of adding new biofuel sectors to the model, biofuel production and conventional biofuel production sectors are added as identity to the sugarcane ethanol or grain ethanol in the model. Prices and quantities of the ethanol are linked as follows:

$$P_{BRA,\ biofuel} = P_{BRA,\ Conv} = P_{BRA,\ sugarcane-Ethanol}$$

$$P_{CHK,\ biofuel} = P_{CHK,\ Conv} = P_{CHK,\ \mathrm{grain}-Ethanol}$$

$$Q_{BRA,\ biofuel} = Q_{BRA,\ Conv} = Q_{BRA,\ sugarcane-Ethanol}$$

$$Q_{CHK,\ biofuel} = Q_{CHK,\ Conv} = Q_{CHK,\ \text{grain}-Ethanol}$$

Policy instruments are also added. The price of ethanol paid by consumers is calculated as the production cost of ethanol minus per gallon subsidy.

$$P_{BRA,\ final} = P_{BRA,\ biofuel} - BRA\ Subsidy$$

Unlike Brazil, China government has an estimated total subsidy for biofuel, which was reported as 616 million in 2020 (Li and Chan-Halbrendt 2009). Therefore, per gallon subsidy is a function of the biofuel quantity in China, and is calculated as total subsidy divided by total quantity of production.

$$P_{\text{CHK},\ final} = P_{CHK,\ biofuel} - \frac{CHK\ Total\ Subsidy}{Q_{CHK,\ biofuel}}$$

The market excess supply of ethanol for both of Brazil and China is

$$Q_{r,\ biofuel} - Q_{r,\ demanded} \geq 0 \quad r = BRA, CHK$$

The policy mandates are imposed as the minimum levels of biofuel supply in the model.

$$Q_{r,\ biofuel} - Mandate_r \geq 0 \quad r = BRA, CHK$$

A new composite petroleum and coal product for consumption in Brazil and China is aggregated by old petroleum and coal products and the grain based ethanol using a CET nest similar to the U.S. The elasticities of substitution, sigmas are exogenously defined. Again, biofuel is not tradable in this model.

### *Adding Food Insecurity Measure*

The FAO method of Food Insecurity measurement is used to map the CGE outputs to the levels of world food insecurity. The aggregated regional CVs, $r_{L,}$, and mean in the base year 2004 are needed. To estimate the regional aggregated daily calorie intake distribution, the Monte Carlo two-step simulation method was adopted. First a country *i* was randomly drawn within the region with probabilities equal to the population weights. Then a number from the specific country's distribution $f_i(x)$ was randomly drawn.  Repeat these two steps, 65,500 numbers were simulated for each region, and $f(x)$ is plotted as the distribution of daily calorie intake. All the simulated distributions appeared to be uni-modal with a log-normal shape.

Food items in the Food Balance Sheets (FBSs) are aggregated into the CGE model for each region. Detail mappings are presented in Table 11. Within each region, the per capita dietary energy supply in each food sector for each country was aggregated by population weights, using the 2004 Food Balance Sheets. The mean ($\bar{x}_i$) for each region *i* in the base year is calculated as the summation of daily per capita calorie intake from each of the 13 food sectors.

Table 11. Aggregation of the food items in the Food Balance Sheets (FBSs)

| **CGE Sectors** | | **Food Balance Sheet Items** |
|---|---|---|
| **wht** | Wheat | Wheat |
| **pcr** | Processed rice | Rice (Milled Equivalent) |
| **gro** | Cereal grains | Barley<br>Maize<br>Rye<br>Oats<br>Millet<br>Sorghum<br>Cereals, Other |
| **sgr** | Sugar | Sugar and Sweeteners |
| **osd** | Oil seeds | Oilcrops |
| **vol** | Vegetable oils and fats | Vegetable Oils |
| **v_f** | Fruits and vegetables | Vegetables<br>Fruits - Excluding Wine<br>Starchy Roots<br>Pulses |
| **ofb** | Other food and beverage products | Stimulants<br>Alcoholic Beverages |
| **cmt** | Bovine meat products | Bovine Meat |
| **omt** | Other meat products | Mutton and Goat Meat<br>Pigmeat<br>Poultry Meat<br>Meat, Other |
| **oap** | Other animal products | Offals, Edible<br>Animal Fats<br>Eggs |
| **mil** | Dairy products | Milk - Excluding Butter<br>Butter, Ghee<br>Cream |
| **fsh** | Fishing | Fish, Seafood<br>Aquatic Products, Other |

Similarly, the lowest energy requirement level $r_L$ is aggregated with population weights of the countries within the specific region. With the daily calorie intake distribution $f(x)$, the lowest energy requirement level ($r_L$) for each region, and the mean $\bar{x}$

corresponding to the results from the CGE model, we can calculate the proportion of undernourished people within each region for different scenarios.

### Descriptive Statistics

The aggregated regional distribution of calorie intake maintained a uni-modal shape for all regions. Table 12 presents the basic food insecurity statistics by regions in 2004. There are total of 840 million of world hunger in 2004. The most food-insecure regions are India, China, Rest of the World, Other Far East, and Latin America and Caribbean. Four of them are also the most populous regions. In these food-insecure regions, the average food supply is less than 3000 kcal per capita per day, and more than 10% of the population is undernourished.

Figure 28 presents the percentage of food calorie intake from aggregated food groups. In 4 of the 5 most food-insecure countries, more than 50% of calorie intake is from food grain cereals (wheat, rice, and other cereal grains), and less than 20% of the calorie intake is from meat and animal products. While in the developed countries, people consume more meat and less food cereal grains.

Table 12. Food Insecurity Statistics in 2004

| Region | Total Population (million) | $r_L$ | Food supply (kcal/capita/day) (kcal) | % Undernourished | Undernourished Population (million) |
|---|---|---|---|---|---|
| India | 1,117 | 1770 | 2330 | 0.26 | 287 |
| Rest of the World | 1,701 | 1615 | 2460 | 0.15 | 259 |
| China and Hong Kong | 1,312 | 1900 | 2938 | 0.11 | 149 |
| Other Far East | 569 | 1836 | 2560 | 0.14 | 80 |
| Latin Amer. and Caribbean | 361 | 1826 | 2796 | 0.10 | 37 |
| Eastern Europe | 383 | 1941 | 3053 | 0.04 | 17 |
| Brazil | 184 | 1850 | 3095 | 0.06 | 11 |
| Western Europe | 429 | 1990 | 3610 | 0.00 | |
| United States | 296 | 1990 | 3829 | 0.00 | |
| **Total** | **6,355** | | | | **841** |

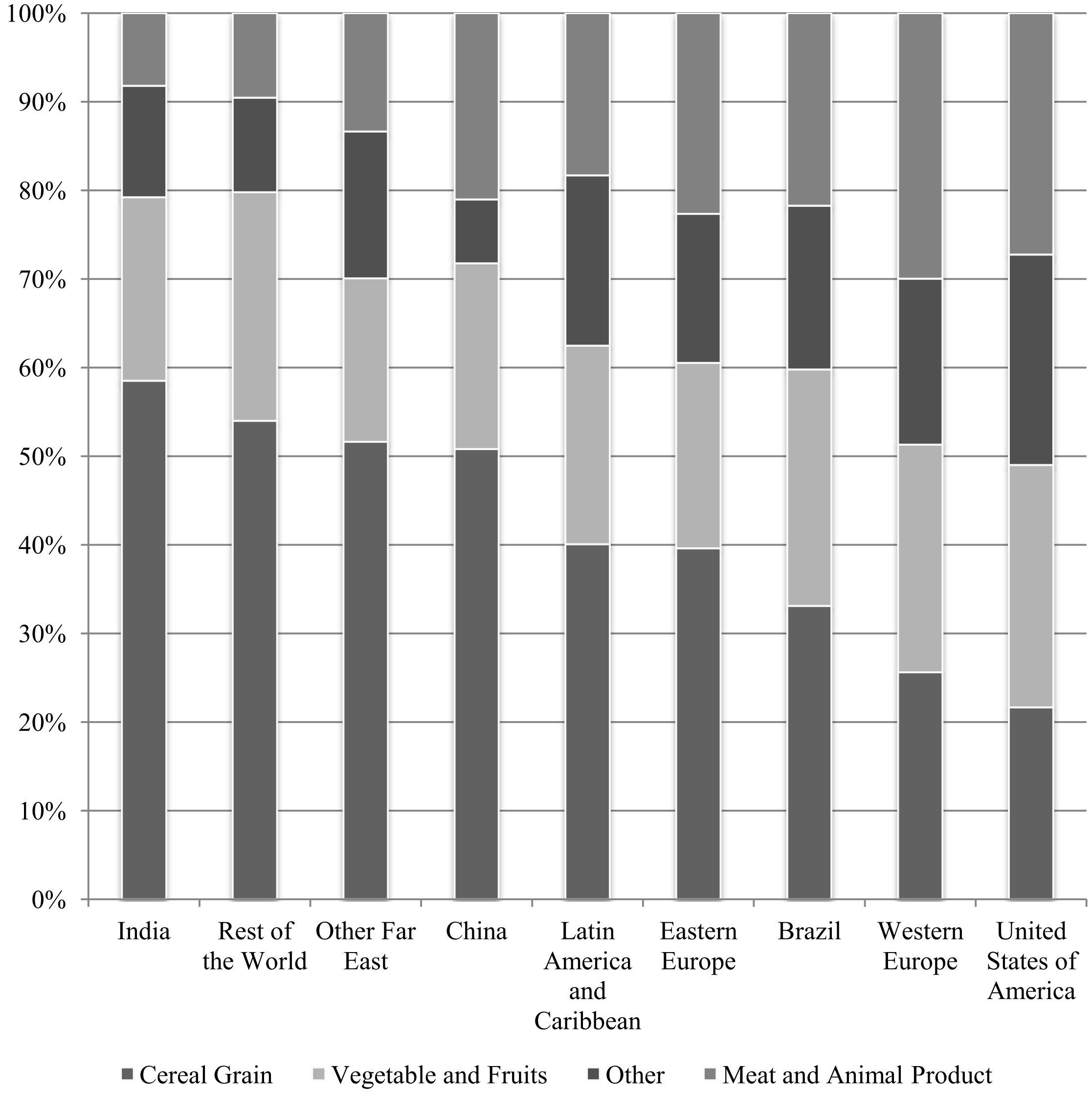


Figure 28. Percentage of Calorie Intake by Food Groups

Around 85% of the total calories from world food cereal grains (rice, wheat and cereal grains) are consumed by the most food-insecure regions (Figure 29).

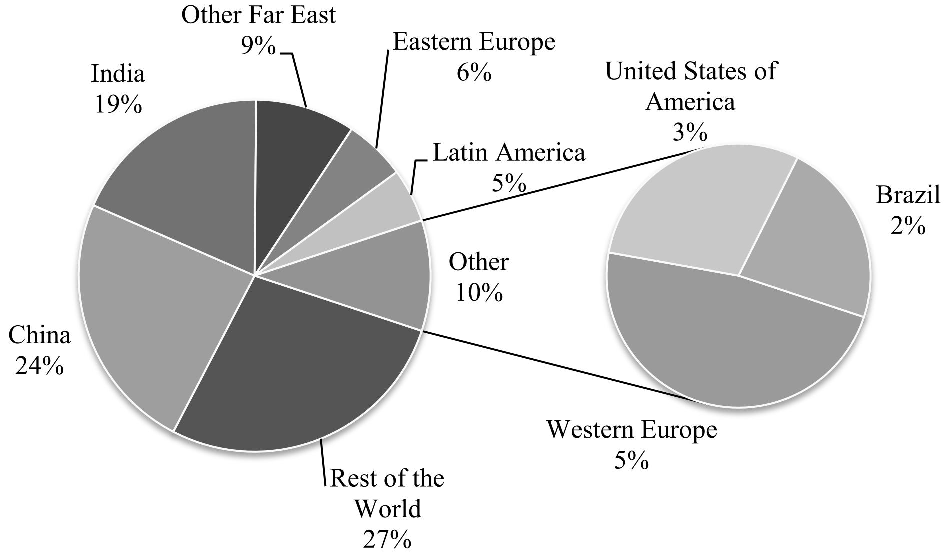


Figure 29. World Food Cereal Grains Calories Consumed by Regions

Local elasticity of food insecurity is estimated using the simulated empirical distribution for daily calorie intake. Table 13 presents the elasticity for each region, which measures the percentage changes in regional food insecure population given 1 per cent change in mean daily calorie intake in the baseline level. In the 5 most food-insecure regions, the absolute values of the elasticities are the highest. It is mainly because in these regions, the cutoff points are more close to the mean in the uni-modal distribution, and the change in percentages of undernourished is much more sensitive to the change of the mean daily calorie. Moreover, as these regions are with huge population, a small percentage change will lead to a huge increase in the number of undernourished people.

Table 13. Elasticity of Food Insecurity

| **Region** | **Elasticity** |
|---|---:|
| Rest of the World | -1.00 |
| India | -1.26 |
| China and Hong Kong | -0.94 |
| Other Far East | -1.07 |
| Latin Amer. and Caribbean | -0.87 |
| Eastern Europe | -0.55 |
| Brazil | -0.68 |
| Western Europe | -0.04 |
| United States | -0.02 |

# CHAPTER V

# RESULTS

This study focuses on the effects of U.S. RFSs, Brazil's sugarcane ethanol mandate, and China's grain ethanol mandate on world hunger separately. The effects of changes in US, Brazil and China's ethanol production on the world food production and trade, as well as the world food insecurity are examined. Results are presented as changes from the 2004 baseline equilibrium. The actual dollar value and shares of food commodity production, exports and imports for the 2004 baseline equilibrium are presented in APPENDIX A, APPENDIX B, and APPENDIX C, respectively.

## *U.S. Renewable Fuel Policies*

Alternative scenarios were run to see how the U.S. RFSs affect the U.S. and world's food market, as well as world hunger (Table 14). Then, current VEETCs were removed in the last three scenarios to measure the effects on world hunger.

Table 14. Basic Scenarios Run

| Scenario | Total RFS | Advanced RFS |
|---|---:|---:|
| No RFS | 0 | 0 |
| RFS1 | 7.5 billion gallons | 0 |
| RFS2 w/o Adv | 36 billion gallons | 0 |
| RFS2 | 36 billion gallons | 21 billion gallons |

## U.S. Biofuel Production

Results indicate that all mandates are binding for all scenarios, either with or without VEETCs. Table 15 only shows the results with VEETCs, as the only difference in the no VEETCs scenarios is that the Average Prices equal the Final Prices. The results are consistent with the fact that biofuels are not cost competitive to the conventional petroleum and coal products, given current technology. If there are no renewable fuel policies, the biofuel production level will be at 1,384 million gallons, which is far less from the mandate, or even the base year production level of 3,390 million gallons. In addition, biofuels become more expensive as RFS increases, particularly when the advanced RFS increases. This indicates that much more subsidies are given to the industry when there is advanced RFS. More than 27 billion will be given as VEETCs in RFS2 scenarios.

Table 15. Biofuel Productions in U.S. with VEETCs

| | **Conventional** | **Advanced** | **Average Price** | **Final Price** | **Total Subsidies** |
|---|---:|---:|---:|---:|---:|
| | (mil. gal.) | (mil. gal.) | $/gal. | $/gal. | Million$ |
| 2004 Base | 3,390 | 10 | 1.21 | 0.75 | 1,564 |
| No Policy | 1,384 | 0 | 1.21 | 1.21 | - |
| RFS1 | 7,500 | 0 | 1.22 | 0.76 | 3,450 |
| RFS2 w/o Adv | 36,000 | 0 | 1.26 | 0.80 | 16,560 |
| RFS2 | 15,000 | 21,000 | 1.76 | 0.99 | 27,720 |

Quantities and prices of biomass with VEETCs are presented in Table 16. Again, results for No VEETCs scenarios are almost the same, which are not presented here. When there is no advanced RFS, no cellulosic biofuels will be produced, therefore switch grass is produced at minimum level, and corn stover is left as waste and does not generate any revenue. The quantity of corn stover is a fixed proportion of the corn production, which increases when conventional RFS increase. In RFS2, 169.62 tons of corn stover and 73.56 tons of switch grass, at the price of USD78.22 per ton, are used in producing cellulosic ethanol. This will lead to additional revenue of USD13.27 billion for corn producers.

Table 16. Quantities and Prices of Biomass in U.S. (with VEETCs)

| | Corn Stover | | Switch grass | |
|---|---|---|---|---|
| | Quantity (mil. tons) | Price (USD/ton) | Quantity (mil. tons) | Price (USD/ton) |
| 2004 Base | 105.36 | 0 | 10.00 | 66.62 |
| No Policy | 101.64 | 0 | 2.07 | 65.70 |
| RFS1 | 113.61 | 0 | 10.00 | 66.94 |
| RFS2 w/o adv | 170.48 | 0 | 10.00 | 69.38 |
| RFS2 | 169.62 | 78.22 | 73.56 | 78.22 |

## U.S. Other Commodities Productions

The RFSs have raised the domestic cereal grain production (Table 17). Results show that increased conventional RFS leads to increase in cereal grains production. However, when we substituted 21 billion gallons of the conventional RFS with advanced

RFS, the increase in cereal grains production has decreased from 78% to 56%. This meets our expectation, as demand for corn goes down when conventional RFS is reduced. Moreover, when there are no VEETCs, Cereal Grains Productions are slightly down. Domestic price of Cereal Grains rises when conventional ethanol production increases, and significantly decreases by almost 28% when advanced RFS is added. This is mainly because conventional ethanol production pushed up the demand for corn, and thus pushes up the cereal grain price. On the other hand, advanced ethanol production uses corn stover and switch grass as feedstocks, and thus free a large amount of corn for feed and food uses, which results in decrease in corn demand and also increase in corn supply.

Table 17. U.S. Cereal Grains Production and Prices (% Change from 2004 base)

| | With VEETCs | | No VEETCs | |
|---|---|---|---|---|
| | Quantity | Price | Quantity | Price |
| No Policy | | | -4.66% | 0.77% |
| RFS1 | 9.68% | 1.18% | 9.65% | 1.23% |
| RFS2 w/o Adv | 77.95% | 7.78% | 77.81% | 8.10% |
| RFS2 | 55.59% | -27.94% | 55.05% | -27.45% |

Because the results of the first two scenarios are not as significant as the others, the following discussions about other commodities, land use and trade, will only focus on the RFS2 with and without advanced RFS scenarios.

Table 18 and Table 19 show the domestic productions and prices change for other food commodities and petroleum and coal products. Other food production shrinks, as well as the petroleum and coal products. The most reduced food productions are in the most land-intensive sectors, including the Wheat, the Oil Seeds, and the Fruit and Vegetables sector. These sectors mostly compete for land with cereal grains production and are land-intensive industries. It is expected that these sector suffer most when land is directed to biofuel production. On the other hand, the slight increases in the Bovine Meat and Dairy sectors in RFS2 scenarios are mainly because more cereal grain becomes available for feed. It is also noted that price of the Petroleum and Coal Products sector increased substantially, due to the high cost of biofuel production.

Overall, changes are small, compared to the Cereal Grains sector. Generally, effect is enlarged with no VEETCs present, especially for the Petroleum and Coal Products sector, in which effects will be doubled when there are no VEETCs.

Table 18. U.S. Other Commodity Production (% Change from 2004 base)

| | RFS2 w/o Adv | | RFS2 | |
|---|---:|---:|---:|---:|
| | w/ VEETCs | w/o VEETCs | w/ VEETCs | w/o VEETCs |
| Wheat | -2.38% | -2.77% | -4.69% | -5.38% |
| Processed Rice | -0.65% | -0.85% | -0.99% | -1.36% |
| Cereal Grains | 77.95% | 77.81% | 55.59% | 55.05% |
| Sugar | -0.68% | -0.83% | -1.10% | -1.38% |
| Oil Seeds | -3.19% | -3.36% | -4.45% | -4.73% |
| Vegetable Oils and Fats | -1.35% | -1.51% | -1.93% | -2.21% |
| Fruits and Vegetables | -1.80% | -1.88% | -3.22% | -3.40% |
| Other Food and Beverage | -0.46% | -0.52% | -0.43% | -0.54% |
| Bovine Meat Products | -0.70% | -0.79% | 0.59% | 0.41% |
| Other Meat Products | -0.46% | -0.54% | -0.14% | -0.29% |
| Other Animal Products | -0.57% | -0.72% | -0.23% | -0.52% |
| Dairy Products | -0.68% | -0.75% | 0.52% | 0.38% |
| Fishing | 0.32% | 0.82% | 0.57% | 1.40% |
| Petroleum and coal products | -3.60% | -7.42% | -5.33% | -10.00% |

Table 19. U.S. Other Commodity Domestic Prices (% Change from 2004 base)

| | RFS2 w/o adv | | RFS2 | |
|---|---:|---:|---:|---:|
| | w/ VEETCs | w/o VEETCs | w/ VEETCs | w/o VEETCs |
| Wheat | 3.24% | 3.83% | 6.68% | 7.78% |
| Processed Rice | 0.82% | 1.19% | 1.32% | 1.97% |
| Cereal Grains | 7.78% | 8.10% | -27.94% | -27.45 |
| Sugar | 0.73% | 0.97% | 1.25% | 1.68% |
| Oil Seeds | 3.69% | 3.83% | 5.11% | 5.36% |
| Vegetable Oils and Fats | 1.77% | 1.94% | 2.47% | 2.78% |
| Fruits and Vegetables | 3.18% | 3.34% | 6.14% | 6.46% |
| Other Food and Beverage | 0.42% | 0.49% | 0.21% | 0.35% |
| Bovine Meat Products | 0.82% | 0.94% | -1.54% | -1.32% |
| Other Meat Products | 0.38% | 0.50% | -0.32% | -0.10% |
| Other Animal Products | 0.58% | 0.80% | -0.10% | 0.29% |
| Dairy Products | 0.77% | 0.87% | -1.43% | -1.23% |
| Fishing | -0.94% | -1.81% | -1.54% | -2.97% |
| Petroleum and coal products | 6.68% | 12.89% | 8.98% | 20.55% |

When comes to the factor markets, the largest change occurs in land (Table 20). As the results are only slightly different between scenarios with and without VEETCs, only the scenarios with VEETCs are reported here. Generally, RFS results in more crop land and less pasture land, since more crop land is needed in growing biofuel feedstock. In RFS2 w/o Adv, most affected AEZs are AEZ10 and AEZ11, where pasture land reduces most. Because cereal grains mostly grow in AEZ10 and AEZ11, which was shown in the SAM data. As a results, for these two AEZs, largely reduced pasture land (-6.32% and -3.56% in respective), results in only moderate percentage increase in crop land (1.56% and 0.99% in respective). In the RFS2, most affected AEZs are AEZ8 and

AEZ9, following by AEZ10 and AEZ11. It is largely because switch grass is mostly produced in AEZ8 and AEZ9.

Table 20. U.S. Agricultural Land Use (% Change from 2004 base)

| | RFS2 w/o Adv* | | RFS2* | |
|---|---|---|---|---|
| | Crop Land | Pasture Land | Crop Land | Pasture Land |
| AEZ7 | 1.79% | -1.47% | 1.30% | -1.05% |
| AEZ8 | 1.01% | -2.69% | 3.73% | -10.00% |
| AEZ9 | 0.16% | -2.73% | 0.51% | -9.32% |
| AEZ10 | 1.56% | -6.32% | 1.52% | -5.98% |
| AEZ11 | 0.99% | -3.56% | 1.04% | -3.54% |
| AEZ12 | 0.11% | -0.24% | 0.43% | -0.98% |
| AEZ13 | 0.33% | -0.03% | -1.01% | 0.40% |
| AEZ14 | 4.58% | -0.05% | 3.40% | 0.22% |
| AEZ15 | -0.47% | 0.10% | -1.66% | 0.38% |

*Scenarios with VEETCs

Ag Land prices increase accordingly (Table 21). Similarly, with only conventional RFS, prices increase most in AEZ10 and AEZ11, where cereal grains mostly grow. With both conventional and advanced RFS, prices of AEZ8 and AEZ9 increase most, followed by AEZ10 and AEZ11. It is primarily because of the sharply increase in switch grass production. Plus, price increases much more in crop land than in pasture land, since biofuel feedstocks – corn and switch grass, has more direct effect on crop land.

Table 21. U.S. Agricultural Land Price (% Change from 2004 base)

| | RFS2 w/o Adv* | | RFS2* | |
|---|---|---|---|---|
| | Crop Land | Pasture Land | Crop Land | Pasture Land |
| AEZ7 | 8.33% | 1.52% | 6.16% | 1.29% |
| AEZ8 | 12.14% | 4.08% | 70.65% | 25.42% |
| AEZ9 | 10.44% | 4.16% | 48.16% | 20.60% |
| AEZ10 | 32.01% | 12.31% | 30.84% | 12.20% |
| AEZ11 | 16.20% | 5.97% | 16.95% | 6.59% |
| AEZ12 | -0.28% | -0.97% | 4.05% | 1.15% |
| AEZ13 | -0.68% | -1.39% | -4.33% | -1.60% |
| AEZ14 | 8.01% | -1.34% | 5.13% | -1.25% |
| AEZ15 | -2.74% | -1.63% | -5.51% | -1.57% |

*Scenarios with VEETCs

**World Food Trade**

U.S. is the world's largest cereal grains producer and exporter. RFSs will certainly change the world food consumption through trade, particularly in the food insecure regions where people consume more food cereal grains. Regions that benefit most from the increased U.S. cereal grains export are the Latin America and Caribbean, the Other Far East, and the Rest of the World (Table 22 and Table 23). These regions are also the largest cereal grains importers of the U.S in the 2004 base.

When there are no renewable fuel policies, U.S. cereal grains production is lower and with higher price, which results in lower export and even lower imports. In RFS2 w/o Adv and RFS2, U.S. export changes by 17.53% and 67.59% (Table 22) and import changes by 48.43% and -20% (Table 23), respectively. It is hard to tell whether world food cereal grains increases when both export and import increase. Yet, the effect of RFS2 is more apparent and significant, where exports decrease in all other regions, and imports increase in all other regions except Brazil and China. However, Brazil and China are net exporters in cereal grains. The small decrease in imports will be compensated by the decrease in exports. In this case, the availability of cereal grains in all regions will be largely improved. The change in food availability in other scenarios is ambiguous with just looking at the change in trade. Plus, RFSs have relatively small spillover effects on the production and trade in other food sectors, which are not reported here.

Table 22. Cereal Grains Exports by Region (% Change from 2004 base)

| | No RFS | RFS1* | RFS2 w/o adv* | RFS2* |
|---|---|---|---|---|
| United States | -1.21% | 2.65% | 17.53% | 67.59% |
| Other Far East | 0.35% | -0.77% | -4.83% | -20.00% |
| China and Hong Kong | 0.30% | -0.67% | -4.19% | -10.00% |
| India | 0.21% | -0.44% | -2.71% | -9.81% |
| Latin Amer. and Caribbean | -0.04% | 0.11% | 1.33% | -7.37% |
| Brazil | 0.13% | -0.32% | -2.08% | -6.30% |
| Rest of the World | 0.00% | -0.02% | 0.13% | -4.70% |
| Western Europe | -0.25% | 0.48% | 3.95% | -3.23% |
| Eastern Europe | 0.00% | -0.02% | -0.13% | -1.43% |

*Scenarios with VEETCs

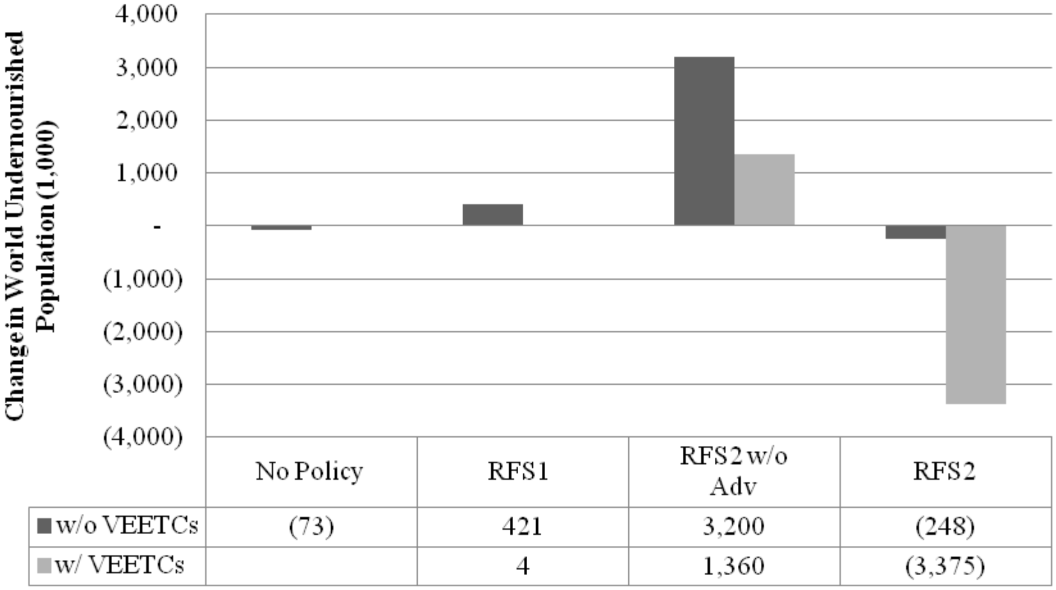
Table 23. Cereal Grains Imports by Region (% Change from 2004 base)

| | No RFS* | RFS1* | RFS2 w/o adv* | RFS2* |
|---|---|---|---|---|
| United States | -3.34% | 6.54% | 48.43% | -20.00% |
| Latin Amer. and Caribbean | -1.06% | 2.28% | 15.12% | 58.87% |
| Other Far East | -0.69% | 1.52% | 9.86% | 35.54% |
| Rest of the World | -0.39% | 0.84% | 5.50% | 20.89% |
| India | -0.12% | 0.25% | 1.62% | 5.83% |
| Western Europe | -0.11% | 0.24% | 1.57% | 5.32% |
| Eastern Europe | -0.05% | 0.11% | 0.76% | 2.08% |
| Brazil | 0.03% | 0.01% | 0.16% | -0.62% |
| China and Hong Kong | 0.10% | -0.21% | -1.36% | -4.98% |

*Scenarios with VEETCs

**World Hunger**

Figure 30 shows the change in the world's undernourished population as results of RFSs. Basically, the conventional RFS tends to intensify world hunger, while the advanced RFS tends to relieve world hunger. Mainly because the cellulosic ethanol production from non-crop feedstock has substituted the conventional ethanol production from cereal grains, thus free cereal grains for food and feed use. Moreover, VEETC subsidies help to alleviate world hunger caused by the expansion of conventional biofuel. It is because the increase in cereal grains export is higher when biofuels are subsidized.



| | No Policy | RFS1 | RFS2 w/o Adv | RFS2 |
|---|---|---|---|---|
| ■ w/o VEETCs | (73) | 421 | 3,200 | (248) |
| ■ w/ VEETCs | | 4 | 1,360 | (3,375) |

Figure 30. Change in World Undernourished Population (1,000)

Table 24 reports the detail changes in world hunger by regions. The RFSs tend to affect different food insecure regions in different ways.

