Trade Implications of the Revised US and EU Biofuel Mandates

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ABSTRACT

The risk of food insecurity in the form of higher food prices has prompted policymakers in the United States (US) and European Union (EU) to revise their approach to biofuel development. The US Renewable Fuel Standard (RFS) and EU Directive 2009/28/EC require long term use of renewable energy in transportation, subject to sustainability. This thesis examines the implications of the US RFS and EU Directive 2009/28/EC in a trade context using a partial equilibrium/comparative static framework.

The focus is on the effect of the revised biofuels policies on opportunities for developing countries to supply the US and/or EU markets. For the US, the implications when the volume produced and/or required under the RFS is technologically infeasible with imports of ethanol as a potential policy alternative are explored. For the EU, the impact of the sustainability criteria on foreign biodiesel suppliers in terms of compliance cost is examined. In general, the US policy may enhance opportunities for trade while the EU policy will likely inhibit trade. A discussion of the implications of the mandates for developing countries and WTO is included.

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Chapter 1: Introduction

1.1 Introduction

The lack of security in international oil supplies and the environmental degradation associated with greenhouse gas (GHG) emissions have spurred an interest in biofuels by governments in recent years. The major producers of biofuel are the United States, Brazil, the European Union, China, Canada and India. Energy security, environmental sustainability and rural development opportunities are the potential benefits expected from supporting the development of a biofuel industry. In addition, consumption mandates lower the risk involved in producing or developing biofuels. However, the risk of food insecurity, in the form of rising food prices, is associated with these benefits. Therefore, policy makers in most of the major biofuels producing nations have attempted to find a balance between food and fuel uses. The Energy Independence and Security Act 2007 (EISA) in the US and the EU 2009 Directive (2009/28/EC) for the promotion of the use of energy from renewable sources are examples of policies attempting to balance green energy and food security.

1.2 Problem Statement

The US and EU biofuels policies differ in significant ways yet both require long term use of renewable energy in transportation. The EISA 2007 of the USrequires 36 billion gallons of renewable fuel comprised of of three different types of biofuels by 2022; and the 2009 Directive of the EU requires a 10% minimum blending share of renewable fuels or 40.2 million tonnes of oil equivalent in total transportation fuel by 2020. In other words, the share of renewable fuel in the US transport sector is expected to be approximately 27 percent relative to petroleum-based fuel. These mandates create a long term demand for biofuels which is unlikely to exist otherwise. As a result, these mandates increase the potential for trade, *ceteris paribus*. Furthermore, trading prospects for alternative energy such as biofuels are enhanced by capacity shortfalls and technological constraints. The US has mandated use of renewable fuel independent of technology and the EU directive requires the European Commission to maintain a balance between domestic production and imports of renewable fuels due to the capacity constraints of some member states. However, little work has been done to examine the mandates in a trade context. For the US, Blandford (2010) briefly discusses the export potential derived from the EISA-Renewable Fuel Standard (RFS). Yano, Blandford and Surry (2010) explore import and export scenarios of the RFS but focus on the impact of changes in tariffs on imports and do not include the impact of the technological constraint on imports. For the EU, the literature concerning the sustainability criteria impact focuses on whether the current practices of foreign suppliers are compliant, notably Brazil (Lendel and Schaus 2010 and Zahniser 2010). Other literature discusses the biofuel mandates impact on energy markets (Kim, Schaible, and Daberkow 2010), the world animal feed market and land use (Hertel, Tyner and Birur 2009). For the EU, studies by Kretschmer, Narita and Peterson (2009) and Doumax (2010) provide estimates of welfare effects.

1.3 Objective of the Study

The thesis models the mandates for biofuels in a trade context using a partial equilibrium/comparative static framework similar to Yano, Blandford and Surry (2010). Specifically, the thesis explores the implications for trade when the volume produced domestically or required under RFS is in disequilibrium with technical capability or use constraints in the case of the US. The impact of the sustainability criteria could have on new and existing foreign suppliers to the EU in terms of compliance cost is addressed. Quantitative cost estimates for compliance or lack thereof are provided. In addition, a discussion of the implications of the mandates for developing countries and the World Trade Organisation is included.

1.4 Organisation of the Study

The thesis is organised as follows: Chapter 2 provides the background information on biofuels. Chapter 3 is an overview of the global biofuel industry. Chapter 4 examines the prevailing biofuel policies of the US and EU. Chapter 5 formally develops the partial equilibrium models for the US and EU. Quantitative estimates are presented in Chapter 6. Chapters 7 and 8 discuss the implications of biofuel mandates for developing countries as well as international trade policy. Chapter 9 concludes the thesis.

Chapter 2: Background on Biofuels

2.1 Background

Biofuels are alternatives to fossil-based sources of energy produced from renewable sources used in transportation. The two major types of biofuels are ethanol and biodiesel. The application of these types of biofuels in transport may be in pure form, that is, 100 percent of the fuel is bio-based and/or blended where a percentage of the fuel is renewable, for example, E15 or B15 implying a 15 percent blend of ethanol or biodiesel with fossil-based fuel. Biofuels offer the potential to reduce greenhouse emissions by displacing the use of fossil fuels. The European Biodiesel Board (EBB) reports[1] that the use of biodiesel results in a reduction of 65 percent to 90 percent in carbon dioxide (CO^2) emissions compared with petroleum-based diesel. The Renewable Fuel Association (RFA) reports[2] that ethanol can reduce CO^{2}emissions by up to 29 percent given current technology. Furthermore, the EU has found[3] emission savings as high as 71 percent[4] for sugar-cane based ethanol. Although, biofuels can be used in pure form and can be more environmentally friendly, its energy content is inferior to fossil-based fuels.

Data from the Alternative Fuels and Advanced Vehicles Data Center[5] (AFDC) shows that biodiesel has 93 percent of the energy of one gallon of diesel and ethanol 85 (E85) contains 77 percent of the energy of one gallon of gasoline. The use of ethanol can be traced back to the early 1900s with Henry Ford's T model being designed to be powered by corn ethanol.

2.1.1. Ethanol

Ethanol may be produced from a variety of inputs or biomass. Currently, sugar cane and corn are the two widely used inputs. The type of input used is normally correlated with climatic conditions as in North America, crops such as corn and wheat are used in contrast to countries with a tropical or near tropical climate, for example, Jamaica and Brazil which are able to

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[1] http://www.ebb-eu.org/biodiesel.php

[2] http://www.ethanolrfa.org/pages/ethanol-facts-environment

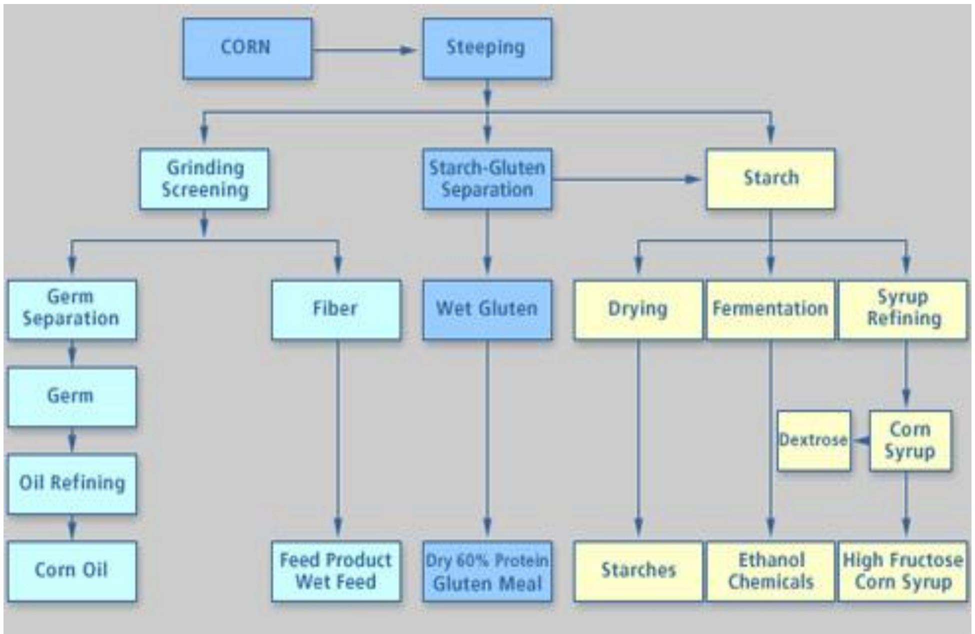
[3] 2009 European Union Directive Promoting the use of energy from renewable sources.

[4] Default greenhouse gas emission savings if produced with no net carbon emissions from land-use change.

[5] http://www.afdc.energy.gov/afdc/progs/fuel_compare.php

produce sugar. First generation technologies of ethanol may be defined as grain or food based, in contrast to second generation technologies which are derived from non food inputs such as cellulose. The production of ethanol can be done in one of two ways; wet and dry milling. Wet milling involves soaking or steeping the grain in water and dilute sulfurous acid for 24 to 48 hours. Figure 2.1 illustrates the wet milling process.

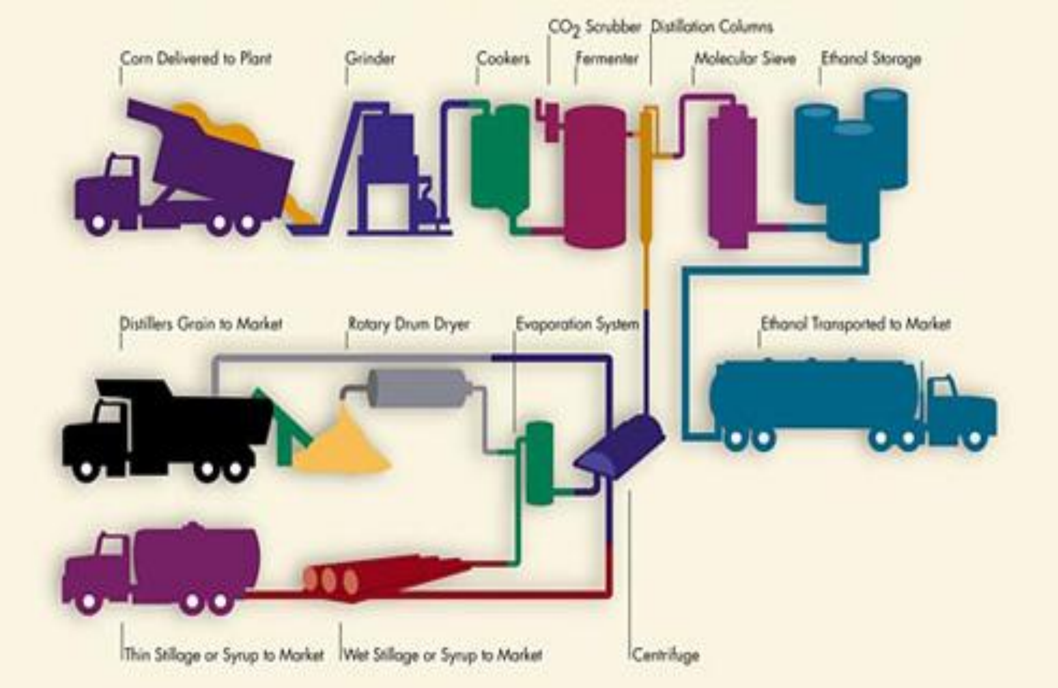
Figure 2.1: Wet Milling Process



Source: Renewable Fuel Association: How Ethanol is Made.

Dry milling involves converting the grain into flour and mixing with water to form a 'mash'. In the US, mash is fermented for 40 to 50 hours producing anhydrous ethanol which is blended with 5 percent natural gasoline to render it undrinkable, thus avoiding any beverage alcohol tax (RFA). Figure 2.2 illustrates the dry milling process.

Figure 2.2: Dry Milling Process



Source: Renewable Fuel Association: How Ethanol is Made.

2.1.2 Biodiesel

Biodiesel is a renewable fuel produced from vegetable oils such as rape seed oil, sunflower seed oil, soybean oil and used frying oils (UFO) or animal fats. The processing of oils and fats to produce biodiesel is done through esterfication technologies. Figure 2.3 shows the production pathway using oils for biodiesel production. The use of biodiesel in transport displaces diesel and given both fuels' distribution systems are similar, no changes are required[6].

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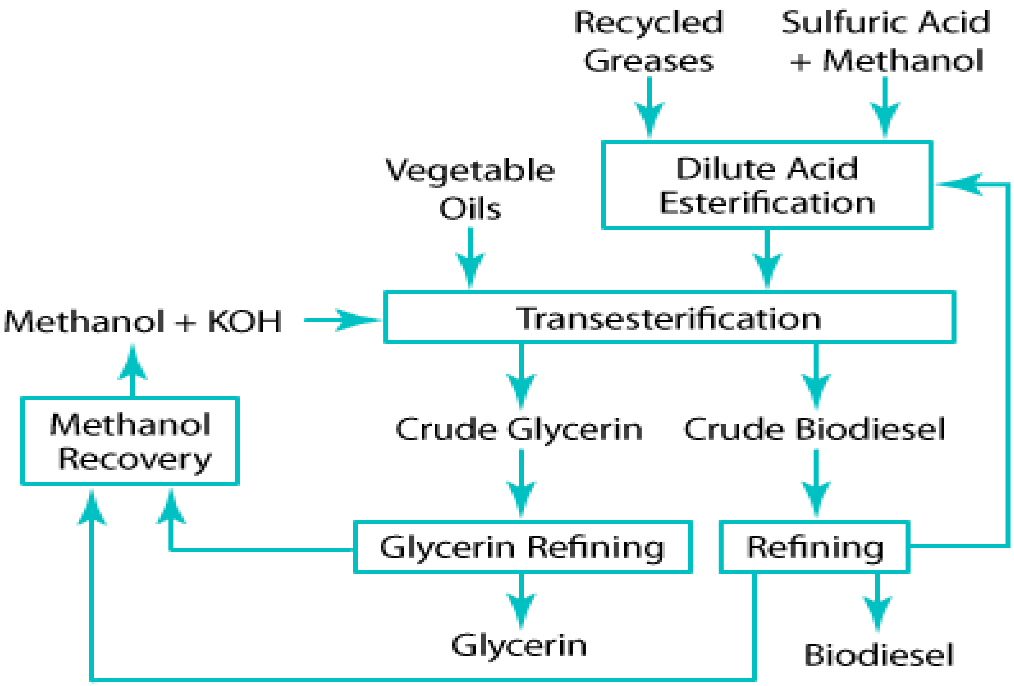
[6] European Biodiesel Board *About Biodiesel:* http://www.ebb-eu.org/biodiesel.php

Figure 2.3: Biodiesel Production Pathway



Source: Alternative Fuels and Advanced Vehicles Data Center

2.2 Summary

Chapter 2 provides the background information on biofuels. The two main types of biofuels are ethanol and biodiesel. These fuels can be used as alternative to fossil-based fuel in transportation. However, biofuel energy content is inferior to fossil-based fuel. The inputs used to produce ethanol and biodiesel varies. Ethanol may be produced from corn or sugar-cane and vegetable oils including soybean and rape seed in the case of biodiesel. The production of ethanol can be done in one of two ways; wet and dry milling. For biodiesel, production may be done through esterfication technologies. The next chapter provides an overview of the global biofuel industry, particularly the major producers of these two types of biofuels.

Chapter 3: The Biofuel Industry Global Perspective

3.1 The Biofuel Industry: Major Producers

The major producers of biofuel are US, Brazil, EU, China, Canada and India. The US Department of Energy (USDOE) in 2008 projected[7] that in 2010, the US, Brazil and the EU will supply more than 90 percent of total biofuels, but this forecast decreases to 70 percent by 2030. Energy security, environmental and rural development opportunities are the main motives for these countries supporting the development of a biofuel industry. In the case of China, Dong (2007) considers the domestic production of biofuels as a means to utilize the excess supply of grains which have depressed grain prices. However, this 'additional benefit' is correlated with rural development as the utilization of excess grain places upward pressure on prices, thus, improving farmer's income and, by extension, boosting rural development.

The two major biofuels traded are ethanol and biodiesel. The main feedstocks used for producing ethanol are sugar, corn, soybeans, wheat and sunflower seeds while vegetable, palm and jatropha oils, rapeseed and soybeans are the inputs for biodiesel. The primary feedstock used in production varies across countries based on climatic conditions. For example, feedstocks such as corn and wheat are used in U.S. and Canada. In contrast, Brazil with its tropical climate, uses sugar cane for biofuel production. In recognition of the competition between grain-derived biofuels and food production as a contributing factor to high food prices, governments have moved towards alternative feedstock or limiting the use of food crops in the production of biofuels. Developing countries such as China and India are pursuing biofuels derived from sweet sorghum, cassava and jatropha.

In terms of the market share of biofuels, the US and Brazil account for 88 percent of global ethanol production (RFA 2010) and the EU is the number one producer of biodiesel with around 60 percent of market share based on 2007 estimates (OECD, 2008). Canada, China and India are the three smaller producers among the major six producing nations with production skewed to

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[7] Report titled "World Biofuels Production Potential:
Understanding the Challenges to Meeting the U.S. Renewable Fuel Standard."

ethanol. The respective governments of these countries have committed to further developing the biofuel industry, notably, second generation biofuels derived from cellulosic conversion. The potential new technologies are believed to not suffer from the adverse effects associated with first generation biofuels as they are expected to have a relatively small impact on agricultural markets (UNCTAD, 2009).