Table 24. Change in Undernourished Population by Regions with U.S. RFSs (1,000)

| | **No Policy** | **RFS1*** | **RFS2 w/o Adv*** | **RFS2*** |
|---|---:|---:|---:|---:|
| Other Far East | 9 | -113 | -504 | -2,799 |
| Latin Amer. and Caribbean | -6 | 0 | 166 | -938 |
| India | 17 | -51 | -136 | -222 |
| Rest of the World | -26 | 130 | 1,350 | -52 |
| Brazil | -3 | -3 | -11 | -31 |
| Eastern Europe | -12 | 0 | -23 | -23 |
| Western Europe | -3 | -3 | -3 | 3 |
| United States | -9 | 5 | 82 | 45 |
| China and Hong Kong | -40 | 40 | 441 | 641 |
| **Total** | **-73** | **4** | **1,360** | **-3,375** |

*Scenarios with VEETCs

The Other Far East benefits most from the RFS, particularly the advanced RFS. This is anticipated when we looked at the change in its cereal grains trade. The region is characterized as high income and with high food production. The high income countries, including Japan and South Korea, are large cereal grains importers which can benefit from increase world cereal grains supply. The low income countries, including Malaysia, Thailand, Indonesia, Vietnam, are major world cereal grains producers, which can benefit from increasing price of cereal grains, thus increase in income and food consumptions.

The Latin America and Caribbean is moderately affected by conventional RFS, but significantly helped by the advanced RFS. Similar to the Other Far East, this region is also one of the largest cereal grains importers of the U.S.

The Rest of the World is greatly hurt by conventional RFS, but helped a little by advanced RFS. This region is characterized by extremely low income. Not only availability but also accessibility of food is important in relieving hunger there. Conventional RFS tends to push up food prices, which reduce the food accessibility in the Rest of the World region.

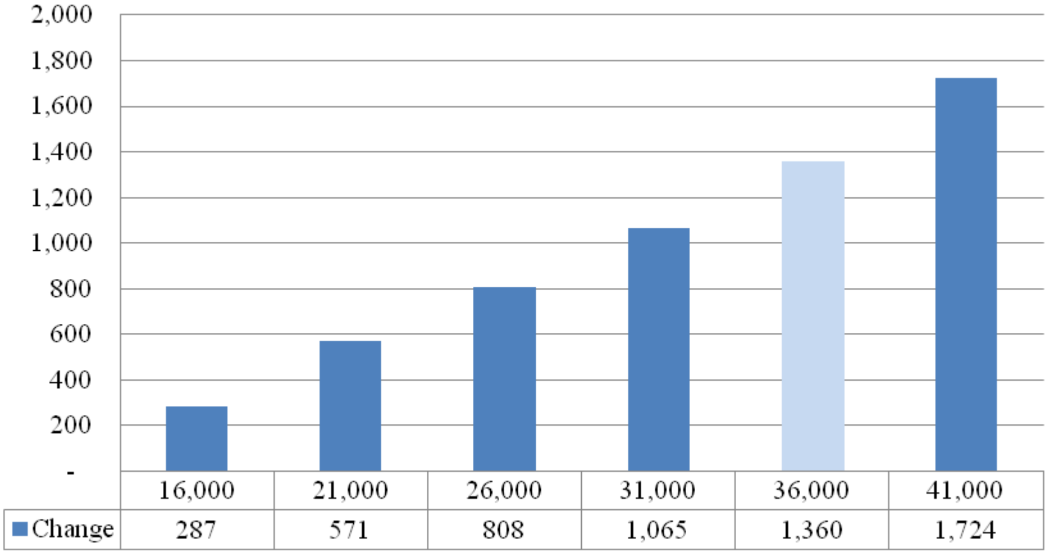
India is not a food importing country, so it should not be affected a lot by the change of food trade. However, as we discussed in the earlier chapter, India is the most populous region, such that a little increase in the food supply could result in a large number decrease in hunger people.

Compared to India, effect from conventional ethanol on China and Hong Kong is slightly greater. It is mainly because China imports more food than India and its food consumption is more sensitive to the world food supply and price. However, China is hurt by the advanced RFS while almost all other regions experience decrease in food insecure population.

The effects on Brazil, Eastern Europe, Western Europe and the United States are very little. These regions are rich and are much less food insecure. The increase in international food price has little effect on the food consumptions in these regions. In general, impact on regions that are closely related to U.S. via food trade is stronger. Also, regions characterized by more food insecure are more likely to be affected by the change in global food supply.

### Alternative Scenarios of RFSs

Results from alternative scenarios with increasing total RFS and zero advanced RFS are examined. As shown in Figure 31, every 5 billion increase in total RFS leads to about 0.2-0.4 million increased in world hunger.

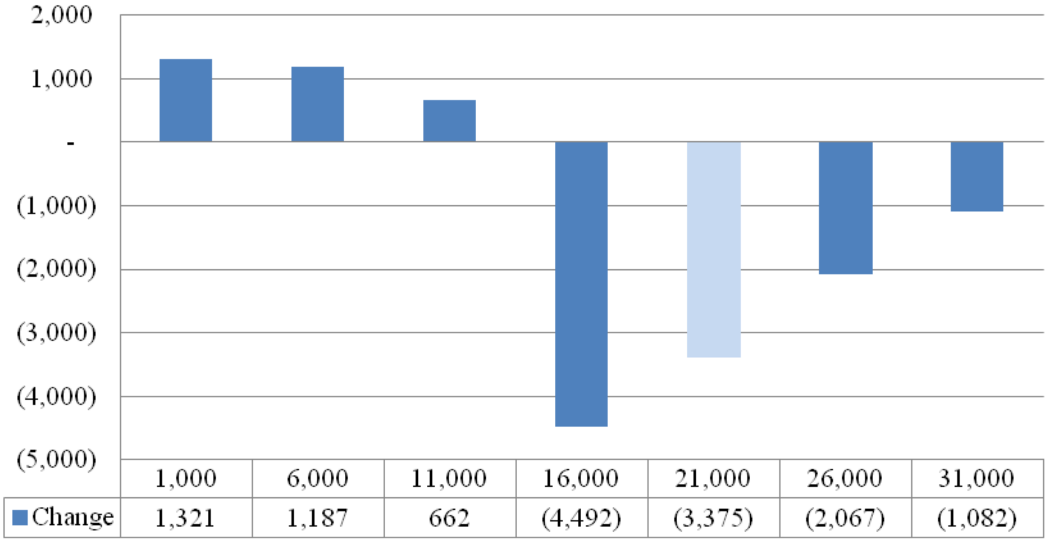


| | 16,000 | 21,000 | 26,000 | 31,000 | 36,000 | 41,000 |
|---|---|---|---|---|---|---|
| ■ Change | 287 | 571 | 808 | 1,065 | 1,360 | 1,724 |

Figure 31. Change in World Hunger with Increasing Total RFS (1,000)

Alternative scenarios with 36 billion gallons of total RFS and increasing advanced RFS are also examined. The results are shown in Figure 32. At the beginning, the increase in world food-insecure population is gradually decreasing when conventional RFS is substituted by advanced RFS. Then when the advanced RFS reaches 16 billion gallons, the food-insecure population is sharply decreased, but the drop shrinks as advanced RFS further increases.

When there is no advanced RFS, corn will be the only biofuel feedstock, which competes for land and other resources with other food. Thus, the world undernourished population would increase by about 1 million. As we gradually substitute advanced RFS for conventional RFS, given the total RFS of 36 billion gallons unchanged, demand for corn as an ethanol feedstock declines, and land price decline as well. In other food sectors, prices decrease and quantity increase, thus world hunger is relieved. When advanced RFS increase to the level of 16 billion, world hunger was dramatically decreased by more than 4 million. Then again, the number decreases as corn stover is not enough and switch grass production increases and competes for land.



| | 1,000 | 6,000 | 11,000 | 16,000 | 21,000 | 26,000 | 31,000 |
|---|---|---|---|---|---|---|---|
| ■ Change | 1,321 | 1,187 | 662 | (4,492) | (3,375) | (2,067) | (1,082) |

Figure 32. Change in World Hunger with Increasing Advanced RFS (1,000)

Figure 33 shows that the quantity of corn stover, as a fixed proportion of corn, decreases at first when conventional RFS decreases, and then increases until switch grass starts to increase.

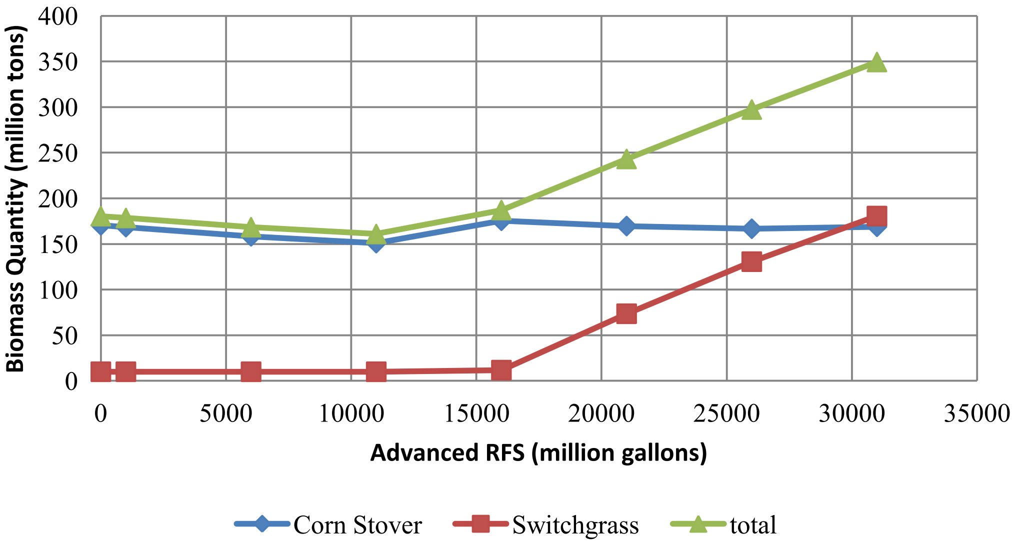


Figure 33. Biomass Quantities with Increasing Advanced RFS

Figure 34 shows the change in prices of biomass. Price of switch grass stays relatively constant when advanced RFS is below 16 billion gallons, as advanced biofuel can be produced by the excessive corn stover at a low price. In this stage, only the minimum level of 10 million tons of switch grass will be produced, which was set when a constraint is not in place. On the other hand, the price of corn stover starts from zero, when the surplus corn stover is left as waste. Then the price gradually increases until the same level as switch grass. It is increased sharply when the advanced RFS increases from 11 billion gallons to 16 billion gallons. In this stage, corn stover is cheaper than switch grass, and is the primary feedstock for cellulosic ethanol production. Demand increase has driven price up to equal the price of switch grass.

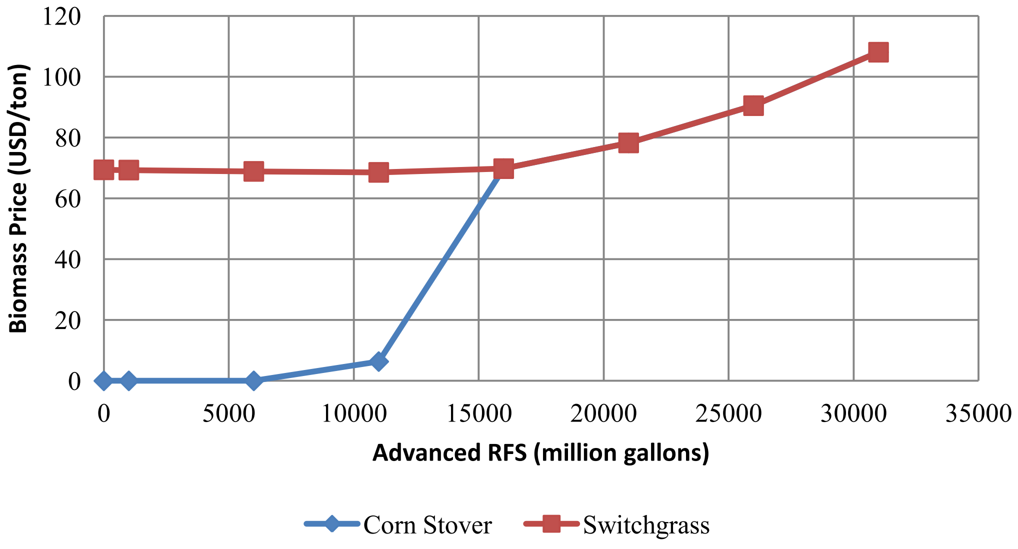


Figure 34. Biomass Price with Increasing Advanced RFS

### *Brazilian Sugarcane Ethanol Mandate*

Brazil aims to set a mandatory blending ratio of 25%, which makes the forecasted mandatory annual ethanol production for domestic consumption to reach 17.2 billion gallons by 2020. Four scenarios are run for analyzing the Brazilian biofuel policies, including the 17.2 billion gallons mandate with or without subsidies, and no mandate with or without subsidies.

### Brazil Summary

Like the case in U.S., the mandate is binding in our result, and ethanol would be priced at USD1.09 per gallon at the production level of 17.2 billion gallons (Table 25). Ethanol is still cost competitive to fossil fuel when being produced at such high level. Sugar cane and beets production will increase by 120%, and the price will increase by

5% with no subsidies. Subsidies can bring down the price a little bit and increase sugarcane production further more. When there is no mandate, production level will be at 3.5 billion gallons, and priced at USD1.06 per gallon with no subsidies. And subsidies would lead to higher production level at 4.59 billion gallons priced at USD0.81per gallon. Accordingly, sugarcane production increases and price decreased very slightly. As when there is no mandate, the result is close to the 2004 base year, when sugarcane ethanol is produced at 3989 million gallons, the following discussion will focus on the scenarios with mandate.

Table 25. Brazil Ethanol Production

| | Scenarios | Ethanol Production (bil. gal.) | Ethanol Prices ($/gal) | Sugarcane Production Changed | Sugarcane Prices Changed |
|---|---|---|---|---|---|
| w/o | w/ sub | 4.59 | 0.81 | 5.85% | -0.04% |
| Mandate | w/o sub | 3.52 | 1.06 | -4.48% | -0.08% |
| w/ | w/ sub | 17.2 | 0.83 | 130.00% | 3.84% |
| Mandate | w/o sub | 17.2 | 1.09 | 120.00% | 5.14% |

The rise in sugarcane production leads to decreases in other food production and increase in prices as shown in Table 26. The percentages decreased in production ranged from 1 to 4 percent except for fishing. The most decrease occurs in Fruits and Vegetables, Processed Rice, Dairy and Meat Products, which mainly compete for land with sugarcane production. It is also noted the production of sugar falls when sugarcane ethanol increase, as less sugarcane is available for sugar production. On the other hand, the price for the new petroleum and coal products increase dramatically, 17.6% with subsidies and 44% without subsidies.

Table 26. Other Commodity Production and Prices in Brazil (% Change from 2004 base)

| | Production | | Price | |
|---|---|---|---|---|
| | w/sub | w/o sub | w/ sub | w/o sub |
| Wheat | -0.48% | -1.14% | 2.25% | 3.59% |
| Processed rice | -2.15% | -3.00% | 1.61% | 2.29% |
| Cereal Grains | -1.59% | -2.01% | 2.76% | 3.85% |
| Sugar | -1.75% | -2.32% | 1.68% | 2.57% |
| Oil Seeds | -1.71% | -2.10% | 2.76% | 4.05% |
| Vegetable Oils and Fats | -1.25% | -2.01% | 2.35% | 3.42% |
| Fruits and Vegetables | -2.98% | -3.84% | 4.03% | 5.17% |
| Other Food and Beverage Products | -1.15% | -1.82% | 1.31% | 1.94% |
| Bovine Meat Products | -2.07% | -2.78% | 1.53% | 2.26% |
| Other Meat Products | -1.95% | -2.67% | 1.11% | 1.50% |
| Other Animal Products | 0.24% | 0.23% | 1.57% | 2.47% |
| Dairy Products | -2.06% | -2.85% | 1.37% | 1.99% |
| Fishing | 8.72% | 11.38% | -9.52% | -13.21% |
| Petroleum and coal products | -10.00% | -30.00% | 17.61% | 44.09% |

Imports and exports change accordingly. Exports decrease for all food commodities except fishing, particularly the Fruits and Vegetables. Petroleum and coal products experienced huge import increase in export decrease. Subsidies tend to increase food imports and bring down food export slightly. But the petroleum and coal products are affected in an opposite way. And the effect is more direct and strong on the petroleum and coal products sector. Because the subsidies directly reduce the price of sugarcane ethanol, which is part of the new petroleum and coal products. These are basically resulting from the prices change as in Table 27.

Table 27. Other Commodity Export and Imports in Brazil (% Change from 2004 base)

| | Import | | Export | |
|---|---|---|---|---|
| | w/sub | w/o sub | w/sub | w/o sub |
| Wheat | 0.16% | -0.51% | -2.64% | -2.75% |
| Processed rice | -0.58% | -2.18% | -1.68% | -1.13% |
| Cereal Grains | 1.26% | 0.47% | -2.77% | -2.47% |
| Sugar | -0.11% | -1.24% | -1.52% | -1.11% |
| Oil Seeds | 1.36% | 0.75% | -2.35% | -2.28% |
| Vegetable Oils and Fats | 0.92% | -0.07% | -2.13% | -1.96% |
| Fruits and Vegetables | 2.16% | 1.09% | -4.62% | -4.58% |
| Other Food and Beverage Products | -0.32% | -1.82% | -0.87% | -0.13% |
| Bovine Meat Products | -0.51% | -1.89% | -1.59% | -1.01% |
| Other Meat Products | -0.94% | -2.71% | -1.02% | -0.04% |
| Other Animal Products | 0.77% | -0.03% | -0.48% | 0.23% |
| Dairy Products | -0.71% | -2.24% | -1.41% | -0.74% |
| Fishing | -7.93% | -10.00% | 19.08% | 28.90% |
| Petroleum and coal products | 11.35% | 28.92% | -20.00% | -40.00% |

Land use in Brazil changes too (Table 28). The subsidies only make a subtle difference on land use, which is not reported here. Basically, crop land increases and pasture land and forestry land decrease. The most affected land is in AEZ5 and AEZ6, where lies mainly the Amazon Rainforest. But the forestry land in the model is exclusively managed forest, i.e. wild forest is not included. But still, we can see there is pressure on deforestation that can free lands for crop and livestock production.

Table 28. Ag Land Quantity and Price in Brazil (% Change from 2004 base)

| | Quantity | | | Price | | |
|---|---|---|---|---|---|---|
| | Crop Land | Pasture Land | Forestry Land | Crop Land | Pasture Land | Forestry Land |
| AEZ1 | 0.61% | -0.45% | | 1.63% | -0.50% | |
| AEZ2 | 0.76% | -2.78% | | 12.07% | 4.34% | |
| AEZ3 | 0.13% | -0.46% | | 0.71% | -0.47% | |
| AEZ4 | 0.65% | -2.23% | -2.46% | 9.33% | 3.16% | 2.68% |
| AEZ5 | 1.80% | -4.15% | -4.38% | 21.08% | 7.34% | 6.84% |
| AEZ6 | 2.06% | -6.62% | -6.83% | 35.07% | 13.08% | 12.55% |
| AEZ10 | 0.02% | -0.15% | | -0.76% | -1.10% | |
| AEZ11 | 0.50% | -2.18% | | 8.78% | 3.06% | |
| AEZ12 | -0.01% | 0.12% | -0.11% | -1.87% | -1.62% | -2.08% |

### World Summary

Compared to the 2004 base, world hunger will be increased by 5.5 million (Figure 35). A USD 0.25 per gallon of subsidy would bring the number down to 4 million. In fact, ethanol production does not change when the subsidy is applied. Only the price of ethanol decreases, and price of energy decrease accordingly. The subsidy probably has affected the household consumption via lower the energy price and increase expenditure on food consumption. On the other hand, when there is no mandate, world hunger stays almost the same as in 2004 base.

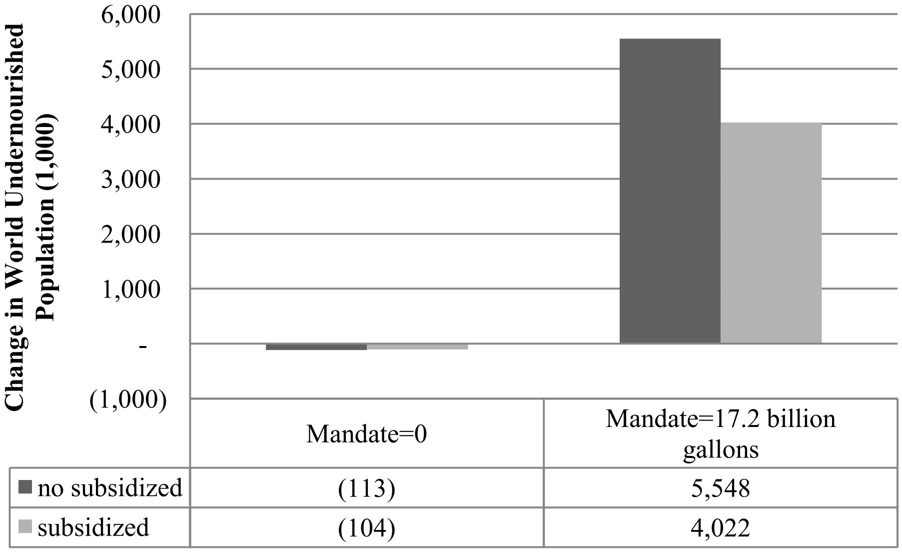


Figure 35. Change in World Hunger with Brazilian Biofuel Mandate (1,000)

Table 29 shows the change in world food insecurity by regions. Most of the increase in world food insecurity is in Brazil itself, amount to 4.6 million. The second most affected region is the Rest of the World, with 0.86 million increase in undernourished population. Because Brazil is neither a large food producer nor food exporter, the change in domestic food production has limited effects on the other regions but itself. Furthermore, sugarcane is not a major food crop, and the effect on other food sectors is via land use change, thus very limited.

The spillover effect of the mandate on the world economy is very negligible. However, the Rest of the World is still affected, mainly because world food supplies decrease and world food prices increase. Plus, the region is so populous that tiny decrease in food could lead to huge increase in the undernourished population.

Table 29. Change in World Undernourished Population by regions (1,000)

| | w/o sub | w/ sub |
|---|---:|---:|
| **United States** | (5) | (5) |
| **Brazil** | 4,626 | 3,121 |
| **India** | (17) | - |
| **China and Hong Kong** | 40 | 80 |
| **Latin America and Caribbean** | 11 | 6 |
| **Western Europe** | 3 | 3 |
| **Other Far East** | 26 | 26 |
| **Eastern Europe** | 6 | 12 |
| **Rest of the World** | 857 | 779 |
| **Total** | **5,548** | **4,022** |

### Alternative Scenarios on Mandate

Alternative scenarios are simulated with increasing mandate levels for Brazilian sugarcane ethanol without subsidies. Results show that the world undernourished population increase at an increasing rate when the Brazilian mandate increase (Figure 36). Every 5 billion increase in the Brazilian mandate would lead to 1.5-5 million increased in world hunger, which is still concentrated in Brazil itself. Compared to U.S. total RFS, the effect to the increase in mandate is much stronger.

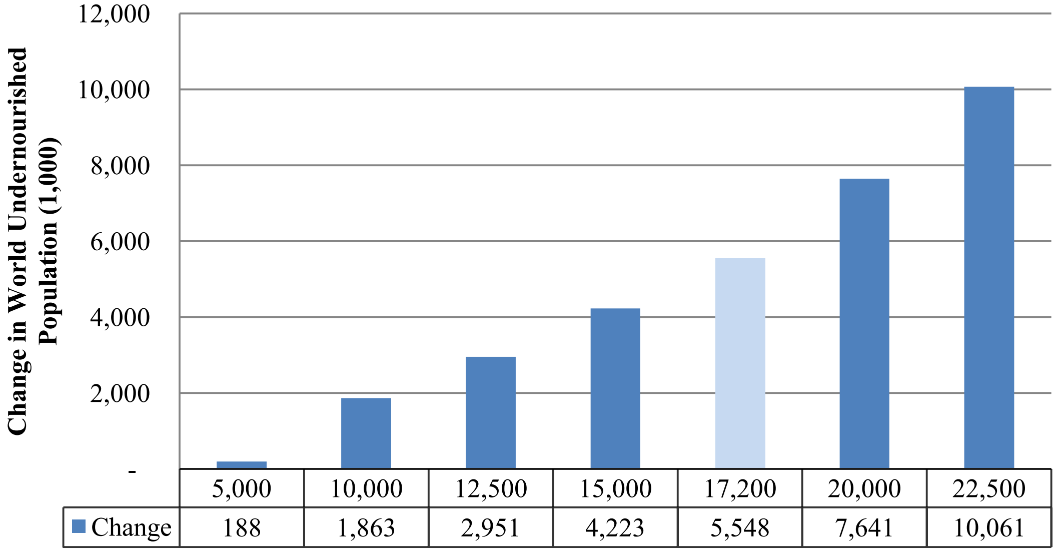


Figure 36. Change in World Hunger with Increasing Brazilian Biofuel Mandate (1,000)

### *Chinese Grain Ethanol Target and Subsidies*

Four scenarios are run for Chinese biofuel policies, including the 3302 million gallons target with or without subsidies, and no target with or without subsidies. Results show that Chinese target of 3,302 million gallons by 2020 is binding. Production of ethanol will be at 3,302 million gallons, priced at 2.23 per gallon with a subsidy of 0.19 per gallon.

### China Summary

Among all the food sectors, the Cereal Grains sector changes most, with production increased by 58.8% and price increased by 2.68% (Table 30). Production in other food sectors only experience minor changes as shown in Table 30. The price of petroleum and coal products is raised a little bit by around 4 percent, because the

Chinese biofuel mandate are relatively small, and the biofuel contribution to the new petroleum and coal products sector is very limited. Again, subsidies on biofuel production tend to increase food production and bring down food prices, but the effects are nearly undetectable, largely because the Chinese per gallon subsidy on biofuel is too small.

Table 30. Other Commodity Productions and Prices in China (% Change from 2004 base)

| | Production | | Price | |
|---|---|---|---|---|
| | w/ sub | w/o sub | w/ sub | w/o sub |
| Wheat | -0.71% | -0.73% | 0.92% | 0.94% |
| Processed rice | -0.18% | -0.19% | 0.09% | 0.09% |
| Cereal Grains | 58.80% | 58.80% | 2.46% | 2.47% |
| Sugar | -0.05% | -0.05% | -0.01% | -0.01% |
| Oil Seeds | -0.54% | -0.54% | 0.94% | 0.95% |
| Vegetable Oils and Fats | -0.16% | -0.16% | 0.08% | 0.08% |
| Fruits and Vegetables | -0.88% | -0.89% | 1.18% | 1.19% |
| Other Food and Beverage Products | -0.32% | -0.32% | 0.34% | 0.34% |
| Bovine Meat Products | -0.28% | -0.28% | 0.18% | 0.18% |
| Other Meat Products | -0.23% | -0.23% | 0.12% | 0.12% |
| Other Animal Products | -0.20% | -0.21% | 0.17% | 0.17% |
| Dairy Products | -0.25% | -0.25% | 0.17% | 0.17% |
| Fishing | 0.19% | 0.22% | -0.55% | -0.60% |
| Petroleum and coal products | -3.33% | -3.83% | 4.15% | 4.77% |

Trade in food commodities and petroleum and coal products change accordingly (Table 31). Only Cereal Grains and Petroleum and Coal Products have significant changes in import and export quantities. Trade results are closely related to the commodity prices.