The respective policies guiding the development of the biofuel industry in the major producing countries, except for Brazil, continue to evolve with new or revised measures being put in place. For example, the mandate for ethanol derived from corn-based ethanol (conventional biofuel) under the US Energy Independent and Security Act (EISA) of 2007 is residual with a maximum of 15 billion gallons(bg) starting 2015. Also, India and China made policy changes in 2008 in response to the apparent inflationary impact of biofuel production on food prices. The changes resulted in a shift away from using primarily food-based feedstock to using non-food feedstocks for the production of biofuels. With regard to subsidies, China is moving away from direct subsidies covering economic losses made to licensed ethanol producers during production, blending and distribution to tax incentives and loans oriented to secure factors of production (Global Subsidies Initiative-GSI, 2008). As of 2008, subsidies are provided based on an evaluation of production facilities performance.

The 2007 update of domestic support by the US and other countries by the GSI suggests that support to the biofuel sector over the period 2006 to 2013 is approximately $92 billion (Earley 2009). The EU and US have expanded their biofuel mandates as evident in the new directive of the European Parliament released in 2009 and the Energy Independence and Security Act of 2007 (EISA, 2007) in the case of US. For Canada, federal legislation in 2008 resulted in the establishment of a mandated use of renewable fuel content in gasoline of 5 percent by 2010 (GSI, 2009). Furthermore, the governments of the major producing countries provide far-reaching assistance in the form of loans, subsidies, research and development (R&D) grants and tax incentives. The major producing nations have used blending or utilization mandates which can be considered another form of subsidy offered by the governments since they guarantee a domestic market that is unlikely to exist otherwise (Murphy 2007). In addition, these measures bring stability and predictability for those considering investing in biofuel facilities (UNCTAD, 2009). A tariff is a type of support measure used by major producing nations of biofuels. The tariff raises the price of biofuel, which is an incentive for domestic producers to expand output. Gaisford and Kerr (2001) argue that increases in the rate of the tariff serve to increase production but reduce consumption and imports. In Tables 3.1 and 3.2, a summary of the support measures by the governments of the major producing nations of biofuels is presented.

Table 3.1 Major Producing Nations Ethanol Support Measures

Measures	**US**	**EU**	**Brazil**	**China**	**India**	**Canada**
Policy Price Support	36 billion gallons by 2022 $0.45 tax credit	5 percent share of renewables in transport fuel by 2015 and a 10 percent target by 2020.	All gasoline must contain between 20 percent and 25 per cent of anhydrous ethanol. Currently, the mandate is 23 percent.	10 percent ethanol blending mandate by 2020.	-20 percent mandatory blending target by 2017 -Minimum Support Price (MSP) for non food feedstock -Statutory Minimum Price (SMP) for sugarcane procurement -Minimum Purchase Price (MPP) for biofuel.	5 percent by 2010
Tariff/TRQ	7 percent duty free access for CBI/CAFTA using non-local feedstock $0.54 USD tariff	22.9 percent to 43 percent tariff	Not enforced at the moment	5 percent tariff	28.64 percent tariff	
Non-tariff	Emission savings: Corn based-20 per cent Sugar based- ≥ 50 percent cellulosic- ≥ 60 percent	Emission savings: 35 percent 50 percent by 2017 60 percent by 2018				

Table 3.2 Major Producing Nations Biodiesel Support Measures

Measures	**US**	**EU**	**Brazil**	**China**	**India**	**Canada**
Policy Price Support	1 billion gallons by 2012 $1.00 tax credit	5 percent share of renewables in transport fuel by 2015 and a 10 per cent target by 2020	5 percent blending target in 2010	-	-20 percent blending target by 2017 (not mandated) -No excise duty -Minimum Support Price (MSP) for non food feedstock -Minimum Purchase Price (MPP) for biofuel.	Federal mandate: 2 per cent by 2012 Provincial mandates: Sask min 5 percent after 2010 Jan1
Tariff/TRQ		Ad valorem tariff of 6.5 percent	Not enforced at the moment		28.64 percent tariff	6.5 percent (MFNs) and 3 percent (GPT) tariff
Non-tariff	Emission savings: 50 percent	Emission savings: 35 percent 50 percent by 2017 60 percent by 2018			Non food feedstock as inputs.	Provincial (Manitoba)- 80 percent of feedstock from local supply.

3.2 Policy Price Support

Table 3.3 outlines the blending or utilization mandates for the major biofuels producing nations as well as plans for second generation biofuels.

Table 3.3: Major Producing Nations Mandates

Country	**Blending/Utilization mandates**	**Plans for Second Generation biofuels**
US[8]	**36 billion** gallons of renewable fuels by **2022**. **1 billion** gallons of bio-mass based diesel by 2012.	16 billion gallons of cellulosic biofuels by 2022.
Brazil[9]	All gasoline must contain between **20 percent and 25 percent** of anhydrous ethanol. **Five perent** biodiesel by **2013.**	
EU[10]	**Five percent** share in transport fuel by **2015** & **10 percent** target by **2020**.	
Canada[11]	**Five percent** share in gasoline by **2010**. **Two percent** share in diesel fuel and heating oil by **2012**.	
China[12]	Ethanol: trial period of **10 percent** blending mandates in some regions. Five Chinese provinces require **10 percent** ethanol blends **-** Heilongjian, Jilin, Liaoning, Anhui, and Henan. **10 percent** ethanol blending mandate by **2020**.	Take non-grain path to biofuel development
India[11]	Ethanol blending; **5 percent** in gasoline in designated states in **2008**, to increase to **20 percent** by **2017**.	No target identified. Promotion of jatropha.

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[8] Energy Independence and Security Act 2007

[9] http://www.ethanolproducer.com/article.jsp?article_id=2466

[10] Directive 2009/28/EC promoting the use of energy from renewable sources.

[11] Report on Economic Assessment of Biofuel Support Policies, OECD Trade and Agriculture Directorate, July 2008.

[12] Tisdell (2009). Working Paper – "The Production of Biofuels: Welfare and Environmental Consequences for Asia."

The long term blending or utilization mandates can be viewed as ambitious given that the EU and US may need imports to satisfy the mandate and ‘inflexible’ since they are long term which could have implications for food prices in the long run. The achievement of targets by each member state of the EU may be a cause for concern as biofuel accounted for only one percent in transport in 2005 and Germany represented two-thirds of the one percent (Commission of the European Communities, 2007). In regards to the EUs policy framework, it was proposed that the level of use of agro-fuels dependent on food crops be fixed on a yearly basis by the European Commission in consultation with the other agencies such as Food and Agriculture Organisation (FAO) and even excluding this type of fuel from greenhouse gas emission reduction efforts (Inside U.S. Trade, 2008b). Furthermore, the technologies needed to achieve the blending targets for second generation biofuels (cellulosic) have yet to be developed to produce the mandated volume.

The divergence between mandated demand from production capacity is an issue facing the industry. In other words, global demand for ethanol due to these mandates is expected to be around 49.4 billion US gallons, while production capacity will only increase to 40 billon US gallons (UNCTAD, 2009). For biodiesel, demand is estimated to be approximately 23.2 billion US gallons, while production capacity will be around nine billion US gallons (UNCTAD, 2009). One effect of this divergence at the country level is higher prices unless international trade can moderate price increases.

Table 3.4 shows the potential demand of ethanol for the six major producing nations based on respective blending or utilization mandates and gasoline consumption estimates for 2006.

Table 3.4: Potential Demand for Ethanol Until 2022

Country	Gasoline Consumption Billion gallons 2006	Potential demand for ethanol until 2022 Billion gallons	Ethanol Production* 2010 Billion gallons
US	140	31	13
EU	39	1.2	1.2
China	18	2.7	.54
Canada	10	0.52	.36
Brazil	6.3	1.3	6.9
India	3.6	0.3	-

Source: Extracted from UNCTAD (2009). *The Biofuels Market: Current Situation and Alternative Scenarios*.
*Renewable Fuel Association

Brazil is the world's number one exporter of ethanol and can be considered the most efficient producer with a biofuel program dating back to the 1970s. The Brazilian government supports the domestic ethanol industry through subsidies and controls to reduce dependence on imported oil. The automotive industry played a fundamental role in the emergence of Brazil's ethanol industry as direct financial support was made available for technical modifications to make existing internal combustion engines capable of running solely on ethanol (Zapata and Nieuwenhuis 2009). Currently, the Brazilian government supports the industry through blending mandates and credit assistance to producers, but not direct assistance or subsidies (Harmer 2009).

3.3 Standards

The standards used for quality control reflect the market conditions in the US, Brazil and the EU and product classification (Tripartite Task Force of Brazil, EU and USA, 2007). For example, standards for biodiesel in the US and Brazil describe a product with a blending component in conventional hydrocarbon based diesel fuel in contrast to the European description of a product that is either a blending component or stand alone diesel fuel. These countries have made an effort to reconcile standards with a White Paper on Internationally Compatible Biofuel Standards

(Tripartite Task Force of Brazil, EU and USA, 2007). The report shows significant differences in standards for ethanol among US, the EU and Brazil, although these differences are not considered to significantly impede international trade in ethanol. However, additional drying and testing will be required by Brazil and US producers wishing to supply the EU. The only fundamental difference in standards for ethanol among these three major producers is the water content requirement with the EU having a limit of 0.24 percent and the US and Brazil having 1 and 0.4 percent respectively. Table 3.5 summarizes the key similarities and differences in ethanol specification for the EU, US and Brazil.

Table 3.5: Key Differences and Similarities in Ethanol Specification

Category A Similar	**Category B** Significant differences	**Category C** Fundamental differences
Colour	Ethanol content	Water content
Appearance	Acidity	
Density	Phosphorus content	
Sulfate content	Chloride acid	
Copper content	Gum/evaportation residue	
Iron content	pHe	
Sodium content		
Electrolytic conductivity		

Source: Tripartite Task Force of Brazil, EU and USA, 2007

Eschols (2009) discusses biofuel certification involving governments refusing to issue certification to a supplier (exporter) and prohibiting biofuel imports, imposing higher tariffs, restricting distribution or requiring special labeling thus raising the cost and difficulties associated with compliance. Therefore, national standards are important in gaining market access, although compliance may be costly if there are wide variations in standards across markets.

3.4. Asia: China and India

China and India are net importers of oil. They are both experiencing rapid economic growth, meaning their oil deficit will likely increase. The move towards biofuels can be considered an attempt by these two countries to improve energy security and to some extent to satisfy environmental commitments; by reduce GHG emissions and promoting rural development through better incomes for producers of feedstock. Although the benefits from engaging in biofuels production may be ‘real’, Asia faces several constraints in increasing their production of biofuels. Tisdell (2009) argues that opportunity costs are associated with the production of biofuels, which alludes to the food versus fuel debate and that the major expansion in biofuel production may result in biodiversity loss as a result of both agricultural intensification and expansion of land. Furthermore, the area of land available for expanding biofuel feedstock production in Asia (including China and India) without reducing food supplies is limited. In light of the constraints, China could be a major importer of biofuels, especially with the government reducing tariffs on ethanol by 25 percentage points (from 30 percent to five percent) effective January 1 2010 (Reuters, 2009).

3.5 Rest of the World

The pursuit of ‘green energy’ technology by countries apart from the major producers suggests that the opportunities from developing a biofuel industry extend beyond the borders of the current major six producing countries. Although, US and Brazil account for 88 percent of global ethanol production (RFA 2010), the US imports ethanol from Jamaica, Costa Rica, El Salvador, Trinidad and Tobago and palm-based biodiesel from Southeast Asia. Countries in Southeast Asia with interest in pursuing renewable energy include Thailand, The Philippines, Indonesia and Malaysia. Olz and Beerepoot (2010) argue that favourable conditions for biomass cultivation, along with economic and social factors, are expected to boost biofuel production in these Southeast Asian countries. In 2009, biodiesel production levels totalled 243,203 and 96 million liters, in Indonesia, Malaysia and The Philippines respectively and are projected to have increases of 25 to 60 percent by 2012 (IEA, 2009).

Malaysia is primarily a producer of biodiesel with no production of ethanol according to Olz and Beerepoot (2010). The production of biodiesel is based on palm oil, as Malaysia is the second largest palm oil producer in the world (Koizumi and Ohga 2007). The Malaysian standards require five percent processed palm oil and 95 percent diesel, known as B5. In 2005, the Malaysia's National Biofuel Policy was implemented with the following objectives:

1. Supplement depleting supplies of fossil fuel with renewable energy
2. Utilization of local resources
3. Boost exports of biofuels to the EU

Walter *et al.* (2007) estimate that Japan's share of the world import ethanol market in 2005 was 11 percent. Koizumi (2008) reports an annual production close to 8,000 US gallons (30 kiloliters -Kl) of ethanol and 792,516 US gallons (3000 Kl) of biodiesel in 2006. The inputs used are molasses, inedible wheat and corn, sorghum and wasted wood for ethanol and used vegetable oil for biodiesel production.

As stated earlier, Jamaica is among those countries which export ethanol to the US and is the lead intermediate destination for ethanol originating from Brazil destined for the US (Cohen 2007). This position arises because Jamaica participates in the Caribbean Basin Initiative Agreement which allows Caribbean countries to export ethanol produced from local feedstock duty free. Furthermore, if non-local feedstock was used to produce the biofuel, the volume allowed to enter duty free will be equal to seven percent of US production. However, experience has shown that CBI countries have not been able to satisfy quota requirements with only 71 percent of the total 2008 quota of 452 million gallons achieved[13]. On average, Jamaica exported 47 million US gallons annually over the period 2002 to 2007 (RFA, Industry Statistics. 2002 to 2007). In 2008, Jamaica, Brazil and the US signed an agreement for cooperation on developing a biofuel industry in Jamaica. The cooperation between the three countries provides Jamaica with technical assistance for biofuel development and policy support aimed at establishing a strong legal and regulatory framework for a vibrant biofuel industry.

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[13] Jamaica Information Service News Report November 24, 2009.

3.6 Summary

Chapter 3 provides an overview of the global biofuel industry. The reasons for pursuing green energy include: energy security, environmental and rural development opportunities. The top six producing nations are US, Brazil, EU, China, Canada and India. The governments of these countries support the biofuel industry through mandates, subsidies, tax credits and tariffs. The US and EU are the major producers of ethanol and biodiesel respectively. The production of biofuels in the US and EU is supported through the Energy Independence and Security Act of 2007 and the EU Directive 2009/28/EC; Promoting the use of energy from renewable sources. Chapter 4 is a review of the biofuel support measures in the US and EU, particularly the mandates.

Chapter 4: Policy Support for Biofuel Industry

4.1 The United States

Policy makers in the US expect to reduce dependence on foreign oil and greenhouse gas emissions, along with increasing domestic sources of energy, through the use of biofuels. At the end of 2010, the US federal government extended the $0.45 per gallon tax credit for ethanol by one year (Ethanol Magazine, December 2010) and reinstated the biodiesel tax credit of $1.00 per gallon (National Biodiesel Board 2010).

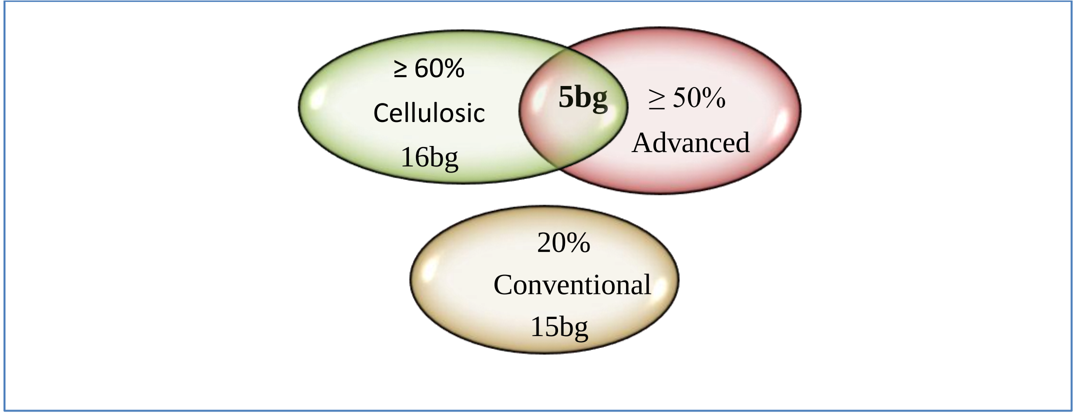
Olfert and Weseen (2007) conclude that, in conjunction with subsidies, producers of biofuel are protected from foreign competitors such as Brazil, the second largest producer of ethanol in the world and the number one exporter to the US, by means of tariffs. It is estimated that the total subsidies for ethanol production in the US amount to US $ 2.5 billion per year (Tyner, 2006). The support to the biofuel industry is not exclusive to the US federal government. At the US state level, at least three states have ethanol consumption mandates. Viju (2008) reports that direct subsidies to the producers of ethanol are used and some states provide low-interest loans and require government vehicles to use ethanol. The 2008 US Farm Bill provides producers of cellulosic biofuel with a tax credit of $1.01 per gal aimed at expanding production of cellulosic biofuels. However, the main constraint to cellulosic biofuel production is infrastructure (USDOE, 2008). The Bill includes substantial funds for research and development as part of the mandatory programs.

4.1.1 Energy Independence and Security Act of 2007

The mandate, as set out by the Renewable Fuels Standards (RFS), requires that transportation fuel sold in the United States on an annual average basis, contain at least the applicable volume of renewable fuel, advanced biofuel[14], cellulosic biofuel, and biomass-based diesel (Energy Independence and Security Act of 2007-EISA). A total of 36 billion gallons of renewable fuel is mandated to be blended with gasoline by 2022. Of the 36 billion gallons, 16 billion gallons should be cellulosic biofuel which reduces green house gas emission (GHG) by at least 60 percent. The applicable volume of advanced biofuel (not derived from corn starch) is five billion gallons and the conventional biofuel (derived from corn starch) requirement is residually capped at 15 billion gallons as of 2015. The GHG emission requirements for advanced and conventional biofuels are at least 50 percent and 20 percent respectively (EPA Regulatory February 2010). Yano, Blandford and Surry (2010) argue that if no cheap alternative other than sugar cane based ethanol is found, fuel based on sugar cane may be use to satisfy the requirements of the advanced biofuel mandate. As US sugar production is limited, imports may become the only viable way to satisfy the mandate. The mandate is shown graphically in Figure 4.1.

Figure 4.1: Ethanol Mix of the US RFS

Universal set =36 billion gallons



The overlapping of cellulosic and advanced means that the ethanol mix under the RFS can be made up of cellulosic that is not advanced and advanced which is cellulosic.

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[14] Advanced biofuel means renewable fuel other than ethanol derived from corn starch, that has lifecycle greenhouse gas emissions that are at least 50 percent less than baseline greenhouse gas (GHG) emissions. The type of fuels eligible for consideration as advanced biofuel include: Ethanol derived from cellulose, hemi-cellulose or lignin, sugar or starch and waste material. Biodiesel, Biogas, Butanol and other fuel derived from cellulosic biomas may be considered (Sec. 201, Paragraph B, Energy Independence and Security Act 2007).

The US Environment Protection Agency (EPA) is responsible for developing and implementing regulations to ensure that transportation fuel sold in the US contains a minimum volume of renewable fuel. Eschols (2009) shows that the EPA uses data gathered by the National Biodiesel Board (NBB) to administer rules regarding the health effects and emission levels of biodiesel.

The EISA 2007 provides new definitions and criteria for both renewable fuels and feedstocks used in production, including new greenhouse gas (GHG) emission thresholds as determined by life cycle analysis. The regulatory requirements for RFS apply to domestic and foreign producers and importers of renewable fuels used in the US (EPA February, 2010). The thresholds of 50 and 60 per cent may be revised only if the levels are not commercially feasible for fuels made using a variety of feedstocks, technologies and processes to meet the applicable reduction (EISA, 2007, Sec 201 1E). The greenhouse gas emissions assessments must evaluate the aggregate quantity of greenhouse gas emissions (including direct emissions and significant indirect emissions such as those arising from land use changes) related to the full lifecycle, including all stages of fuel and feedstock production, distribution and use by the consumer. Corn-based ethanol produced by new technologies and at new facilities (or existing facilities that have increased capacity) should reduce GHG emissions by 20 percent, and are higher for sugar-based ethanol at 50 percent (EPA, 2010a). Thus, imported ethanol from Brazil (or any other source of sugar based ethanol imports) is required to reduce GHG emissions at a higher rate than most domestically produced ethanol. This is because US ethanol is mainly derived from corn, a less efficient source of ethanol. Biodiesel from soy oil and renewable diesel from waste oils, fats, and greases are expected to comply with the 50 percent threshold reduction in GHG emissions.

Eventhough, the EISA requires 36bg of biofuels by 2022 for use in transportation, the US transport sector is faced with a technological constraint on demand of 21 billion gallons (15 percent of 140bg). The technological constraint is the blend wall (BW) which restricts the volume of renewable fuel that can be blended with gasoline. A BW of 15 percent suggests that the maximum share for renewable fuel of total gasoline consumed is 15 percent or E15, and the remaining 85 percent represents the share of gasoline produced from petroleum. Thus, at any price, the BW constraint is 15 percent of the total gasoline consumption. The US EPA waived a limitation on selling fuel that is more than 10 percent ethanol for model year 2007 and newer cars such as 2008 to 2010 models, as well as light trucks (EPA News Release 2010b[15]). The waiver increases the BW by 50 percent to 15 percent as with a 10 percent BW; the RFS mandated quantities would have exceeded the BW as early as 2012[16].

4.1.2 Standards for 2011

For 2011, the EPA set the renewable fuel standard at 13.95 bg. The cellulosic standard is set at 6.6 million gallons (mg), biomass-based diesel at 0.80 bg and 1.35 bg for advanced biofuel apart from biodiesel as shown in Table 4.1. The cellulosic standard is subject to revision on a yearly basis in accordance to market conditions.

Table 4.1: Renewable Fuel Standards 2011

Fuel Catergory	**Percentage**	**Volume (billion gallons)**
Cellulosic biofuel	0.003%	.0066
Biomass-based diesel	0.69%	.80
Other advanced biofuel	0.78%	1.35
Renewable fuel	8.01%	13.95

Source: EPA 2010

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[15] In January 2011, the waiver was extended to model cars produced during the period 2001-2006, but older cars and light trucks or any motorcycles, heavy-duty vehicles, and non-road engines are not considered for a waiver because of lack of test data. In light of the limits of the waiver, the EPA is proposing E15 pump labeling requirements, including a requirement that the fuel industry specify the ethanol content of gasoline sold to retailers. There would also be a quarterly survey of retail stations to help ensure their gas pumps are properly labeled.

[16] The issue of RFS exceeding the BW still remains. The increase in the blend wall only pushes back the year the RFS exceeds the BW as the mandate of 36 billion and average gasoline consumption of 140 billion gallons suggest that the blending rate will be approximately 26 per cent by 2022. Hence, at the 10 percent, RFS exceeds the BW as early as 2012 with a requirement of 15.2 billion gallons. The increase in the BW to 15 per cent implies that the RFS will exceed the BW in 2016 with a requirement of 22.25 billion gallons. In essence, the 50 percent increase provides ‘breathing room’ of 4 years before the RFS exceeds BW. Noteworthy, the petition for the increase was submitted to the EPA in March 2009 and approved October 2010 under the condition that the new fuel will not cause or contribute to the failure of the engine parts that ensure compliance with the Clean Air Act emissions limits (EPA News Release October 2010).

4.1.3 Requirements for Feedstock Producers

The feedstocks used to produce renewable fuels are required to be renewable biomass. Renewable biomass, as defined by Section 201 (I) of EISA 2007, may be planted crops, crop residue harvested from agricultural land, planted trees, tree residue, animal waste material and animal by-products. The EISA 2007 limits the types of biomass and, in addition, the types of lands from which the biomass may be harvested. For both domestic and foreign non-agricultural sector feedstocks, renewable fuel producers are required to collect and maintain appropriate records from their feedstock suppliers to ensure compliance with the renewable biomass requirement. Alternatively, an independent third party may conduct annual biomass quality-assurance surveys based on a plan approved by the EPA (EPA Regulatory Announcement 2010a). Furthermore, renewable fuel producers using agriculturally-based feedstocks grown in the US will be compliant based on EPAs aggregate compliance[17] determination. Similarly, for foreign based agriculture-feedstocks used to produce biofuel, the future aggregate option is available if the source region can provide sufficient data to support aggregate analysis and a monitoring program. For example, on March 15, 2011, the EPA issued a notice[18] of receipt of a petition from the Government of Canada to authorize the use of an aggregate approach for compliance with the Renewable Fuel Standard renewable biomass provisions. The petition requests the EPA to determine that an aggregate compliance approach will provide ‘reasonable assurance’ that planted crops and crop residue from Canada meet the definition of renewable biomass.

4.1.4 Non-Tariff Barriers

The non-tariff barriers imposed by the US include both technical and sustainability standards (Earley, 2009). The technical standards can be effective import barriers as evident in the US with

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[17] The aggregate compliance approach refers to the EPA using the total amount of agricultural land in 2007 as a baseline. The EPA declares that inputs from planted crops and crop residues will be considered to be consistent with the definition of renewable biomass unless the agricultural land baseline in 2007 is exceeded. The EPA took this approach based on its assumption that renewable biofuel demands, stimulated by the EISA and other incentives, and other demands for crop production will not require clearing and cultivation of additional land (National Sustainable Agriculture Coalition 2011).

[18] http://www.federalregister.gov/articles/2011/03/15/2011-6033/notice-of-receipt-of-petition-from-the-government-of-canada-for-application-of-the-renewable-fuel

the states of Georgia and Florida both imposing time specificity[19] on ethanol use which is estimated to depress demand by about 3 billion gallons (Westervelt, 2008).

Sustainability standards are required under the RFS as amended by the EISA 2007. The new RFS require lifecycle analysis of particular biofuels before they can count towards utilization mandates. In addition, the use of renewable biomass is required to significantly reduce greenhouse gas emissions: more than 50 percent over their lifecycle in the case of advanced biofuels. The EISA 2007 requires the EPA to report on the current and future environmental effects of these measures inclusive of imports. These criteria are to evaluate biofuels production in terms of its environmental effects as established by the EPA and other relevant agencies, such as the US Department of Agriculture (USDA). Sustainability standards also exist at the state level, for example, California requires life cycle analysis-LFCS. Earley (2009) argues that these standards should not prohibit imports of biofuels by virtue of the Technical Barriers to Trade (TBT) Agreement unless it falls within one of the General Agreement on Tariffs and Trade exceptions to the Agreement or otherwise can be argued to be consistent with WTO commitments. Article XX of the GATT allows exemptions for measures relating to conservation of exhaustible natural resources if such measures are not discriminatory, in other words, the measures should apply to both domestic and foreign parties. Generally, the Article discusses the circumstances under which members of the WTO may impose trade inhibiting measures that contravene GATT rules.

4.2 The European Union

The EU supports the biofuel industry through tax exemptions, investment subsidies and blending mandates. In 2008, the EU support per liter of ethanol and biodiesel was reduced to €0.24 and €0.22 respectively from €0.34 in 2007. Exemptions from excise taxes amounted to €2.80 billion in foregone tax revenue (GSI 2010). Individual member states defray investments costs for the production of biofuels through investment subsidies. The 2003 EU Biofuel Directive target was 5.75 percent share for biofuel in transportation by 2010. The transport sector accounts for 21

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[19] Time specificity refers to a time constraint on the consumption or demand for ethanol. For example, in 2008, the States of Florida and Georgia passed restrictions on the time of year ethanol can be used.

percent of the emissions of GHG and in 2003, whereas biofuels accounted for approximately 0.6 per cent of total transport fuel (Commission of the European Communities, 2006).

4.2.1 Directive 2009/28/EC

In 2009, the EU Parliament issued a new directive to member states concerning the use of renewable energy. Its objective is to reduce environmental degradation and lower dependence on foreign oil. By 2020, 20 percent of overall EU energy consumption must come from renewable sources. Furthermore, there is a mandatory 10 percent minimum target for all member states for the consumption share of biofuels in transportation. The EU mandate is a blending target, which is in contrast to the utilization target of the US. Paragraph 18 of the directive defines the 10 percent target as that share of final energy consumed in transport which is to be achieved from renewable sources as a whole, and not solely from biofuels (L.140/18). In addition, second generation biofuels, that is, biofuels made from wastes, residues, non-food cellulosic material, and lingo-cellulosic material, contribution to the target is twice that made by other biofuels (Article 21(2)).

The Directive allows cooperation among member states in order to achieve the respective targets in the following ways:

1. Statistical Transfers
2. Joint projects between Member states (trading between members)

The trading of renewable energy among EU members arises due to the forecast of five member states falling short of the target, while at least ten member states are expected to be producing a surplus according to information released through the Commission's Transparency Platform,[20] Statistical Transfers involve Member state governments exchanging statistically[21] a given

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[20] http://ec.europa.eu/energy/renewables/transparency_platform/doc/0_forecast_summary.pdf

[21] Article 3(1) states that each member state should ensure that the share of energy from renewable sources in gross final energy consumption is at least 20 percent by 2020. Therefore, a member state which exceeds the minimum requirement by 1 percentage point, that is, 21 percent may transfer statistically one percentage point to another member state with 19 percent.

quantity of renewable energy produced but the transfer should not adversely affect the ability of the member state making the transfer to achieve its own target (Article 6). Furthermore, a transfer is only considered effective when the transfer has been reported to the Commission (Article 6(3)). On this note, it is possible a transfer may be deemed null and void by the Commission, particularly in the case where the transfer compromises the ability of the member state making the transfer to meet its national target. The other approach to meeting the targets is through a joint venture with other member states and/or third countries. In such an arrangement, the output from the new capacity may be shared statistically between member states.

The Directive provides that, for renewable fuels to be counted towards the blending target, the sustainability criteria for biofuels as set out in Article 17[22] should be met. However, biofuel produced from waste and residues, other than agriculture, fisheries and forestry residues only need to satisfy sustainability criterion A (Article 17). The sustainability criteria that apply to EU produced renewable energy and imports are set out as follows:

A. The greenhouse gas emission (GHG) saving[23] is at least 35 percent, increasing to 50 percent effective January 1 2017 and further increasing to 60 percent, effective January 1 2018 (paragraph 2). Biofuels produced by 'installations' that were in operation as of 23 January 2008 are exempted from complying with this criterion until 1 April 2013. The term installation includes any processing installation used in the production process and production facilities added to the production chain with the intention of qualifying for the exemption (Commission Communication 19.06.2010). In the case of a production pathway with a typical or default GHG saving value below the minimum GHG emission saving rate, producers may calculate the actual value (Lendle and Schaus 2010). If the actual value is at least the required saving rate, this type of biofuel would have satisfied the GHG emissions savings of the sustainability criteria. A typical value means an estimate of the representative green house gas emissions savings for a particular biofuel production pathway (Article 2(n)) and default value means a value derived

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[22] The criteria are discussed below.
[23] See Annex V of Directive 2009/ 28/EC for typical and default greenhouse gas emission saving values by production pathway if no net carbon emissions is from land use change.

from a typical value by the application of pre-determined factors and that may, in circumstances specified in the Directive, be used in place of an actual value (Article 2 (O)).

B. Are not produced from raw materials obtained from land with high biodiversity value[24] and high carbon stock (Paragraphs 3 and 4).

C. Are not produced from raw materials on peatland in January 2008 unless evidence is provided that the cultivation and harvesting of that raw material does not involve drainage of previously undrained soil (Paragraph 5).

D. The agricultural raw materials cultivated in the Community and used in the production of biofuels are obtained in accordance with the requirements and standards under the provisions referred to “Environment” in part A and point 9 under Public, Animal and Plant Health of Council Regulation (EC) No 73/2009 of 19 January 2009.

The likely results if these measures are not met include:

1. Biofuel failing to comply with the requirements of the Directive concerning national targets;
2. Failure to comply with renewable energy obligations; and
3. Ineligible for financial support for the consumption of biofuels.

Criteria B and C can be viewed as capacity constraints or ‘land specificity’ requirements on economic operators willing to fulfill the target of 10 percent. Hence, operators from countries with abundant land and who do not violate the ‘land specificity’conditions may have a competitive advantage in having their product considered for the 10 percent. The sustainability scheme implemented by member states is expected to promote the use of restored degraded land because the promotion of biofuels has the effect of increasing the demand for agricultural commodities that are not produced for human consumption. Verification of biofuels meeting the

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[24] A draft consultation document on the criteria and geographic ranges to determine which grassland can be considered to be highly biodiverse grassland is available at: http://ec.europa.eu/energy/renewables/consultations/doc/2010.

criteria will be done by the mass balance method. The mass balance system allows consignments of raw material or biofuel with differing sustainability characteristics to be mixed but requires information about the sustainability characteristics (Article 18; paragraph 1 (a) and (b)). In addition, the Commission may act on its own initiative or on request from a member state to examine the application of sustainability criteria for a source of biofuel and within six months of receipt of a request and in accordance with Article 25(3)[25] decide whether the member state may take biofuel from that source (Article 18 (8)). In other words, the Commission can independently rule a source of biofuel unfit, and hence, not allow a member state to take biofuel from that source. This clearly increases the risks associated with producing crops as an input to biofuels.

The new directive requires a report every two years prepared by the European Commission on the impact of increased demand for biofuel on social sustainability[26]; involving land usage and availability, agricultural practices and competition with food in the EU as well as in third countries. The first report on sustainability is due 2012. It should inform the European Parliament and Council on the impact of biofuel policy on the availability of foodstuffs at affordable prices, especially for developing countries and whether countries which are significant sources of biofuel consumed within the EU have ratified and implemented the Cartagena Protocol on Biosafety, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and eight[27] Conventions of the International Labour Organization (Article 17 (7)). As a guide, the EU released an Implementation Plan for economic players to satisfy the criteria related to GHG savings and land use.

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[25] Further reference to Articles 3 and 7 of Decision 1999/468/EC applies having regard to the provisions of Article 8.

[26] The 2009 Directive requires the EU to only use biofuels that have no negative impact on biodiversity and land use. European Commission 2010- http://ec.europa.eu/energy/renewables/biofuels/biofuels_en.htm

[27] See Article 17, paragraph 7 of Directive 2009/28/EC

4.3 EU Sustainability Criteria Implementation Plan: Green House Gas Savings and Land Use

Economic players in the biofuel trade are able to satisfy the criteria related to GHG saving in one of the three ways;

1. Providing data to the relevant national authority showing compliance with the requirements of the Member state (Sec 2.1 2010/C 160/02[28]).
2. A voluntary scheme recognised by the Commission. If the scheme satisfies the requirements, as a general rule, the scheme will be recognised for a maximum period of five (5) years (Sec 2.1 2010/C 160/02).
3. Provision of a bilateral or multilateral agreement concluded by the Union which the Commission has recognised. In other words, the EU can conclude bilateral or multilateral agreements which consist of sustainability criteria that correspond with the Directive (Sec 2.1, 2010/C 160/02).

The implementation plan for sustainability for the EU lowers the risk and cost for economic players engaged in the trade of biofuel, particularly, developing countries. The three options for compliance offer flexibility in meeting the criteria and GHG savings which stakeholders can manipulate to their own economic benefit. In other words, from an international trade perspective, operators will seek to adopt the option with the least compliance cost in order to maximize returns/profits. The first option allows the economic operator to provide data in accordance with member state requirements. Therefore, one can assume the requirements across all member states will be identical and, if not, this lack of consistency will have negative impacts on exporters to multiple member states. In other words, the issue of the impact on suppliers facing varying standards within the EU is a concern.