Table 31. Other Commodity Imports and Exports in China (% Change from 2004 base)

| | Import | | Export | |
|---|---|---|---|---|
| | w/ sub | w/o sub | w/ sub | w/o sub |
| Wheat | 0.69% | 0.70% | -1.52% | -1.56% |
| Processed rice | -0.03% | -0.05% | -0.19% | -0.19% |
| Cereal Grains | 32.20% | 32.26% | 21.10% | 21.04% |
| Sugar | -0.06% | -0.07% | -0.02% | 0.00% |
| Oil Seeds | 0.47% | 0.47% | -1.74% | -1.75% |
| Vegetable Oils and Fats | -0.05% | -0.06% | -0.18% | -0.18% |
| Fruits and Vegetables | 1.03% | 1.02% | -1.70% | -1.71% |
| Other Food and Beverage Products | 0.21% | 0.20% | -0.56% | -0.56% |
| Bovine Meat Products | 0.01% | 0.01% | -0.41% | -0.40% |
| Other Meat Products | -0.03% | -0.04% | -0.26% | -0.25% |
| Other Animal Products | 0.09% | 0.07% | -0.29% | -0.29% |
| Dairy Products | -0.01% | -0.02% | -0.39% | -0.38% |
| Fishing | -0.56% | -0.62% | 0.69% | 0.77% |
| Petroleum and coal products | 3.09% | 3.51% | -6.57% | -7.50% |

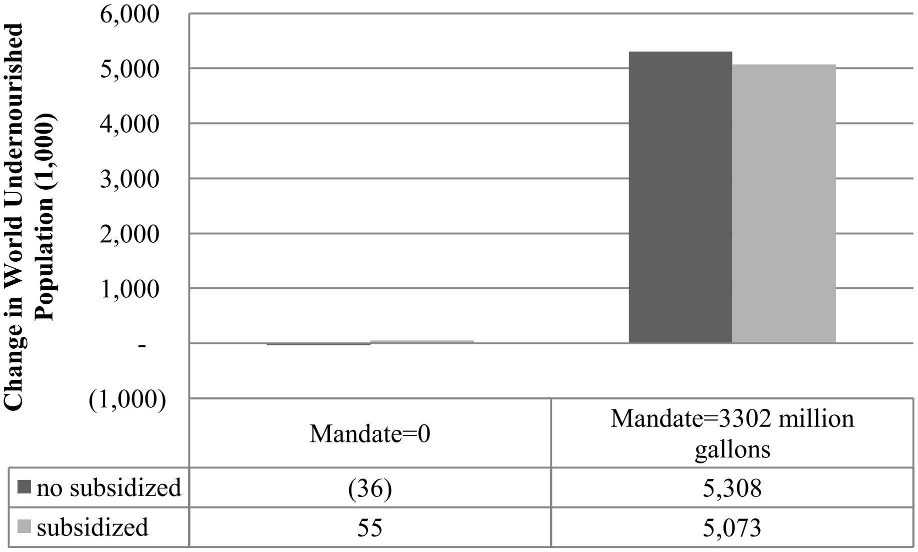
Land use and price change as well (Table 32). The results of no subsidies only have minor difference from the results with subsidies, thus are not reported here. It is shown that certain amount of pasture land will be substituted for crop land for almost all AEZs, mostly in AEZ7, AEZ8 and AEZ9. The prices of crop land increase by around 10 percent in AEZ8 and AEZ9, where cereal grains grow most in China. Effect on crop land is much greater than on pasture land, because such change has come from the changing demand for corn, which directly affects the demand for crop land. Land use and price changes in different AEZs are largely determined by the degree of substitution.

Table 32. Ag Land Quantity and Price in China (% Change from 2004 base)

| | Quantity | | Price | |
|---|---|---|---|---|
| | Crop Land | Pasture Land | Crop Land | Pasture Land |
| AEZ4 | 0.00% | -0.15% | -0.13% | -0.44% |
| AEZ5 | 0.02% | -0.13% | -0.16% | -0.47% |
| AEZ6 | -0.01% | 0.00% | -0.74% | -0.73% |
| AEZ7 | 0.73% | -1.03% | 4.94% | 1.32% |
| AEZ8 | 0.54% | -2.70% | 11.94% | 4.84% |
| AEZ9 | 0.36% | -2.25% | 9.48% | 3.87% |
| AEZ10 | 0.27% | -1.28% | 5.06% | 1.84% |
| AEZ11 | 0.22% | -0.56% | 1.94% | 0.36% |
| AEZ12 | 0.05% | -0.19% | 0.13% | -0.36% |
| AEZ13 | 0.39% | -0.37% | 1.50% | -0.02% |
| AEZ14 | 0.18% | -0.17% | 0.30% | -0.41% |
| AEZ15 | 1.09% | -0.35% | 2.84% | -0.06% |
| AEZ16 | 0.13% | -0.34% | 0.87% | -0.07% |
| AEZ17 | 0.00% | -0.20% | 0.05% | -0.35% |

**World Summary**

As a result, world hunger is greatly enlarged by the Chinese mandate (Figure 37). The total subsidy of 616 billion, that is USD0.187 per gallon, is too small to make a significant effect. But that the fact that subsidies could bring down the world undernourished populations is still shown in the results. This is because food prices are lower when with subsidies, as shown in previous discussion.



| | Mandate=0 | Mandate=3302 million gallons |
|---|---|---|
| ■ no subsidized | (36) | 5,308 |
| ▨ subsidized | 55 | 5,073 |

Figure 37. Change in World Hunger with Chinese Biofuel Mandate and Subsidies (1,000)

Similar to the case in Brazil, the main increase in the world undernourished population occurs in China itself and the Rest of the World (Table 33). The increased hunger in the Rest of the World (0.42 million) is less than when in the case of Brazilian mandate (0.86 million). Still, the effects on other regions are very limited compare to the base of more than 800 million of world food insecure population.

Table 33. Change in World Undernourished Population by regions (1,000)

| | **w/o sub** | **w/sub** |
|---|---:|---:|
| **United States** | (5) | (5) |
| **Brazil** | 8 | 8 |
| **India** | 17 | 17 |
| **China and Hong Kong** | 4,869 | 4,669 |
| **Latin America and Caribbean** | - | - |
| **Western Europe** | (3) | (3) |
| **Other Far East** | (26) | (35) |
| **Eastern Europe** | 6 | 6 |
| **Rest of the World** | 441 | 415 |
| **Total** | **5,308** | **5,073** |

### Alternative Scenarios on Ethanol Target

By gradually increasing the Chinese Biofuel target with no subsidies, results for alternative scenarios are presented in Figure 38. It shows that the effect of the Chinese biofuel mandate on world hunger is much stronger, compared to the U.S total RFS and the Brazilian mandate. On average, every 1 billion gallons increase in the Chinese mandate would lead to about 2 million more of undernourished people. Similarly, most of the increase in world food insecurity is in China itself. The results are partly because of the fact that China's undernourished population is more sensitive to the food supply and food prices than Brazil and U.S.

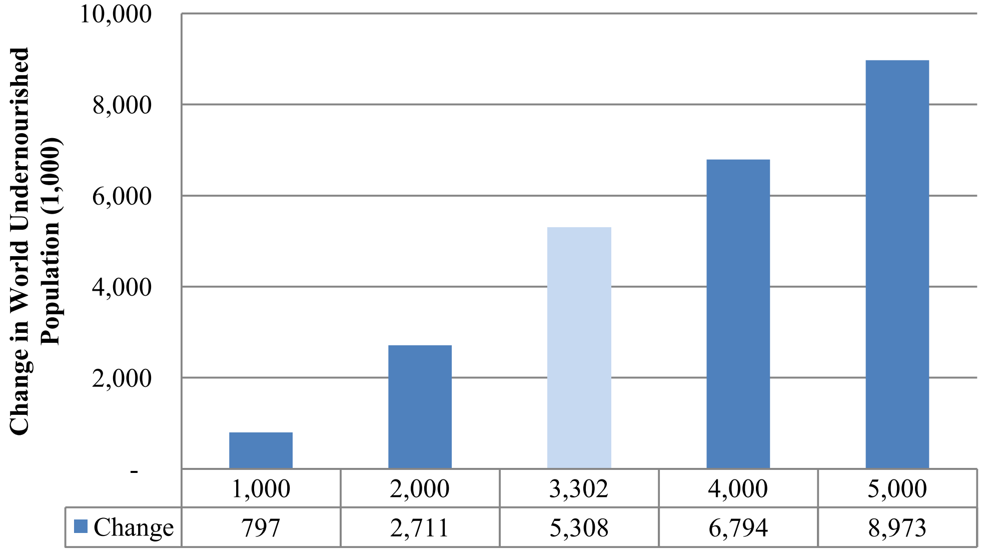


Figure 38. Changes in World Hunger with Increasing Chinese Biofuel Target (1,000)

# CHAPTER VI

# CONCLUSIONS

## ***Results Summary***

Results show that under current production technology, huge biofuel expansion is not possible without any policy enforcement or incentives. Biofuels are still not cost competitive enough to substitute fossil fuel to a large extent. However, expansion of biofuel production does not necessarily lead to booms in world hunger, and the effects are largely depending on which feedstock is used and which region is producing biofuel. Increase production in conventional ethanol from corn in U.S. and China, and sugarcane in Brazil result in rise in world food insecurity. While U.S. biofuel policies have impact on the food insecurity mostly in other countries rather than itself, Brazil and China's biofuel policies only affect the food insecurity domestically and the region of the Rest of the World. On the other hand, increase production in cellulosic ethanol from corn stover in U.S. helps to relieve world food insecurity, but the reduction in hunger shrinks when production of cellulosic ethanol from switch grass in U.S. increases.

For the U.S. RFSs, results show that conventional RFS tends to increase world food insecurity because it pushes up the cereal grains price by increasing the world demand for corn. On the other hand, advanced RFS at certain levels helps to reduce world food insecurity. However, the change in world undernourished population concentrates in three regions including the Other Far East, Latin America and the Caribbean, and the Rest of the World. These regions are characterized as severe food-insecure regions with large population, and more importantly, the largest importers of U.S. food commodities. These regions are net food importers and benefit most from the increase in global food supply. It is also surprised to find that the U.S. RFSs with the highest mandate have the minimum effect on world food insecurity than the biofuel mandates in Brazil and China.

Brazilian biofuel mandate of 17.2 billion gallons by 2020 is much greater than the Chinese biofuel target of 3.3 million gallons in 2020, but their effects on world food insecurity are almost equal, around 5.5 million increase in world undernourished population. The expansion of sugarcane ethanol production in Brazil is much less painful than the expansion of grain ethanol production in China. There are several reasons behind this. First, sugarcane is not a major food crop, so that the ethanol production in Brazil is not directly competing with food commodities. In this case, ethanol production only competes for land and other resources with food commodities. Such indirect effects on domestic agricultural commodity production are small, thus effects on food supply are even smaller. Second, sugarcane ethanol industry in Brazil is established long ago and is the most cost competitive in today's world biofuel industry, for this reason the Brazilian mandatory production and use of ethanol do not increase domestic energy prices as high as Chinese biofuel target does. Consequently, Brazilian consumers' expenditure on food is not reduced a lot by the higher energy price. Third, Brazil does not suffer from severe food insecurity as China does, and its population is very small compared to China's, thus Brazil's food insecurity is much less sensitive to the reduction in food supply than China's.

Subsidy plays an important role to reduce the effect of biofuel mandate on world food insecurity in general. It is also noted that the more subsidy placed on ethanol production, the more reduction in food insecure population will be achieved. As mentioned previously, the CGE model is like a black box and what happen inside is unknown. However, by examining the results, it is found that not only price of petroleum and coal products is lower, but also food prices are lower with subsidies when biofuel mandates are imposed in U.S., Brazil, and China. One possible reason is that, when energy price is lower, consumers' expenditure is lower and households are able to afford more food.

Countries or regions that suffer from food insecurity are more likely to be affected by changing food supply, and thus more likely to be hurt by expansion of the grain-based biofuel production, especially biofuel from major food crops. However, supply of other food commodities other than the biofuel feedstock (cereal grains in this study), is indirectly affected via land use change. Such effects are very small. Thus the overall household food consumption is not largely affected.

It is also noticed that biofuel expansion in developing country is more painful than in developed countries. Because developing countries are usually more food-insecure and populous, biofuel production would firstly impact food consumption and food prices domestically.

Compare to other studies, the price effects are a minimal in contrast to those in Mitchell (2008) and von Braun (2007), which suggest biofuel industry cause food prices to increase significantly. And Runge and Senauer (2007) projected that the number of food insecure would rise to 1.2 billion by 2025 is not likely to happen in this study. On the other hand, Results in this study have same conclusion as Zezza et al. (2008) and Lovendal et al. (2007) that net food buyers and low income groups are mostly affected when food price increases.

Some policy implications can be generated from the above results. First, advanced biofuel production, especially the cellulosic ethanol from crop residue, should be encouraged over conventional biofuels from food crops. Though the results only showed that U.S. advanced biofuel is better than conventional biofuels, regarding the change in world food insecurity, conclusion can be also extended to other countries or regions. Because the use of crop residue such as corn stover for biofuel production did release corn for food and feed use, and the use of switch grass for biofuel production did show less competition for land comparing to the use of corn grain. Second,

### *Caveats*

There are some limitations in this study. First, the CGE results are long-term equilibria, which should take lengthy adjustments to achieve. Hence, short term variations in the market cannot be identified. Second, yield growth and technology advances in the biofuel industry are not accounted for. When there is technological breakthrough in producing cellulosic biofuels, production cost can be largely decreased, and the food insecure countries will be better off. Third, biofuel production for other regions such as EU and India and also the biodiesel production are not incorporated in this study. Although the quantity of production is very limited right now, the three countries we studied have introduced a small mandate on biodiesel production. The emerging market for biodiesel can grow very quickly with policy supports. Fourth, petroleum supply is expected to decrease in the future, which is not accounted for. Fifth, for the food insecurity measurement, population growth is considered.

### *Further Studies*

To adjust the caveats mentioned above, further studies are recommended. Firstly, the model can be improved by adding other types of biofuel production, including cellulosic ethanol in China, biodiesel in EU and U.S.  Second, crop yield growth and technological advances in biofuel production can be incorporated and make it a dynamic CGE model. A dynamic CGE model can also facilitate the population growth, which leads to food demand growth. Third, biofuel trade should be added to facilitate a better representation of the economy. And also more studies on the specification of the elasticities are needed. Fourth, population growth is also needed to add to the food insecurity measurement.

Also, to have a thoroughly understanding of the biofuel issues, alternative scenarios with various levels of petroleum productions, crop yield growth rates, and various biofuel policies from other countries and regions are needed to be simulated and examined.

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# APPENDIX A

## Value of Commodity Production by Region

USA Commodity Production in 2004 Base

| **Commodity** | **Value (Million dollars)** |
|---|---|
| Wheat | 2,264 |
| Processed rice | 1,697 |
| Other cereal grains | 18,407 |
| Processed sugar | 16,452 |
| Oil seeds | 10,225 |
| Vegetable oils and fats | 15,959 |
| Fruits/Vegetables | 53,530 |
| Other food and beverage products | 419,678 |
| Meat products (corresponds to ctl) | 84,194 |
| Other meat products | 63,901 |
| Other animals and products | 40,275 |
| Dairy products | 82,624 |
| Fishing | 6,547 |
| Paddy rice | 1,043 |
| Sugar cane and beets | 2,032 |
| Plant-based fibers | 9,381 |
| Other crops | 25,629 |
| Livestock (cattle, sheep, goats) | 35,058 |
| Raw milk | 26,520 |
| Wool and silk worm cocoons | 70 |
| Forestry and logging | 16,790 |
| Coal mining | 39,988 |
| Crude oil extraction | 203,267 |
| Natural gas extraction | 36,855 |
| Other mineral mining | 33,131 |
| Textiles and clothing products | 329,812 |
| Wood and paper products | 666,578 |
| Petroleum and coal products | 313,929 |
| Chemical rubber and plastic products | 738,206 |
| Other manufactured products | 3,015,593 |
| Electricity | 303,491 |
| Gas manufacturing and distribution | 87,550 |
| Water | 108,479 |

| Commodity | Value (Million dollars) |
|---|---|
| Services | 13,653,940 |
| Transportation | 765,970 |

Note: See Figure 19 for definitions.

BRA Commodity Production in 2004 Base

| Commodity | Value (Million dollars) |
|---|---|
| Wheat | 1,007 |
| Processed rice | 1,562 |
| Other cereal grains | 2,740 |
| Processed sugar | 3,591 |
| Oil seeds | 7,946 |
| Vegetable oils and fats | 7,304 |
| Fruits/Vegetables | 5,725 |
| Other food and beverage products | 35,574 |
| Meat products (corresponds to ctl) | 9,356 |
| Other meat products | 3,137 |
| Other animals and products | 6,520 |
| Dairy products | 7,580 |
| Fishing | 227 |
| Paddy rice | 2,498 |
| Sugar cane and beets | 5,127 |
| Plant-based fibers | 702 |
| Other crops | 16,779 |
| Livestock (cattle, sheep, goats) | 6,964 |
| Raw milk | 3,184 |
| Wool and silk worm cocoons | 36 |
| Forestry and logging | 1,171 |
| Coal mining | 1,051 |
| Crude oil extraction | 19,831 |
| Natural gas extraction | 1,084 |
| Other mineral mining | 5,257 |
| Textiles and clothing products | 23,983 |
| Wood and paper products | 23,729 |
| Petroleum and coal products | 39,221 |
| Chemical rubber and plastic products | 65,459 |
| Other manufactured products | 169,383 |
| Electricity | 33,301 |
| Gas manufacturing and distribution | 1,187 |
| Water | 5,798 |
| Services | 515,465 |
| Transportation | 32,743 |

Note: See Figure 19 for definitions.

CHK Commodity Production in 2004 Base

| **Commodity** | **Value (Million dollars)** |
|---|---|
| Wheat | 10,755 |
| Processed rice | 27,069 |
| Other cereal grains | 10,062 |
| Processed sugar | 652 |
| Oil seeds | 14,699 |
| Vegetable oils and fats | 11,602 |
| Fruits/Vegetables | 122,557 |
| Other food and beverage products | 128,453 |
| Meat products (corresponds to ctl) | 3,760 |
| Other meat products | 16,710 |
| Other animals and products | 98,000 |
| Dairy products | 2,153 |
| Fishing | 38,472 |
| Paddy rice | 19,214 |
| Sugar cane and beets | 1,170 |
| Plant-based fibers | 9,740 |
| Other crops | 1,876 |
| Livestock (cattle, sheep, goats) | 8,785 |
| Raw milk | 2,872 |
| Wool and silk worm cocoons | 4,947 |
| Forestry and logging | 38,497 |
| Coal mining | 49,842 |
| Crude oil extraction | 68,253 |
| Natural gas extraction | 664 |
| Other mineral mining | 77,847 |
| Textiles and clothing products | 225,994 |
| Wood and paper products | 134,974 |
| Petroleum and coal products | 135,500 |
| Chemical rubber and plastic products | 366,858 |
| Other manufactured products | 1,359,129 |
| Electricity | 112,029 |
| Gas manufacturing and distribution | 2,991 |
| Water | 8,544 |
| Services | 1,610,515 |
| Transportation | 272,116 |

Note: See Figure 19 for definitions.

IND Commodity Production in 2004 Base

| Commodity | Value (Million dollars) |
|---|---|
| Wheat | 18,752 |
| Processed rice | 23,786 |
| Other cereal grains | 5,601 |
| Processed sugar | 8,384 |
| Oil seeds | 23,036 |
| Vegetable oils and fats | 11,148 |
| Fruits/Vegetables | 33,557 |
| Other food and beverage products | 35,486 |
| Meat products (corresponds to ctl) | 1,014 |
| Other meat products | 18 |
| Other animals and products | 13,244 |
| Dairy products | 14,795 |
| Fishing | 6,258 |
| Paddy rice | 11,316 |
| Sugar cane and beets | 9,775 |
| Plant-based fibers | 7,349 |
| Other crops | 20,723 |
| Livestock (cattle, sheep, goats) | 5,297 |
| Raw milk | 4,984 |
| Wool and silk worm cocoons | 3,547 |
| Forestry and logging | 8,633 |
| Coal mining | 6,330 |
| Crude oil extraction | 35,836 |
| Natural gas extraction | 4,340 |
| Other mineral mining | 12,037 |
| Textiles and clothing products | 43,967 |
| Wood and paper products | 17,760 |
| Petroleum and coal products | 47,021 |
| Chemical rubber and plastic products | 70,739 |
| Other manufactured products | 199,899 |
| Electricity | 53,501 |
| Gas manufacturing and distribution | 108 |
| Water | 1,941 |
| Services | 388,516 |
| Transportation | 90,301 |

Note: See Figure 19 for definitions.

OFE Commodity Production in 2004 Base

| Commodity | Value (Million dollars) |
|---|---|
| Wheat | 6,640 |
| Processed rice | 49,372 |
| Other cereal grains | 11,660 |
| Processed sugar | 12,971 |
| Oil seeds | 13,510 |
| Vegetable oils and fats | 26,881 |
| Fruits/Vegetables | 77,279 |
| Other food and beverage products | 428,005 |
| Meat products (corresponds to ctl) | 31,676 |
| Other meat products | 39,971 |
| Other animals and products | 34,321 |
| Dairy products | 40,534 |
| Fishing | 40,736 |
| Paddy rice | 41,754 |
| Sugar cane and beets | 3,646 |
| Plant-based fibers | 6,712 |
| Other crops | 31,938 |
| Livestock (cattle, sheep, goats) | 17,357 |
| Raw milk | 13,168 |
| Wool and silk worm cocoons | 1,270 |
| Forestry and logging | 19,168 |
| Coal mining | 20,493 |
| Crude oil extraction | 156,129 |
| Natural gas extraction | 25,021 |
| Other mineral mining | 60,070 |
| Textiles and clothing products | 225,663 |
| Wood and paper products | 345,874 |
| Petroleum and coal products | 270,690 |
| Chemical rubber and plastic products | 670,917 |
| Other manufactured products | 2,642,510 |
| Electricity | 242,973 |
| Gas manufacturing and distribution | 9,269 |
| Water | 44,088 |
| Services | 7,479,910 |
| Transportation | 645,477 |

Note: See Figure 19 for definitions.

EUF Commodity Production in 2004 Base

| Commodity | Value (Million dollars) |
|---|---|
| Wheat | 17,167 |
| Processed rice | 4,089 |
| Other cereal grains | 18,517 |
| Processed sugar | 24,468 |
| Oil seeds | 20,247 |
| Vegetable oils and fats | 40,830 |
| Fruits/Vegetables | 120,680 |
| Other food and beverage products | 950,910 |
| Meat products (corresponds to ctl) | 67,371 |
| Other meat products | 79,560 |
| Other animals and products | 61,274 |
| Dairy products | 193,277 |
| Fishing | 31,676 |
| Paddy rice | 1,414 |
| Sugar cane and beets | 6,764 |
| Plant-based fibers | 9,374 |
| Other crops | 89,081 |
| Livestock (cattle, sheep, goats) | 40,003 |
| Raw milk | 54,787 |
| Wool and silk worm cocoons | 953 |
| Forestry and logging | 45,723 |
| Coal mining | 21,194 |
| Crude oil extraction | 184,044 |
| Natural gas extraction | 54,025 |
| Other mineral mining | 91,257 |
| Textiles and clothing products | 651,111 |
| Wood and paper products | 826,522 |
| Petroleum and coal products | 323,446 |
| Chemical rubber and plastic products | 1,332,139 |
| Other manufactured products | 4,636,552 |
| Electricity | 348,898 |
| Gas manufacturing and distribution | 20,354 |
| Water | 50,787 |
| Services | 14,223,600 |
| Transportation | 1,157,802 |

Note: See Figure 19 for definitions.

RSA Commodity Production in 2004 Base

| **Commodity** | **Value (Million dollars)** |
|---|---|
| Wheat | 5,260 |
| Processed rice | 5,067 |
| Other cereal grains | 16,963 |
| Processed sugar | 8,859 |
| Oil seeds | 10,189 |
| Vegetable oils and fats | 12,533 |
| Fruits/Vegetables | 22,636 |
| Other food and beverage products | 130,529 |
| Meat products (corresponds to ctl) | 19,507 |
| Other meat products | 14,709 |
| Other animals and products | 20,217 |
| Dairy products | 45,113 |
| Fishing | 8,781 |
| Paddy rice | 2,723 |
| Sugar cane and beets | 4,767 |
| Plant-based fibers | 3,654 |
| Other crops | 13,032 |
| Livestock (cattle, sheep, goats) | 13,413 |
| Raw milk | 11,659 |
| Wool and silk worm cocoons | 315 |
| Forestry and logging | 6,886 |
| Coal mining | 1,423 |
| Crude oil extraction | 52,340 |
| Natural gas extraction | 11,105 |
| Other mineral mining | 12,971 |
| Textiles and clothing products | 94,109 |
| Wood and paper products | 82,858 |
| Petroleum and coal products | 75,437 |
| Chemical rubber and plastic products | 197,975 |
| Other manufactured products | 538,341 |
| Electricity | 48,329 |
| Gas manufacturing and distribution | 8,422 |
| Water | 5,551 |
| Services | 1,008,673 |
| Transportation | 109,168 |

Note: See Figure 19 for definitions.

EUO Commodity Production in 2004 Base

| **Commodity** | **Value (Million dollars)** |
|---|---|
| Wheat | 13,471 |
| Processed rice | 2,844 |
| Other cereal grains | 18,378 |
| Processed sugar | 11,915 |
| Oil seeds | 3,588 |
| Vegetable oils and fats | 10,594 |
| Fruits/Vegetables | 49,053 |
| Other food and beverage products | 139,646 |
| Meat products (corresponds to ctl) | 27,399 |
| Other meat products | 25,441 |
| Other animals and products | 22,555 |
| Dairy products | 41,849 |
| Fishing | 3,872 |
| Paddy rice | 389 |
| Sugar cane and beets | 2,619 |
| Plant-based fibers | 2,489 |
| Other crops | 18,985 |
| Livestock (cattle, sheep, goats) | 13,647 |
| Raw milk | 30,901 |
| Wool and silk worm cocoons | 1,686 |
| Forestry and logging | 13,804 |
| Coal mining | 15,640 |
| Crude oil extraction | 80,520 |
| Natural gas extraction | 44,156 |
| Other mineral mining | 26,844 |
| Textiles and clothing products | 97,250 |
| Wood and paper products | 91,294 |
| Petroleum and coal products | 109,376 |
| Chemical rubber and plastic products | 163,867 |
| Other manufactured products | 616,855 |
| Electricity | 152,758 |
| Gas manufacturing and distribution | 19,068 |
| Water | 16,487 |
| Services | 1,284,817 |
| Transportation | 186,720 |

Note: See Figure 19 for definitions.

ROW Commodity Production in 2004 Base

| **Commodity** | **Value (Million dollars)** |
|---|---|
| Wheat | 26,451 |
| Processed rice | 23,117 |
| Other cereal grains | 27,420 |
| Processed sugar | 19,554 |
| Oil seeds | 8,886 |
| Vegetable oils and fats | 24,364 |
| Fruits/Vegetables | 93,247 |
| Other food and beverage products | 144,573 |
| Meat products (corresponds to ctl) | 19,090 |
| Other meat products | 19,406 |
| Other animals and products | 30,476 |
| Dairy products | 35,721 |
| Fishing | 20,690 |
| Paddy rice | 18,693 |
| Sugar cane and beets | 6,749 |
| Plant-based fibers | 15,325 |
| Other crops | 23,073 |
| Livestock (cattle, sheep, goats) | 23,497 |
| Raw milk | 26,288 |
| Wool and silk worm cocoons | 4,733 |
| Forestry and logging | 17,026 |
| Coal mining | 8,839 |
| Crude oil extraction | 110,360 |
| Natural gas extraction | 28,364 |
| Other mineral mining | 28,508 |
| Textiles and clothing products | 166,161 |
| Wood and paper products | 95,407 |
| Petroleum and coal products | 143,784 |
| Chemical rubber and plastic products | 189,656 |
| Other manufactured products | 665,120 |
| Electricity | 102,106 |
| Gas manufacturing and distribution | 22,618 |
| Water | 14,244 |
| Services | 1,574,963 |
| Transportation | 217,152 |

Note: See Figure 19 for definitions.

Commodity Production by Region in 2004 Base (% of Total)

| **Commodity** | **USA** | **BRA** | **CHK** | **IND** | **ofe** | **euf** | **rsa** | **euo** | **row** |
|---|---|---|---|---|---|---|---|---|---|
| Wheat | 2% | 1% | 11% | 18% | 7% | 17% | 5% | 13% | 26% |
| Processed rice | 1% | 1% | 20% | 17% | 36% | 3% | 4% | 2% | 17% |
| Other cereal grains | 14% | 2% | 8% | 4% | 9% | 14% | 13% | 14% | 21% |
| Processed sugar | 15% | 3% | 1% | 8% | 12% | 23% | 8% | 11% | 18% |
| Oil seeds | 9% | 7% | 13% | 21% | 12% | 18% | 9% | 3% | 8% |
| Vegetable oils and fats | 10% | 5% | 7% | 7% | 17% | 25% | 8% | 7% | 15% |
| Fruits/Vegetables | 9% | 1% | 21% | 6% | 13% | 21% | 4% | 8% | 16% |
| Other food and beverage products | 17% | 1% | 5% | 1% | 18% | 39% | 5% | 6% | 6% |
| Meat products (corresponds to ctl) | 32% | 4% | 1% | 0% | 12% | 26% | 7% | 10% | 7% |
| Other meat products | 24% | 1% | 6% | 0% | 15% | 30% | 6% | 10% | 7% |
| Other animals and products | 12% | 2% | 30% | 4% | 10% | 19% | 6% | 7% | 9% |
| Dairy products | 18% | 2% | 0% | 3% | 9% | 42% | 10% | 9% | 8% |
| Fishing | 4% | 0% | 24% | 4% | 26% | 20% | 6% | 2% | 13% |
| Paddy rice | 1% | 3% | 19% | 11% | 42% | 1% | 3% | 0% | 19% |
| Sugar cane and beets | 5% | 12% | 3% | 23% | 9% | 16% | 11% | 6% | 16% |
| Plant-based fibers | 14% | 1% | 15% | 11% | 10% | 14% | 6% | 4% | 24% |
| Other crops | 11% | 7% | 1% | 9% | 13% | 37% | 5% | 8% | 10% |
| Livestock (cattle, sheep, goats) | 21% | 4% | 5% | 3% | 11% | 24% | 8% | 8% | 14% |
| Raw milk | 15% | 2% | 2% | 3% | 8% | 31% | 7% | 18% | 15% |
| Wool and silk worm cocoons | 0% | 0% | 28% | 20% | 7% | 5% | 2% | 10% | 27% |

| **Commodity** | **USA** | **BRA** | **CHK** | **IND** | **ofe** | **euf** | **rsa** | **euo** | **row** |
|---|---|---|---|---|---|---|---|---|---|
| Forestry and logging | 10% | 1% | 23% | 5% | 11% | 27% | 4% | 8% | 10% |
| Coal mining | 24% | 1% | 30% | 4% | 12% | 13% | 1% | 9% | 5% |
| Crude oil extraction | 22% | 2% | 7% | 4% | 17% | 20% | 6% | 9% | 12% |
| Natural gas extraction | 18% | 1% | 0% | 2% | 12% | 26% | 5% | 21% | 14% |
| Other mineral mining | 10% | 2% | 22% | 3% | 17% | 26% | 4% | 8% | 8% |
| Textiles and clothing products | 18% | 1% | 12% | 2% | 12% | 35% | 5% | 5% | 9% |
| Wood and paper products | 29% | 1% | 6% | 1% | 15% | 36% | 4% | 4% | 4% |
| Petroleum and coal products | 22% | 3% | 9% | 3% | 19% | 22% | 5% | 7% | 10% |
| Chemical rubber and plastic products | 19% | 2% | 10% | 2% | 18% | 35% | 5% | 4% | 5% |
| Other manufactured products | 22% | 1% | 10% | 1% | 19% | 33% | 4% | 4% | 5% |
| Electricity | 22% | 2% | 8% | 4% | 17% | 25% | 3% | 11% | 7% |
| Gas manufacturing and distribution | 51% | 1% | 2% | 0% | 5% | 12% | 5% | 11% | 13% |
| Water | 42% | 2% | 3% | 1% | 17% | 20% | 2% | 6% | 6% |
| Services | 33% | 1% | 4% | 1% | 18% | 34% | 2% | 3% | 4% |
| Transportation | 22% | 1% | 8% | 3% | 19% | 33% | 3% | 5% | 6% |

Note: See Figure 19 for definitions.

# APPENDIX B

## Value of Commodity Export by Region

USA Commodity Export in 2004 Base

| | **wbra** | **wrsa** | **wchk** | **wind** | **wofe** | **weuf** | **weuo** | **wrow** |
|---|---|---|---|---|---|---|---|---|
| dwht | 10.40 | 1,367.47 | 549.80 | 0.00 | 1,447.83 | 366.25 | 127.31 | 2,183.55 |
| dpcr | 0.15 | 248.20 | 3.25 | 0.01 | 204.16 | 128.89 | 7.24 | 134.00 |
| dgro | 1.11 | 2,016.93 | 6.32 | 0.25 | 4,018.68 | 439.93 | 29.78 | 1,254.42 |
| dsgr | 0.72 | 57.83 | 0.90 | 0.30 | 8.65 | 50.44 | 1.21 | 4.93 |
| dosd | 0.05 | 991.76 | 2,579.37 | 0.02 | 2,149.90 | 1,560.09 | 24.24 | 281.30 |
| dvol | 4.05 | 915.29 | 27.19 | 28.39 | 348.19 | 711.63 | 54.33 | 665.53 |
| dv_f | 9.91 | 621.81 | 363.65 | 133.22 | 1,499.82 | 4,160.45 | 99.14 | 341.21 |
| dofb | 99.08 | 3,428.94 | 972.79 | 51.84 | 6,159.35 | 8,367.86 | 424.85 | 1,582.97 |
| dcmt | 1.15 | 993.45 | 120.68 | 0.69 | 210.31 | 193.05 | 27.94 | 126.10 |
| domt | 1.97 | 1,268.90 | 268.38 | 0.71 | 1,617.25 | 811.62 | 753.65 | 267.48 |
| doap | 29.57 | 327.81 | 759.81 | 2.86 | 773.74 | 412.08 | 31.94 | 109.42 |
| dmil | 4.69 | 607.93 | 61.42 | 3.38 | 359.62 | 187.03 | 31.31 | 129.01 |
| dfsh | 0.58 | 18.34 | 19.73 | 0.28 | 152.41 | 577.73 | 5.61 | 7.02 |
| dpdr | 9.57 | 290.04 | 0.02 | 0.02 | 63.84 | 63.78 | 1.02 | 85.20 |
| dc_b | 0.00 | 0.04 | 0.00 | 0.00 | 0.02 | 0.01 | 0.00 | 0.00 |
| dpfb | 94.08 | 721.69 | 1,494.17 | 58.76 | 922.48 | 230.26 | 8.12 | 788.85 |
| docr | 16.57 | 308.07 | 86.74 | 5.36 | 821.31 | 1,115.83 | 147.43 | 154.29 |
| dctl | 3.24 | 27.04 | 1.09 | 0.32 | 88.16 | 166.05 | 3.63 | 97.23 |
| drmk | 0.04 | 0.54 | 0.47 | 0.05 | 2.26 | 3.33 | 0.46 | 0.51 |
| dwol | 0.03 | 3.95 | 6.93 | 1.94 | 0.59 | 12.82 | 0.62 | 5.30 |
| dfrs | 1.51 | 61.17 | 83.26 | 1.69 | 702.81 | 685.01 | 7.13 | 36.86 |
| dcoa | 206.52 | 69.76 | 0.75 | 82.49 | 602.81 | 1,264.71 | 70.58 | 228.36 |
| doil | 0.00 | 4.16 | 9.58 | 0.01 | 24.47 | 87.23 | 0.02 | 24.25 |
| dgas | 0.00 | 1,266.54 | 0.00 | 0.00 | 120.77 | 626.54 | 0.00 | 0.11 |
| domn | 47.56 | 387.03 | 306.81 | 50.92 | 780.31 | 1,996.41 | 67.40 | 393.18 |
| dclt | 128.71 | 11,005.79 | 1,012.60 | 65.27 | 2,108.75 | 5,870.39 | 301.34 | 799.30 |
| dwdp | 199.08 | 6,838.69 | 2,138.40 | 193.37 | 4,480.42 | 15,887.93 | 295.74 | 1,152.20 |
| dp_c | 315.46 | 6,387.06 | 828.25 | 75.83 | 2,611.32 | 5,315.31 | 240.79 | 1,004.16 |
| dcrp | 3,760.01 | 28,016.33 | 8,116.18 | 1,333.78 | 27,502.03 | 69,820.34 | 1,759.24 | 4,888.91 |
| dmfg | 7,748.37 | 82,480.94 | 27,860.65 | 3,928.09 | 103,719.90 | 243,372.60 | 8,858.72 | 28,018.20 |
| dely | 48.55 | 7.30 | 52.22 | 4.52 | 11.32 | 973.59 | 48.28 | 46.87 |
| dgdt | 0.86 | 12.07 | 24.43 | 0.01 | 83.76 | 153.77 | 20.32 | 12.94 |
| dwtr | 1.97 | 24.85 | 21.75 | 2.39 | 104.43 | 153.85 | 21.39 | 23.76 |
| dsrv | 1,699.26 | 10,562.22 | 8,147.99 | 2,475.97 | 48,174.00 | 100,277.70 | 12,229.34 | 23,174.21 |
| dtrn | 258.35 | 2,524.36 | 2,806.77 | 327.90 | 11,999.10 | 24,963.10 | 2,523.55 | 4,530.80 |

Note: See Figure 19 and Table 7 for definitions.

BRA Commodity Export in 2004 Base

| | **wusa** | **wrsa** | **wchk** | **wind** | **wofe** | **weuf** | **weuo** | **wrow** |
|---|---|---|---|---|---|---|---|---|
| dwht | 0.01 | 0.01 | 0.00 | 0.00 | 0.02 | 19.99 | 66.89 | 208.12 |
| dpcr | 0.56 | 2.48 | 0.14 | 0.02 | 1.00 | 2.41 | 0.20 | 4.15 |
| dgro | 0.69 | 16.19 | 0.01 | 0.00 | 249.88 | 239.73 | 67.79 | 265.67 |
| dsgr | 69.42 | 44.09 | 0.18 | 173.28 | 46.25 | 170.90 | 662.64 | 1,612.12 |
| dosd | 72.70 | 183.71 | 1,607.61 | 0.00 | 527.86 | 2,743.33 | 38.48 | 393.78 |
| dvol | 106.35 | 146.36 | 494.13 | 152.02 | 466.85 | 1,825.23 | 289.54 | 894.53 |
| dv_f | 170.45 | 29.59 | 0.96 | 0.83 | 11.31 | 562.84 | 29.25 | 18.26 |
| dofb | 680.47 | 601.19 | 83.29 | 190.63 | 452.04 | 1,139.56 | 165.04 | 230.58 |
| dcmt | 4.86 | 236.89 | 128.23 | 0.20 | 78.87 | 817.84 | 310.84 | 574.83 |
| domt | 199.65 | 223.71 | 288.85 | 0.05 | 730.52 | 940.34 | 817.08 | 1,022.86 |
| doap | 86.73 | 26.80 | 8.52 | 0.08 | 23.98 | 129.30 | 14.85 | 8.93 |
| dmil | 13.45 | 29.03 | 0.84 | 0.07 | 8.14 | 6.28 | 0.89 | 53.72 |
| dfsh | 40.90 | 0.44 | 0.44 | 0.00 | 6.38 | 23.85 | 0.21 | 0.29 |
| dpdr | 0.00 | 0.30 | 0.00 | 0.00 | 0.02 | 0.00 | 0.01 | 0.08 |
| dc_b | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| dpfb | 4.33 | 67.14 | 35.39 | 11.90 | 164.76 | 71.30 | 4.79 | 67.43 |
| docr | 548.81 | 185.03 | 63.55 | 1.77 | 383.60 | 1,665.83 | 283.65 | 230.35 |
| dctl | 3.01 | 3.74 | 0.01 | 0.00 | 0.04 | 0.78 | 0.01 | 8.75 |
| drmk | 0.22 | 0.05 | 0.09 | 0.01 | 0.27 | 0.81 | 0.10 | 0.12 |
| dwol | 0.08 | 5.71 | 0.05 | 0.11 | 0.04 | 0.80 | 0.00 | 0.00 |
| dfrs | 4.70 | 5.15 | 0.34 | 0.43 | 1.11 | 13.87 | 0.39 | 1.57 |
| dcoa | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 |
| doil | 460.15 | 757.57 | 268.28 | 0.24 | 88.18 | 215.26 | 0.30 | 36.84 |
| dgas | | | | | 0.00 | 0.00 | | 0.00 |
| domn | 297.45 | 474.34 | 2,490.43 | 96.65 | 1,558.36 | 2,674.57 | 260.88 | 406.76 |
| dclt | 1,864.79 | 1,104.33 | 327.80 | 18.59 | 334.15 | 1,389.22 | 59.84 | 181.18 |
| dwdp | 2,570.17 | 1,090.25 | 523.05 | 3.02 | 491.83 | 2,621.32 | 73.48 | 308.12 |
| dp_c | 1,785.47 | 414.80 | 22.44 | 3.55 | 121.37 | 117.37 | 121.28 | 430.43 |
| dcrp | 1,197.57 | 3,338.61 | 197.22 | 72.76 | 389.34 | 1,393.67 | 110.69 | 442.39 |
| dmfg | 11,744.28 | 13,091.40 | 994.55 | 148.87 | 2,669.82 | 7,804.71 | 686.07 | 2,450.91 |
| dely | 0.04 | 0.24 | 0.06 | 0.01 | 0.01 | 0.33 | 0.07 | 0.06 |
| dgdt | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 |
| dwtr | 2.09 | 0.51 | 0.83 | 0.09 | 2.53 | 7.67 | 0.96 | 1.13 |
| dsrv | 1,467.43 | 184.41 | 233.45 | 86.49 | 1,036.98 | 3,954.58 | 386.26 | 784.81 |
| dtrn | 218.13 | 91.21 | 90.40 | 22.69 | 594.89 | 1,429.41 | 120.69 | 196.30 |

Note: See Figure 19 and Table 7 for definitions.

CHK Commodity Export in 2004 Base

| | **wusa** | **wbra** | **wrsa** | **wchk** | **wind** | **wofe** | **weuf** | **weuo** | **wrow** |
|---|---|---|---|---|---|---|---|---|---|
| dwht | 0.25 | 0.01 | 0.06 | 0.04 | 0.01 | 105.80 | 0.86 | 1.01 | 31.39 |
| dpcr | 35.41 | 0.70 | 4.79 | 6.38 | 0.87 | 78.93 | 74.88 | 39.62 | 108.72 |
| dgro | 1.01 | 0.18 | 0.14 | 1.11 | 0.01 | 417.53 | 18.41 | 2.83 | 12.87 |
| dsgr | 0.64 | 0.00 | 0.02 | 4.78 | 0.00 | 9.69 | 1.36 | 1.40 | 6.03 |
| dosd | 23.44 | 0.04 | 15.14 | 1.58 | 0.08 | 254.30 | 183.24 | 61.87 | 66.93 |
| dvol | 11.02 | 0.21 | 0.79 | 17.75 | 0.94 | 326.65 | 17.15 | 4.48 | 41.45 |
| dv_f | 222.89 | 13.80 | 71.76 | 92.16 | 25.83 | 1,329.67 | 571.92 | 145.29 | 357.39 |
| dofb | 2,383.95 | 17.39 | 137.04 | 555.08 | 14.41 | 7,657.83 | 2,586.56 | 350.80 | 802.96 |
| dcmt | 1.22 | 0.19 | 1.13 | 7.41 | 0.12 | 9.47 | 4.74 | 3.87 | 38.64 |
| domt | 26.25 | 0.33 | 3.89 | 161.61 | 0.40 | 922.23 | 29.81 | 119.60 | 174.47 |
| doap | 426.51 | 4.10 | 18.88 | 136.98 | 11.69 | 489.33 | 425.02 | 128.01 | 136.03 |
| dmil | 10.12 | 0.30 | 0.56 | 17.75 | 0.11 | 27.96 | 17.49 | 1.40 | 18.16 |
| dfsh | 44.83 | 0.65 | 4.54 | 49.65 | 1.98 | 915.06 | 84.46 | 9.73 | 26.27 |
| dpdr | 1.16 | 0.04 | 0.38 | 0.19 | 0.05 | 32.94 | 4.80 | 4.25 | 22.52 |
| dc_b | 0.13 | 0.01 | 0.03 | 0.02 | 0.01 | 0.16 | 0.48 | 0.06 | 0.06 |
| dpfb | 0.53 | 0.00 | 0.52 | 0.48 | 0.56 | 16.43 | 1.48 | 0.18 | 1.23 |
| docr | 127.35 | 0.30 | 20.79 | 50.11 | 16.20 | 684.92 | 238.35 | 49.19 | 238.54 |
| dctl | 0.77 | 0.02 | 0.12 | 7.19 | 0.03 | 1.40 | 1.73 | 0.25 | 8.95 |
| drmk | 0.38 | 0.01 | 0.09 | 0.06 | 0.02 | 0.43 | 1.38 | 0.17 | 0.16 |
| dwol | 5.51 | 0.13 | 1.57 | 0.48 | 0.59 | 6.24 | 35.49 | 1.50 | 3.79 |
| dfrs | 12.72 | 0.18 | 3.83 | 1.77 | 1.73 | 43.76 | 55.34 | 2.50 | 5.15 |
| dcoa | 28.47 | 15.80 | 4.31 | 30.06 | 117.07 | 3,195.86 | 153.81 | 11.28 | 136.79 |
| doil | 113.13 | 0.02 | 0.92 | 0.00 | 0.12 | 608.20 | 0.66 | 0.14 | 97.52 |
| dgas | 3.38 | 0.11 | 0.66 | 3.47 | 0.00 | 9.68 | 33.98 | 2.66 | 2.31 |
| domn | 391.25 | 9.62 | 30.54 | 14.92 | 147.59 | 881.03 | 932.88 | 66.62 | 154.56 |
| dclt | 28,933.55 | 526.59 | 4,449.04 | 13,321.41 | 1,123.50 | 38,639.48 | 28,310.81 | 8,495.93 | 15,237.97 |
| dwdp | 10,843.09 | 16.53 | 380.89 | 1,831.54 | 75.83 | 5,403.13 | 5,141.91 | 227.86 | 1,032.33 |
| dp_c | 888.50 | 452.52 | 672.84 | 122.27 | 145.34 | 3,414.38 | 1,256.24 | 137.88 | 1,233.65 |
| dcrp | 12,027.40 | 481.09 | 1,712.82 | 3,849.70 | 1,325.24 | 12,843.64 | 10,341.54 | 1,268.73 | 4,735.24 |
| dmfg | 119,934.70 | 1,908.90 | 12,323.85 | 16,483.71 | 3,848.51 | 111,151.40 | 108,556.80 | 9,840.64 | 22,300.87 |
| dely | 64.08 | 73.92 | 9.29 | 36.37 | 6.65 | 16.71 | 244.57 | 56.84 | 66.61 |
| dgdt | 10.74 | 0.37 | 2.09 | 11.01 | 0.01 | 29.66 | 107.82 | 8.43 | 6.64 |
| dwtr | 14.82 | 0.47 | 2.81 | 2.30 | 0.57 | 20.20 | 41.05 | 5.27 | 5.32 |
| dsrv | 14,457.01 | 746.74 | 2,397.29 | 16,814.13 | 805.66 | 22,774.58 | 38,950.73 | 2,942.52 | 5,686.80 |
| dtrn | 5,560.59 | 187.72 | 736.06 | 450.42 | 255.37 | 7,388.65 | 8,657.62 | 974.98 | 1,515.86 |

Note: See Figure 19 and Table 7 for definitions.

IND Commodity Export in 2004 Base

| | **wusa** | **wbra** | **wrsa** | **wchk** | **wofe** | **weuf** | **weuo** | **wrow** |
|---|---|---|---|---|---|---|---|---|
| dwht | 3.20 | 0.12 | 0.76 | 1.25 | 146.00 | 11.66 | 1.44 | 349.44 |
| dpcr | 27.22 | 0.18 | 4.19 | 1.87 | 24.86 | 51.95 | 5.11 | 1,067.72 |
| dgro | 1.18 | 0.04 | 0.27 | 1.59 | 128.16 | 4.65 | 0.50 | 81.12 |
| dsgr | 4.80 | 0.05 | 0.38 | 0.57 | 2.66 | 19.46 | 0.69 | 26.33 |
| dosd | 38.87 | 0.88 | 12.38 | 24.04 | 86.08 | 98.05 | 19.94 | 50.09 |
| dvol | 94.36 | 0.07 | 2.59 | 56.02 | 610.69 | 159.70 | 4.90 | 379.73 |
| dv_f | 245.87 | 0.20 | 4.23 | 12.85 | 97.63 | 300.51 | 21.38 | 379.03 |
| dofb | 533.32 | 3.05 | 16.11 | 71.02 | 547.54 | 717.33 | 105.56 | 450.97 |
| dcmt | 0.66 | 0.01 | 0.07 | 0.33 | 196.24 | 11.85 | 23.61 | 249.63 |
| domt | 0.20 | 0.00 | 0.07 | 1.30 | 3.49 | 2.33 | 0.09 | 6.78 |
| doap | 13.06 | 0.13 | 0.62 | 2.78 | 17.73 | 50.15 | 1.17 | 44.24 |
| dmil | 35.97 | 0.11 | 0.94 | 1.19 | 10.65 | 21.32 | 1.45 | 60.77 |
| dfsh | 3.80 | 0.10 | 0.99 | 4.48 | 21.18 | 18.98 | 1.14 | 8.99 |
| dpdr | 12.00 | 0.04 | 0.36 | 0.46 | 1.58 | 109.68 | 0.56 | 3.89 |
| dc_b | 1.13 | 0.06 | 0.27 | 0.45 | 1.34 | 4.20 | 0.52 | 0.59 |
| dpfb | 1.14 | 0.02 | 0.20 | 47.20 | 82.19 | 6.04 | 0.63 | 135.66 |
| docr | 96.99 | 2.68 | 9.16 | 8.80 | 127.01 | 366.90 | 140.98 | 271.85 |
| dctl | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.04 | 0.00 | 4.19 |
| drmk | 0.62 | 0.02 | 0.15 | 0.25 | 0.74 | 2.32 | 0.29 | 0.32 |
| dwol | 3.18 | 0.11 | 0.71 | 1.10 | 3.47 | 10.51 | 1.33 | 1.57 |
| dfrs | 17.65 | 1.06 | 8.75 | 3.02 | 20.67 | 64.40 | 4.68 | 28.93 |
| dcoa | 0.62 | 0.03 | 0.17 | 0.21 | 0.71 | 1.79 | 0.31 | 36.31 |
| doil | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.20 |
| dgas | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| domn | 45.24 | 0.32 | 8.46 | 2,977.32 | 638.75 | 549.79 | 115.18 | 238.06 |
| dclt | 4,139.79 | 62.18 | 309.53 | 427.58 | 1,316.48 | 8,110.62 | 465.00 | 3,176.05 |
| dwdp | 142.99 | 0.51 | 10.73 | 18.73 | 79.43 | 320.83 | 12.78 | 376.78 |
| dp_c | 195.96 | 139.27 | 11.11 | 30.07 | 1,258.58 | 275.91 | 7.48 | 1,650.93 |
| dcrp | 1,463.40 | 277.87 | 560.69 | 728.82 | 1,623.29 | 2,473.21 | 707.63 | 3,341.07 |
| dmfg | 8,318.38 | 79.28 | 598.82 | 2,212.33 | 4,581.50 | 7,574.03 | 515.06 | 9,758.12 |
| dely | 0.29 | 0.45 | 0.07 | 0.47 | 0.10 | 2.57 | 0.50 | 0.43 |
| dgdt | 0.01 | 0.00 | 0.00 | 0.01 | 0.03 | 0.10 | 0.01 | 0.01 |
| dwtr | 0.19 | 0.01 | 0.05 | 0.08 | 0.23 | 0.71 | 0.09 | 0.10 |
| dsrv | 1,694.98 | 256.33 | 296.04 | 508.83 | 1,729.18 | 9,197.97 | 779.52 | 770.70 |
| dtrn | 359.80 | 22.07 | 94.38 | 141.50 | 543.81 | 1,534.65 | 164.32 | 231.66 |

Note: See Figure 19 and Table 7 for definitions.

OFE Commodity Export in 2004 Base

| | wusa | wbra | wrsa | wchk | wind | wofe | weuf | weuo | wrow |
|---|---|---|---|---|---|---|---|---|---|
| dwht | 0.23 | 0.00 | 0.43 | 273.69 | 0.00 | 1,353.30 | 102.67 | 0.10 | 955.60 |
| dpcr | 170.73 | 22.83 | 41.52 | 366.37 | 0.82 | 467.52 | 211.60 | 64.78 | 1,538.48 |
| dgro | 1.40 | 0.03 | 27.51 | 183.46 | 0.68 | 352.66 | 7.15 | 0.50 | 356.05 |
| dsgr | 114.73 | 0.41 | 1.99 | 157.03 | 13.82 | 1,154.28 | 90.95 | 13.38 | 192.56 |
| dosd | 9.42 | 0.38 | 1.34 | 2.14 | 6.44 | 343.81 | 79.70 | 1.10 | 146.56 |
| dvol | 479.78 | 29.73 | 95.52 | 2,488.60 | 1,427.64 | 1,972.60 | 1,371.14 | 277.14 | 4,010.14 |
| dv_f | 293.37 | 2.69 | 13.52 | 875.67 | 90.58 | 1,931.47 | 1,005.31 | 44.21 | 408.66 |
| dofb | 5,531.54 | 28.53 | 250.41 | 2,152.00 | 78.39 | 13,194.60 | 5,031.83 | 509.40 | 2,614.37 |
| dcmt | 2,188.49 | 0.48 | 139.97 | 240.35 | 2.61 | 3,352.46 | 1,397.19 | 54.51 | 479.19 |
| domt | 87.56 | 3.92 | 4.78 | 68.50 | 1.51 | 863.85 | 501.15 | 23.69 | 118.69 |
| doap | 116.06 | 4.91 | 15.26 | 627.70 | 9.35 | 709.61 | 267.92 | 43.65 | 131.66 |
| dmil | 483.04 | 4.22 | 458.34 | 381.38 | 4.23 | 2,503.76 | 407.97 | 98.13 | 1,393.78 |
| dfsh | 221.79 | 1.98 | 10.38 | 369.60 | 2.02 | 1,487.78 | 201.55 | 13.88 | 81.37 |
| dpdr | 2.40 | 0.21 | 0.70 | 1.20 | 0.07 | 27.07 | 39.40 | 3.38 | 117.82 |
| dc_b | 1.39 | 0.06 | 0.31 | 0.56 | 0.06 | 1.45 | 5.11 | 0.61 | 0.53 |
| dpfb | 4.60 | 0.12 | 0.69 | 136.70 | 5.76 | 520.90 | 38.44 | 1.43 | 60.27 |
| docr | 502.68 | 32.87 | 39.06 | 124.69 | 35.12 | 1,193.96 | 603.22 | 94.97 | 217.16 |
| dctl | 14.76 | 0.16 | 14.89 | 177.89 | 0.08 | 303.19 | 12.71 | 0.70 | 227.36 |
| drmk | 0.63 | 0.02 | 0.08 | 0.49 | 0.02 | 1.17 | 0.72 | 0.15 | 0.22 |
| dwol | 16.54 | 0.15 | 7.08 | 696.41 | 154.07 | 102.62 | 444.92 | 75.07 | 25.68 |
| dfrs | 25.99 | 0.52 | 3.73 | 586.10 | 202.87 | 710.74 | 53.63 | 3.89 | 130.44 |
| dcoa | 49.11 | 336.60 | 252.18 | 733.65 | 832.58 | 8,983.78 | 1,834.08 | 87.66 | 291.57 |
| doil | 824.23 | 10.14 | 30.44 | 1,957.23 | 799.54 | 7,592.37 | 10.74 | 2.22 | 149.62 |
| dgas | 131.78 | 0.08 | 0.98 | 11.43 | 0.00 | 9,392.04 | 24.76 | 1.66 | 5.94 |
| domn | 261.22 | 1.16 | 45.58 | 3,309.22 | 610.76 | 6,545.20 | 2,250.61 | 136.42 | 477.49 |
| dclt | 15,875.09 | 462.77 | 2,315.36 | 15,738.12 | 816.51 | 12,186.68 | 12,444.99 | 1,267.10 | 11,580.91 |
| dwdp | 6,189.46 | 34.76 | 390.43 | 5,833.94 | 306.88 | 14,528.12 | 5,509.48 | 321.12 | 3,736.63 |
| dp_c | 1,263.39 | 83.45 | 110.92 | 7,476.54 | 196.98 | 11,912.32 | 413.55 | 27.17 | 3,475.28 |
| dcrp | 25,783.48 | 1,095.52 | 3,649.68 | 56,169.36 | 2,791.22 | 64,747.62 | 28,690.46 | 2,791.53 | 13,997.84 |
| dmfg | 229,923.70 | 5,075.03 | 27,669.92 | 236,605.70 | 13,283.28 | 341,718.70 | 203,224.40 | 24,402.18 | 74,105.15 |
| dely | 1.75 | 2.45 | 0.32 | 3.40 | 0.24 | 0.52 | 13.76 | 2.17 | 2.23 |
| dgdt | 11.41 | 0.61 | 2.14 | 20.69 | 0.01 | 30.75 | 103.31 | 11.40 | 24.24 |
| dwtr | 43.43 | 1.42 | 6.83 | 32.96 | 1.72 | 66.43 | 85.23 | 12.52 | 15.35 |
| dsrv | 24,961.45 | 1,245.48 | 3,217.70 | 9,635.32 | 1,361.70 | 24,009.60 | 52,832.96 | 7,217.32 | 9,904.51 |
| dtrn | 11,143.90 | 572.35 | 1,935.17 | 4,032.75 | 643.77 | 13,942.11 | 20,663.73 | 2,443.53 | 3,987.43 |

Note: See Figure 19 and Table 7 for definitions.