4.3.1 Provision of data

The provision of information to a member state is the responsibility of the party or parties who pay the excise duty. Information must be available regarding the sustainability criteria along the entire fuel chain (Commission 2010/C160/02). All economic operators are required to provide

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[28] Communication from the Commission on the practical implementation of the EU biofuels and bioliquids sustainability scheme and counting rules for biofuels.

member states with information on country of origin of all transport fuels, fossil and renewable, and place of purchase. The information submitted by economic operators should be audited by an independent party to verify compliance.

4.3.2 Voluntary Schemes

The sustainability scheme employed by a member state is subject to approval by the EU Commission, suggesting the likelihood of different requirements by member states. The voluntary scheme may be the most flexible compliance measure available to operators but has a life span of five years. Therefore, for long term business arrangements, the re-evaluation of schemes is necessary, *ceteris paribus*. Table 4.2 summarises the assessment and recognition process of voluntary schemes as found in the Communication from the Commission, 2010/C 160/01.

Table 4.2: Voluntary Scheme Assessment

1. Assess a scheme regardless of its origin, whether e.g. developed by government or private organizations.
2. Assess a scheme regardless of whether another recognised scheme already covers the same type of feedstocks, area, etc.
3. Assess a scheme against the sustainability criteria of the Directive and the assessment and recognition requirements set out in the next section.
4. Assess whether the scheme can also serve as a source of accurate data on other sustainability issues not covered by the sustainability criteria in the Directive.

Source: Communication Sec 2.6, 2010/C 160/01

Note: Item 4 is dependent on feasibility as the Commission may not do this immediately, however, the intention exists.

The recognition of voluntary schemes by the Commission suggests independent auditing is a feature of these compliance schemes. It should be emphasized that member states are required to adhere to the sustainability criteria laid down in the 2009 Directive and prevented from imposing additional sustainability requirements which exclude biofuels that would have been included under the 2009 Directive. Table 4.3 shows the guidelines for auditing in attempt to prevent audits which may be questionable due to conflict of interest.

Table 4.3: Guidelines for Auditing

1. The audit is to be performed by an external auditor.
2. Auditors are independent of the activity being audited and free from conflict of interest.
3. The verification body has the general skills for performing audits.
4. Auditors have the skills necessary for conducting the audit related to the scheme's criteria.

Source: Communication Sec 2.6, 2010/C 160/01

4.3.3 Land-related criteria

Raw materials for biofuels cannot be taken from land categorized with high carbon stock on January 2008 even though it may no longer be in this category. The status of the land prior to 2008 may be used as evidence of compliance with some or all of the land-related criteria if it can be shown that the land was cropland. In cases where an exception applies, land that qualifies under more than one criterion and is eligible for exception under one criterion would not provide an exception from other criteria that apply.

4.3.4 Land with High Carbon Stock

Inputs to biofuels cannot be obtained from wetland, continuously forested areas; land spanning more than one hectare with trees higher than five meters and a canopy cover of between 10-30 per cent and peatland if the ‘status’ (physical categories) of the land has changed compared to its status in January 2008.

4.3.5 Exceptions

<u>Wetland</u>

If raw material is taken from land that was wetland in January 2008 and the status of the land does not change after the raw material is taken, using such material would not breach the criterion.

Areas with 10-30 per cent canopy cover

An exception may be allowed for land with 10-30 percent canopy cover if evidence is provided that the greenhouse gas impact including any changes since January 2008 in the carbon stock of the area concerned, meets the appropriate threshold for the greenhouse gas saving criterion. The evidence is expected to be provided by the supplier as proof of compliance.

Peatland

For biofuels produced from biomass grown on land that was peatland in January 2008, an exception is possible if evidence is provided that:

- The soil was completely drained in January 2008, or
- There has not been draining of the soil since January 2008.

The forms of evidence that can be used to show compliance with the land related criteria are:

- Aerial photographs,
- Satellite images, maps,
- Land register entries/databases and,
- Site surveys

4.4 Summary

The US EISA (RFS) and EU 2009/28/EC create long term demand for biofuels. The mandates require specific GHG emissions savings and impose capacity constraints in the development of biofuels. The US RFS requires 36 billion gallons made up of three types of biofuels which are differentiated based on inputs and GHG emission saving levels, ranging from 20 percent to 60 percent. However, the maximum volume of renewable fuels that can be blended is 21 bg, known as the blend wall. The EU requires a 10 percent share for renewable fuels in transportation. Biofuels counted towards the 10 percent should satisfy the sustainability criteria involving GHG emissions and land use. The sustainability criteria implementation plan is a guide to economic operators to comply with the sustainability criteria. The plan specifies the type of compliance that will be recognized and exceptions in the case of land use. Chapter 4 is an overview of policies fostering the biofuel industry. The theoretical framework for the US and EU mandates will be outlined in the next chapter.

Chapter 5: Modelling of Biofuel Mandates

5.1 Introduction

The partial equilibrium models of the US and EU mandates are presented in this chapter. The development of both models involved specific assumptions due to the design of the respective mandates as well as general assumptions concerning supplies of petroleum based fuel and imports as a policy alternative. For the US, modeling includes disaggregation of the three mandates and investigation of the technological constraint on demand. In the case of the EU, the likely effect of compliance costs on foreign suppliers is discussed.

5.2 The United States

Assumptions;

1. The focus of the model is the ethanol requirement of the Renewable Fuel Standard (RFS) for 36 billion gallons of renewable fuel by 2022. The biodiesel requirement of 1 billion gallons by 2012 is excluded for ease of exposition.

2. The cost of ethanol is higher than petroleum based products. The provision of the subsidy to ethanol shifts the supply curve to the right. The tax credit/subsidy reduces the price of ethanol making this type of energy more competitive with petroleum based products and encourages the blending of renewable fuel with gasoline.

3. The price of ethanol is tied to the price of oil. Ethanol priced above the price of gasoline will not be produced unless blending is mandated (required). Static prices for gasoline and ethanol are used, that is, prices are fixed for analyses.

4. Ethanol is a substitute for petroleum based gasoline.

5. The supply of gasoline is elastic. That is, suppliers will be able to meet an increase in demand for gasoline by using oil in the short run. In other words, the US can easily import more oil to satisfy increased gasoline demand.

6. Supplies of ethanol surplus to domestic US demand can be sold on the world market at the same price as gasoline, however, adjusted for differences in fuel energy.

7. Supply of cellulosic ethanol is relatively fixed due to technological constraints. There is no causal relationship between incentives and cellulosic ethanol production due to technical limitations. Supply of cellulosic ethanol is, hence, constrained by technology/capacity.

8. The mandate is met through domestic production and/or imports; that is, it is assumed that no waiver to the mandate is granted. In the case of the advanced[29] (sugar cane based) biofuel requirement, the mandate is expected to be satisfied primarily by Brazil[30].

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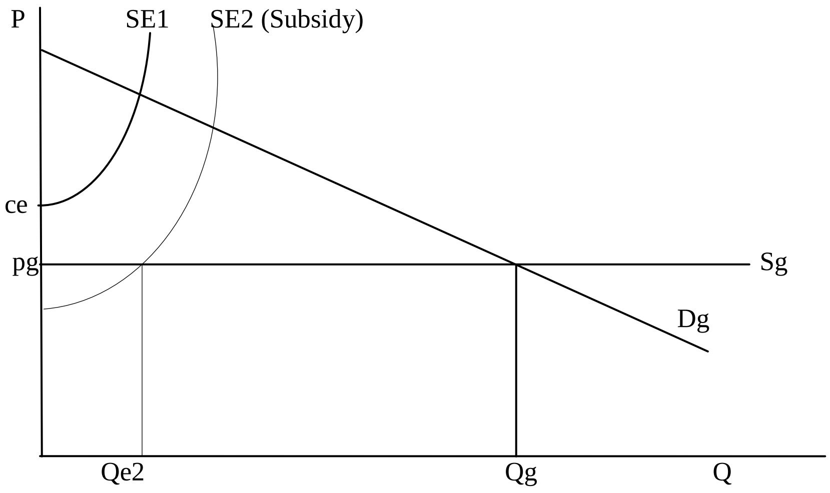
[29] Advanced Biofuel means renewable fuel other than ethanol derived from corn starch that has a lifecycle greenhouse gas emission that is at least 50 per cent less than baseline greenhouse gas (GHG) emissions. The type of fuels eligible for consideration as advanced biofuel include: Ethanol derived from cellulose, hemi-cellulose or lignin, sugar or starch and waste material. Biodiesel, Biogas, Butanol and other fuel derived from cellulosic biomas may be considered (Sec. 201, Paragraph B, Energy Independence and Security Act 2007).

[30] Brazil is the number one supplier of ethanol imports (sugar- cane based) for the US (Renewable Fuel Association 2010).

5.2.1 Economic Analysis of the US market for Transportation Fuel: The Case of Ethanol

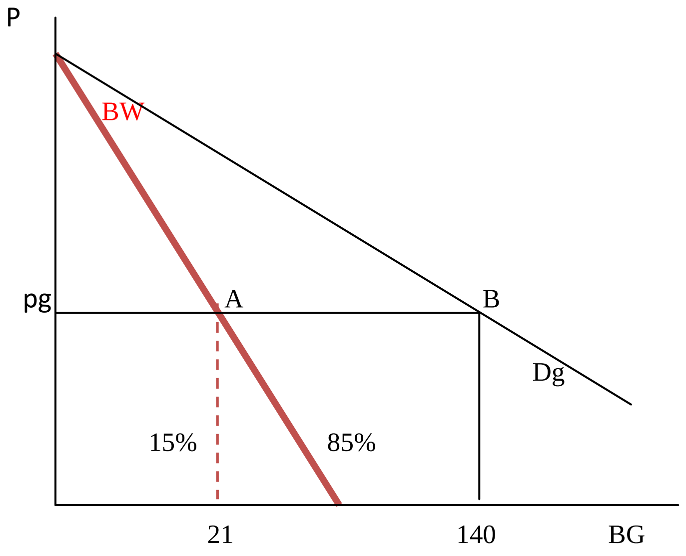
Figure 5.1: US Market with Ethanol Blends used in Transportation



In Figure 5.1, Dg is the demand for pure and/or blended gasoline as ethanol and petroleum based gasoline are substitutes for each other. The downward slope of Dg suggests that as the price for gasoline increases, the quantity demanded decreases. The price of gasoline in the US is pg and Qg is the quantity of gasoline consumed. Sg is the supply function of pure gasoline and/or blended gasoline since ethanol and petroleum based gasoline are substitutes for each other. The supply of gasoline is perfectly elastic given that suppliers will be able to meet an increase in demand for gasoline by using imported oil in the short run.

For SE1, which is the unsubsidized supply of ethanol, the cost to produce ethanol is higher than the price of gasoline at every point (ce>pg; SE1>Sg for all Q) – where SE1 depicts the marginal cost of producing ethanol and pg is the supply (marginal) cost/price of gasoline at every Q. The result is no blended gasoline and the entire market is supplied by petroleum-based gasoline. Subsidizing ethanol production shifts the supply curve to the right from SE1 to SE2, allowing gasoline to be blended with ethanol. Given SE2, blenders are willing to supply Qe2 at pg. The upward slope of the SE curves suggests that as the price for ethanol increases, producers will respond by increasing the quantity supplied.

Figure 5.2: US Demand for Blended Gasoline with Blend Wall



Graph is not drawn to scale

Figure 5.2 imposes a blend wall based on the demand curve for gasoline. Dg is the demand for pure and/or blended gasoline as ethanol and petroleum based gasoline are substitutes for each other. The downward slope of Dg suggests that as the price for gasoline increases, the quantity demanded decreases. BW is the blend wall which restricts the volume of renewable fuel that can be blended with gasoline. The BW of 15 percent suggests that the maximum share for renewable fuel of total gasoline consumed is 15 percent or E15, and the remaining 85 percent represents the share of gasoline produced from petroleum. Thus, at any price, BW is 15 percent of the quantity indicated by Dg. Point A on the Figure 5.2 is the maximum quantity of renewable fuel that can be blended with gasoline based on forecasted total gasoline demand/consumption on an annual basis. Point B is the projected total annual gasoline consumption in 2022. The US Energy Information Administration (USEIA) projects gasoline consumption will be around 140 billion gallons in 2022 (US EIA Annual Energy Outlook 2010). Therefore, at E15, a maximum of 21 billion gallons of renewable fuel can be blended with gasoline. The difference between the renewable fuel share and total consumption gives the volume of petroleum based gasoline -119 billion gallons. As the price of gasoline increases, the quantity of gasoline consumed declines as well as the maximum volume of ethanol that can be used for blending. The BW line is derived from the maximum quantity of ethanol that can be blended with gasoline or a percentage of total gasoline consumption (Dg). In other words, an increase in the maximum is conditional on a higher demand for total gasoline or an increase in the blend wall itself. For example, total gasoline consumption of 150 bg implies an increase in the maximum of renewable fuel that can be blended with gasoline to 22.5bg (.15*150bg) from 21bg.

Figure 5.3: US Ethanol Market with RFS

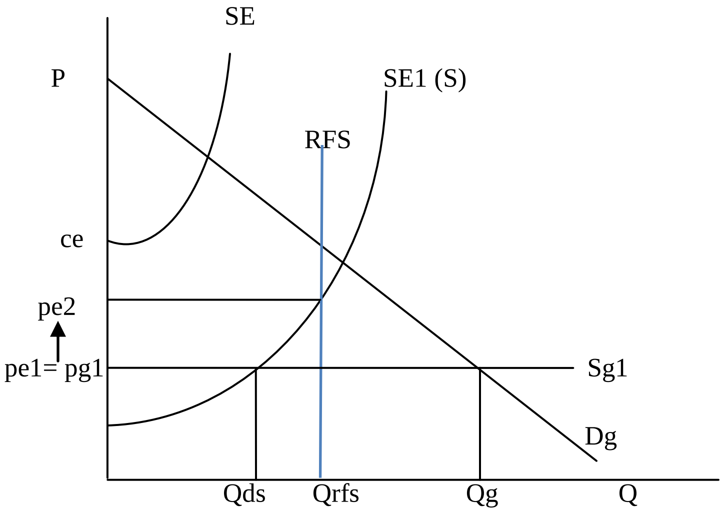


Figure 5.3 shows the case where US domestic production is lower than the mandate and no technological restriction on demand exists for satisfying the mandate; that is, no blend wall[31]. Dg is the demand for pure and/or blended gasoline as ethanol and petroleum based gasoline are substitutes for each other. The price of gasoline in the US is pg1 and Qg is the quantity of gasoline consumed. Sg1 is the supply of pure gasoline and/or blended gasoline with supply being perfectly elastic given suppliers will be able to meet an increase in demand for gasoline by using oil in the short run. SE is the supply of unsubsidized ethanol. With supply curve SE, ethanol will

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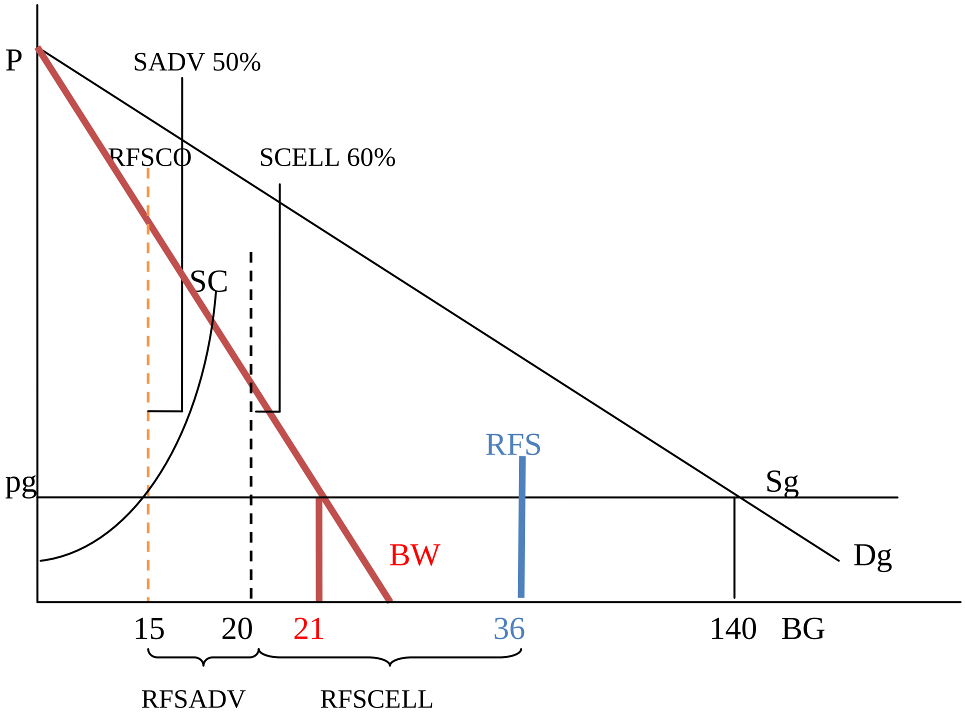
[31] This assumption regarding the blend wall is made for expository simplicity and will be dropped subsequently.

not be produced given the cost to produce it is higher than the supply cost/price of petroleum-based gasoline at every Q. The introduction of subsidy (S) pushes the SE curve to SE1, the supply of subsidized ethanol (blender's credit of $0.45), and blending occurs at pe1 = pg1 where pe1 is the price of ethanol. At pg1, producers are willing to supply Qds, which is less than the mandate, Qrfs. Qrfs is the quantity of ethanol required to meet the mandate regardless of price, thus, it is a vertical line. As Qrfs exceeds Qds, blenders have to raise the price they pay for ethanol. To bring forth quantity Qrfs of ethanol – to satisfy the mandate – will require blenders to pay pe2 for ethanol. The supply cost of blended gasoline will be the weighted sum of pg1**x**(Qg-Qrfs)+pe2**x**(Qrfs), meaning a rise in the supply cost of gasoline – above pg1. For simplicity we have not illustrated this increase in the supply cost.