EUF Commodity Export in 2004 Base

| | wusa | wbra | wrsa | wchk | wind | wofe | weuf | weuo | wrow |
|---|---|---|---|---|---|---|---|---|---|
| dwht | 160.95 | 2.61 | 592.06 | 515.35 | 0.13 | 577.35 | 3,665.73 | 146.88 | 1,726.92 |
| dpcr | 5.61 | 1.39 | 3.74 | 0.71 | 0.35 | 6.16 | 559.59 | 73.94 | 82.50 |
| dgro | 331.01 | 15.49 | 49.84 | 66.78 | 0.16 | 87.85 | 3,221.55 | 247.82 | 351.08 |
| dsgr | 101.73 | 0.65 | 48.80 | 14.38 | 2.51 | 65.51 | 2,214.62 | 243.86 | 803.49 |
| dosd | 216.76 | 1.51 | 414.84 | 117.71 | 1.28 | 719.48 | 1,424.04 | 77.02 | 304.48 |
| dvol | 1,431.77 | 95.54 | 177.80 | 213.78 | 12.49 | 616.93 | 6,318.28 | 1,200.31 | 869.57 |
| dv_f | 1,175.70 | 27.73 | 243.55 | 45.67 | 125.41 | 181.59 | 21,365.51 | 1,770.31 | 690.41 |
| dofb | 18,514.48 | 443.73 | 2,375.43 | 1,459.69 | 118.54 | 8,767.98 | 101,180.00 | 9,513.02 | 8,813.27 |
| dcmt | 1,271.33 | 3.34 | 394.13 | 224.73 | 2.76 | 177.24 | 8,498.93 | 823.25 | 244.47 |
| domt | 1,566.14 | 6.17 | 233.81 | 179.21 | 4.13 | 2,523.91 | 17,838.86 | 1,577.18 | 709.71 |
| doap | 863.71 | 30.14 | 66.12 | 1,075.83 | 27.92 | 371.26 | 5,047.33 | 582.44 | 553.86 |
| dmil | 1,254.56 | 21.01 | 549.57 | 207.20 | 23.47 | 1,120.83 | 23,297.94 | 1,038.47 | 2,962.90 |
| dfsh | 826.14 | 0.82 | 18.67 | 139.92 | 1.55 | 297.98 | 5,358.52 | 247.87 | 100.71 |
| dpdr | 1.31 | 0.33 | 0.26 | 0.07 | 0.01 | 0.20 | 197.42 | 2.75 | 5.22 |
| dc_b | 0.35 | 0.01 | 0.06 | 0.09 | 0.01 | 0.23 | 12.17 | 0.15 | 0.20 |
| dpfb | 25.25 | 2.22 | 4.15 | 31.86 | 11.72 | 75.40 | 241.83 | 76.92 | 352.72 |
| docr | 940.87 | 25.43 | 158.31 | 150.96 | 14.13 | 548.31 | 9,345.75 | 1,264.44 | 597.57 |
| dctl | 266.91 | 2.59 | 22.82 | 25.15 | 0.20 | 59.72 | 2,713.38 | 64.58 | 374.91 |
| drmk | 9.26 | 0.42 | 1.87 | 3.83 | 0.53 | 7.05 | 55.69 | 4.35 | 4.74 |
| dwol | 4.72 | 0.65 | 2.45 | 33.38 | 14.01 | 4.55 | 129.47 | 18.55 | 4.67 |
| dfrs | 307.20 | 4.68 | 25.13 | 92.16 | 9.99 | 306.94 | 1,987.23 | 107.59 | 74.26 |
| dcoa | 98.36 | 59.61 | 38.48 | 74.77 | 2.68 | 317.79 | 321.98 | 18.46 | 60.45 |
| doil | 18,261.12 | 2.26 | 250.69 | 641.33 | 12.55 | 390.07 | 40,363.66 | 73.08 | 28.00 |
| dgas | 12,280.17 | 0.53 | 77.43 | 9.90 | 0.00 | 27.81 | 16,521.28 | 37.49 | 29.84 |
| domn | 1,589.11 | 99.23 | 230.84 | 1,574.17 | 5,450.44 | 1,349.43 | 12,809.23 | 774.82 | 5,232.66 |
| dclt | 13,844.06 | 348.49 | 1,979.47 | 3,765.48 | 404.69 | 8,775.52 | 98,523.93 | 23,443.68 | 12,622.33 |
| dwdp | 42,378.62 | 539.62 | 3,131.23 | 3,294.47 | 838.38 | 10,568.08 | 117,956.30 | 14,894.65 | 9,871.72 |
| dp_c | 14,724.21 | 350.15 | 730.52 | 514.02 | 45.96 | 1,046.82 | 36,493.03 | 2,520.33 | 5,249.50 |
| dcrp | 83,414.11 | 5,427.29 | 11,611.36 | 12,361.37 | 2,699.56 | 36,842.63 | 403,922.60 | 46,860.59 | 39,122.81 |
| dmfg | 280,041.70 | 10,728.40 | 35,399.84 | 61,911.82 | 14,087.74 | 113,901.30 | 1,053,485.00 | 165,864.80 | 153,225.30 |
| dely | 1,287.80 | 538.74 | 83.28 | 300.91 | 39.77 | 94.58 | 10,949.14 | 975.71 | 477.64 |
| dgdt | 70.40 | 2.60 | 7.16 | 44.39 | 0.04 | 155.13 | 413.00 | 50.28 | 69.21 |
| dwtr | 78.32 | 3.77 | 17.36 | 33.50 | 4.64 | 64.00 | 438.01 | 40.98 | 43.86 |
| dsrv | 94,352.55 | 6,054.03 | 16,921.81 | 25,190.84 | 8,608.82 | 65,773.49 | 388,731.20 | 37,475.41 | 46,693.73 |
| dtrn | 27,915.38 | 2,046.44 | 6,050.73 | 6,091.63 | 2,080.93 | 25,040.11 | 103,918.20 | 8,653.77 | 12,562.67 |

Note: See Figure 19 and Table 7 for definitions.

RSA Commodity Export in 2004 Base

| | **wusa** | **wbra** | **wrsa** | **wchk** | **wind** | **wofe** | **weuf** | **weuo** | **wrow** |
|---|---|---|---|---|---|---|---|---|---|
| dwht | 2.33 | 697.68 | 148.24 | 4.27 | 0.01 | 20.75 | 76.11 | 24.12 | 705.12 |
| dpcr | 3.70 | 91.23 | 45.74 | 1.12 | 0.12 | 4.47 | 26.82 | 2.17 | 28.95 |
| dgro | 97.76 | 59.18 | 361.06 | 1.29 | 0.47 | 215.71 | 332.30 | 12.08 | 590.34 |
| dsgr | 388.42 | 0.14 | 364.07 | 93.62 | 0.15 | 55.51 | 421.11 | 243.25 | 75.58 |
| dosd | 45.65 | 71.51 | 703.17 | 993.83 | 0.33 | 382.60 | 760.04 | 13.76 | 367.61 |
| dvol | 122.81 | 80.76 | 2,044.27 | 713.25 | 394.14 | 734.53 | 2,075.98 | 263.07 | 1,605.62 |
| dv_f | 5,884.98 | 174.33 | 622.53 | 115.12 | 3.35 | 286.27 | 4,893.70 | 806.53 | 183.22 |
| dofb | 7,598.70 | 592.31 | 3,352.99 | 683.11 | 23.82 | 2,036.95 | 5,449.12 | 403.91 | 480.91 |
| dcmt | 441.78 | 82.87 | 293.81 | 48.62 | 0.41 | 58.55 | 729.30 | 239.11 | 272.91 |
| domt | 138.77 | 2.89 | 211.69 | 48.61 | 0.48 | 449.47 | 357.87 | 16.95 | 56.83 |
| doap | 91.66 | 9.73 | 93.78 | 27.86 | 0.46 | 46.54 | 310.59 | 18.65 | 24.52 |
| dmil | 115.84 | 71.80 | 555.38 | 5.12 | 0.58 | 47.50 | 74.89 | 30.12 | 230.86 |
| dfsh | 345.62 | 30.57 | 48.73 | 9.39 | 0.13 | 97.81 | 103.05 | 1.50 | 2.46 |
| dpdr | 0.84 | 80.18 | 34.90 | 0.01 | 0.00 | 0.69 | 16.49 | 0.09 | 1.51 |
| dc_b | 1.41 | 0.04 | 1.69 | 0.54 | 0.03 | 0.73 | 2.39 | 0.30 | 0.32 |
| dpfb | 28.94 | 50.36 | 40.50 | 52.48 | 4.36 | 50.94 | 32.42 | 3.27 | 23.74 |
| docr | 2,171.49 | 15.03 | 215.14 | 7.27 | 3.35 | 438.92 | 2,088.85 | 121.18 | 165.61 |
| dctl | 528.56 | 0.59 | 208.00 | 0.78 | 0.06 | 2.13 | 18.75 | 0.50 | 43.51 |
| drmk | 1.51 | 0.04 | 0.25 | 0.42 | 0.05 | 1.14 | 3.73 | 0.46 | 0.44 |
| dwol | 0.46 | 0.09 | 18.13 | 7.42 | 1.42 | 0.54 | 36.70 | 6.46 | 0.32 |
| dfrs | 66.59 | 2.19 | 16.48 | 5.14 | 20.45 | 40.98 | 216.61 | 5.77 | 24.00 |
| dcoa | 739.19 | 40.82 | 170.92 | 0.56 | 4.79 | 21.66 | 1,164.55 | 21.78 | 239.38 |
| doil | 44,041.08 | 273.29 | 4,234.92 | 264.17 | 489.75 | 691.38 | 3,774.50 | 14.94 | 91.33 |
| dgas | 1,557.27 | 552.00 | 728.58 | 0.22 | 0.00 | 10.32 | 12.18 | 0.28 | 1.20 |
| domn | 749.60 | 609.79 | 748.73 | 1,474.90 | 486.87 | 4,043.44 | 3,114.43 | 340.16 | 220.43 |
| dclt | 19,381.95 | 270.27 | 2,287.26 | 362.18 | 47.49 | 549.77 | 2,083.40 | 166.14 | 235.15 |
| dwdp | 7,119.11 | 224.72 | 2,698.13 | 347.04 | 12.15 | 841.72 | 1,476.39 | 46.57 | 208.76 |
| dp_c | 8,510.83 | 840.23 | 3,856.03 | 299.97 | 3.52 | 143.00 | 1,203.26 | 24.92 | 218.54 |
| dcrp | 8,977.77 | 2,067.22 | 8,541.92 | 441.48 | 76.38 | 1,181.39 | 3,989.29 | 220.42 | 455.82 |
| dmfg | 109,556.40 | 2,751.84 | 12,330.79 | 4,177.03 | 228.46 | 7,124.02 | 25,836.95 | 1,583.12 | 2,149.42 |
| dely | 62.77 | 507.08 | 524.61 | 45.03 | 3.71 | 11.40 | 377.51 | 353.27 | 157.56 |
| dgdt | 8.66 | 0.28 | 1.59 | 6.61 | 0.00 | 22.77 | 78.12 | 7.76 | 15.71 |
| dwtr | 25.44 | 0.55 | 3.18 | 5.39 | 0.66 | 14.28 | 45.37 | 5.77 | 5.80 |
| dsrv | 6,646.50 | 216.99 | 818.40 | 1,149.63 | 284.45 | 3,850.08 | 12,765.50 | 1,415.73 | 2,058.31 |
| dtrn | 5,260.51 | 183.44 | 670.73 | 864.90 | 164.70 | 3,361.82 | 9,143.71 | 954.74 | 1,297.26 |

Note: See Figure 19 and Table 7 for definitions.

EUO Commodity Export in 2004 Base

| | wusa | wbra | wrsa | wchk | wind | wofe | weuf | weuo | wrow |
|---|---|---|---|---|---|---|---|---|---|
| dwht | 12.39 | 0.22 | 1.46 | 2.31 | 0.26 | 65.07 | 344.93 | 827.97 | 542.83 |
| dpcr | 0.75 | 0.03 | 0.19 | 0.30 | 0.04 | 0.77 | 4.32 | 28.33 | 2.08 |
| dgro | 11.29 | 0.12 | 0.92 | 1.23 | 0.14 | 3.44 | 407.86 | 500.33 | 563.04 |
| dsgr | 6.09 | 0.13 | 1.12 | 1.36 | 0.17 | 9.55 | 468.28 | 616.29 | 21.25 |
| dosd | 10.06 | 0.09 | 10.21 | 1.86 | 2.02 | 2.72 | 704.08 | 171.06 | 221.90 |
| dvol | 7.12 | 0.16 | 39.04 | 11.55 | 0.19 | 4.67 | 465.82 | 867.04 | 342.19 |
| dv_f | 35.17 | 1.32 | 6.80 | 36.88 | 9.27 | 31.50 | 868.64 | 979.67 | 82.42 |
| dofb | 725.91 | 7.44 | 46.38 | 695.15 | 5.60 | 1,252.49 | 4,980.93 | 7,254.13 | 648.21 |
| dcmt | 20.16 | 1.21 | 4.57 | 9.30 | 0.87 | 20.73 | 364.41 | 408.90 | 11.13 |
| domt | 54.39 | 0.68 | 5.87 | 13.65 | 0.83 | 110.16 | 1,123.30 | 760.07 | 14.21 |
| doap | 51.45 | 1.79 | 4.81 | 53.39 | 1.95 | 76.90 | 678.28 | 420.35 | 85.06 |
| dmil | 97.58 | 3.06 | 64.95 | 19.02 | 2.03 | 123.15 | 1,091.80 | 1,521.71 | 341.38 |
| dfsh | 6.35 | 0.07 | 0.67 | 1.21 | 0.10 | 83.49 | 272.03 | 34.45 | 3.42 |
| dpdr | 0.02 | 0.00 | 0.01 | 0.00 | 0.00 | 0.01 | 0.08 | 1.59 | 0.29 |
| dc_b | 0.59 | 0.03 | 0.13 | 0.23 | 0.03 | 0.63 | 2.35 | 9.99 | 3.41 |
| dpfb | 5.98 | 0.74 | 1.32 | 230.07 | 15.16 | 73.29 | 157.97 | 552.35 | 472.89 |
| docr | 64.62 | 0.98 | 4.72 | 7.23 | 0.73 | 38.45 | 323.63 | 327.92 | 58.70 |
| dctl | 13.07 | 0.42 | 2.07 | 2.79 | 0.35 | 7.63 | 490.73 | 137.73 | 51.30 |
| drmk | 17.03 | 0.61 | 3.44 | 6.33 | 0.74 | 15.87 | 61.80 | 6.85 | 7.69 |
| dwol | 6.77 | 0.26 | 1.45 | 10.06 | 0.68 | 6.51 | 30.19 | 13.63 | 5.77 |
| dfrs | 10.95 | 0.30 | 1.97 | 1,042.55 | 0.56 | 561.82 | 1,605.23 | 363.70 | 154.82 |
| dcoa | 31.04 | 11.76 | 17.60 | 21.54 | 11.55 | 493.86 | 2,088.01 | 1,804.85 | 415.53 |
| doil | 1,808.01 | 2.88 | 1,655.74 | 2,727.05 | 42.76 | 875.24 | 33,409.22 | 19,164.89 | 1,340.74 |
| dgas | 15.53 | 0.88 | 15.28 | 2.78 | 0.00 | 31.39 | 1,559.96 | 8,397.78 | 57.14 |
| domn | 71.70 | 20.00 | 63.89 | 357.93 | 52.01 | 121.48 | 1,998.14 | 2,528.40 | 450.07 |
| dclt | 1,255.47 | 12.99 | 104.94 | 141.37 | 39.32 | 378.12 | 24,620.31 | 5,104.43 | 822.83 |
| dwdp | 875.06 | 9.88 | 91.56 | 569.44 | 125.38 | 715.42 | 19,123.51 | 8,714.66 | 1,820.04 |
| dp_c | 3,186.90 | 41.35 | 540.61 | 1,160.01 | 27.78 | 806.93 | 10,802.88 | 6,471.25 | 2,763.34 |
| dcrp | 2,922.60 | 1,023.47 | 872.00 | 2,154.07 | 516.44 | 1,271.79 | 18,321.75 | 18,412.20 | 3,766.25 |
| dmfg | 12,995.54 | 470.33 | 2,490.24 | 4,797.86 | 1,938.11 | 12,484.71 | 134,814.40 | 53,750.33 | 20,502.93 |
| dely | 105.62 | 349.47 | 25.77 | 130.55 | 20.41 | 42.08 | 2,666.70 | 3,962.13 | 274.01 |
| dgdt | 232.58 | 12.51 | 34.33 | 66.11 | 0.04 | 497.99 | 1,525.07 | 179.15 | 780.09 |
| dwtr | 25.63 | 1.04 | 5.50 | 10.03 | 1.25 | 24.22 | 108.38 | 14.67 | 12.43 |
| dsrv | 5,557.23 | 357.30 | 1,099.56 | 1,841.66 | 496.42 | 6,277.29 | 26,958.21 | 3,489.52 | 3,504.34 |
| dtrn | 4,943.54 | 233.53 | 845.97 | 1,057.30 | 221.72 | 3,884.15 | 14,615.40 | 1,643.91 | 1,797.05 |

Note: See Figure 19 and Table 7 for definitions.

ROW Commodity Export in 2004 Base

| | wusa | wbra | wrsa | wchk | wind | wofe | weuf | weuo | wrow |
|---|---|---|---|---|---|---|---|---|---|
| dwht | 13.00 | 0.55 | 3.00 | 4.76 | 0.67 | 13.44 | 79.38 | 11.90 | 282.86 |
| dpcr | 20.50 | 5.29 | 206.36 | 11.92 | 1.44 | 343.22 | 85.70 | 94.69 | 1,222.52 |
| dgro | 18.05 | 0.65 | 10.04 | 8.06 | 0.97 | 50.66 | 82.57 | 12.47 | 502.74 |
| dsgr | 61.80 | 0.58 | 22.81 | 7.22 | 46.09 | 112.06 | 887.23 | 41.59 | 782.81 |
| dosd | 20.25 | 2.11 | 12.67 | 31.41 | 20.23 | 180.96 | 184.61 | 24.74 | 330.84 |
| dvol | 113.58 | 1.78 | 9.22 | 33.42 | 72.12 | 88.65 | 1,065.52 | 102.58 | 1,361.29 |
| dv_f | 482.08 | 21.69 | 46.14 | 298.12 | 617.85 | 541.43 | 6,172.70 | 1,080.68 | 2,206.48 |
| dofb | 1,767.57 | 21.00 | 138.27 | 483.11 | 72.94 | 3,207.50 | 7,905.63 | 1,066.11 | 6,146.21 |
| dcmt | 20.58 | 0.98 | 4.74 | 7.53 | 1.41 | 22.96 | 195.87 | 28.38 | 229.95 |
| domt | 28.10 | 0.86 | 5.38 | 60.65 | 1.30 | 36.85 | 175.85 | 24.78 | 270.55 |
| doap | 71.16 | 2.95 | 8.09 | 92.94 | 20.91 | 103.38 | 643.74 | 53.44 | 290.92 |
| dmil | 34.02 | 1.07 | 7.39 | 9.72 | 2.74 | 29.76 | 121.98 | 31.26 | 937.31 |
| dfsh | 89.33 | 0.73 | 8.70 | 209.58 | 14.27 | 543.41 | 697.79 | 14.22 | 206.16 |
| dpdr | 8.58 | 0.12 | 0.90 | 1.26 | 0.16 | 8.05 | 60.20 | 24.46 | 128.60 |
| dc_b | 2.65 | 0.12 | 0.59 | 1.05 | 0.12 | 2.78 | 9.64 | 1.17 | 2.42 |
| dpfb | 35.25 | 9.60 | 15.51 | 490.25 | 142.41 | 657.50 | 565.86 | 116.59 | 1,065.55 |
| docr | 1,073.12 | 32.21 | 153.38 | 144.73 | 113.42 | 803.24 | 5,405.56 | 793.87 | 1,667.78 |
| dctl | 10.73 | 0.74 | 2.23 | 4.12 | 0.94 | 26.69 | 190.89 | 7.48 | 789.54 |
| drmk | 4.77 | 0.29 | 1.38 | 2.61 | 0.34 | 5.40 | 28.07 | 8.60 | 2.89 |
| dwol | 7.51 | 0.23 | 2.62 | 8.78 | 7.33 | 12.94 | 133.21 | 24.15 | 17.17 |
| dfrs | 54.18 | 1.49 | 16.83 | 569.44 | 406.52 | 345.46 | 678.68 | 26.93 | 267.13 |
| dcoa | 9.03 | 36.20 | 13.42 | 186.93 | 13.92 | 304.66 | 2,404.68 | 14.15 | 610.14 |
| doil | 60,377.77 | 4,262.58 | 1,948.62 | 22,262.08 | 22,388.20 | 114,612.10 | 52,026.65 | 555.93 | 16,205.28 |
| dgas | 607.11 | 0.87 | 11.41 | 16.47 | 3.07 | 6,320.81 | 9,092.08 | 23.32 | 2,279.46 |
| domn | 854.73 | 97.30 | 190.88 | 2,249.38 | 1,440.43 | 2,123.75 | 12,131.90 | 809.73 | 1,853.27 |
| dclt | 22,184.34 | 88.63 | 954.77 | 1,493.89 | 356.71 | 4,080.09 | 43,836.22 | 3,259.58 | 8,654.75 |
| dwdp | 1,016.73 | 20.16 | 86.41 | 198.68 | 213.37 | 1,728.32 | 4,512.17 | 511.08 | 3,769.79 |
| dp_c | 3,203.27 | 699.34 | 229.66 | 3,119.12 | 1,784.35 | 15,025.47 | 6,864.61 | 453.53 | 10,332.39 |
| dcrp | 4,243.20 | 820.80 | 618.55 | 2,950.49 | 2,766.00 | 6,703.52 | 12,109.66 | 2,108.25 | 15,709.54 |
| dmfg | 20,050.89 | 434.41 | 1,797.54 | 3,972.27 | 7,510.14 | 18,644.83 | 48,579.29 | 7,189.02 | 40,224.30 |
| dely | 49.46 | 209.90 | 11.11 | 72.18 | 7.57 | 16.01 | 454.55 | 233.98 | 368.73 |
| dgdt | 44.72 | 2.61 | 10.10 | 24.99 | 0.01 | 115.17 | 370.59 | 48.25 | 72.47 |
| dwtr | 35.38 | 1.46 | 7.45 | 12.63 | 1.69 | 34.38 | 116.31 | 16.22 | 12.15 |
| dsrv | 13,977.55 | 725.67 | 2,079.62 | 3,158.77 | 790.54 | 9,952.42 | 37,506.90 | 5,395.88 | 5,443.56 |
| dtrn | 9,834.53 | 318.32 | 1,424.96 | 2,095.47 | 430.67 | 6,232.73 | 22,364.99 | 4,260.54 | 2,527.80 |

Note: See Figure 19 and Table 7 for definitions.

# APPENDIX C

## Value of Commodity Import by Region

### USA Commodity Import in 2004 Base

| | wbra | wrsa | wchk | wind | wofe | weuf | weuo | wrow |
|---|---|---|---|---|---|---|---|---|
| dwht | 0.01 | 2.33 | 0.25 | 3.20 | 0.23 | 160.95 | 12.39 | 13.00 |
| dpcr | 0.56 | 3.70 | 35.41 | 27.22 | 170.73 | 5.61 | 0.75 | 20.50 |
| dgro | 0.69 | 97.76 | 1.01 | 1.18 | 1.40 | 331.01 | 11.29 | 18.05 |
| dsgr | 69.42 | 388.42 | 0.64 | 4.80 | 114.73 | 101.73 | 6.09 | 61.80 |
| dosd | 72.70 | 45.65 | 23.44 | 38.87 | 9.42 | 216.76 | 10.06 | 20.25 |
| dvol | 106.35 | 122.81 | 11.02 | 94.36 | 479.78 | 1,431.77 | 7.12 | 113.58 |
| dv_f | 170.45 | 5,884.98 | 222.89 | 245.87 | 293.37 | 1,175.70 | 35.17 | 482.08 |
| dofb | 680.47 | 7,598.70 | 2,383.95 | 533.32 | 5,531.54 | 18,514.48 | 725.91 | 1,767.57 |
| dcmt | 4.86 | 441.78 | 1.22 | 0.66 | 2,188.49 | 1,271.33 | 20.16 | 20.58 |
| domt | 199.65 | 138.77 | 26.25 | 0.20 | 87.56 | 1,566.14 | 54.39 | 28.10 |
| doap | 86.73 | 91.66 | 426.51 | 13.06 | 116.06 | 863.71 | 51.45 | 71.16 |
| dmil | 13.45 | 115.84 | 10.12 | 35.97 | 483.04 | 1,254.56 | 97.58 | 34.02 |
| dfsh | 40.90 | 345.62 | 44.83 | 3.80 | 221.79 | 826.14 | 6.35 | 89.33 |
| dpdr | 0.00 | 0.84 | 1.16 | 12.00 | 2.40 | 1.31 | 0.02 | 8.58 |
| dc_b | 0.00 | 1.41 | 0.13 | 1.13 | 1.39 | 0.35 | 0.59 | 2.65 |
| dpfb | 4.33 | 28.94 | 0.53 | 1.14 | 4.60 | 25.25 | 5.98 | 35.25 |
| docr | 548.81 | 2,171.49 | 127.35 | 96.99 | 502.68 | 940.87 | 64.62 | 1,073.12 |
| dctl | 3.01 | 528.56 | 0.77 | 0.00 | 14.76 | 266.91 | 13.07 | 10.73 |
| drmk | 0.22 | 1.51 | 0.38 | 0.62 | 0.63 | 9.26 | 17.03 | 4.77 |
| dwol | 0.08 | 0.46 | 5.51 | 3.18 | 16.54 | 4.72 | 6.77 | 7.51 |
| dfrs | 4.70 | 66.59 | 12.72 | 17.65 | 25.99 | 307.20 | 10.95 | 54.18 |
| dcoa | 0.00 | 739.19 | 28.47 | 0.62 | 49.11 | 98.36 | 31.04 | 9.03 |
| doil | 460.15 | 44,041.08 | 113.13 | 0.00 | 824.23 | 18,261.12 | 1,808.01 | 60,377.77 |
| dgas | | 1,557.27 | 3.38 | 0.00 | 131.78 | 12,280.17 | 15.53 | 607.11 |
| domn | 297.45 | 749.60 | 391.25 | 45.24 | 261.22 | 1,589.11 | 71.70 | 854.73 |
| dclt | 1,864.79 | 19,381.95 | 28,933.55 | 4,139.79 | 15,875.09 | 13,844.06 | 1,255.47 | 22,184.34 |
| dwdp | 2,570.17 | 7,119.11 | 10,843.09 | 142.99 | 6,189.46 | 42,378.62 | 875.06 | 1,016.73 |
| dp_c | 1,785.47 | 8,510.83 | 888.50 | 195.96 | 1,263.39 | 14,724.21 | 3,186.90 | 3,203.27 |
| dcrp | 1,197.57 | 8,977.77 | 12,027.40 | 1,463.40 | 25,783.48 | 83,414.11 | 2,922.60 | 4,243.20 |
| dmfg | 11,744.28 | 109,556.40 | 119,934.70 | 8,318.38 | 229,923.70 | 280,041.70 | 12,995.54 | 20,050.89 |
| dely | 0.04 | 62.77 | 64.08 | 0.29 | 1.75 | 1,287.80 | 105.62 | 49.46 |
| dgdt | 0.00 | 8.66 | 10.74 | 0.01 | 11.41 | 70.40 | 232.58 | 44.72 |
| dwtr | 2.09 | 25.44 | 14.82 | 0.19 | 43.43 | 78.32 | 25.63 | 35.38 |

| | **wbra** | **wrsa** | **wchk** | **wind** | **wofe** | **weuf** | **weuo** | **wrow** |
|---|---|---|---|---|---|---|---|---|
| dsrv | 1,467.43 | 6,646.50 | 14,457.01 | 1,694.98 | 24,961.45 | 94,352.55 | 5,557.23 | 13,977.55 |
| dtrn | 218.13 | 5,260.51 | 5,560.59 | 359.80 | 11,143.90 | 27,915.38 | 4,943.54 | 9,834.53 |

Note: See Figure 19 and Table 7 for definitions.

BRA Commodity Import in 2004 Base

| | wusa | wrsa | wchk | wind | wofe | weuf | weuo | wrow |
|---|---|---|---|---|---|---|---|---|
| dwht | 10.40 | 697.68 | 0.01 | 0.12 | 0.00 | 2.61 | 0.22 | 0.55 |
| dpcr | 0.15 | 91.23 | 0.70 | 0.18 | 22.83 | 1.39 | 0.03 | 5.29 |
| dgro | 1.11 | 59.18 | 0.18 | 0.04 | 0.03 | 15.49 | 0.12 | 0.65 |
| dsgr | 0.72 | 0.14 | 0.00 | 0.05 | 0.41 | 0.65 | 0.13 | 0.58 |
| dosd | 0.05 | 71.51 | 0.04 | 0.88 | 0.38 | 1.51 | 0.09 | 2.11 |
| dvol | 4.05 | 80.76 | 0.21 | 0.07 | 29.73 | 95.54 | 0.16 | 1.78 |
| dv_f | 9.91 | 174.33 | 13.80 | 0.20 | 2.69 | 27.73 | 1.32 | 21.69 |
| dofb | 99.08 | 592.31 | 17.39 | 3.05 | 28.53 | 443.73 | 7.44 | 21.00 |
| dcmt | 1.15 | 82.87 | 0.19 | 0.01 | 0.48 | 3.34 | 1.21 | 0.98 |
| domt | 1.97 | 2.89 | 0.33 | 0.00 | 3.92 | 6.17 | 0.68 | 0.86 |
| doap | 29.57 | 9.73 | 4.10 | 0.13 | 4.91 | 30.14 | 1.79 | 2.95 |
| dmil | 4.69 | 71.80 | 0.30 | 0.11 | 4.22 | 21.01 | 3.06 | 1.07 |
| dfsh | 0.58 | 30.57 | 0.65 | 0.10 | 1.98 | 0.82 | 0.07 | 0.73 |
| dpdr | 9.57 | 80.18 | 0.04 | 0.04 | 0.21 | 0.33 | 0.00 | 0.12 |
| dc_b | 0.00 | 0.04 | 0.01 | 0.06 | 0.06 | 0.01 | 0.03 | 0.12 |
| dpfb | 94.08 | 50.36 | 0.00 | 0.02 | 0.12 | 2.22 | 0.74 | 9.60 |
| docr | 16.57 | 15.03 | 0.30 | 2.68 | 32.87 | 25.43 | 0.98 | 32.21 |
| dctl | 3.24 | 0.59 | 0.02 | 0.00 | 0.16 | 2.59 | 0.42 | 0.74 |
| drmk | 0.04 | 0.04 | 0.01 | 0.02 | 0.02 | 0.42 | 0.61 | 0.29 |
| dwol | 0.03 | 0.09 | 0.13 | 0.11 | 0.15 | 0.65 | 0.26 | 0.23 |
| dfrs | 1.51 | 2.19 | 0.18 | 1.06 | 0.52 | 4.68 | 0.30 | 1.49 |
| dcoa | 206.52 | 40.82 | 15.80 | 0.03 | 336.60 | 59.61 | 11.76 | 36.20 |
| doil | 0.00 | 273.29 | 0.02 | 0.00 | 10.14 | 2.26 | 2.88 | 4,262.58 |
| dgas | 0.00 | 552.00 | 0.11 | 0.00 | 0.08 | 0.53 | 0.88 | 0.87 |
| domn | 47.56 | 609.79 | 9.62 | 0.32 | 1.16 | 99.23 | 20.00 | 97.30 |
| dclt | 128.71 | 270.27 | 526.59 | 62.18 | 462.77 | 348.49 | 12.99 | 88.63 |
| dwdp | 199.08 | 224.72 | 16.53 | 0.51 | 34.76 | 539.62 | 9.88 | 20.16 |
| dp_c | 315.46 | 840.23 | 452.52 | 139.27 | 83.45 | 350.15 | 41.35 | 699.34 |
| dcrp | 3,760.01 | 2,067.22 | 481.09 | 277.87 | 1,095.52 | 5,427.29 | 1,023.47 | 820.80 |
| dmfg | 7,748.37 | 2,751.84 | 1,908.90 | 79.28 | 5,075.03 | 10,728.40 | 470.33 | 434.41 |
| dely | 48.55 | 507.08 | 73.92 | 0.45 | 2.45 | 538.74 | 349.47 | 209.90 |
| dgdt | 0.86 | 0.28 | 0.37 | 0.00 | 0.61 | 2.60 | 12.51 | 2.61 |
| dwtr | 1.97 | 0.55 | 0.47 | 0.01 | 1.42 | 3.77 | 1.04 | 1.46 |
| dsrv | 1,699.26 | 216.99 | 746.74 | 256.33 | 1,245.48 | 6,054.03 | 357.30 | 725.67 |
| dtrn | 258.35 | 183.44 | 187.72 | 22.07 | 572.35 | 2,046.44 | 233.53 | 318.32 |

Note: See Figure 19 and Table 7 for definitions.