5.3 Modelling of US RFS 2022 for Transportation Fuel

Figure 5.4: RFS 2022 for Transportation Fuel



Graph not drawn to scale

Figure 5.4 disaggregates the US RFS for ethanol as found in the EISA of 2007 and imposes the mandate on the US transport sector- see Figure 4.1. A total of 36 billion gallons of renewable fuel is mandated to be blended with gasoline by 2022. Of the 36 billion gallons, 16 billion gallons should be cellulosic biofuel. The applicable volume of advanced biofuel (not derived from corn starch) is 5 billion gallons and the conventional biofuel (derived from corn starch) requirement is residual at 15 billion gallons as of 2015. Dg is the demand for pure and/or blended gasoline as ethanol and petroleum based gasoline are substitutes for each other. The price of gasoline in the US is pg. The supply of pure gasoline and/or blended gasoline is Sg with supply being perfectly elastic given suppliers will be able to meet an increase in demand for gasoline by using oil in the short run. BW is the blend wall of 21 bg and RFS is mandate of 36 bg. In other words, the mandate exceeds the maximum amount of renewable fuel that can be blended with gasoline. RFSCO is the residual requirement of 15 bg for conventional ethanol. SC is the supply of corn-based ethanol at 15 bg which is expected to be met by domestic producers as current capacity stands at 14bg[32] (RFA 2010). The contribution of corn based ethanol to the RFS is capped at 15 bg as of 2015. In other words, production of corn based ethanol above the 15bg cannot be used to satisfy the cellulosic or advanced biofuels component of the RFS since it is residual.

RFSCELL is the mandate of 16bg for cellulosic ethanol with a GHG emission saving of at least 60 percent. SCELL is the supply of cellulosic ethanol with a GHG emission savings of at least 60 percent. RFSADV is the mandate of 5 bg for advanced ethanol with a GHG emission saving of at least 50 percent. SADV is the domestic supply of advanced biofuel with a GHG emission savings of at least 50 percent. Imported cane based ethanol will be considered below. The shape of the SCELL and SADV curves implies technological and/or commercial infeasibility for the mandated volumes. The lines become vertical beyond small quantities.

The US DOE (2008) reported that infrastructure is a major constraint on cellulosic ethanol supply. In addition, the expected production capacity of cellulosic ethanol is 250 million gallons

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[32] Pg=SC at exactly 15bg is assumed here for exposition convenience. SC may equal pg at quantities greater than 15bg. This case will be explored later in the thesis.

(mg) per year[33]. The EPA is responsible for setting the annual volume of mandated cellulosic. For 2011, the RFS requires 250 mg of cellulosic ethanol but the EPA has set a significantly lower target of 6.6 mg (a decrease of 97 percent), which implies domestic cellulosic supply is significantly lower than the mandated volume as found in the EISA. As such, it may be inferred that the 2022 mandate of 16 billion gallons is unlikely to be realized domestically due to technical infeasibility. In regards to the advanced ethanol supply, the assumption of commercial infeasibility for the mandated advanced biofuels volume domestically is based on the higher production cost of sugar cane-based ethanol compared to corn-based ethanol (USDA 2006). The USDA reported that the total cost for producing sugar cane-based ethanol is $2.40 per gallon compared to $1.05 per gallon for corn based ethanol (dry milling). In essence, using sugar cane to produce ethanol in the US more than doubles the production costs for producers, therefore, production of ethanol is skewed to corn as an input. Given the infeasibility of producing advanced and cellulosic ethanol domestically, the import potential under the RFS is explored later in the thesis.

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[33] http://www.eia.doe.gov/oiaf/analysispaper/biomass.html

5.4 US Case Study

5.4.1 Scenario 1: BW<DS<RFS

Figure 5.5: RFS Exceeds Domestic Consumption

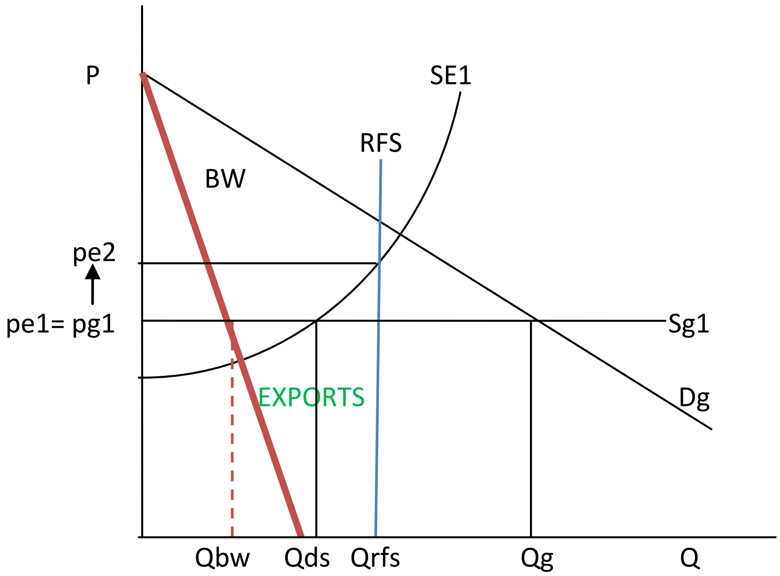

Figure 5.5 shows a technological restriction on demand exists, or the blend wall in the US transport sector and domestic supply of ethanol, Qds, exceeds the BW or Qbw. Dg is the demand for pure and/or blended gasoline as ethanol and petroleum based gasoline are substitutes for each other. The downward slope of Dg suggests that as the price for gasoline increases, the quantity demanded decreases. The price of gasoline in the US is pg1 and Qg is the quantity of gasoline consumed. Sg1 is the supply of pure gasoline and/or blended gasoline with supply being perfectly elastic given suppliers will be able to meet an increase in demand for gasoline by using oil in the short run. SE1 is the supply of subsidized corn-based ethanol. At pg1, Qds would be supplied, however, Qbw is the maximum amount of ethanol that can be blended. Qrfs is the mandated quantity. To satisfy the mandate, gasoline producers must pay ethanol producers pe2. In this case, demand is less than the mandated supply and Qrfs-Qbw is exported at price pg1.

In this market scenario, the RFS may evolve into an export subsidy (ES). Given the blend wall constraint on domestic demand, blenders will be forced to export regardless of price (Blandford, 2010). An export subsidy is only received when the good or service is exported and mandates can be considered a subsidy as it creates demand that is unlikely to exist otherwise (Murphy 2007). On this note, suppliers are willing to supply ethanol at the intersection of SE1 and Pg1, but the RFS requires supply to be at the right of Qds. This effectively raises the price paid by blenders for ethanol from pe1 to pe2 in order to satisfy the mandate. The BW prevents the ‘additional volume’ required by the RFS to be consumed in the US market. Hence, Qbw- Qrfs is exported at price pe1 while ethanol producers receive pe2. In other words, mandated renewable fuel produced beyond the blend wall can only be exported. Given the supply price of Qrfs is pe2 and exports can only take place at pe1, exports take place at a subsidy rate of pe2 minus pe1 per unit.

Blandford (2010) argues that implicitly subsidized exports pose a problem if world ethanol prices fall. Export subsidies are classified as prohibited or ‘red box’ by the World Trade Organization (WTO) and, hence; are challengeable, especially in the case of the US which uses a tariff to keep out cheap imports from the world market (a feature of export subsidy regimes; Gaisford and Kerr 2001) and being a major player in the trade of ethanol and, hence, able to negatively affect the world price. Gaisford and Kerr (2001) discuss the implications of an ES by a large country including the “beggar thy neighbor” response from trading partners that may follow. Furthermore, an area of conflict may be found with subsidized US exports of blended fuel competing with non-subsidized Brazilian ethanol (Blandford 2010). As a result, the question of whether Brazil will be able to carry out a successful challenge at the WTO arises.

5.4.2 Scenario 2: DS >RFSCO

Figure 5.6: Conventional Ethanol Supply Exceeds RFSCO

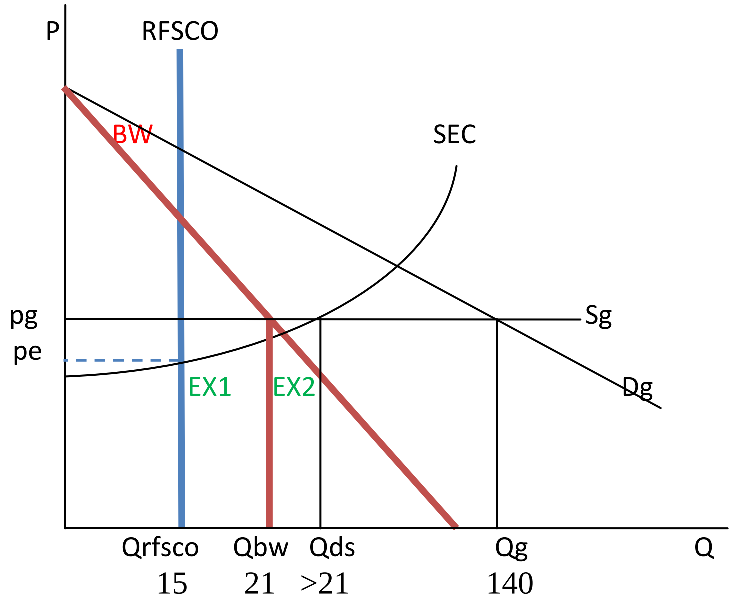

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Figure 5.6 illustrates ethanol supply exceeds the conventional target of the RFS. Dg is the demand for pure and/or blended gasoline as ethanol and petroleum based gasoline are substitutes for each other. The price of gasoline in the US is pg and Qg is the quantity of gasoline consumed. Sg is the supply of pure gasoline and/or blended gasoline with supply being perfectly elastic given suppliers will be able to meet an increase in demand for gasoline by using petroleum based fuel in the short run. SEC is the supply curve for subsidised conventional (corn based) ethanol priced. At pg, the ethanol supply would be Qds; domestic supply of ethanol. Qbw is the maximum amount of ethanol that can be blended, which is to the left of Qds and Qrfsco is the quantity for the conventional ethanol mandate. As Qds is greater than Qrfsco, it suggests that the US ethanol industry satisfies the mandate for conventional ethanol but at the same time exacerbates the problem posed by the BW. That is, the area representing potential exports expands from Qbw-Qrfsco (EX1) by the addition of Qbw-Qds (EX1+EX2). In addition, Yano, Blandford and Surry (2010) argue that if domestic ethanol price is lower than the world ethanol price, the US may export corn based ethanol to Europe, Asia or Northern Brazil. In this case, the surplus supply will be sold on the world market at pg. In early April 2011, Raphael Hudson, Hart Energy's Director of research and consulting for Latin America, predicted US exports to Brazil to be around 200 million litres (ml) for the month of April. He further stated that " …it (200 ml) still isn't a huge deal, but given you are coming closer to that blend wall, I guess every little bit helps" (Ethanol Producer April 2011).

5.4.3 Scenario 3: RFS> DS

Figure 5.7: US Domestic Supply Less Than RFS

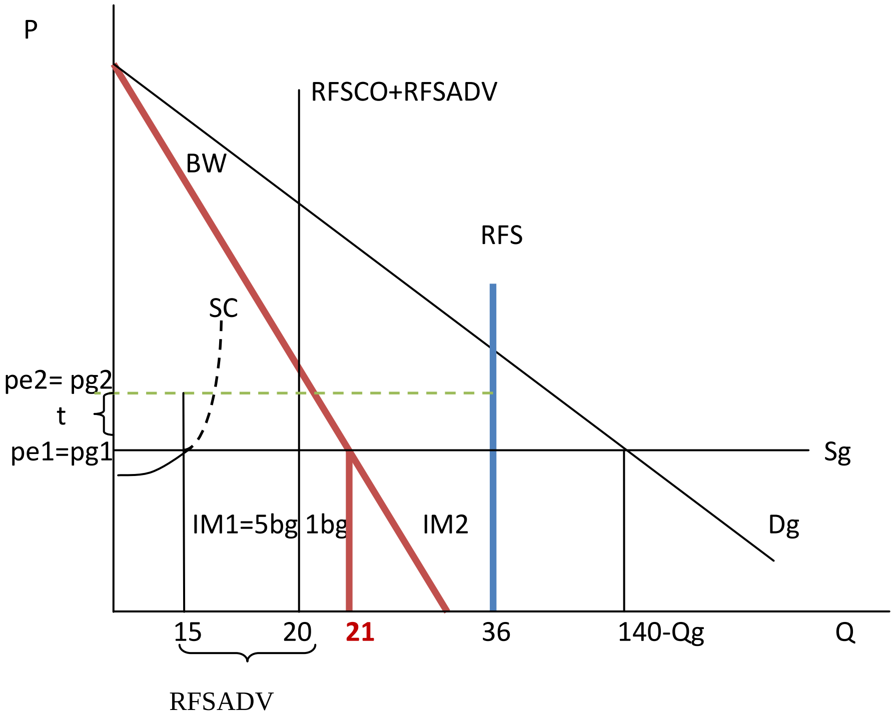

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Figure 5.7 shows the potential to import under the US RFS. In this model, it is assumed that domestic production of advanced and cellulosic ethanol remain technically constrained at near zero levels, thus, supplies of both are not illustrated. The case is a worst case scenario whereby the US is an importer of non-conventional ethanol[34]. In other words, the US is expected to satisfy

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[34] Conversely it is the best case scenario for developing country exporters of ethanol.

the conventional mandate of 15 bg and may import the remaining 21 bg. Dg is the demand for pure and/or blended gasoline as ethanol and petroleum based gasoline are substitutes for each other. The downward slope of Dg suggests that as the price for gasoline increases, the quantity demanded decreases. The price of gasoline in the US is pg1 and Qg is the quantity of gasoline consumed. Sg is the supply of pure gasoline and/or blended gasoline with supply being perfectly elastic given suppliers will be able to meet an increase in demand for gasoline by using oil in the short run. SC is the supply of subsidized corn-based ethanol. At pg1, 15 bg is supplied and pe2=pg2 is the new price of ethanol given the tariff on ethanol imports, or pe1+t. Given the 140 bg demand for gasoline, the 15 percent blend wall quantity of ethanol that can be used is 21 bg. Hence, the difference between 36-15 or 21 bg is the share of non conventional ethanol which may be imported, particularly advanced biofuel derived from cane. Given the quantity required by the RFS is to the right of the quantity supplied domestically, we assume the US may import the difference in order to satisfy the mandate. The quantity needed through imports is 21 bg; 5 bg of advanced ethanol and 16 bg of cellulosic ethanol or IM1+IM2. However, the quantity of potential imports is limited by the technological constraint of the blend wall. This is due to the fact that with no BW, potential imports are represented by IM1+IM2 and the introduction of the BW constrains the quantity of imports to IM1 or 6bg. If IM1 is embraced, blenders will pay a higher price for ethanol relative to the price of gasoline (binding mandate) due to the tariff. Also, if we assume the US is only able to import the advanced portion (IM1) of the RFS due to the non-realization of cellulosic ethanol of at least 60 percent[35], then potential imports decrease by 1bg to 5bg since advance ethanol does not satisfy the cellulosic requirement of the RFS as was shown in Figure 4.1. Consequently, the issue of hitting or exceeding the BW no longer exists.

Although tariffs increase the price of foreign products and normally reduces imports given a downward sloping demand curve, the tariff has no such effect in this model. That is, the volume of imports to satisfy the RFSADV is unaffected by the level of tariff. For example, 5bg are needed to satisfy the RFSADV, at a tariff of USD$0.54, the volume of imports will be 5bg regardless of the tariff being above or below USD$0.54. At a price above USD$0.54, this effectively raises the price for blended gasoline. Hence, the BW rather than the tariff influences the quantity/volume of ethanol imported. The maximum level of import is 6 bg due to the blend

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[35] Greenhouse gas emission savings

wall and given virtually no domestic production of advanced and cellulosic ethanol. Therefore, imports would fall from maximum levels indicated in this analysis if domestic advanced or cellulosic production becomes feasible in larger quantities. The higher price for ethanol encourages domestic producers of conventional ethanol to increase supply but moving up the supply curve along the broken lines will not satisfy the other requirements of the RFS because conventional ethanol requirement is a residual. Thus, supply of SC beyond 15bg cannot be used to satisfy the requirements for advanced or cellulosic as suggested in Figure 4.1. In other words, the quantity of conventional ethanol supplied by the domestic industry produces exceeding 15bg is likely to be exported.

5.4.4 Summary of US Case Study

The scenarios illustrate the trade potential under the US RFS. In scenarios 1 and 2, the export potential arising from the blend wall and the inability to substitute advanced and cellulosic with conventional under the mandate is outlined. In scenario 3, the import potential under the mandate is discussed with the domestic industry only able to satisfy the conventional ethanol mandate and meet the advanced and cellulosic mandates through imports. The presence of the blend wall constrains the volume of imports needed to meet the non-conventional ethanol mandates. In addition, the US RFS creates an inelastic demand for ethanol resulting in the tariff on ethanol having no impact on the volume of imports.

5.5 The European Union

Assumptions;

1. The model focuses on biodiesel satisfying the EU requirement of a renewable fuel share in transportation of 10 per cent by 2020.

2. The cost to produce biodiesel is higher than diesel, therefore, given the higher cost for biodiesel, blenders have no incentive to exceed the mandate.