CHK Commodity Import in 2004 Base

| | wusa | wbra | wrsa | wchk | wind | wofe | weuf | weuo | wrow |
|---|---|---|---|---|---|---|---|---|---|
| dwht | 549.80 | 0.00 | 4.27 | 0.04 | 1.25 | 273.69 | 515.35 | 2.31 | 4.76 |
| dpcr | 3.25 | 0.14 | 1.12 | 6.38 | 1.87 | 366.37 | 0.71 | 0.30 | 11.92 |
| dgro | 6.32 | 0.01 | 1.29 | 1.11 | 1.59 | 183.46 | 66.78 | 1.23 | 8.06 |
| dsgr | 0.90 | 0.18 | 93.62 | 4.78 | 0.57 | 157.03 | 14.38 | 1.36 | 7.22 |
| dosd | 2,579.37 | 1,607.61 | 993.83 | 1.58 | 24.04 | 2.14 | 117.71 | 1.86 | 31.41 |
| dvol | 27.19 | 494.13 | 713.25 | 17.75 | 56.02 | 2,488.60 | 213.78 | 11.55 | 33.42 |
| dv_f | 363.65 | 0.96 | 115.12 | 92.16 | 12.85 | 875.67 | 45.67 | 36.88 | 298.12 |
| dofb | 972.79 | 83.29 | 683.11 | 555.08 | 71.02 | 2,152.00 | 1,459.69 | 695.15 | 483.11 |
| dcmt | 120.68 | 128.23 | 48.62 | 7.41 | 0.33 | 240.35 | 224.73 | 9.30 | 7.53 |
| domt | 268.38 | 288.85 | 48.61 | 161.61 | 1.30 | 68.50 | 179.21 | 13.65 | 60.65 |
| doap | 759.81 | 8.52 | 27.86 | 136.98 | 2.78 | 627.70 | 1,075.83 | 53.39 | 92.94 |
| dmil | 61.42 | 0.84 | 5.12 | 17.75 | 1.19 | 381.38 | 207.20 | 19.02 | 9.72 |
| dfsh | 19.73 | 0.44 | 9.39 | 49.65 | 4.48 | 369.60 | 139.92 | 1.21 | 209.58 |
| dpdr | 0.02 | 0.00 | 0.01 | 0.19 | 0.46 | 1.20 | 0.07 | 0.00 | 1.26 |
| dc_b | 0.00 | 0.00 | 0.54 | 0.02 | 0.45 | 0.56 | 0.09 | 0.23 | 1.05 |
| dpfb | 1,494.17 | 35.39 | 52.48 | 0.48 | 47.20 | 136.70 | 31.86 | 230.07 | 490.25 |
| docr | 86.74 | 63.55 | 7.27 | 50.11 | 8.80 | 124.69 | 150.96 | 7.23 | 144.73 |
| dctl | 1.09 | 0.01 | 0.78 | 7.19 | 0.00 | 177.89 | 25.15 | 2.79 | 4.12 |
| drmk | 0.47 | 0.09 | 0.42 | 0.06 | 0.25 | 0.49 | 3.83 | 6.33 | 2.61 |
| dwol | 6.93 | 0.05 | 7.42 | 0.48 | 1.10 | 696.41 | 33.38 | 10.06 | 8.78 |
| dfrs | 83.26 | 0.34 | 5.14 | 1.77 | 3.02 | 586.10 | 92.16 | 1,042.55 | 569.44 |
| dcoa | 0.75 | 0.00 | 0.56 | 30.06 | 0.21 | 733.65 | 74.77 | 21.54 | 186.93 |
| doil | 9.58 | 268.28 | 264.17 | 0.00 | 0.00 | 1,957.23 | 641.33 | 2,727.05 | 22,262.08 |
| dgas | 0.00 | | 0.22 | 3.47 | 0.00 | 11.43 | 9.90 | 2.78 | 16.47 |
| domn | 306.81 | 2,490.43 | 1,474.90 | 14.92 | 2,977.32 | 3,309.22 | 1,574.17 | 357.93 | 2,249.38 |
| dclt | 1,012.60 | 327.80 | 362.18 | 13,321.41 | 427.58 | 15,738.12 | 3,765.48 | 141.37 | 1,493.89 |
| dwdp | 2,138.40 | 523.05 | 347.04 | 1,831.54 | 18.73 | 5,833.94 | 3,294.47 | 569.44 | 198.68 |
| dp_c | 828.25 | 22.44 | 299.97 | 122.27 | 30.07 | 7,476.54 | 514.02 | 1,160.01 | 3,119.12 |
| dcrp | 8,116.18 | 197.22 | 441.48 | 3,849.70 | 728.82 | 56,169.36 | 12,361.37 | 2,154.07 | 2,950.49 |
| dmfg | 27,860.65 | 994.55 | 4,177.03 | 16,483.71 | 2,212.33 | 236,605.70 | 61,911.82 | 4,797.86 | 3,972.27 |
| dely | 52.22 | 0.06 | 45.03 | 36.37 | 0.47 | 3.40 | 300.91 | 130.55 | 72.18 |
| dgdt | 24.43 | 0.00 | 6.61 | 11.01 | 0.01 | 20.69 | 44.39 | 66.11 | 24.99 |
| dwtr | 21.75 | 0.83 | 5.39 | 2.30 | 0.08 | 32.96 | 33.50 | 10.03 | 12.63 |
| dsrv | 8,147.99 | 233.45 | 1,149.63 | 16,814.13 | 508.83 | 9,635.32 | 25,190.84 | 1,841.66 | 3,158.77 |
| dtrn | 2,806.77 | 90.40 | 864.90 | 450.42 | 141.50 | 4,032.75 | 6,091.63 | 1,057.30 | 2,095.47 |

Note: See Figure 19 and Table 7 for definitions.

IND Commodity Import in 2004 Base

| IND | wusa | wbra | wrsa | wchk | wofe | weuf | weuo | wrow |
|---|---|---|---|---|---|---|---|---|
| dwht | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 | 0.13 | 0.26 | 0.67 |
| dpcr | 0.01 | 0.02 | 0.12 | 0.87 | 0.82 | 0.35 | 0.04 | 1.44 |
| dgro | 0.25 | 0.00 | 0.47 | 0.01 | 0.68 | 0.16 | 0.14 | 0.97 |
| dsgr | 0.30 | 173.28 | 0.15 | 0.00 | 13.82 | 2.51 | 0.17 | 46.09 |
| dosd | 0.02 | 0.00 | 0.33 | 0.08 | 6.44 | 1.28 | 2.02 | 20.23 |
| dvol | 28.39 | 152.02 | 394.14 | 0.94 | 1,427.64 | 12.49 | 0.19 | 72.12 |
| dv_f | 133.22 | 0.83 | 3.35 | 25.83 | 90.58 | 125.41 | 9.27 | 617.85 |
| dofb | 51.84 | 190.63 | 23.82 | 14.41 | 78.39 | 118.54 | 5.60 | 72.94 |
| dcmt | 0.69 | 0.20 | 0.41 | 0.12 | 2.61 | 2.76 | 0.87 | 1.41 |
| domt | 0.71 | 0.05 | 0.48 | 0.40 | 1.51 | 4.13 | 0.83 | 1.30 |
| doap | 2.86 | 0.08 | 0.46 | 11.69 | 9.35 | 27.92 | 1.95 | 20.91 |
| dmil | 3.38 | 0.07 | 0.58 | 0.11 | 4.23 | 23.47 | 2.03 | 2.74 |
| dfsh | 0.28 | 0.00 | 0.13 | 1.98 | 2.02 | 1.55 | 0.10 | 14.27 |
| dpdr | 0.02 | 0.00 | 0.00 | 0.05 | 0.07 | 0.01 | 0.00 | 0.16 |
| dc_b | 0.00 | 0.00 | 0.03 | 0.01 | 0.06 | 0.01 | 0.03 | 0.12 |
| dpfb | 58.76 | 11.90 | 4.36 | 0.56 | 5.76 | 11.72 | 15.16 | 142.41 |
| docr | 5.36 | 1.77 | 3.35 | 16.20 | 35.12 | 14.13 | 0.73 | 113.42 |
| dctl | 0.32 | 0.00 | 0.06 | 0.03 | 0.08 | 0.20 | 0.35 | 0.94 |
| drmk | 0.05 | 0.01 | 0.05 | 0.02 | 0.02 | 0.53 | 0.74 | 0.34 |
| dwol | 1.94 | 0.11 | 1.42 | 0.59 | 154.07 | 14.01 | 0.68 | 7.33 |
| dfrs | 1.69 | 0.43 | 20.45 | 1.73 | 202.87 | 9.99 | 0.56 | 406.52 |
| dcoa | 82.49 |  | 4.79 | 117.07 | 832.58 | 2.68 | 11.55 | 13.92 |
| doil | 0.01 | 0.24 | 489.75 | 0.12 | 799.54 | 12.55 | 42.76 | 22,388.20 |
| dgas | 0.00 |  | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.07 |
| domn | 50.92 | 96.65 | 486.87 | 147.59 | 610.76 | 5,450.44 | 52.01 | 1,440.43 |
| dclt | 65.27 | 18.59 | 47.49 | 1,123.50 | 816.51 | 404.69 | 39.32 | 356.71 |
| dwdp | 193.37 | 3.02 | 12.15 | 75.83 | 306.88 | 838.38 | 125.38 | 213.37 |
| dp_c | 75.83 | 3.55 | 3.52 | 145.34 | 196.98 | 45.96 | 27.78 | 1,784.35 |
| dcrp | 1,333.78 | 72.76 | 76.38 | 1,325.24 | 2,791.22 | 2,699.56 | 516.44 | 2,766.00 |
| dmfg | 3,928.09 | 148.87 | 228.46 | 3,848.51 | 13,283.28 | 14,087.74 | 1,938.11 | 7,510.14 |
| dely | 4.52 | 0.01 | 3.71 | 6.65 | 0.24 | 39.77 | 20.41 | 7.57 |
| dgdt | 0.01 |  | 0.00 | 0.01 | 0.01 | 0.04 | 0.04 | 0.01 |
| dwtr | 2.39 | 0.09 | 0.66 | 0.57 | 1.72 | 4.64 | 1.25 | 1.69 |
| dsrv | 2,475.97 | 86.49 | 284.45 | 805.66 | 1,361.70 | 8,608.82 | 496.42 | 790.54 |
| dtrn | 327.90 | 22.69 | 164.70 | 255.37 | 643.77 | 2,080.93 | 221.72 | 430.67 |

Note: See Figure 19 and Table 7 for definitions.

OFE Commodity Import in 2004 Base

| | wusa | wbra | wrsa | wchk | wind | wofe | weuf | weuo | wrow |
|---|---|---|---|---|---|---|---|---|---|
| dwht | 1,447.83 | 0.02 | 20.75 | 105.80 | 146.00 | 1,353.30 | 577.35 | 65.07 | 13.44 |
| dpcr | 204.16 | 1.00 | 4.47 | 78.93 | 24.86 | 467.52 | 6.16 | 0.77 | 343.22 |
| dgro | 4,018.68 | 249.88 | 215.71 | 417.53 | 128.16 | 352.66 | 87.85 | 3.44 | 50.66 |
| dsgr | 8.65 | 46.25 | 55.51 | 9.69 | 2.66 | 1,154.28 | 65.51 | 9.55 | 112.06 |
| dosd | 2,149.90 | 527.86 | 382.60 | 254.30 | 86.08 | 343.81 | 719.48 | 2.72 | 180.96 |
| dvol | 348.19 | 466.85 | 734.53 | 326.65 | 610.69 | 1,972.60 | 616.93 | 4.67 | 88.65 |
| dv_f | 1,499.82 | 11.31 | 286.27 | 1,329.67 | 97.63 | 1,931.47 | 181.59 | 31.50 | 541.43 |
| dofb | 6,159.35 | 452.04 | 2,036.95 | 7,657.83 | 547.54 | 13,194.60 | 8,767.98 | 1,252.49 | 3,207.50 |
| dcmt | 210.31 | 78.87 | 58.55 | 9.47 | 196.24 | 3,352.46 | 177.24 | 20.73 | 22.96 |
| domt | 1,617.25 | 730.52 | 449.47 | 922.23 | 3.49 | 863.85 | 2,523.91 | 110.16 | 36.85 |
| doap | 773.74 | 23.98 | 46.54 | 489.33 | 17.73 | 709.61 | 371.26 | 76.90 | 103.38 |
| dmil | 359.62 | 8.14 | 47.50 | 27.96 | 10.65 | 2,503.76 | 1,120.83 | 123.15 | 29.76 |
| dfsh | 152.41 | 6.38 | 97.81 | 915.06 | 21.18 | 1,487.78 | 297.98 | 83.49 | 543.41 |
| dpdr | 63.84 | 0.02 | 0.69 | 32.94 | 1.58 | 27.07 | 0.20 | 0.01 | 8.05 |
| dc_b | 0.02 | 0.00 | 0.73 | 0.16 | 1.34 | 1.45 | 0.23 | 0.63 | 2.78 |
| dpfb | 922.48 | 164.76 | 50.94 | 16.43 | 82.19 | 520.90 | 75.40 | 73.29 | 657.50 |
| docr | 821.31 | 383.60 | 438.92 | 684.92 | 127.01 | 1,193.96 | 548.31 | 38.45 | 803.24 |
| dctl | 88.16 | 0.04 | 2.13 | 1.40 | 0.03 | 303.19 | 59.72 | 7.63 | 26.69 |
| drmk | 2.26 | 0.27 | 1.14 | 0.43 | 0.74 | 1.17 | 7.05 | 15.87 | 5.40 |
| dwol | 0.59 | 0.04 | 0.54 | 6.24 | 3.47 | 102.62 | 4.55 | 6.51 | 12.94 |
| dfrs | 702.81 | 1.11 | 40.98 | 43.76 | 20.67 | 710.74 | 306.94 | 561.82 | 345.46 |
| dcoa | 602.81 | 0.00 | 21.66 | 3,195.86 | 0.71 | 8,983.78 | 317.79 | 493.86 | 304.66 |
| doil | 24.47 | 88.18 | 691.38 | 608.20 | 0.01 | 7,592.37 | 390.07 | 875.24 | 114,612.10 |
| dgas | 120.77 | 0.00 | 10.32 | 9.68 | 0.00 | 9,392.04 | 27.81 | 31.39 | 6,320.81 |
| domn | 780.31 | 1,558.36 | 4,043.44 | 881.03 | 638.75 | 6,545.20 | 1,349.43 | 121.48 | 2,123.75 |
| dclt | 2,108.75 | 334.15 | 549.77 | 38,639.48 | 1,316.48 | 12,186.68 | 8,775.52 | 378.12 | 4,080.09 |
| dwdp | 4,480.42 | 491.83 | 841.72 | 5,403.13 | 79.43 | 14,528.12 | 10,568.08 | 715.42 | 1,728.32 |
| dp_c | 2,611.32 | 121.37 | 143.00 | 3,414.38 | 1,258.58 | 11,912.32 | 1,046.82 | 806.93 | 15,025.47 |
| dcrp | 27,502.03 | 389.34 | 1,181.39 | 12,843.64 | 1,623.29 | 64,747.62 | 36,842.63 | 1,271.79 | 6,703.52 |
| dmfg | 103,719.90 | 2,669.82 | 7,124.02 | 111,151.40 | 4,581.50 | 341,718.70 | 113,901.30 | 12,484.71 | 18,644.83 |
| dely | 11.32 | 0.01 | 11.40 | 16.71 | 0.10 | 0.52 | 94.58 | 42.08 | 16.01 |
| dgdt | 83.76 | 0.00 | 22.77 | 29.66 | 0.03 | 30.75 | 155.13 | 497.99 | 115.17 |
| dwtr | 104.43 | 2.53 | 14.28 | 20.20 | 0.23 | 66.43 | 64.00 | 24.22 | 34.38 |
| dsrv | 48,174.00 | 1,036.98 | 3,850.08 | 22,774.58 | 1,729.18 | 24,009.60 | 65,773.49 | 6,277.29 | 9,952.42 |
| dtrn | 11,999.10 | 594.89 | 3,361.82 | 7,388.65 | 543.81 | 13,942.11 | 25,040.11 | 3,884.15 | 6,232.73 |

Note: See Figure 19 and Table 7 for definitions.

EUF Commodity Import in 2004 Base

| | wusa | wbra | wrsa | wchk | wind | wofe | weuf | weuo | wrow |
|---|---|---|---|---|---|---|---|---|---|
| dwht | 366.25 | 19.99 | 76.11 | 0.86 | 11.66 | 102.67 | 3,665.73 | 344.93 | 79.38 |
| dpcr | 128.89 | 2.41 | 26.82 | 74.88 | 51.95 | 211.60 | 559.59 | 4.32 | 85.70 |
| dgro | 439.93 | 239.73 | 332.30 | 18.41 | 4.65 | 7.15 | 3,221.55 | 407.86 | 82.57 |
| dsgr | 50.44 | 170.90 | 421.11 | 1.36 | 19.46 | 90.95 | 2,214.62 | 468.28 | 887.23 |
| dosd | 1,560.09 | 2,743.33 | 760.04 | 183.24 | 98.05 | 79.70 | 1,424.04 | 704.08 | 184.61 |
| dvol | 711.63 | 1,825.23 | 2,075.98 | 17.15 | 159.70 | 1,371.14 | 6,318.28 | 465.82 | 1,065.52 |
| dv_f | 4,160.45 | 562.84 | 4,893.70 | 571.92 | 300.51 | 1,005.31 | 21,365.51 | 868.64 | 6,172.70 |
| dofb | 8,367.86 | 1,139.56 | 5,449.12 | 2,586.56 | 717.33 | 5,031.83 | 101,180.00 | 4,980.93 | 7,905.63 |
| dcmt | 193.05 | 817.84 | 729.30 | 4.74 | 11.85 | 1,397.19 | 8,498.93 | 364.41 | 195.87 |
| domt | 811.62 | 940.34 | 357.87 | 29.81 | 2.33 | 501.15 | 17,838.86 | 1,123.30 | 175.85 |
| doap | 412.08 | 129.30 | 310.59 | 425.02 | 50.15 | 267.92 | 5,047.33 | 678.28 | 643.74 |
| dmil | 187.03 | 6.28 | 74.89 | 17.49 | 21.32 | 407.97 | 23,297.94 | 1,091.80 | 121.98 |
| dfsh | 577.73 | 23.85 | 103.05 | 84.46 | 18.98 | 201.55 | 5,358.52 | 272.03 | 697.79 |
| dpdr | 63.78 | 0.00 | 16.49 | 4.80 | 109.68 | 39.40 | 197.42 | 0.08 | 60.20 |
| dc_b | 0.01 | 0.00 | 2.39 | 0.48 | 4.20 | 5.11 | 12.17 | 2.35 | 9.64 |
| dpfb | 230.26 | 71.30 | 32.42 | 1.48 | 6.04 | 38.44 | 241.83 | 157.97 | 565.86 |
| docr | 1,115.83 | 1,665.83 | 2,088.85 | 238.35 | 366.90 | 603.22 | 9,345.75 | 323.63 | 5,405.56 |
| dctl | 166.05 | 0.78 | 18.75 | 1.73 | 0.04 | 12.71 | 2,713.38 | 490.73 | 190.89 |
| drmk | 3.33 | 0.81 | 3.73 | 1.38 | 2.32 | 0.72 | 55.69 | 61.80 | 28.07 |
| dwol | 12.82 | 0.80 | 36.70 | 35.49 | 10.51 | 444.92 | 129.47 | 30.19 | 133.21 |
| dfrs | 685.01 | 13.87 | 216.61 | 55.34 | 64.40 | 53.63 | 1,987.23 | 1,605.23 | 678.68 |
| dcoa | 1,264.71 | 0.00 | 1,164.55 | 153.81 | 1.79 | 1,834.08 | 321.98 | 2,088.01 | 2,404.68 |
| doil | 87.23 | 215.26 | 3,774.50 | 0.66 | 0.00 | 10.74 | 40,363.66 | 33,409.22 | 52,026.65 |
| dgas | 626.54 | 0.00 | 12.18 | 33.98 | 0.00 | 24.76 | 16,521.28 | 1,559.96 | 9,092.08 |
| domn | 1,996.41 | 2,674.57 | 3,114.43 | 932.88 | 549.79 | 2,250.61 | 12,809.23 | 1,998.14 | 12,131.90 |
| dclt | 5,870.39 | 1,389.22 | 2,083.40 | 28,310.81 | 8,110.62 | 12,444.99 | 98,523.93 | 24,620.31 | 43,836.22 |
| dwdp | 15,887.93 | 2,621.32 | 1,476.39 | 5,141.91 | 320.83 | 5,509.48 | 117,956.30 | 19,123.51 | 4,512.17 |
| dp_c | 5,315.31 | 117.37 | 1,203.26 | 1,256.24 | 275.91 | 413.55 | 36,493.03 | 10,802.88 | 6,864.61 |
| dcrp | 69,820.34 | 1,393.67 | 3,989.29 | 10,341.54 | 2,473.21 | 28,690.46 | 403,922.60 | 18,321.75 | 12,109.66 |
| dmfg | 243,372.60 | 7,804.71 | 25,836.95 | 108,556.80 | 7,574.03 | 203,224.40 | 1,053,485.00 | 134,814.40 | 48,579.29 |
| dely | 973.59 | 0.33 | 377.51 | 244.57 | 2.57 | 13.76 | 10,949.14 | 2,666.70 | 454.55 |
| dgdt | 153.77 | 0.00 | 78.12 | 107.82 | 0.10 | 103.31 | 413.00 | 1,525.07 | 370.59 |
| dwtr | 153.85 | 7.67 | 45.37 | 41.05 | 0.71 | 85.23 | 438.01 | 108.38 | 116.31 |
| dsrv | 100,277.70 | 3,954.58 | 12,765.50 | 38,950.73 | 9,197.97 | 52,832.96 | 388,731.20 | 26,958.21 | 37,506.90 |
| dtrn | 24,963.10 | 1,429.41 | 9,143.71 | 8,657.62 | 1,534.65 | 20,663.73 | 103,918.20 | 14,615.40 | 22,364.99 |

Note: See Figure 19 and Table 7 for definitions.

RSA Commodity Import in 2004 Base

| | wusa | wbra | wrsa | wchk | wind | wofe | weuf | weuo | wrow |
|---|---|---|---|---|---|---|---|---|---|
| dwht | 1,367.47 | 0.01 | 148.24 | 0.06 | 0.76 | 0.43 | 592.06 | 1.46 | 3.00 |
| dpcr | 248.20 | 2.48 | 45.74 | 4.79 | 4.19 | 41.52 | 3.74 | 0.19 | 206.36 |
| dgro | 2,016.93 | 16.19 | 361.06 | 0.14 | 0.27 | 27.51 | 49.84 | 0.92 | 10.04 |
| dsgr | 57.83 | 44.09 | 364.07 | 0.02 | 0.38 | 1.99 | 48.80 | 1.12 | 22.81 |
| dosd | 991.76 | 183.71 | 703.17 | 15.14 | 12.38 | 1.34 | 414.84 | 10.21 | 12.67 |
| dvol | 915.29 | 146.36 | 2,044.27 | 0.79 | 2.59 | 95.52 | 177.80 | 39.04 | 9.22 |
| dv_f | 621.81 | 29.59 | 622.53 | 71.76 | 4.23 | 13.52 | 243.55 | 6.80 | 46.14 |
| dofb | 3,428.94 | 601.19 | 3,352.99 | 137.04 | 16.11 | 250.41 | 2,375.43 | 46.38 | 138.27 |
| dcmt | 993.45 | 236.89 | 293.81 | 1.13 | 0.07 | 139.97 | 394.13 | 4.57 | 4.74 |
| domt | 1,268.90 | 223.71 | 211.69 | 3.89 | 0.07 | 4.78 | 233.81 | 5.87 | 5.38 |
| doap | 327.81 | 26.80 | 93.78 | 18.88 | 0.62 | 15.26 | 66.12 | 4.81 | 8.09 |
| dmil | 607.93 | 29.03 | 555.38 | 0.56 | 0.94 | 458.34 | 549.57 | 64.95 | 7.39 |
| dfsh | 18.34 | 0.44 | 48.73 | 4.54 | 0.99 | 10.38 | 18.67 | 0.67 | 8.70 |
| dpdr | 290.04 | 0.30 | 34.90 | 0.38 | 0.36 | 0.70 | 0.26 | 0.01 | 0.90 |
| dc_b | 0.04 | 0.00 | 1.69 | 0.03 | 0.27 | 0.31 | 0.06 | 0.13 | 0.59 |
| dpfb | 721.69 | 67.14 | 40.50 | 0.52 | 0.20 | 0.69 | 4.15 | 1.32 | 15.51 |
| docr | 308.07 | 185.03 | 215.14 | 20.79 | 9.16 | 39.06 | 158.31 | 4.72 | 153.38 |
| dctl | 27.04 | 3.74 | 208.00 | 0.12 | 0.00 | 14.89 | 22.82 | 2.07 | 2.23 |
| drmk | 0.54 | 0.05 | 0.25 | 0.09 | 0.15 | 0.08 | 1.87 | 3.44 | 1.38 |
| dwol | 3.95 | 5.71 | 18.13 | 1.57 | 0.71 | 7.08 | 2.45 | 1.45 | 2.62 |
| dfrs | 61.17 | 5.15 | 16.48 | 3.83 | 8.75 | 3.73 | 25.13 | 1.97 | 16.83 |
| dcoa | 69.76 | 0.00 | 170.92 | 4.31 | 0.17 | 252.18 | 38.48 | 17.60 | 13.42 |
| doil | 4.16 | 757.57 | 4,234.92 | 0.92 | 0.00 | 30.44 | 250.69 | 1,655.74 | 1,948.62 |
| dgas | 1,266.54 | | 728.58 | 0.66 | 0.00 | 0.98 | 77.43 | 15.28 | 11.41 |
| domn | 387.03 | 474.34 | 748.73 | 30.54 | 8.46 | 45.58 | 230.84 | 63.89 | 190.88 |
| dclt | 11,005.79 | 1,104.33 | 2,287.26 | 4,449.04 | 309.53 | 2,315.36 | 1,979.47 | 104.94 | 954.77 |
| dwdp | 6,838.69 | 1,090.25 | 2,698.13 | 380.89 | 10.73 | 390.43 | 3,131.23 | 91.56 | 86.41 |
| dp_c | 6,387.06 | 414.80 | 3,856.03 | 672.84 | 11.11 | 110.92 | 730.52 | 540.61 | 229.66 |
| dcrp | 28,016.33 | 3,338.61 | 8,541.92 | 1,712.82 | 560.69 | 3,649.68 | 11,611.36 | 872.00 | 618.55 |
| dmfg | 82,480.94 | 13,091.40 | 12,330.79 | 12,323.85 | 598.82 | 27,669.92 | 35,399.84 | 2,490.24 | 1,797.54 |
| dely | 7.30 | 0.24 | 524.61 | 9.29 | 0.07 | 0.32 | 83.28 | 25.77 | 11.11 |
| dgdt | 12.07 | 0.00 | 1.59 | 2.09 | 0.00 | 2.14 | 7.16 | 34.33 | 10.10 |
| dwtr | 24.85 | 0.51 | 3.18 | 2.81 | 0.05 | 6.83 | 17.36 | 5.50 | 7.45 |
| dsrv | 10,562.22 | 184.41 | 818.40 | 2,397.29 | 296.04 | 3,217.70 | 16,921.81 | 1,099.56 | 2,079.62 |
| dtrn | 2,524.36 | 91.21 | 670.73 | 736.06 | 94.38 | 1,935.17 | 6,050.73 | 845.97 | 1,424.96 |

Note: See Figure 19 and Table 7 for definitions.