3. The price for blended diesel in the EU is a reference point for the world price, that is, the EU being the largest producer and consumer of biodiesel is able to influence the world price.

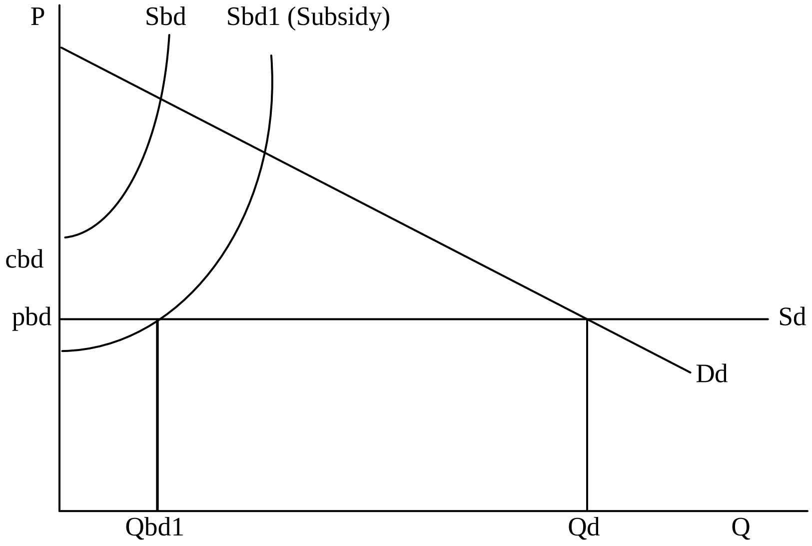
4. Biodiesel is a substitute for petroleum based diesel.

5. Supply of diesel is elastic. That is, suppliers will be able to meet an increase in demand for diesel by using oil in the short run; that is, the EU can easily import more oil to satisfy increased diesel demand.

6. Imports are expected to supplement the domestic production required to meet the blending mandate, that is, no waiver of the mandate will be granted due to shortfall in production by member states.

5.5.1 Economic Analysis of the EU Market for Transportation Fuel: The Case of Biodiesel

Figure 5.8: EU Market With Biodiesel Used in Transportation



In Figure 5.8, Dd is demand for pure and/or blended diesel as biodiesel and petroleum based diesel are substitutes for each other. The downward slope of Dd suggests that as the price for diesel increases, the quantity demanded decreases. The price of diesel is pbd while Qd is the quantity of diesel consumed. Sd is the supply of pure and/or blended diesel since biodiesel and petroleum are substitutes for each other. The supply of diesel is perfectly elastic given that suppliers will be able to meet an increase in demand for diesel by using imported oil in the short run.

For Sbd, which is the unsubsidized supply of biodiesel, the cost to produce biodiesel is higher than the price of diesel at every point (cbd>pbd andSbd>Sd for all Q. The result is no biodiesel and the entire market is supplied by petroleum-based diesel. Subsidizing biodiesel production shifts the supply curve to the right from Sbd to Sbd1, allowing biodiesel to enter the market for diesel. At Sbd1, blenders are willing to supply Qbd1 at pbd. The upward slope of the Sbd1 curves suggests that as the price for biodiesel increases, producers will respond by increasing the quantity supplied.

5.6 Modelling of EU Renewable Fuel Directive 2009

Figure 5.9: Model of EU Renewable Fuel Directive 2009

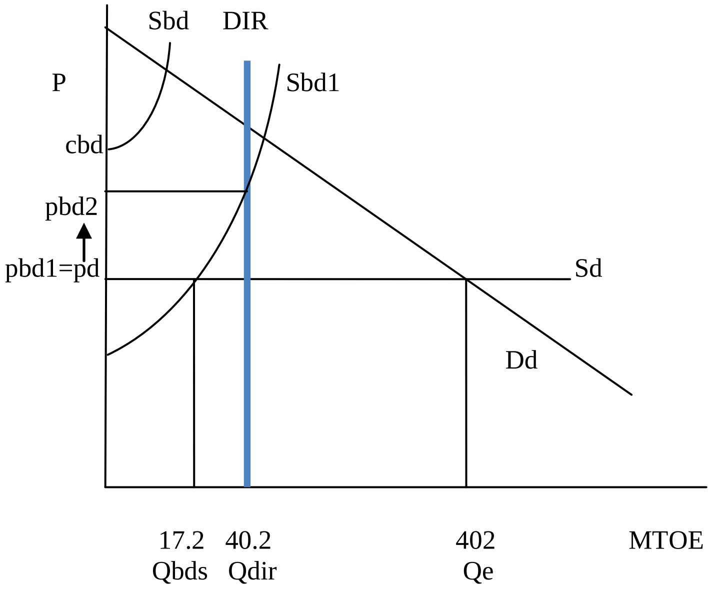


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Figure 5.9 shows the case where EU production of biodiesel is less than the mandate. The mandate as set out in the Directive of 2009 promoting the use of energy from renewable sources requires minimum share of 10 percent for renewable fuel in transportation by 2020. The International Energy Agency (IEA) projects energy consumption or Qe in the EUs transport sector to be 402 million tonnes of oil equivalent (MTOE) (Zahniser 2010). Dd is the demand curve for pure and/or blended diesel as biodiesel and petroleum based diesel are substitutes for each other. The downward slope of Dd suggests that as the price for diesel increases, the quantity demanded decreases. The price of diesel in the EU is pd and Sd is the supply of pure and/or blended diesel based energy as biodiesel and petroleum based diesel are substitutes for each other. Sbd is the supply of unsubsidized biodiesel. Biodiesel will not be produced since Sbd is higher than the supply cost/price of diesel at every Q. The introduction of subsidy pushes the Sbd curve right to Sbd1. At pbd1=pd1, where pbd1 is the price of biodiesel, domestic producers are willing to supply Qbds 17.2 MTOE[36] of biodiesel, which is less than the mandate, DIR. The vertical line is the mandate for the share of renewable energy in transport regardless of price. Qdir is mandated quantity of renewable fuel in transport- 40.2 MTOE or 10 percent of the total energy consumed (402MTOE). In order to satisfy the DIR, blenders will need to pay a higher price, pbd2, to induce suppliers to produce the additional volume. The supply cost of blended gasoline will be the weighted sum of pd1**x** (Qd-Qdir+pbd2**x**(Qdir) and will lead to an increase in the supply cost of diesel although we have not illustrated this increase diagrammatically for expositional simplicity.

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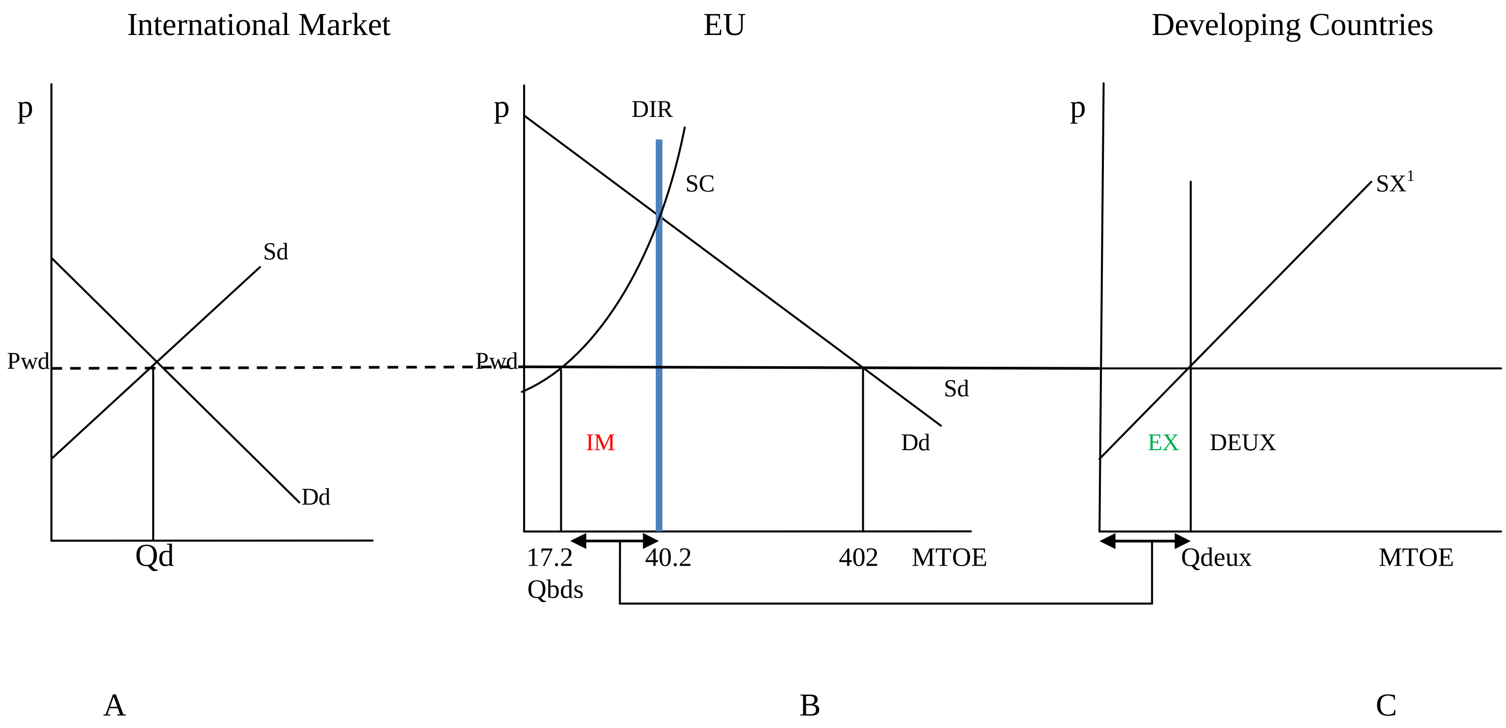
[36] European Biodiesel Board

5.7 EU Case Study

5.7.1 Scenario 1: International Trade of Biodiesel

Figure 5.10: Trading of Biodiesel



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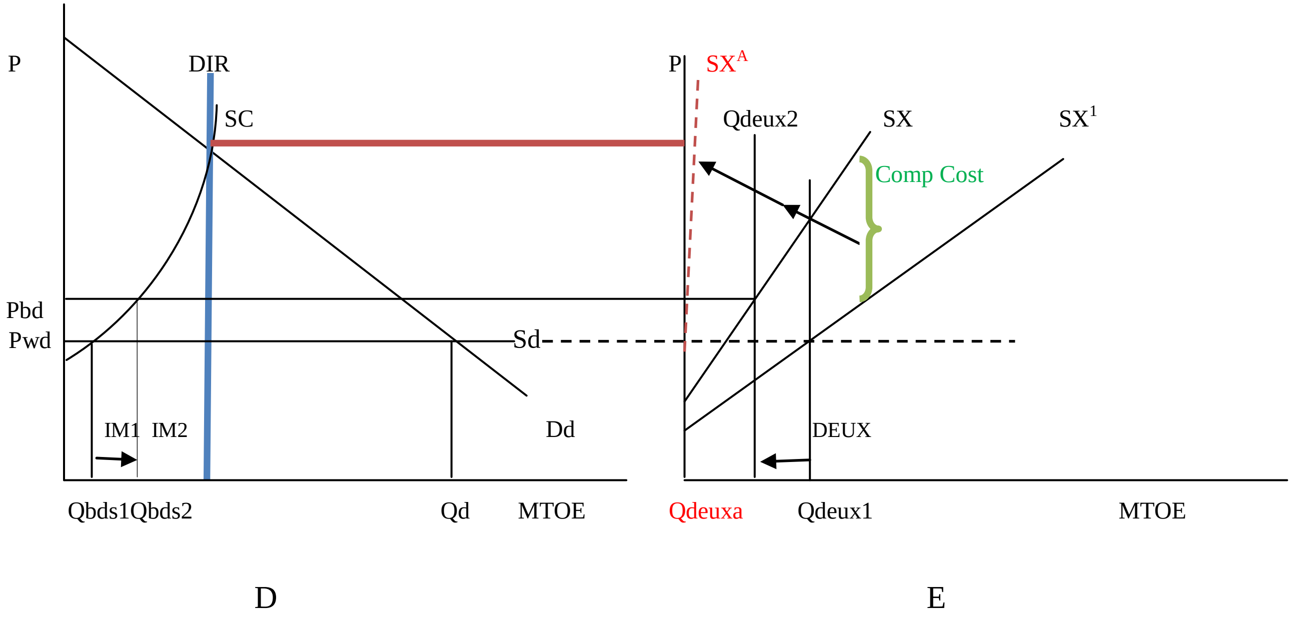
Panel A of Figure 5.10 represents the international market for diesel. Sd is the supply of diesel on the world market. Dd is the demand for diesel in the rest of the world, that is, excluding the EU. The EU is assumed to be price taker in the global diesel market. The intersection of the two curves is where the market clears, which gives the world price for diesel; Pwd.

Panel B of Figure 5.10 models Directive/2009/28/EC for renewable fuel in transportation. Dd is the demand curve for pure and/or blended diesel as biodiesel and petroleum based diesel are substitutes for each other. The downward slope of Dd suggests that as the price for diesel increases, the quantity demanded decreases. Sd is the supply of pure and/or blended diesel as biodiesel and petroleum based diesel are substitutes for each other. SC is the supply of subsidised biodiesel compliant with the EUs sustainability criteria produced in the EU. At Pwd, EU domestic producers are willing to supply Qbds=17.2MTOE, which does not fulfill the mandate of 40.2MTOE. The shortfall is assumed to be filled by imports complying with the EUs sustainability criteria.

Panel C of Figure 5.10 illustrates developing countries potential to export to the EU. SX^1 represents the export supply of developing countries to the EU. This export supply is assumed to satisfy EU sustainability criteria at zero compliance costs. DEUX is the demand by EU for biodiesel from developing countries. It represents the difference between EU domestic supply of sustainable biodiesel and the 10 percent mandate at the price of biodiesel. In otherwords, Qdeux is the quantity of biodiesel the EU demands from developing countries to satisfy the DIR. Thus, it is perfectly inelastic at Qdeux. Therefore, IM=Qdeux is necessary to satisfy the DIR. For example, a decrease in imports by the EU from developing countries due to higher domestic output simultaneously results in the same decline in the quantity of biodiesel exported to EU by developing countries. The DEUX vertical line would shift to the left.

5.7.2 Scenario 2: Trading of Biodiesel and Compliance Costs

Figure 5.11: Impact of Compliance Costs on Trade of Biodiesel



Scenario 2, Figure 5.11 shows the potential impact of DIR on imports as a result of compliance costs and how increasing compliance costs borne by foreign suppliers may eventually lead to no imports. Dd is the demand curve for pure and/or blended diesel as biodiesel and petroleum based diesel are substitutes for each other. The price of diesel in the EU is pwd and Qd is the quantity of energy consumed in tonnes of oil equivalent (TOE). Sd is the supply of pure and/or blended diesel based energy as biodiesel and petroleum based diesel are fuel substitutes.

In Panel D of Figure 5.11, SC is the supply of subsidised biodiesel, which meets the sustainability criteria, that is, produced within the EU. Producers in the EU are willing to supply Qbds1 at the world price, Pwd. Qbds1 is to the left of the DIR. Therefore, we assume this shortfall may be filled by imports. IM1+IM2 represent total imports needed from developing countries to satisfy the 10 percent mandate.

In Panel E of Figure 5.11, SX^1 represents the supply (export) of developing countries to the EU without compliance costs. Compliance costs may well be incurred if EU sustainability criteria are to be met. The addition of compliance costs incurred by exporters increases cost and the supply curve shifts to SX; the supply of sustainable biodiesel. The compliance costs include monitoring costs and using less productive land due to the EU's land use constraints. The inward shift in supply in conjunction with inelastic demand, DEUX, causes a rise in the price of biodiesel as shown in Panel C. At a higher price, Pbd, EU producers would increase supply moving up SC leading to a leftward shift in Qdeux. Exports from developing countries would decline given IM=Qdeux. The increased compliance costs leads to a simultaneous increase in domestic EU supply and a leftward shift in the quantity required for export, DEUX shifts leftward. Therefore, EU quantity supplied domestically increases from Qbds1 to Qbds2 and imports reduce to IM2. Thus, the quantity exported by developing countries declines to Qdeux2= IM2. Furthermore, increasing compliance costs effectively raises the cost of exporting to the EU and shifts the supply curve further leftward. If they are sufficiently high, these compliance costs may effectively result in autarky for the EU. In other words, the model shows that increasing compliance costs have the potential to be effective trade barriers, as a worst case if SX rises to

SX^A, then DEUX lies on the vertical axis of Panel E and Qdeuxa=0. In other words, in Panel D, domestic production in the EU is sufficient to supply the entire mandate.

5.7.3 Summary of EU Case study

The scenarios illustrate the import potential and the threat posed by the compliance costs to the export opportunities under the EU DIR. In scenario 1, the trading of biodiesel is shown with the EU importing from developing countries in order to satisfy the mandate. In scenario 2, the effects of the compliance costs on EU biodiesel output and developing countries exports are shown. These costs contract supply from developing countries and leads to higher output by the EU as producers respond to an increase in the price of biodiesel. Hence, the value of trade arising from the DIR diminishes.

5.8 Summary

Chapter 5 provides the theoretical framework for analysing the US RFS and EU 2009/28/EC. The modeling involves disaggregation of the three mandates for the US and the impact of the technological constraint on demand. For the EU, the likely effect of compliance costs on by foreign suppliers is discussed. The technological constraint and compliance costs for the respective models have implications for trade. For the US, the mandates can be viewed as inelastic demand for biofuels, which leads to zero effect of the tariff rate on the volume of imports to satisfy the RFS. In addition, the US is faced with a blend wall which is a constraint on demand for biofuels, and imports of biofuels by extension. The compliance costs associated with the EUs sustainability criteria may cause a contraction in supply which can act as barriers to trade. In the next chapter, quantitative estimates trade effects of the mandates and various constraints are made.

Chapter 6: Empirical Analysis

6.1 Introduction

Chapter 6 provides quantitative estimates of the value of potential trade which may arise as a result of the US RFS and EU Directive 2009/EC/28. For the US, the value of trade is calculated on the assumption that the non-conventional mandate will be achieved through import. Furthermore, given the likelihood of the non-realization of the mandated volume for cellulosic ethanol, the alternative of substituting with advanced or sugar cane based ethanol will be estimated. As part of the sensitivity exercise, estimates of the effect of partial provision of the non-conventional mandates domestically on imports are made. The increasing effect of compliance costs arising from the EUs sustainability criteria on the value of trade with the EU is provided by estimating the effect on trade for a range of compliance costs measured as a percentage of the price of diesel.

The failure of renewable fuels to satisfactorily substitute for petroleum based fuels at the RFS volumes presents two policy options for the US: reduce the quantity of fuel supplied in the market by exactly the shortfall in renewable fuel; or use more petroleum based gasoline to compensate for the shortfall in renewable fuel. In effect, both approaches effectively waive/relax the mandate, but the welfare effects differ. The effect of both policies will be examined with the expectation that the first alternative reducing consumer surplus.

6.2 US Case Study

Figure 6.1: US Domestic Supply Less Than RFS 2022

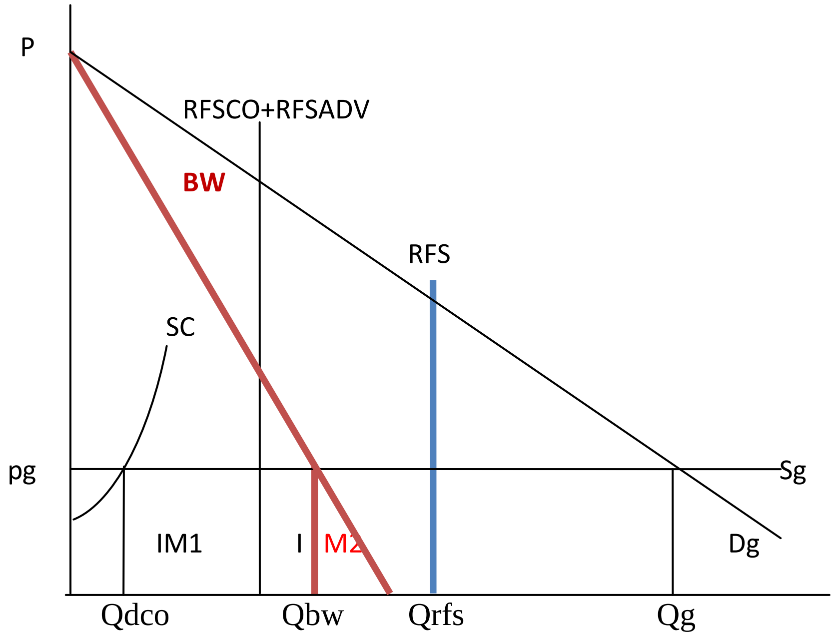


Figure 6.1 illustrates the import potential under the US mandate as discussed in Chapter 5. Dg is the demand for pure and/or blended gasoline. Sg is the supply of pure gasoline and/or blended gasoline with supply being perfectly elastic given suppliers will be able to meet an increase in demand for gasoline by using petroleum based fuel in the short run. The intersection of Dg and Sg is the annual gasoline consumption. RFS is the mandate of 36 billion gallons of renewable fuel. At pg, quantity supplied of conventional or corn based ethanol domestically is Qdco, which satisfies the conventional mandate. However, given the infeasibility of producing advanced and cellulosic-IM1 and IM2 respectively domestically, the quantities needed to satisfy both mandates could be met through importation. Therefore, imports would be Qrfs-Qdco. The blend wall narrows the area for imports to Qbw-Qdco from Qrfs-Qdco.

Table 6.1: Market Data for the US

Quantity of Gasoline	140 BG[a]
Average price for gasoline	$3.13[a]
Renewable Fuel Standard	36 BG[b]
Domestic Supply	15 BG[c]
Demand Elasticity- ε^D	-0.8[d]
Imports	21BG
Imports with BW	6BG

[a] US EIA

[b] Energy Independence and Security Act 2007

[c] Source: Renewable Fuel Association. Note: The current capacity is 14bg. Therefore, it is assumed capacity will increase to 15bg by 2022.

[d] US own price elasticity of fuel. Source: Devadoss and Kuffel 2010.

Table 6.1 consists of market data for gasoline and ethanol in the US. The quantities supplied and expected under the RFS are shown. Given the difference between the quantity supplied and demand (RFS), we are able to calculate the quantity of imports needed to fulfill the mandate.

6.2.1 Value of Trade Estimate

Table 6.2: Value of Trade Under EISA RFS 2022

Average USD price per gallon*	Domestic Supply	IMPORTS		Value of Trade in 2022 USD billion dollars (Imports*$3.13/gallon)
		Advanced	Cellulosic	
$3.13	15	5BG	16BG	$65.7
$3.13	15	21BG	0	$65.7
$3.13	15	5BG	1BG	$18.8
$3.13	15	5 BG	0	$15.7

*US EIA Projections 2010-2022

Table 6.2 shows the value of trade under the RFS with no demand constraint is estimated at $65.7 billion. The US is expected to import the non-conventional portion of the RFS equaling 21 billion gallons of advanced and cellulosic (Table 6.2). In the case that cellulosic is not commercial at the RFS levels, the US may substitute cellulosic with advanced or cane based ethanol which may be produced by developing countries, particularly, Brazil. In both scenarios, the value of trade remains at $65.7 billion. Although, 21bg is required through imports to meet the RFS, only 6 bg will be imported due to the BW since it is a constraint on demand. Therefore, the BW results in the value of trade being reduced to $18.8 billion from $65.7 billion, a decline of 71 percent. Furthermore, since cellulosic is not substitutable, expected imports may further decline to 5 bg or a value of $15.7 billion. Without a major change in the US biofuel policy this is the most likely outcome. Thus, while the mandate itself may suggest large export opportunities for developing countries, given the technological constraints that exist, in reality, export opportunities are limited.

6.2.2 Policy Alternative

A credible threat to the RFS is the non-commercialisation of cellulosic due to technology constraints. The US EIA has projected 140 billion gallons to be consumed in the US transport sector. The share of cellulosic is 16 billion gallons. Therefore, 124 billion gallons represent non cellulosic fuel. If the US holds firm to its plan of improving environmental preservation by reducing fossil fuel usage, then the quantity supplied equals 124 billion gallons. Hence, the divergence leads to upward pressure on fuel prices. An alternative approach would be to allow the use of more fossil fuel which is able to crowd out any rise in fuel price.

Using the demand elasticity for gasoline of -0.8 –see Table 6.1 - a demand curve for gasoline was generated to determine the price effect of a change in quantity. For example, Figure 6.2 shows a change in price from $3 to $5 due to a decline in supply by four units. In the case of reduced quantity of fuel available in the market due to the inability to satisfy the mandate, an increase in the price of gasoline was estimated.

Figure 6.2: Change in Price

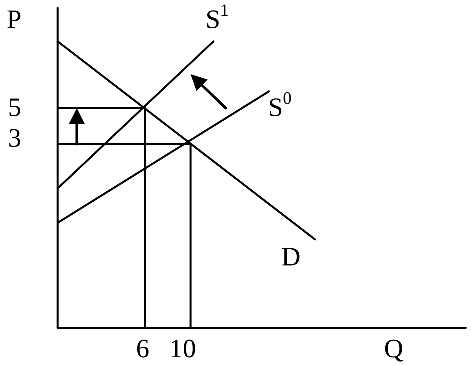


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Table 6.3: Change in Price of Gasoline

Policy	Quantity	Price/gallon
Higher oil usage	140	$3.13
No cellulosic	124	$3.58

The higher price for fuel in Table 6.3 suggests that reducing quantity supplied based on the RFS leads to an increase of $0.45, or a 14 percent increase in the price of gasoline. Alternatively, if the use of more fossil fuel is allowed to compensate for the shortfall in cellulosic, price would remain constant at $3.13.

6.2.3 Sensitivity Analysis for US Case Study

Table 6.4: Sensitivity Analysis for Elasticity in US case study

	ε^D	change in price	$change
Base level	0.80	$ 0.45	-
Higher level (+10 percent)	.88	$ 0.41	0.04
Lower level(-10 percent)	.72	$0.50	0.05

The sensitivity analysis presented in Table 6.4 suggests that the rise in price caused by a shortfall in the volume required under the cellulosic ethanol mandate is not impacted significantly by the elasticity value. The range of difference is $0.04 and $0.05 from the base level increase of $0.45.

Table 6.5 Trade Effects of US Domestic Cellulosic and Advanced Ethanol Supply

	Scenario1	Scenario 2	Scenario 3	Scenario 4	Scenario 5		Scenario 6		Scenario 7		Scenario 8	
	Cellulosic	Advanced	Cellulosic	Advanced	Cell	Adv	Cell	Adv	Cell	Adv	Cell	Adv
10 % of RFSCELL / RFSADV	1.6	0.5	-	-	1.6	0.5	-	-	1.6	-	-	0.5
20% of RFSCELL /RFSADV	-	-	3.2	1	-	-	3.2	1	-	1	3.2	-
Imports Billions/gallon	4.4	5.5	2.8	5	3.9		1.8		3.4		2.3	
Value of Trade $/Billion	13.8	17.2	8.8	15.7	12.2		5.6		10.6		7.2	

Table 6.5 shows the trade effects of positive changes in domestic cellulosic and advanced ethanol supply. In Chapter 5, the quantity of imports needed by the US to satisfy the RFS is 21 bg, but, actual imports equals 6 bg due to the blend wall (See Figure 5.7). At the base level, domestic production of cellulosic and advanced ethanol is zero. In other words, the US will depend on foreign suppliers to meet the mandate in full. As shown in Figure 5.7, the US may import 5 bg of advanced ethanol and 1 bg of cellulosic ethanol. However, these quantities are conditional on the assumption that the US domestic industry only satisfies the conventional mandate which is capped at 15 bg. If the assumption is relaxed, partial provision of the cellulosic and advanced mandates by both 10 percent and 20 percent, leads to a larger domestic supply of ethanol. As a result, the level of imports may be impacted.

In the scenario where the US is able to produce 10 percent of the cellulosic or advanced mandate, the quantity of imports declines by the same amount. For example, of the 6 bg available to be imported, scenario1 assumes the US is able to produce 1.6bg of cellulosic ethanol and case 2 assumes 500mg of advanced ethanol. Although, the domestic output increases by 10 percent in both scenarios, the trade effects are different as the value of trade in scenario 1 is lower than case 2. At 20 percent provision of the cellulosic and advanced mandates by the domestic industry-scenarios 3 and 4, a similar effect is observed. For example, if the US is able to produce 3.2 bg of cellulosic ethanol and 1 bg of advanced ethanol, the expected total quantity of imports is 1.8 bg (6bg-4.2bg). Scenarios 5 to 8 illustrate the combined effect on the value of trade as the industry is able to supply 10 percent and/or 20 percent of the cellulosic and advanced mandates simultaneously. Therefore, increasing domestic supply diminishes the value of trade available as a result of the mandate. In other words, the value of trade is negatively impacted by positive changes in domestic supply of cellulosic and advanced ethanol. Thus if the technological constraints on production of domestic alternatives to corn-based ethanol can be overcome, the export opportunities for developing countries will decline.

The best case scenario under the US RFS for developing countries is threatened by higher than expected domestic production of advanced and cellulosic ethanol and the blend wall. The blend wall reduces potential imports by the US to 6 bg from 21 bg and partial provision of the advanced and/or cellulosic mandates by the US biofuel industry further decreases potential imports of 6bg.

6.3 EU Case Study

Table 6.6: Market Data for Biodiesel in the EU

Quantity of Energy	402 MTOE[a]
Average USD price per gallon (2010)	USD $2.51[b]
Quantity Directive (10percent)	40.2 MTOE[c]
[37]Domestic Supply	17.2MTOE[d]
Imports	23 MTOE
Exports	23 MTOE
Supply elasticity- ε^S	2[e]

2010 EU production capacity[38]

[a] Source: Zahinser 2010

[b] Source: US EIA

[c] EU Directive 2009/28/EC

[d] Source: European Biodiesel Board

[e] The supply elasticity noted represents France's biodiesel elasticity of supply sourced from Doumax (2010). France is the second largest producer of biodiesel in the EU behind Germany and for this exercise; we will use the elasticity of France as a proxy for EU biodiesel supply. The elasticity of supply represents 'pre sustainability criteria' conditions of the EU biodiesel capacity. It may be that the sustainability criteria results in a more inelastic EU supply.

Table 6.6 consists of market data for biodiesel in the EU. The quantities supplied and expected under the DIR are shown. Given the difference between the quantity supplied and demand (DIR), we are able to calculate the quantity of imports needed to fulfill the mandate. The estimated volume of imports needed by the EU is 23 million tonnes of oil equivalent (MTOE).

Using a domestic supply elasticity of 2.0 – see Table 6.6 – a supply curve for EU domestic supply was generated. This was then used to produce the estimated quantities that arise from increasing compliance costs.

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[37] The EU produced 9,046,000 tonnes of biodiesel in 2009 or 7,779,560 tonnes of equivalent (TOE) (European Biodiesel Board)

[38] The figure represents the EU production capacity as of 2010. The EU reports production and consumption data in different units. Therefore, the production capacity was converted into ton of oil equivalent for analysis. The European Biodiesel Board reports a capacity of 20,000,000 tonnes for biodiesel. One tonne of biodiesel is equal to 0.86tonnes of oil equivalent (European Commission, Statistics Explained). In 2009, the EU produced 7.8MTOE (European Biodiesel Board)

6.3.1 Value of Trade Estimate

Table 6.7: EU Value of Trade Estimates

(Average USD price per gallon 2010)	Compliance Cost/gallon	Domestic Supply MTOE	Imports MTOE	Imports US gallons of diesel (millions)	Value of trade in 2022 (2010 $/billon dollars)
$2.51	0	17.2	23.00	6,572.2	16.5
$2.51	(10%) 0.251	20.64	19.56	5,588.3	14.0
$2.51	(20%) 0.502	24.28	15.92	4,548.3	11.4
$2.51	(30%) 0.753	27.92	12.28	3,508.4	8.8
$2.51	(40%) 1.004	31.56	8.64	2,468.4	6.2
$2.51	(50%) 1.255	35.2	5.0	1,428.5	3.6
$2.51	(60%) 1.506	38.84	1.36	388.6	0.97
$2.51	(70%) 1.757	42.48	(2.28)	(651.4)	0

Note: The conversion to gallons from tonne of oil equivalent was done to conveniently calculate the value of trade given that price for fuel is reported by gallon or litre and not ton of oil equivalent (TOE). One tonne of oil equivalent is equal to 285.7 US gallons.

Table 6.7 shows that as the compliance costs increases, domestic output increases while imports needed to satisfy the DIR decreases. The value of trade is estimated at $16.5 billion dollars with zero compliance costs. It is assumed that the compliance costs will prevent firms from entering the market or cause firms to exit the market. As a result, supply of biodiesel to the EU from third countries will contract. The value of trade diminishes with increasing compliance costs. These compliance costs are derived as a percentage of the price of diesel, similar in effect to a tariff. Furthermore, these crude estimates of compliance costs were calculated because, as yet, there is no information available on actual costs. It is argued that these compliance costs will increase as the GHG emission savings for the EU DIR increases from a current minimum of 35 percent to 60 percent by January 1 2018 and voluntary schemes of compliance are only valid for five years.

The empirical analyses are based on an elastic supply of biodiesel of 2.0. In the case of a fairly inelastic supply by EU domestic producers and a decrease in imports due to sustainability standards, an upward pressure is placed on the price for diesel unless it is crowded out by using more petroleum based diesel. As such, petroleum based diesel is used as a substitute for biodiesel in case of a shortfall. In essence, the domestic supply response within the EU to an increase in price of biodiesel results in a decline in imports and eventually autarky.

6.3.2 Sensitivity Analysis for EU Case Study

In Table 6.8, the impact of a 10 percent increase in the value of the elasticity of supply or ε^S equals 2.2 on domestic output is shown. Domestic output rises above 3 MTOE in response to a change in price caused by a change in price related to the compliance cost of $0.251 (10%). EU producers increase production at a faster rate, which reduces the value of trade to $13.8B from the $14.0B base level highlighted in Table 6.7.

Table 6.8: Higher Level Elasticity Effect on EU Value of trade

(Average USD price per gallon 2010)	Compliance Cost/gallon	Domestic Supply MTOE	Imports MTOE	Imports US gallons of diesel (millions)	Value of trade (2010 billon dollars) $
$2.51	0	17.2	23	6,572.2	16.5
$2.51	0.251	20.98	19.22	5,490.0	13.8
$2.51	0.502	24.97	15.23	4,351.8	10.9
$2.51	0.753	28.95	11.25	3,213.6	8.1
$2.51	1.004	32.94	7.26	2,075.3	5.2
$2.51	1.255	36.92	3.28	937.1	2.4
$2.51	1.506	40.90	(0.70)	(201.1)	(0.50)
$2.51	1.757	44.89	(4.69)	(1,339.4)	(3.4)

Conversely, the impact of a 10 percent decrease in the value of the elasticity of supply or supply or ε^S equals 1.8 on domestic output is shown in Table 6.9. At the lower elasticity value, domestic output rises above 3 MTOE in response to a change in price related to the compliance cost of $0.251 (10%). EU producers increase production at a slower rate resulting in a higher value of trade $14.3B compared to the $14.0B base case in Table 6.7.