EUO Commodity Imports in 2004 Base

| | wusa | wbra | wrsa | wchk | wind | wofe | weuf | weuo | wrow |
|---|---|---|---|---|---|---|---|---|---|
| dwht | 127.31 | 66.89 | 24.12 | 1.01 | 1.44 | 0.10 | 146.88 | 827.97 | 11.90 |
| dpcr | 7.24 | 0.20 | 2.17 | 39.62 | 5.11 | 64.78 | 73.94 | 28.33 | 94.69 |
| dgro | 29.78 | 67.79 | 12.08 | 2.83 | 0.50 | 0.50 | 247.82 | 500.33 | 12.47 |
| dsgr | 1.21 | 662.64 | 243.25 | 1.40 | 0.69 | 13.38 | 243.86 | 616.29 | 41.59 |
| dosd | 24.24 | 38.48 | 13.76 | 61.87 | 19.94 | 1.10 | 77.02 | 171.06 | 24.74 |
| dvol | 54.33 | 289.54 | 263.07 | 4.48 | 4.90 | 277.14 | 1,200.31 | 867.04 | 102.58 |
| dv_f | 99.14 | 29.25 | 806.53 | 145.29 | 21.38 | 44.21 | 1,770.31 | 979.67 | 1,080.68 |
| dofb | 424.85 | 165.04 | 403.91 | 350.80 | 105.56 | 509.40 | 9,513.02 | 7,254.13 | 1,066.11 |
| dcmt | 27.94 | 310.84 | 239.11 | 3.87 | 23.61 | 54.51 | 823.25 | 408.90 | 28.38 |
| domt | 753.65 | 817.08 | 16.95 | 119.60 | 0.09 | 23.69 | 1,577.18 | 760.07 | 24.78 |
| doap | 31.94 | 14.85 | 18.65 | 128.01 | 1.17 | 43.65 | 582.44 | 420.35 | 53.44 |
| dmil | 31.31 | 0.89 | 30.12 | 1.40 | 1.45 | 98.13 | 1,038.47 | 1,521.71 | 31.26 |
| dfsh | 5.61 | 0.21 | 1.50 | 9.73 | 1.14 | 13.88 | 247.87 | 34.45 | 14.22 |
| dpdr | 1.02 | 0.01 | 0.09 | 4.25 | 0.56 | 3.38 | 2.75 | 1.59 | 24.46 |
| dc_b | 0.00 | 0.00 | 0.30 | 0.06 | 0.52 | 0.61 | 0.15 | 9.99 | 1.17 |
| dpfb | 8.12 | 4.79 | 3.27 | 0.18 | 0.63 | 1.43 | 76.92 | 552.35 | 116.59 |
| docr | 147.43 | 283.65 | 121.18 | 49.19 | 140.98 | 94.97 | 1,264.44 | 327.92 | 793.87 |
| dctl | 3.63 | 0.01 | 0.50 | 0.25 | 0.00 | 0.70 | 64.58 | 137.73 | 7.48 |
| drmk | 0.46 | 0.10 | 0.46 | 0.17 | 0.29 | 0.15 | 4.35 | 6.85 | 8.60 |
| dwol | 0.62 | 0.00 | 6.46 | 1.50 | 1.33 | 75.07 | 18.55 | 13.63 | 24.15 |
| dfrs | 7.13 | 0.39 | 5.77 | 2.50 | 4.68 | 3.89 | 107.59 | 363.70 | 26.93 |
| dcoa | 70.58 | 0.00 | 21.78 | 11.28 | 0.31 | 87.66 | 18.46 | 1,804.85 | 14.15 |
| doil | 0.02 | 0.30 | 14.94 | 0.14 | 0.00 | 2.22 | 73.08 | 19,164.89 | 555.93 |
| dgas | 0.00 | | 0.28 | 2.66 | 0.00 | 1.66 | 37.49 | 8,397.78 | 23.32 |
| domn | 67.40 | 260.88 | 340.16 | 66.62 | 115.18 | 136.42 | 774.82 | 2,528.40 | 809.73 |
| dclt | 301.34 | 59.84 | 166.14 | 8,495.93 | 465.00 | 1,267.10 | 23,443.68 | 5,104.43 | 3,259.58 |
| dwdp | 295.74 | 73.48 | 46.57 | 227.86 | 12.78 | 321.12 | 14,894.65 | 8,714.66 | 511.08 |
| dp_c | 240.79 | 121.28 | 24.92 | 137.88 | 7.48 | 27.17 | 2,520.33 | 6,471.25 | 453.53 |
| dcrp | 1,759.24 | 110.69 | 220.42 | 1,268.73 | 707.63 | 2,791.53 | 46,860.59 | 18,412.20 | 2,108.25 |
| dmfg | 8,858.72 | 686.07 | 1,583.12 | 9,840.64 | 515.06 | 24,402.18 | 165,864.80 | 53,750.33 | 7,189.02 |
| dely | 48.28 | 0.07 | 353.27 | 56.84 | 0.50 | 2.17 | 975.71 | 3,962.13 | 233.98 |
| dgdt | 20.32 | 0.00 | 7.76 | 8.43 | 0.01 | 11.40 | 50.28 | 179.15 | 48.25 |
| dwtr | 21.39 | 0.96 | 5.77 | 5.27 | 0.09 | 12.52 | 40.98 | 14.67 | 16.22 |
| dsrv | 12,229.34 | 386.26 | 1,415.73 | 2,942.52 | 779.52 | 7,217.32 | 37,475.41 | 3,489.52 | 5,395.88 |
| dtrn | 2,523.55 | 120.69 | 954.74 | 974.98 | 164.32 | 2,443.53 | 8,653.77 | 1,643.91 | 4,260.54 |

Note: See Figure 19 and Table 7 for definitions.

ROW Commodity Imports in 2004 Base

| | **wusa** | **wbra** | **wrsa** | **wchk** | **wind** | **wofe** | **weuf** | **weuo** | **wrow** |
|---|---|---|---|---|---|---|---|---|---|
| dwht | 2,183.55 | 208.12 | 705.12 | 31.39 | 349.44 | 955.60 | 1,726.92 | 542.83 | 282.86 |
| dpcr | 134.00 | 4.15 | 28.95 | 108.72 | 1,067.72 | 1,538.48 | 82.50 | 2.08 | 1,222.52 |
| dgro | 1,254.42 | 265.67 | 590.34 | 12.87 | 81.12 | 356.05 | 351.08 | 563.04 | 502.74 |
| dsgr | 4.93 | 1,612.12 | 75.58 | 6.03 | 26.33 | 192.56 | 803.49 | 21.25 | 782.81 |
| dosd | 281.30 | 393.78 | 367.61 | 66.93 | 50.09 | 146.56 | 304.48 | 221.90 | 330.84 |
| dvol | 665.53 | 894.53 | 1,605.62 | 41.45 | 379.73 | 4,010.14 | 869.57 | 342.19 | 1,361.29 |
| dv_f | 341.21 | 18.26 | 183.22 | 357.39 | 379.03 | 408.66 | 690.41 | 82.42 | 2,206.48 |
| dofb | 1,582.97 | 230.58 | 480.91 | 802.96 | 450.97 | 2,614.37 | 8,813.27 | 648.21 | 6,146.21 |
| dcmt | 126.10 | 574.83 | 272.91 | 38.64 | 249.63 | 479.19 | 244.47 | 11.13 | 229.95 |
| domt | 267.48 | 1,022.86 | 56.83 | 174.47 | 6.78 | 118.69 | 709.71 | 14.21 | 270.55 |
| doap | 109.42 | 8.93 | 24.52 | 136.03 | 44.24 | 131.66 | 553.86 | 85.06 | 290.92 |
| dmil | 129.01 | 53.72 | 230.86 | 18.16 | 60.77 | 1,393.78 | 2,962.90 | 341.38 | 937.31 |
| dfsh | 7.02 | 0.29 | 2.46 | 26.27 | 8.99 | 81.37 | 100.71 | 3.42 | 206.16 |
| dpdr | 85.20 | 0.08 | 1.51 | 22.52 | 3.89 | 117.82 | 5.22 | 0.29 | 128.60 |
| dc_b | 0.00 | 0.00 | 0.32 | 0.06 | 0.59 | 0.53 | 0.20 | 3.41 | 2.42 |
| dpfb | 788.85 | 67.43 | 23.74 | 1.23 | 135.66 | 60.27 | 352.72 | 472.89 | 1,065.55 |
| docr | 154.29 | 230.35 | 165.61 | 238.54 | 271.85 | 217.16 | 597.57 | 58.70 | 1,667.78 |
| dctl | 97.23 | 8.75 | 43.51 | 8.95 | 4.19 | 227.36 | 374.91 | 51.30 | 789.54 |
| drmk | 0.51 | 0.12 | 0.44 | 0.16 | 0.32 | 0.22 | 4.74 | 7.69 | 2.89 |
| dwol | 5.30 | 0.00 | 0.32 | 3.79 | 1.57 | 25.68 | 4.67 | 5.77 | 17.17 |
| dfrs | 36.86 | 1.57 | 24.00 | 5.15 | 28.93 | 130.44 | 74.26 | 154.82 | 267.13 |
| dcoa | 228.36 | 0.00 | 239.38 | 136.79 | 36.31 | 291.57 | 60.45 | 415.53 | 610.14 |
| doil | 24.25 | 36.84 | 91.33 | 97.52 | 0.20 | 149.62 | 28.00 | 1,340.74 | 16,205.28 |
| dgas | 0.11 | 0.00 | 1.20 | 2.31 | 0.01 | 5.94 | 29.84 | 57.14 | 2,279.46 |
| domn | 393.18 | 406.76 | 220.43 | 154.56 | 238.06 | 477.49 | 5,232.66 | 450.07 | 1,853.27 |
| dclt | 799.30 | 181.18 | 235.15 | 15,237.97 | 3,176.05 | 11,580.91 | 12,622.33 | 822.83 | 8,654.75 |
| dwdp | 1,152.20 | 308.12 | 208.76 | 1,032.33 | 376.78 | 3,736.63 | 9,871.72 | 1,820.04 | 3,769.79 |
| dp_c | 1,004.16 | 430.43 | 218.54 | 1,233.65 | 1,650.93 | 3,475.28 | 5,249.50 | 2,763.34 | 10,332.39 |
| dcrp | 4,888.91 | 442.39 | 455.82 | 4,735.24 | 3,341.07 | 13,997.84 | 39,122.81 | 3,766.25 | 15,709.54 |
| dmfg | 28,018.20 | 2,450.91 | 2,149.42 | 22,300.87 | 9,758.12 | 74,105.15 | 153,225.30 | 20,502.93 | 40,224.30 |
| dely | 46.87 | 0.06 | 157.56 | 66.61 | 0.43 | 2.23 | 477.64 | 274.01 | 368.73 |
| dgdt | 12.94 | 0.00 | 15.71 | 6.64 | 0.01 | 24.24 | 69.21 | 780.09 | 72.47 |
| dwtr | 23.76 | 1.13 | 5.80 | 5.32 | 0.10 | 15.35 | 43.86 | 12.43 | 12.15 |
| dsrv | 23,174.21 | 784.81 | 2,058.31 | 5,686.80 | 770.70 | 9,904.51 | 46,693.73 | 3,504.34 | 5,443.56 |
| dtrn | 4,530.80 | 196.30 | 1,297.26 | 1,515.86 | 231.66 | 3,987.43 | 12,562.67 | 1,797.05 | 2,527.80 |

Note: See Figure 19 and Table 7 for definitions.

# APPENDIX D

## Value of Commodity Import by Region

USA Commodity Import in 2004 Base

| | **wbra** | **wrsa** | **wchk** | **wind** | **wofe** | **weuf** | **weuo** | **wrow** |
|---|---|---|---|---|---|---|---|---|
| dwht | 0.01 | 2.33 | 0.25 | 3.20 | 0.23 | 160.95 | 12.39 | 13.00 |
| dpcr | 0.56 | 3.70 | 35.41 | 27.22 | 170.73 | 5.61 | 0.75 | 20.50 |
| dgro | 0.69 | 97.76 | 1.01 | 1.18 | 1.40 | 331.01 | 11.29 | 18.05 |
| dsgr | 69.42 | 388.42 | 0.64 | 4.80 | 114.73 | 101.73 | 6.09 | 61.80 |
| dosd | 72.70 | 45.65 | 23.44 | 38.87 | 9.42 | 216.76 | 10.06 | 20.25 |
| dvol | 106.35 | 122.81 | 11.02 | 94.36 | 479.78 | 1,431.77 | 7.12 | 113.58 |
| dv_f | 170.45 | 5,884.98 | 222.89 | 245.87 | 293.37 | 1,175.70 | 35.17 | 482.08 |
| dofb | 680.47 | 7,598.70 | 2,383.95 | 533.32 | 5,531.54 | 18,514.48 | 725.91 | 1,767.57 |
| dcmt | 4.86 | 441.78 | 1.22 | 0.66 | 2,188.49 | 1,271.33 | 20.16 | 20.58 |
| domt | 199.65 | 138.77 | 26.25 | 0.20 | 87.56 | 1,566.14 | 54.39 | 28.10 |
| doap | 86.73 | 91.66 | 426.51 | 13.06 | 116.06 | 863.71 | 51.45 | 71.16 |
| dmil | 13.45 | 115.84 | 10.12 | 35.97 | 483.04 | 1,254.56 | 97.58 | 34.02 |
| dfsh | 40.90 | 345.62 | 44.83 | 3.80 | 221.79 | 826.14 | 6.35 | 89.33 |
| dpdr | 0.00 | 0.84 | 1.16 | 12.00 | 2.40 | 1.31 | 0.02 | 8.58 |
| dc_b | 0.00 | 1.41 | 0.13 | 1.13 | 1.39 | 0.35 | 0.59 | 2.65 |
| dpfb | 4.33 | 28.94 | 0.53 | 1.14 | 4.60 | 25.25 | 5.98 | 35.25 |
| docr | 548.81 | 2,171.49 | 127.35 | 96.99 | 502.68 | 940.87 | 64.62 | 1,073.12 |
| dctl | 3.01 | 528.56 | 0.77 | 0.00 | 14.76 | 266.91 | 13.07 | 10.73 |
| drmk | 0.22 | 1.51 | 0.38 | 0.62 | 0.63 | 9.26 | 17.03 | 4.77 |
| dwol | 0.08 | 0.46 | 5.51 | 3.18 | 16.54 | 4.72 | 6.77 | 7.51 |
| dfrs | 4.70 | 66.59 | 12.72 | 17.65 | 25.99 | 307.20 | 10.95 | 54.18 |
| dcoa | 0.00 | 739.19 | 28.47 | 0.62 | 49.11 | 98.36 | 31.04 | 9.03 |
| doil | 460.15 | 44,041.08 | 113.13 | 0.00 | 824.23 | 18,261.12 | 1,808.01 | 60,377.77 |
| dgas | | 1,557.27 | 3.38 | 0.00 | 131.78 | 12,280.17 | 15.53 | 607.11 |
| domn | 297.45 | 749.60 | 391.25 | 45.24 | 261.22 | 1,589.11 | 71.70 | 854.73 |
| dclt | 1,864.79 | 19,381.95 | 28,933.55 | 4,139.79 | 15,875.09 | 13,844.06 | 1,255.47 | 22,184.34 |
| dwdp | 2,570.17 | 7,119.11 | 10,843.09 | 142.99 | 6,189.46 | 42,378.62 | 875.06 | 1,016.73 |
| dp_c | 1,785.47 | 8,510.83 | 888.50 | 195.96 | 1,263.39 | 14,724.21 | 3,186.90 | 3,203.27 |
| dcrp | 1,197.57 | 8,977.77 | 12,027.40 | 1,463.40 | 25,783.48 | 83,414.11 | 2,922.60 | 4,243.20 |
| dmfg | 11,744.28 | 109,556.40 | 119,934.70 | 8,318.38 | 229,923.70 | 280,041.70 | 12,995.54 | 20,050.89 |
| dely | 0.04 | 62.77 | 64.08 | 0.29 | 1.75 | 1,287.80 | 105.62 | 49.46 |
| dgdt | 0.00 | 8.66 | 10.74 | 0.01 | 11.41 | 70.40 | 232.58 | 44.72 |
| dwtr | 2.09 | 25.44 | 14.82 | 0.19 | 43.43 | 78.32 | 25.63 | 35.38 |
| dsrv | 1,467.43 | 6,646.50 | 14,457.01 | 1,694.98 | 24,961.45 | 94,352.55 | 5,557.23 | 13,977.55 |
| dtrn | 218.13 | 5,260.51 | 5,560.59 | 359.80 | 11,143.90 | 27,915.38 | 4,943.54 | 9,834.53 |

Note: See Figure 19 and Table 7 for definitions.

BRA Commodity Import in 2004 Base

| | **wusa** | **wrsa** | **wchk** | **wind** | **wofe** | **weuf** | **weuo** | **wrow** |
|---|---|---|---|---|---|---|---|---|
| dwht | 10.40 | 697.68 | 0.01 | 0.12 | 0.00 | 2.61 | 0.22 | 0.55 |
| dpcr | 0.15 | 91.23 | 0.70 | 0.18 | 22.83 | 1.39 | 0.03 | 5.29 |
| dgro | 1.11 | 59.18 | 0.18 | 0.04 | 0.03 | 15.49 | 0.12 | 0.65 |
| dsgr | 0.72 | 0.14 | 0.00 | 0.05 | 0.41 | 0.65 | 0.13 | 0.58 |
| dosd | 0.05 | 71.51 | 0.04 | 0.88 | 0.38 | 1.51 | 0.09 | 2.11 |
| dvol | 4.05 | 80.76 | 0.21 | 0.07 | 29.73 | 95.54 | 0.16 | 1.78 |
| dv_f | 9.91 | 174.33 | 13.80 | 0.20 | 2.69 | 27.73 | 1.32 | 21.69 |
| dofb | 99.08 | 592.31 | 17.39 | 3.05 | 28.53 | 443.73 | 7.44 | 21.00 |
| dcmt | 1.15 | 82.87 | 0.19 | 0.01 | 0.48 | 3.34 | 1.21 | 0.98 |
| domt | 1.97 | 2.89 | 0.33 | 0.00 | 3.92 | 6.17 | 0.68 | 0.86 |
| doap | 29.57 | 9.73 | 4.10 | 0.13 | 4.91 | 30.14 | 1.79 | 2.95 |
| dmil | 4.69 | 71.80 | 0.30 | 0.11 | 4.22 | 21.01 | 3.06 | 1.07 |
| dfsh | 0.58 | 30.57 | 0.65 | 0.10 | 1.98 | 0.82 | 0.07 | 0.73 |
| dpdr | 9.57 | 80.18 | 0.04 | 0.04 | 0.21 | 0.33 | 0.00 | 0.12 |
| dc_b | 0.00 | 0.04 | 0.01 | 0.06 | 0.06 | 0.01 | 0.03 | 0.12 |
| dpfb | 94.08 | 50.36 | 0.00 | 0.02 | 0.12 | 2.22 | 0.74 | 9.60 |
| docr | 16.57 | 15.03 | 0.30 | 2.68 | 32.87 | 25.43 | 0.98 | 32.21 |
| dctl | 3.24 | 0.59 | 0.02 | 0.00 | 0.16 | 2.59 | 0.42 | 0.74 |
| drmk | 0.04 | 0.04 | 0.01 | 0.02 | 0.02 | 0.42 | 0.61 | 0.29 |
| dwol | 0.03 | 0.09 | 0.13 | 0.11 | 0.15 | 0.65 | 0.26 | 0.23 |
| dfrs | 1.51 | 2.19 | 0.18 | 1.06 | 0.52 | 4.68 | 0.30 | 1.49 |
| dcoa | 206.52 | 40.82 | 15.80 | 0.03 | 336.60 | 59.61 | 11.76 | 36.20 |
| doil | 0.00 | 273.29 | 0.02 | 0.00 | 10.14 | 2.26 | 2.88 | 4,262.58 |
| dgas | 0.00 | 552.00 | 0.11 | 0.00 | 0.08 | 0.53 | 0.88 | 0.87 |
| domn | 47.56 | 609.79 | 9.62 | 0.32 | 1.16 | 99.23 | 20.00 | 97.30 |
| dclt | 128.71 | 270.27 | 526.59 | 62.18 | 462.77 | 348.49 | 12.99 | 88.63 |
| dwdp | 199.08 | 224.72 | 16.53 | 0.51 | 34.76 | 539.62 | 9.88 | 20.16 |
| dp_c | 315.46 | 840.23 | 452.52 | 139.27 | 83.45 | 350.15 | 41.35 | 699.34 |
| dcrp | 3,760.01 | 2,067.22 | 481.09 | 277.87 | 1,095.52 | 5,427.29 | 1,023.47 | 820.80 |
| dmfg | 7,748.37 | 2,751.84 | 1,908.90 | 79.28 | 5,075.03 | 10,728.40 | 470.33 | 434.41 |
| dely | 48.55 | 507.08 | 73.92 | 0.45 | 2.45 | 538.74 | 349.47 | 209.90 |
| dgdt | 0.86 | 0.28 | 0.37 | 0.00 | 0.61 | 2.60 | 12.51 | 2.61 |
| dwtr | 1.97 | 0.55 | 0.47 | 0.01 | 1.42 | 3.77 | 1.04 | 1.46 |
| dsrv | 1,699.26 | 216.99 | 746.74 | 256.33 | 1,245.48 | 6,054.03 | 357.30 | 725.67 |
| dtrn | 258.35 | 183.44 | 187.72 | 22.07 | 572.35 | 2,046.44 | 233.53 | 318.32 |

Note: See Figure 19 and Table 7 for definitions.

CHK Commodity Import in 2004 Base

| | wusa | wbra | wrsa | wchk | wind | wofe | weuf | weuo | wrow |
|---|---|---|---|---|---|---|---|---|---|
| dwht | 549.80 | 0.00 | 4.27 | 0.04 | 1.25 | 273.69 | 515.35 | 2.31 | 4.76 |
| dpcr | 3.25 | 0.14 | 1.12 | 6.38 | 1.87 | 366.37 | 0.71 | 0.30 | 11.92 |
| dgro | 6.32 | 0.01 | 1.29 | 1.11 | 1.59 | 183.46 | 66.78 | 1.23 | 8.06 |
| dsgr | 0.90 | 0.18 | 93.62 | 4.78 | 0.57 | 157.03 | 14.38 | 1.36 | 7.22 |
| dosd | 2,579.37 | 1,607.61 | 993.83 | 1.58 | 24.04 | 2.14 | 117.71 | 1.86 | 31.41 |
| dvol | 27.19 | 494.13 | 713.25 | 17.75 | 56.02 | 2,488.60 | 213.78 | 11.55 | 33.42 |
| dv_f | 363.65 | 0.96 | 115.12 | 92.16 | 12.85 | 875.67 | 45.67 | 36.88 | 298.12 |
| dofb | 972.79 | 83.29 | 683.11 | 555.08 | 71.02 | 2,152.00 | 1,459.69 | 695.15 | 483.11 |
| dcmt | 120.68 | 128.23 | 48.62 | 7.41 | 0.33 | 240.35 | 224.73 | 9.30 | 7.53 |
| domt | 268.38 | 288.85 | 48.61 | 161.61 | 1.30 | 68.50 | 179.21 | 13.65 | 60.65 |
| doap | 759.81 | 8.52 | 27.86 | 136.98 | 2.78 | 627.70 | 1,075.83 | 53.39 | 92.94 |
| dmil | 61.42 | 0.84 | 5.12 | 17.75 | 1.19 | 381.38 | 207.20 | 19.02 | 9.72 |
| dfsh | 19.73 | 0.44 | 9.39 | 49.65 | 4.48 | 369.60 | 139.92 | 1.21 | 209.58 |
| dpdr | 0.02 | 0.00 | 0.01 | 0.19 | 0.46 | 1.20 | 0.07 | 0.00 | 1.26 |
| dc_b | 0.00 | 0.00 | 0.54 | 0.02 | 0.45 | 0.56 | 0.09 | 0.23 | 1.05 |
| dpfb | 1,494.17 | 35.39 | 52.48 | 0.48 | 47.20 | 136.70 | 31.86 | 230.07 | 490.25 |
| docr | 86.74 | 63.55 | 7.27 | 50.11 | 8.80 | 124.69 | 150.96 | 7.23 | 144.73 |
| dctl | 1.09 | 0.01 | 0.78 | 7.19 | 0.00 | 177.89 | 25.15 | 2.79 | 4.12 |
| drmk | 0.47 | 0.09 | 0.42 | 0.06 | 0.25 | 0.49 | 3.83 | 6.33 | 2.61 |
| dwol | 6.93 | 0.05 | 7.42 | 0.48 | 1.10 | 696.41 | 33.38 | 10.06 | 8.78 |
| dfrs | 83.26 | 0.34 | 5.14 | 1.77 | 3.02 | 586.10 | 92.16 | 1,042.55 | 569.44 |
| dcoa | 0.75 | 0.00 | 0.56 | 30.06 | 0.21 | 733.65 | 74.77 | 21.54 | 186.93 |
| doil | 9.58 | 268.28 | 264.17 | 0.00 | 0.00 | 1,957.23 | 641.33 | 2,727.05 | 22,262.08 |
| dgas | 0.00 | | 0.22 | 3.47 | 0.00 | 11.43 | 9.90 | 2.78 | 16.47 |
| domn | 306.81 | 2,490.43 | 1,474.90 | 14.92 | 2,977.32 | 3,309.22 | 1,574.17 | 357.93 | 2,249.38 |
| dclt | 1,012.60 | 327.80 | 362.18 | 13,321.41 | 427.58 | 15,738.12 | 3,765.48 | 141.37 | 1,493.89 |
| dwdp | 2,138.40 | 523.05 | 347.04 | 1,831.54 | 18.73 | 5,833.94 | 3,294.47 | 569.44 | 198.68 |
| dp_c | 828.25 | 22.44 | 299.97 | 122.27 | 30.07 | 7,476.54 | 514.02 | 1,160.01 | 3,119.12 |
| dcrp | 8,116.18 | 197.22 | 441.48 | 3,849.70 | 728.82 | 56,169.36 | 12,361.37 | 2,154.07 | 2,950.49 |
| dmfg | 27,860.65 | 994.55 | 4,177.03 | 16,483.71 | 2,212.33 | 236,605.70 | 61,911.82 | 4,797.86 | 3,972.27 |
| dely | 52.22 | 0.06 | 45.03 | 36.37 | 0.47 | 3.40 | 300.91 | 130.55 | 72.18 |
| dgdt | 24.43 | 0.00 | 6.61 | 11.01 | 0.01 | 20.69 | 44.39 | 66.11 | 24.99 |
| dwtr | 21.75 | 0.83 | 5.39 | 2.30 | 0.08 | 32.96 | 33.50 | 10.03 | 12.63 |
| dsrv | 8,147.99 | 233.45 | 1,149.63 | 16,814.13 | 508.83 | 9,635.32 | 25,190.84 | 1,841.66 | 3,158.77 |
| dtrn | 2,806.77 | 90.40 | 864.90 | 450.42 | 141.50 | 4,032.75 | 6,091.63 | 1,057.30 | 2,095.47 |

Note: See Figure 19 and Table 7 for definitions.

IND Commodity Import in 2004 Base

| IND | wusa | wbra | wrsa | wchk | wind | wofe | weuf | weuo | wrow |
|---|---|---|---|---|---|---|---|---|---|
| dwht | 0.00 | 0.00 | 0.01 | 0.01 |  | 0.00 | 0.13 | 0.26 | 0.67 |
| dpcr | 0.01 | 0.02 | 0.12 | 0.87 |  | 0.82 | 0.35 | 0.04 | 1.44 |
| dgro | 0.25 | 0.00 | 0.47 | 0.01 |  | 0.68 | 0.16 | 0.14 | 0.97 |
| dsgr | 0.30 | 173.28 | 0.15 | 0.00 |  | 13.82 | 2.51 | 0.17 | 46.09 |
| dosd | 0.02 | 0.00 | 0.33 | 0.08 |  | 6.44 | 1.28 | 2.02 | 20.23 |
| dvol | 28.39 | 152.02 | 394.14 | 0.94 |  | 1,427.64 | 12.49 | 0.19 | 72.12 |
| dv_f | 133.22 | 0.83 | 3.35 | 25.83 |  | 90.58 | 125.41 | 9.27 | 617.85 |
| dofb | 51.84 | 190.63 | 23.82 | 14.41 |  | 78.39 | 118.54 | 5.60 | 72.94 |
| dcmt | 0.69 | 0.20 | 0.41 | 0.12 |  | 2.61 | 2.76 | 0.87 | 1.41 |
| domt | 0.71 | 0.05 | 0.48 | 0.40 |  | 1.51 | 4.13 | 0.83 | 1.30 |
| doap | 2.86 | 0.08 | 0.46 | 11.69 |  | 9.35 | 27.92 | 1.95 | 20.91 |
| dmil | 3.38 | 0.07 | 0.58 | 0.11 |  | 4.23 | 23.47 | 2.03 | 2.74 |
| dfsh | 0.28 | 0.00 | 0.13 | 1.98 |  | 2.02 | 1.55 | 0.10 | 14.27 |
| dpdr | 0.02 | 0.00 | 0.00 | 0.05 |  | 0.07 | 0.01 | 0.00 | 0.16 |
| dc_b | 0.00 | 0.00 | 0.03 | 0.01 |  | 0.06 | 0.01 | 0.03 | 0.12 |
| dpfb | 58.76 | 11.90 | 4.36 | 0.56 |  | 5.76 | 11.72 | 15.16 | 142.41 |
| docr | 5.36 | 1.77 | 3.35 | 16.20 |  | 35.12 | 14.13 | 0.73 | 113.42 |
| dctl | 0.32 | 0.00 | 0.06 | 0.03 |  | 0.08 | 0.20 | 0.35 | 0.94 |
| drmk | 0.05 | 0.01 | 0.05 | 0.02 |  | 0.02 | 0.53 | 0.74 | 0.34 |
| dwol | 1.94 | 0.11 | 1.42 | 0.59 |  | 154.07 | 14.01 | 0.68 | 7.33 |
| dfrs | 1.69 | 0.43 | 20.45 | 1.73 |  | 202.87 | 9.99 | 0.56 | 406.52 |
| dcoa | 82.49 |  | 4.79 | 117.07 |  | 832.58 | 2.68 | 11.55 | 13.92 |
| doil | 0.01 | 0.24 | 489.75 | 0.12 |  | 799.54 | 12.55 | 42.76 | 22,388.20 |
| dgas | 0.00 |  | 0.00 | 0.00 |  | 0.00 | 0.00 | 0.00 | 3.07 |
| domn | 50.92 | 96.65 | 486.87 | 147.59 |  | 610.76 | 5,450.44 | 52.01 | 1,440.43 |
| dclt | 65.27 | 18.59 | 47.49 | 1,123.50 |  | 816.51 | 404.69 | 39.32 | 356.71 |
| dwdp | 193.37 | 3.02 | 12.15 | 75.83 |  | 306.88 | 838.38 | 125.38 | 213.37 |
| dp_c | 75.83 | 3.55 | 3.52 | 145.34 |  | 196.98 | 45.96 | 27.78 | 1,784.35 |
| dcrp | 1,333.78 | 72.76 | 76.38 | 1,325.24 |  | 2,791.22 | 2,699.56 | 516.44 | 2,766.00 |
| dmfg | 3,928.09 | 148.87 | 228.46 | 3,848.51 |  | 13,283.28 | 14,087.74 | 1,938.11 | 7,510.14 |
| dely | 4.52 | 0.01 | 3.71 | 6.65 |  | 0.24 | 39.77 | 20.41 | 7.57 |
| dgdt | 0.01 |  | 0.00 | 0.01 |  | 0.01 | 0.04 | 0.04 | 0.01 |
| dwtr | 2.39 | 0.09 | 0.66 | 0.57 |  | 1.72 | 4.64 | 1.25 | 1.69 |
| dsrv | 2,475.97 | 86.49 | 284.45 | 805.66 |  | 1,361.70 | 8,608.82 | 496.42 | 790.54 |
| dtrn | 327.90 | 22.69 | 164.70 | 255.37 |  | 643.77 | 2,080.93 | 221.72 | 430.67 |

Note: See Figure 19 and Table 7 for definitions.

OFE Commodity Import in 2004 Base

| | **wusa** | **wbra** | **wrsa** | **wchk** | **wind** | **wofe** | **weuf** | **weuo** | **wrow** |
|---|---|---|---|---|---|---|---|---|---|
| dwht | 1,447.83 | 0.02 | 20.75 | 105.80 | 146.00 | 1,353.30 | 577.35 | 65.07 | 13.44 |
| dpcr | 204.16 | 1.00 | 4.47 | 78.93 | 24.86 | 467.52 | 6.16 | 0.77 | 343.22 |
| dgro | 4,018.68 | 249.88 | 215.71 | 417.53 | 128.16 | 352.66 | 87.85 | 3.44 | 50.66 |
| dsgr | 8.65 | 46.25 | 55.51 | 9.69 | 2.66 | 1,154.28 | 65.51 | 9.55 | 112.06 |
| dosd | 2,149.90 | 527.86 | 382.60 | 254.30 | 86.08 | 343.81 | 719.48 | 2.72 | 180.96 |
| dvol | 348.19 | 466.85 | 734.53 | 326.65 | 610.69 | 1,972.60 | 616.93 | 4.67 | 88.65 |
| dv_f | 1,499.82 | 11.31 | 286.27 | 1,329.67 | 97.63 | 1,931.47 | 181.59 | 31.50 | 541.43 |
| dofb | 6,159.35 | 452.04 | 2,036.95 | 7,657.83 | 547.54 | 13,194.60 | 8,767.98 | 1,252.49 | 3,207.50 |
| dcmt | 210.31 | 78.87 | 58.55 | 9.47 | 196.24 | 3,352.46 | 177.24 | 20.73 | 22.96 |
| domt | 1,617.25 | 730.52 | 449.47 | 922.23 | 3.49 | 863.85 | 2,523.91 | 110.16 | 36.85 |
| doap | 773.74 | 23.98 | 46.54 | 489.33 | 17.73 | 709.61 | 371.26 | 76.90 | 103.38 |
| dmil | 359.62 | 8.14 | 47.50 | 27.96 | 10.65 | 2,503.76 | 1,120.83 | 123.15 | 29.76 |
| dfsh | 152.41 | 6.38 | 97.81 | 915.06 | 21.18 | 1,487.78 | 297.98 | 83.49 | 543.41 |
| dpdr | 63.84 | 0.02 | 0.69 | 32.94 | 1.58 | 27.07 | 0.20 | 0.01 | 8.05 |
| dc_b | 0.02 | 0.00 | 0.73 | 0.16 | 1.34 | 1.45 | 0.23 | 0.63 | 2.78 |
| dpfb | 922.48 | 164.76 | 50.94 | 16.43 | 82.19 | 520.90 | 75.40 | 73.29 | 657.50 |
| docr | 821.31 | 383.60 | 438.92 | 684.92 | 127.01 | 1,193.96 | 548.31 | 38.45 | 803.24 |
| dctl | 88.16 | 0.04 | 2.13 | 1.40 | 0.03 | 303.19 | 59.72 | 7.63 | 26.69 |
| drmk | 2.26 | 0.27 | 1.14 | 0.43 | 0.74 | 1.17 | 7.05 | 15.87 | 5.40 |
| dwol | 0.59 | 0.04 | 0.54 | 6.24 | 3.47 | 102.62 | 4.55 | 6.51 | 12.94 |
| dfrs | 702.81 | 1.11 | 40.98 | 43.76 | 20.67 | 710.74 | 306.94 | 561.82 | 345.46 |
| dcoa | 602.81 | 0.00 | 21.66 | 3,195.86 | 0.71 | 8,983.78 | 317.79 | 493.86 | 304.66 |
| doil | 24.47 | 88.18 | 691.38 | 608.20 | 0.01 | 7,592.37 | 390.07 | 875.24 | 114,612.10 |
| dgas | 120.77 | 0.00 | 10.32 | 9.68 | 0.00 | 9,392.04 | 27.81 | 31.39 | 6,320.81 |
| domn | 780.31 | 1,558.36 | 4,043.44 | 881.03 | 638.75 | 6,545.20 | 1,349.43 | 121.48 | 2,123.75 |
| dclt | 2,108.75 | 334.15 | 549.77 | 38,639.48 | 1,316.48 | 12,186.68 | 8,775.52 | 378.12 | 4,080.09 |
| dwdp | 4,480.42 | 491.83 | 841.72 | 5,403.13 | 79.43 | 14,528.12 | 10,568.08 | 715.42 | 1,728.32 |
| dp_c | 2,611.32 | 121.37 | 143.00 | 3,414.38 | 1,258.58 | 11,912.32 | 1,046.82 | 806.93 | 15,025.47 |
| dcrp | 27,502.03 | 389.34 | 1,181.39 | 12,843.64 | 1,623.29 | 64,747.62 | 36,842.63 | 1,271.79 | 6,703.52 |
| dmfg | 103,719.90 | 2,669.82 | 7,124.02 | 111,151.40 | 4,581.50 | 341,718.70 | 113,901.30 | 12,484.71 | 18,644.83 |
| dely | 11.32 | 0.01 | 11.40 | 16.71 | 0.10 | 0.52 | 94.58 | 42.08 | 16.01 |
| dgdt | 83.76 | 0.00 | 22.77 | 29.66 | 0.03 | 30.75 | 155.13 | 497.99 | 115.17 |
| dwtr | 104.43 | 2.53 | 14.28 | 20.20 | 0.23 | 66.43 | 64.00 | 24.22 | 34.38 |
| dsrv | 48,174.00 | 1,036.98 | 3,850.08 | 22,774.58 | 1,729.18 | 24,009.60 | 65,773.49 | 6,277.29 | 9,952.42 |
| dtrn | 11,999.10 | 594.89 | 3,361.82 | 7,388.65 | 543.81 | 13,942.11 | 25,040.11 | 3,884.15 | 6,232.73 |

Note: See Figure 19 and Table 7 for definitions.

EUF Commodity Import in 2004 Base

| | **wusa** | **wbra** | **wrsa** | **wchk** | **wind** | **wofe** | **weuf** | **weuo** | **wrow** |
|---|---|---|---|---|---|---|---|---|---|
| dwht | 366.25 | 19.99 | 76.11 | 0.86 | 11.66 | 102.67 | 3,665.73 | 344.93 | 79.38 |
| dpcr | 128.89 | 2.41 | 26.82 | 74.88 | 51.95 | 211.60 | 559.59 | 4.32 | 85.70 |
| dgro | 439.93 | 239.73 | 332.30 | 18.41 | 4.65 | 7.15 | 3,221.55 | 407.86 | 82.57 |
| dsgr | 50.44 | 170.90 | 421.11 | 1.36 | 19.46 | 90.95 | 2,214.62 | 468.28 | 887.23 |
| dosd | 1,560.09 | 2,743.33 | 760.04 | 183.24 | 98.05 | 79.70 | 1,424.04 | 704.08 | 184.61 |
| dvol | 711.63 | 1,825.23 | 2,075.98 | 17.15 | 159.70 | 1,371.14 | 6,318.28 | 465.82 | 1,065.52 |
| dv_f | 4,160.45 | 562.84 | 4,893.70 | 571.92 | 300.51 | 1,005.31 | 21,365.51 | 868.64 | 6,172.70 |
| dofb | 8,367.86 | 1,139.56 | 5,449.12 | 2,586.56 | 717.33 | 5,031.83 | 101,180.00 | 4,980.93 | 7,905.63 |
| dcmt | 193.05 | 817.84 | 729.30 | 4.74 | 11.85 | 1,397.19 | 8,498.93 | 364.41 | 195.87 |
| domt | 811.62 | 940.34 | 357.87 | 29.81 | 2.33 | 501.15 | 17,838.86 | 1,123.30 | 175.85 |
| doap | 412.08 | 129.30 | 310.59 | 425.02 | 50.15 | 267.92 | 5,047.33 | 678.28 | 643.74 |
| dmil | 187.03 | 6.28 | 74.89 | 17.49 | 21.32 | 407.97 | 23,297.94 | 1,091.80 | 121.98 |
| dfsh | 577.73 | 23.85 | 103.05 | 84.46 | 18.98 | 201.55 | 5,358.52 | 272.03 | 697.79 |
| dpdr | 63.78 | 0.00 | 16.49 | 4.80 | 109.68 | 39.40 | 197.42 | 0.08 | 60.20 |
| dc_b | 0.01 | 0.00 | 2.39 | 0.48 | 4.20 | 5.11 | 12.17 | 2.35 | 9.64 |
| dpfb | 230.26 | 71.30 | 32.42 | 1.48 | 6.04 | 38.44 | 241.83 | 157.97 | 565.86 |
| docr | 1,115.83 | 1,665.83 | 2,088.85 | 238.35 | 366.90 | 603.22 | 9,345.75 | 323.63 | 5,405.56 |
| dctl | 166.05 | 0.78 | 18.75 | 1.73 | 0.04 | 12.71 | 2,713.38 | 490.73 | 190.89 |
| drmk | 3.33 | 0.81 | 3.73 | 1.38 | 2.32 | 0.72 | 55.69 | 61.80 | 28.07 |
| dwol | 12.82 | 0.80 | 36.70 | 35.49 | 10.51 | 444.92 | 129.47 | 30.19 | 133.21 |
| dfrs | 685.01 | 13.87 | 216.61 | 55.34 | 64.40 | 53.63 | 1,987.23 | 1,605.23 | 678.68 |
| dcoa | 1,264.71 | 0.00 | 1,164.55 | 153.81 | 1.79 | 1,834.08 | 321.98 | 2,088.01 | 2,404.68 |
| doil | 87.23 | 215.26 | 3,774.50 | 0.66 | 0.00 | 10.74 | 40,363.66 | 33,409.22 | 52,026.65 |
| dgas | 626.54 | 0.00 | 12.18 | 33.98 | 0.00 | 24.76 | 16,521.28 | 1,559.96 | 9,092.08 |
| domn | 1,996.41 | 2,674.57 | 3,114.43 | 932.88 | 549.79 | 2,250.61 | 12,809.23 | 1,998.14 | 12,131.90 |
| dclt | 5,870.39 | 1,389.22 | 2,083.40 | 28,310.81 | 8,110.62 | 12,444.99 | 98,523.93 | 24,620.31 | 43,836.22 |
| dwdp | 15,887.93 | 2,621.32 | 1,476.39 | 5,141.91 | 320.83 | 5,509.48 | 117,956.30 | 19,123.51 | 4,512.17 |
| dp_c | 5,315.31 | 117.37 | 1,203.26 | 1,256.24 | 275.91 | 413.55 | 36,493.03 | 10,802.88 | 6,864.61 |
| dcrp | 69,820.34 | 1,393.67 | 3,989.29 | 10,341.54 | 2,473.21 | 28,690.46 | 403,922.60 | 18,321.75 | 12,109.66 |
| dmfg | 243,372.60 | 7,804.71 | 25,836.95 | 108,556.80 | 7,574.03 | 203,224.40 | 1,053,485.00 | 134,814.40 | 48,579.29 |
| dely | 973.59 | 0.33 | 377.51 | 244.57 | 2.57 | 13.76 | 10,949.14 | 2,666.70 | 454.55 |
| dgdt | 153.77 | 0.00 | 78.12 | 107.82 | 0.10 | 103.31 | 413.00 | 1,525.07 | 370.59 |
| dwtr | 153.85 | 7.67 | 45.37 | 41.05 | 0.71 | 85.23 | 438.01 | 108.38 | 116.31 |
| dsrv | 100,277.70 | 3,954.58 | 12,765.50 | 38,950.73 | 9,197.97 | 52,832.96 | 388,731.20 | 26,958.21 | 37,506.90 |
| dtrn | 24,963.10 | 1,429.41 | 9,143.71 | 8,657.62 | 1,534.65 | 20,663.73 | 103,918.20 | 14,615.40 | 22,364.99 |

Note: See Figure 19 and Table 7 for definitions.

RSA Commodity Import in 2004 Base

| | wusa | wbra | wrsa | wchk | wind | wofe | weuf | weuo | wrow |
|---|---|---|---|---|---|---|---|---|---|
| dwht | 1,367.47 | 0.01 | 148.24 | 0.06 | 0.76 | 0.43 | 592.06 | 1.46 | 3.00 |
| dpcr | 248.20 | 2.48 | 45.74 | 4.79 | 4.19 | 41.52 | 3.74 | 0.19 | 206.36 |
| dgro | 2,016.93 | 16.19 | 361.06 | 0.14 | 0.27 | 27.51 | 49.84 | 0.92 | 10.04 |
| dsgr | 57.83 | 44.09 | 364.07 | 0.02 | 0.38 | 1.99 | 48.80 | 1.12 | 22.81 |
| dosd | 991.76 | 183.71 | 703.17 | 15.14 | 12.38 | 1.34 | 414.84 | 10.21 | 12.67 |
| dvol | 915.29 | 146.36 | 2,044.27 | 0.79 | 2.59 | 95.52 | 177.80 | 39.04 | 9.22 |
| dv_f | 621.81 | 29.59 | 622.53 | 71.76 | 4.23 | 13.52 | 243.55 | 6.80 | 46.14 |
| dofb | 3,428.94 | 601.19 | 3,352.99 | 137.04 | 16.11 | 250.41 | 2,375.43 | 46.38 | 138.27 |
| dcmt | 993.45 | 236.89 | 293.81 | 1.13 | 0.07 | 139.97 | 394.13 | 4.57 | 4.74 |
| domt | 1,268.90 | 223.71 | 211.69 | 3.89 | 0.07 | 4.78 | 233.81 | 5.87 | 5.38 |
| doap | 327.81 | 26.80 | 93.78 | 18.88 | 0.62 | 15.26 | 66.12 | 4.81 | 8.09 |
| dmil | 607.93 | 29.03 | 555.38 | 0.56 | 0.94 | 458.34 | 549.57 | 64.95 | 7.39 |
| dfsh | 18.34 | 0.44 | 48.73 | 4.54 | 0.99 | 10.38 | 18.67 | 0.67 | 8.70 |
| dpdr | 290.04 | 0.30 | 34.90 | 0.38 | 0.36 | 0.70 | 0.26 | 0.01 | 0.90 |
| dc_b | 0.04 | 0.00 | 1.69 | 0.03 | 0.27 | 0.31 | 0.06 | 0.13 | 0.59 |
| dpfb | 721.69 | 67.14 | 40.50 | 0.52 | 0.20 | 0.69 | 4.15 | 1.32 | 15.51 |
| docr | 308.07 | 185.03 | 215.14 | 20.79 | 9.16 | 39.06 | 158.31 | 4.72 | 153.38 |
| dctl | 27.04 | 3.74 | 208.00 | 0.12 | 0.00 | 14.89 | 22.82 | 2.07 | 2.23 |
| drmk | 0.54 | 0.05 | 0.25 | 0.09 | 0.15 | 0.08 | 1.87 | 3.44 | 1.38 |
| dwol | 3.95 | 5.71 | 18.13 | 1.57 | 0.71 | 7.08 | 2.45 | 1.45 | 2.62 |
| dfrs | 61.17 | 5.15 | 16.48 | 3.83 | 8.75 | 3.73 | 25.13 | 1.97 | 16.83 |
| dcoa | 69.76 | 0.00 | 170.92 | 4.31 | 0.17 | 252.18 | 38.48 | 17.60 | 13.42 |
| doil | 4.16 | 757.57 | 4,234.92 | 0.92 | 0.00 | 30.44 | 250.69 | 1,655.74 | 1,948.62 |
| dgas | 1,266.54 | | 728.58 | 0.66 | 0.00 | 0.98 | 77.43 | 15.28 | 11.41 |
| domn | 387.03 | 474.34 | 748.73 | 30.54 | 8.46 | 45.58 | 230.84 | 63.89 | 190.88 |
| dclt | 11,005.79 | 1,104.33 | 2,287.26 | 4,449.04 | 309.53 | 2,315.36 | 1,979.47 | 104.94 | 954.77 |
| dwdp | 6,838.69 | 1,090.25 | 2,698.13 | 380.89 | 10.73 | 390.43 | 3,131.23 | 91.56 | 86.41 |
| dp_c | 6,387.06 | 414.80 | 3,856.03 | 672.84 | 11.11 | 110.92 | 730.52 | 540.61 | 229.66 |
| dcrp | 28,016.33 | 3,338.61 | 8,541.92 | 1,712.82 | 560.69 | 3,649.68 | 11,611.36 | 872.00 | 618.55 |
| dmfg | 82,480.94 | 13,091.40 | 12,330.79 | 12,323.85 | 598.82 | 27,669.92 | 35,399.84 | 2,490.24 | 1,797.54 |
| dely | 7.30 | 0.24 | 524.61 | 9.29 | 0.07 | 0.32 | 83.28 | 25.77 | 11.11 |
| dgdt | 12.07 | 0.00 | 1.59 | 2.09 | 0.00 | 2.14 | 7.16 | 34.33 | 10.10 |
| dwtr | 24.85 | 0.51 | 3.18 | 2.81 | 0.05 | 6.83 | 17.36 | 5.50 | 7.45 |
| dsrv | 10,562.22 | 184.41 | 818.40 | 2,397.29 | 296.04 | 3,217.70 | 16,921.81 | 1,099.56 | 2,079.62 |
| dtrn | 2,524.36 | 91.21 | 670.73 | 736.06 | 94.38 | 1,935.17 | 6,050.73 | 845.97 | 1,424.96 |

Note: See Figure 19 and Table 7 for definitions.

EUO Commodity Imports in 2004 Base

| | **wusa** | **wbra** | **wrsa** | **wchk** | **wind** | **wofe** | **weuf** | **weuo** | **wrow** |
|---|---|---|---|---|---|---|---|---|---|
| dwht | 127.31 | 66.89 | 24.12 | 1.01 | 1.44 | 0.10 | 146.88 | 827.97 | 11.90 |
| dpcr | 7.24 | 0.20 | 2.17 | 39.62 | 5.11 | 64.78 | 73.94 | 28.33 | 94.69 |
| dgro | 29.78 | 67.79 | 12.08 | 2.83 | 0.50 | 0.50 | 247.82 | 500.33 | 12.47 |
| dsgr | 1.21 | 662.64 | 243.25 | 1.40 | 0.69 | 13.38 | 243.86 | 616.29 | 41.59 |
| dosd | 24.24 | 38.48 | 13.76 | 61.87 | 19.94 | 1.10 | 77.02 | 171.06 | 24.74 |
| dvol | 54.33 | 289.54 | 263.07 | 4.48 | 4.90 | 277.14 | 1,200.31 | 867.04 | 102.58 |
| dv_f | 99.14 | 29.25 | 806.53 | 145.29 | 21.38 | 44.21 | 1,770.31 | 979.67 | 1,080.68 |
| dofb | 424.85 | 165.04 | 403.91 | 350.80 | 105.56 | 509.40 | 9,513.02 | 7,254.13 | 1,066.11 |
| dcmt | 27.94 | 310.84 | 239.11 | 3.87 | 23.61 | 54.51 | 823.25 | 408.90 | 28.38 |
| domt | 753.65 | 817.08 | 16.95 | 119.60 | 0.09 | 23.69 | 1,577.18 | 760.07 | 24.78 |
| doap | 31.94 | 14.85 | 18.65 | 128.01 | 1.17 | 43.65 | 582.44 | 420.35 | 53.44 |
| dmil | 31.31 | 0.89 | 30.12 | 1.40 | 1.45 | 98.13 | 1,038.47 | 1,521.71 | 31.26 |
| dfsh | 5.61 | 0.21 | 1.50 | 9.73 | 1.14 | 13.88 | 247.87 | 34.45 | 14.22 |
| dpdr | 1.02 | 0.01 | 0.09 | 4.25 | 0.56 | 3.38 | 2.75 | 1.59 | 24.46 |
| dc_b | 0.00 | 0.00 | 0.30 | 0.06 | 0.52 | 0.61 | 0.15 | 9.99 | 1.17 |
| dpfb | 8.12 | 4.79 | 3.27 | 0.18 | 0.63 | 1.43 | 76.92 | 552.35 | 116.59 |
| docr | 147.43 | 283.65 | 121.18 | 49.19 | 140.98 | 94.97 | 1,264.44 | 327.92 | 793.87 |
| dctl | 3.63 | 0.01 | 0.50 | 0.25 | 0.00 | 0.70 | 64.58 | 137.73 | 7.48 |
| drmk | 0.46 | 0.10 | 0.46 | 0.17 | 0.29 | 0.15 | 4.35 | 6.85 | 8.60 |
| dwol | 0.62 | 0.00 | 6.46 | 1.50 | 1.33 | 75.07 | 18.55 | 13.63 | 24.15 |
| dfrs | 7.13 | 0.39 | 5.77 | 2.50 | 4.68 | 3.89 | 107.59 | 363.70 | 26.93 |
| dcoa | 70.58 | 0.00 | 21.78 | 11.28 | 0.31 | 87.66 | 18.46 | 1,804.85 | 14.15 |
| doil | 0.02 | 0.30 | 14.94 | 0.14 | 0.00 | 2.22 | 73.08 | 19,164.89 | 555.93 |
| dgas | 0.00 | | 0.28 | 2.66 | 0.00 | 1.66 | 37.49 | 8,397.78 | 23.32 |
| domn | 67.40 | 260.88 | 340.16 | 66.62 | 115.18 | 136.42 | 774.82 | 2,528.40 | 809.73 |
| dclt | 301.34 | 59.84 | 166.14 | 8,495.93 | 465.00 | 1,267.10 | 23,443.68 | 5,104.43 | 3,259.58 |
| dwdp | 295.74 | 73.48 | 46.57 | 227.86 | 12.78 | 321.12 | 14,894.65 | 8,714.66 | 511.08 |
| dp_c | 240.79 | 121.28 | 24.92 | 137.88 | 7.48 | 27.17 | 2,520.33 | 6,471.25 | 453.53 |
| dcrp | 1,759.24 | 110.69 | 220.42 | 1,268.73 | 707.63 | 2,791.53 | 46,860.59 | 18,412.20 | 2,108.25 |
| dmfg | 8,858.72 | 686.07 | 1,583.12 | 9,840.64 | 515.06 | 24,402.18 | 165,864.80 | 53,750.33 | 7,189.02 |
| dely | 48.28 | 0.07 | 353.27 | 56.84 | 0.50 | 2.17 | 975.71 | 3,962.13 | 233.98 |
| dgdt | 20.32 | 0.00 | 7.76 | 8.43 | 0.01 | 11.40 | 50.28 | 179.15 | 48.25 |
| dwtr | 21.39 | 0.96 | 5.77 | 5.27 | 0.09 | 12.52 | 40.98 | 14.67 | 16.22 |
| dsrv | 12,229.34 | 386.26 | 1,415.73 | 2,942.52 | 779.52 | 7,217.32 | 37,475.41 | 3,489.52 | 5,395.88 |
| dtrn | 2,523.55 | 120.69 | 954.74 | 974.98 | 164.32 | 2,443.53 | 8,653.77 | 1,643.91 | 4,260.54 |

Note: See Figure 19 and Table 7 for definitions.

ROW Commodity Imports in 2004 Base

| | wusa | wbra | wrsa | wchk | wind | wofe | weuf | weuo | wrow |
|---|---|---|---|---|---|---|---|---|---|
| dwht | 2,183.55 | 208.12 | 705.12 | 31.39 | 349.44 | 955.60 | 1,726.92 | 542.83 | 282.86 |
| dpcr | 134.00 | 4.15 | 28.95 | 108.72 | 1,067.72 | 1,538.48 | 82.50 | 2.08 | 1,222.52 |
| dgro | 1,254.42 | 265.67 | 590.34 | 12.87 | 81.12 | 356.05 | 351.08 | 563.04 | 502.74 |
| dsgr | 4.93 | 1,612.12 | 75.58 | 6.03 | 26.33 | 192.56 | 803.49 | 21.25 | 782.81 |
| dosd | 281.30 | 393.78 | 367.61 | 66.93 | 50.09 | 146.56 | 304.48 | 221.90 | 330.84 |
| dvol | 665.53 | 894.53 | 1,605.62 | 41.45 | 379.73 | 4,010.14 | 869.57 | 342.19 | 1,361.29 |
| dv_f | 341.21 | 18.26 | 183.22 | 357.39 | 379.03 | 408.66 | 690.41 | 82.42 | 2,206.48 |
| dofb | 1,582.97 | 230.58 | 480.91 | 802.96 | 450.97 | 2,614.37 | 8,813.27 | 648.21 | 6,146.21 |
| dcmt | 126.10 | 574.83 | 272.91 | 38.64 | 249.63 | 479.19 | 244.47 | 11.13 | 229.95 |
| domt | 267.48 | 1,022.86 | 56.83 | 174.47 | 6.78 | 118.69 | 709.71 | 14.21 | 270.55 |
| doap | 109.42 | 8.93 | 24.52 | 136.03 | 44.24 | 131.66 | 553.86 | 85.06 | 290.92 |
| dmil | 129.01 | 53.72 | 230.86 | 18.16 | 60.77 | 1,393.78 | 2,962.90 | 341.38 | 937.31 |
| dfsh | 7.02 | 0.29 | 2.46 | 26.27 | 8.99 | 81.37 | 100.71 | 3.42 | 206.16 |
| dpdr | 85.20 | 0.08 | 1.51 | 22.52 | 3.89 | 117.82 | 5.22 | 0.29 | 128.60 |
| dc_b | 0.00 | 0.00 | 0.32 | 0.06 | 0.59 | 0.53 | 0.20 | 3.41 | 2.42 |
| dpfb | 788.85 | 67.43 | 23.74 | 1.23 | 135.66 | 60.27 | 352.72 | 472.89 | 1,065.55 |
| docr | 154.29 | 230.35 | 165.61 | 238.54 | 271.85 | 217.16 | 597.57 | 58.70 | 1,667.78 |
| dctl | 97.23 | 8.75 | 43.51 | 8.95 | 4.19 | 227.36 | 374.91 | 51.30 | 789.54 |
| drmk | 0.51 | 0.12 | 0.44 | 0.16 | 0.32 | 0.22 | 4.74 | 7.69 | 2.89 |
| dwol | 5.30 | 0.00 | 0.32 | 3.79 | 1.57 | 25.68 | 4.67 | 5.77 | 17.17 |
| dfrs | 36.86 | 1.57 | 24.00 | 5.15 | 28.93 | 130.44 | 74.26 | 154.82 | 267.13 |
| dcoa | 228.36 | 0.00 | 239.38 | 136.79 | 36.31 | 291.57 | 60.45 | 415.53 | 610.14 |
| doil | 24.25 | 36.84 | 91.33 | 97.52 | 0.20 | 149.62 | 28.00 | 1,340.74 | 16,205.28 |
| dgas | 0.11 | 0.00 | 1.20 | 2.31 | 0.01 | 5.94 | 29.84 | 57.14 | 2,279.46 |
| domn | 393.18 | 406.76 | 220.43 | 154.56 | 238.06 | 477.49 | 5,232.66 | 450.07 | 1,853.27 |
| dclt | 799.30 | 181.18 | 235.15 | 15,237.97 | 3,176.05 | 11,580.91 | 12,622.33 | 822.83 | 8,654.75 |
| dwdp | 1,152.20 | 308.12 | 208.76 | 1,032.33 | 376.78 | 3,736.63 | 9,871.72 | 1,820.04 | 3,769.79 |
| dp_c | 1,004.16 | 430.43 | 218.54 | 1,233.65 | 1,650.93 | 3,475.28 | 5,249.50 | 2,763.34 | 10,332.39 |
| dcrp | 4,888.91 | 442.39 | 455.82 | 4,735.24 | 3,341.07 | 13,997.84 | 39,122.81 | 3,766.25 | 15,709.54 |
| dmfg | 28,018.20 | 2,450.91 | 2,149.42 | 22,300.87 | 9,758.12 | 74,105.15 | 153,225.30 | 20,502.93 | 40,224.30 |
| dely | 46.87 | 0.06 | 157.56 | 66.61 | 0.43 | 2.23 | 477.64 | 274.01 | 368.73 |
| dgdt | 12.94 | 0.00 | 15.71 | 6.64 | 0.01 | 24.24 | 69.21 | 780.09 | 72.47 |
| dwtr | 23.76 | 1.13 | 5.80 | 5.32 | 0.10 | 15.35 | 43.86 | 12.43 | 12.15 |
| dsrv | 23,174.21 | 784.81 | 2,058.31 | 5,686.80 | 770.70 | 9,904.51 | 46,693.73 | 3,504.34 | 5,443.56 |
| dtrn | 4,530.80 | 196.30 | 1,297.26 | 1,515.86 | 231.66 | 3,987.43 | 12,562.67 | 1,797.05 | 2,527.80 |

Note: See Figure 19 and Table 7 for definitions.

# VITA

Name: Jiamin Lu

Address: AGLS 408J, 2124 TAMU, College Station, TX 77843-2124

Email Address: lujiamin@gmail.com

Education: B.S., Economics, Lingnan University, Hong Kong, 2005

Ph.D., Agricultural Economics, Texas A&M University, 2011