Table 6.9: Lower Level Elasticity Effect on EU Value of Trade

(Average USD price per gallon 2010)	Compliance Cost/gallon	Domestic Supply* MTOE	Imports MTOE	Imports US gallon of diesel	Value of trade (2010 billon dollars)
$2.51	0	17.20	23	6,572.2	16.5
$2.51	0.251	20.30	19.90	5,686.6	14.3
$2.51	0.502	23.59	16.61	4,744.9	12.0
$2.51	0.753	26.89	13.31	3,803.2	9.5
$2.51	1.004	30.18	10.02	2,861.6	7.2
$2.51	1.255	33.48	6.72	1,919.9	4.8
$2.51	1.506	36.80	3.42	978.2	2.5
$2.51	1.757	40.10	0.13	36.6	0.09

The estimated value of trade available through the EU DIR is $16.5B. The value of trade diminishes with higher domestic output spurred by the higher price for biodiesel due to compliance costs. The rate at which the value of trade diminishes is dependent on the elasticity of supply in the EU.

6.4 Summary

The estimated value of trade as a result of the US RFS and EU DIR is $35.3B. The value of trade available through the RFS is estimated at $65.7B, but is reduced to $18.8B because of the blend wall. For suppliers to the EU, the value of trade as a result of the EU DIR is estimated at $16.5B. The ability of foreign suppliers to reap these earnings is subjected to the sustainability provisions of the mandate. It is believed that the favourable conditions in most developing countries affords producers in these countries an advantage to exploit export opportunities as a result of the US RFS and the EU DIR and benefit all parties involved in the trading of biofuels. Chapter 7 examines the implications of both mandates for developing countries, focusing on whether the sustainability provisions may inhibit the ability of developing countries to reap the potential benefits that exporting biofuels could bring.

Chapter 7: Trade Implications of US and EU Mandates for Developing Countries

7.1 International Trade of Biofuels

The US and EU mandates boost the international trade of biofuels. In Chapter 6, the estimated combined value of trade as a result of the RFS and DIR is US$35.3B. Foreign producers of biofuels including Brazil, are able to reap these potential benefits by satisfying the sustainability conditions of both mandates. Currently, Brazil is a major exporter to the US and the EU. In 2007, Brazil accounted for 50 percent (3.5 billion liters) of global exports of ethanol with the US, EU and Canada being importers (OECD 2008). The US imposes a $0.54 tariff on ethanol originating from Brazil, but the latter is able to circumvent the tariff by up to 7 percent of US production and gain an even greater market share by using Caribbean Basin Initiative[39]countries such as Jamaica as an intermediate destination for the refining of ethanol destined for the US. Furthermore, in 2006, an estimated 400 million gallons of Brazilian ethanol entered the US duty free under the duty drawback scheme for jet fuel blenders (Inside US Trade, 2007). According to the Renewable Fuel Association, the US imported 433.7 million gallons of ethanol from Brazil in 2006, resulting in over 90 percent of Brazilian biofuel entering duty free. In addition to Brazil, the US imports ethanol from Jamaica, China, Costa Rica, El Salvador, Trinidad and Tobago and Canada. Brazil has the major share of imports, even though the Brazilian price is 32.7 per cent higher than the average Chinese price (Yeboah, Boadu and Li, 2010). They conclude that the ethanol industry operating costs are lower in China than Brazil because of cheaper labour and the intensive land use. However, Brazil is closer to the US geographically and, hence, enjoys lower transportation costs than China.

The US imports biodiesel (soy-based) from Brazil and palm-oil based biodiesel from Southeast Asia. Countries in Southeast Asia pursuing renewable energy include Thailand, The Philippines,

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[39] Caribbean Basin Initiative (CBI) allows duty-free access to US market for a number of Caribbean countries products including fuel ethanol under certain conditions. Ethanol produced from at least 50 per cent local feedstocks may be imported duty-free. If the local feedstock content is lower, limitations apply on the quantity of duty-free ethanol. In the case where 100 per cent foreign feedstock is used, duty free access of ethanol produced from the feedstock is allowed up to 7 percent of US production. (http://www.nationalaglawcenter.org/assets/crs/RS21930.pdf)

Indonesia and Malaysia but their engagement in trade as exporters on the world stage in the near future may be thwarted by high production costs, and other constraints such as technical/infrastructure barriers, administrative burden and lack of financing (Olz and Beerepoot 2010). However, the favourable conditions for biomass cultivation, along with the potential benefits of improved energy and job security, are expected to boost biofuel production. For example, Malaysia and Indonesia produced 203 million and 243 million liters of ethanol respectively in 2009.

The trade in biofuels is mainly characterized either by the trading of feedstock for the production of biodiesel, rather than the product itself, or in contrast to ethanol where the final product is traded for the most part (Oosterveer and Mol (2010). However, trade in biodiesel between the US and EU has resulted in the latter imposing high duties on the grounds that EU producers were facing unfair competition from subsidized US producers (Stearns 2008). The US exports biodiesel to the EU, which is boosted by the splash and dash program[40] where biodiesel is imported into the US but destined for re-export after receiving a tax credit of $1.00 per gallon. According to de Gorter, Drabik and Just (2010), the US Congress has plugged this loophole making only domestically produced biodiesel eligible for the tax credit, but the EU still followed through with an anti-dumping case. The European Biodiesel Board (EBB) contends that the US biodiesel exports are supported by a domestic subsidy and also benefits from an EU subsidy while EU exports are not eligible for European incentives (Inside US Trade 2008a). The inequity in benefits between the two countries stem from the fact that US producers benefit from the blender tax credit as well as the EU tax exemption because the EU sets the world price for biodiesel (de Gorter, Drabik and Just 2010). In other words, the combination of EU and US tax incentives makes US biodiesel technically cheaper than EU biodiesel since both enhance the competitiveness of biodiesel, while EU producers only benefit from the effect of EU incentives on the world price if they decide to sell on the world market. Therefore, EU producers are protected from imports through countervailing duties compounding the ad valorem tariff of 6.5 percent on biodiesel imports (Oosterveer and Mol 2010). In essence, the EU took an anti-

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[40] The ‘splash and dash’ refers to the practice of importing biodiesel from a third country and receiving the tax credit of $1.00 by merely producing a blend of 99.9 per cent imported biodiesel with 0.1 percent diesel(Carriquiry and Babcock 2008).

dumping action against the US as well as imposing countervailing duties on imports of biodiesel from the US. These measures protect domestic producers' share of the market.

In Canada, biodiesel imports are subjected to tariffs of 6.5 percent for Most Favoured Nations (MFNs) and three percent for countries under the General Preferential Tariff (GSI 2009). In addition, non-tariff barriers are used. For example, in Manitoba, 80 percent of the feedstock used by Husky Energy for its wheat-based facility must be supplied by Manitoba producers. This type of barrier may be deemed a production subsidy that distorts the trade in biofuels for both inputs and the finished product. This type of support has been challenged at the WTO by the Japanese Government. A program by the Government of Ontario which guarantees long term pricing (above feed in tariffs) for solar and wind generators made with a certain percentage of locally-produced components was considered to be a prohibited red box subsidy (WTO Dispute Settlement DS412, Oct 2010).

The setting of blending or utilization targets increases the probability of trade in biofuels given the divergence of demand from domestic production capacity. Although revision of current targets may occur, it is assumed in this thesis that countries will embrace imports as a first option. The EU Directive 2009/28/EC charges the Commission with maintaining a balance between domestic production and imports, therefore, implying that the EU is open to imports in an attempt to achieve the blending target by 2020 but aware of the potential negative impact imports can have on the domestic industry. Furthermore, the EU Parliament requires a report on the effects of imports, which may be used to inform decisions regarding policy revisions pertaining to imports.

7.2 Domestic Production

The mandates encourage domestic production by reducing the risk associated with developing biofuels. Recall from Chapter 6, imports are estimated to be 6 bg under the RFS due to the BW and no domestic production of cellulosic and advanced is technically feasible. Table 6.5 illustrates the effect of relaxing the assumption of no domestic production of cellulosic and advanced and the market being faced with a BW on use of ethanol. If the US is able to produce

10 percent of both mandates, the quantity of imports declines by the same amount, for example, of the 6 bg available to be imported, the US is able to produce 2.1 bg, hence, imports reduce to 3.9 bg. As expected, higher domestic production diminishes the need for imports to satisfy the mandate through trade. Given the BW, however, the maximum value of imports occurs when domestic production is able to meet 6 bg of the 21 bg. Similarly, the rise in price of biodiesel attributed to compliance costs results in increase in output by EU producers. Table 6.7 shows the diminishing effect on the value of trade to developing countries as compliance costs increase. Furthermore, as discussed in Chapter 3, the domestic industry in the US and EU are protected through various trade barriers which enhances the competitiveness for biofuel stakeholders in the US and EU to the detriment of stakeholders in developing countries.

7.3 Potential Barriers

The competition between food and fuel for inputs and land has resulted in a shift in biofuel policy for some of the major producers. The competition is intensified as a result of the far-reaching government support in developed countries to encourage domestic production of biofuels through various forms of mandates, which creates artificial demand with the objective of displacing fossil fuels. The level of support has the potential to place upward pressure on food prices which can compromise food security. As a result, developed countries are adopting sustainability standards to mitigate the adverse effects from the production of biofuels, both for domestic and foreign production. A guiding principle for the establishment of these sustainability standards is that biofuel production should offer GHG emissions savings. These sustainability standards are to be met by both domestic and foreign suppliers of biofuel. The EU allows only biofuels that have satisfied the sustainability standards to be counted towards the mandated blending target. The US has made the contribution of ethanol derived from corn a residual under the current system of mandates-effectively capping the production of corn based ethanol. Consequently, greenhouse gas emission savings and capacity constraints are imposed by the EU and US governments. These sustainability standards can prove to be effective barriers to trade. The US and EU have both outlined different GHG emissions requirements of biofuels. The US requirement varies from 20 to 60 percent depending on the type of fuel. In the case of the EU, the minimum is 35 percent.

The greenhouse gas savings requirements for the US and EU markets differ as the EU emission levels gradually increases to 60 percent while for the US, emission levels have been set and categorized based on the type of renewable energy. The US requires corn based ethanol produced by new technologies and at new facilities (or existing facilities that have increased capacity) to reduce GHG emissions by 20 percent. For sugar-based ethanol, the requirement is at least 50 percent (EISA 2007). Thus, imported sugar based ethanol is required to reduce GHG emissions at a higher rate than most domestic ethanol, since US ethanol is derived primarily from corn. As a result, this regulation can be considered a non-tariff barrier and complements the existing support to the biofuel industry by both levels of government. The question of whether setting a higher standard for a 'like product' complies with WTO rules remains to be answered.

The EU standard for biofuel is currently higher than the US standard for corn-based ethanol (from new plants) with GHG emissions reductions of 20 percent, but lower than the US standard for biodiesel which is set at minimum of 50 percent. The GHG emissions requirement for the EU is a minimum of 35 percent, increasing to 60 percent by 2018. Apart from differences in savings rates for both markets, Lendel and Schaus (2010) show that corn based ethanol from the US will not satisfy the EU GHG savings requirement because it is below the 35 percent threshold (calculated at 34 percent) and the EU default value of 49 percent cannot be applied. A default value means a value derived from a typical value[41] by the application of pre-determined factors that may, in circumstances specified in the Directive, be used in place of an actual value (Article 2 (O)). The analysis can be extended to other foreign producers, for example, developing countries, of corn-based ethanol intent on supplying the EU.

In Chapter 6, the value of imports into the EU is estimated at $16.5B under the DIR, but diminishes when compliance costs are included, or technological infeasibility in the case of the US. Nevertheless, developing countries can exploit the trading opportunities available through the mandates. For example, in 2008, Brazil exported 401 million gallons[42] to the US, which represents approximately 7 percent of the potential imports (6 bg) under the RFS. Furthermore,

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[41] Typical value means an estimate of the representative green house gas emissions savings for a particular biofuel production pathway (Article 2(n)).
[42] http://www.oecd.org/dataoecd/29/1/43457520.pdf

Brazil produced 6.9 bg of ethanol in 2010 (RFA), therefore Brazil can almost double production (87%) to supply the international market and earn $18.8B through exports of ethanol to the US.

7.4 Case of Soybeans

In regard to biofuels originating from Brazil, Lendel and Schaus (2010) posit soybean biodiesel from Brazil for the EU market meets the GHG emissions saving requirements, because low weight biodiesel is shipped rather than bulky soybeans. Interestingly, given that soybeans have a default value below 35 percent, Lendel and Schaus (2010) fail to prove that soybean biodiesel from Brazil meets the GHG emission savings by means of an actual value. On this note, the default value for soybean biodiesel and the impact on US soybean producers is discussed below.

In 2010, a case involving the US soybean producers provides us with an insight into the kind of challenges or issues which may be faced by developing countries arising from differing GHG emissions standards and extensive monitoring expectations. US soybean producers have brought to the attention of the USDA and the United States Trade Representative (USTR) that the EU directive on renewable energy may act as a barrier to trade (Inside US Trade, 2010). This is due to soybean based biodiesel not qualifying for EUs sustainability criteria when using default GHG emission savings values; therefore, exporters will need to prove compliance. The default GHG emission savings value for soybean based biodiesel is 31 percent (2009/28/EC) while the EU directive requires a minimum of 35 percent. As of January 2011, qualifying renewable fuels must carry proof of sustainability certificates but soy producers and biodiesel representatives have told the USTR that the information required for the certificates is too difficult to provide. They argue that it is simply not feasible to trace soybeans used as feedstock back to specific farms (Inside US Trade, 2010). Although the US traders may use actual GHG emission saving values to show compliance with Criterion A of the EU sustainability criteria, an administration cost is attached that may effectively place US biodiesel at a competitive disadvantage. Furthermore, the American Soybean Association contends that soy biodiesel represents a 52 percent reduction in GHG emissions compared to fossil fuels when US data is used (Inside US Trade, 2010). In essence, the detailed monitoring expected of suppliers appears to be an area of tension as suppliers may need to invest significant time and resources to provide the necessary information in order to have their product counted towards the EU mandate. The contention of the US soybean producers raises the issue of the practicality of any supplier being able to satisfactorily monitor the supply chain in such detail, particularly suppliers from developing countries.

The EU and US GHG emission saving rates for biodiesel are different under the respective biofuel mandates. Presently, the US standard is higher than the EU standard as biodiesel is expected to reduce GHG emissions by at least 50 percent in contrast to the EUs minimum of 35 percent. As a result, the US soybean producers claim that the EU erred in calculating that soy-based biodiesel only provides a 31 percent reduction in GHG emissions may be lent support. Hence, the question of correct science arises and the WTO rules relating to the scientific evidence used to support the imposition of trade barriers will be considered in Chapter 8.

7.5 Summary

In Chapter 7, the implications of the mandates for developing countries have been discussed. Sugar cane-based ethanol is required to reduce GHG emissions at a higher rate than corn-based ethanol. The conventional or corn based ethanol requirement is a residual under the RFS. Therefore, corn-based ethanol is not a substitute for cellulosic or advanced ethanol. Partial provision of the advanced and cellulosic ethanol mandates by the domestic industry reduces the value of trade for developing countries. The GHG emissions standards under the US and EU mandates are different. The GHG emission for biodiesel is at least 50 percent under the US while the minimum is 35 percent for the EU. The verification of GHG emission levels may prove to be an area of tension between players in the market with each side advancing their own correct science. Chapter 8 will assess the compatibility of the US and EU mandates with WTO rules given their potential to distort trade.

Chapter 8: Compatibility of US and EU Mandates with the WTO

8.1 The WTO

The World Trade Organisation (WTO) was established to continue the work of removing barriers to international trade following several agreed principles. One core principle is accepted retaliation (Kerr and Perdikis, 1995). Accepted retaliation means that if a country chooses to ignore its WTO commitments, affected members can seek compensation equal to the value of the trade loss or use retaliatory trade measures (normally tariffs) on products imported from the offending country (Gaisford and Kerr 2001). A second core principle is non-discrimination. Article I of the General Agreement on Tariffs and Trade of 1947 (GATT) provides that a country should not discriminate among members of the WTO and is known as Most Favored Nation treatment. That is, products from foreign sources should be treated equally on an unconditional basis. The principle of non discrimination is upheld with two other concepts: national treatment; and ‘like products’. Article III provides that imported products should be treated in the same manner as domestic products so as to avoid protectionism. The concept of ‘like products’ prohibits products being discriminated against through trade barriers on the grounds of the production and processing methods (PPMs) used. Hobbs *et al*. 2002 posit that the rationale for not allowing a trade barrier based on PPMs is that it is the end products and not the PPMs which are traded. In addition, Marceau (2010) raises the question of whether non-product related criteria can be used to distinguish two otherwise like products, for example, counting the emissions involved in transporting the biofuel as in the case of the EU. Exceptions to the non-discrimination principle are set out in Article XX. This article allows members to retreat from these principles in cases of protection for human health or the environment. The US and EU mandates distinguish biofuels products on the bases of PPM’s; inputs and GHG emissions. Although, contrary to Article III, it is allowable if the goal is to protect the environment from further degradation. Nonetheless, the policies should not arbitrarily or unjustly distort the trading of biofuel especially if alternative policies can be adopted that are less trade distorting.

8.2 Biofuel Mandates

The US RFS requires three types of ethanol which are differentiated by inputs and GHG emissions reduction levels or savings. Imported sugar cane-based ethanol (advanced) is required to reduce GHG emissions at a higher rate than most domestic ethanol, since US ethanol is overwhelmingly derived from corn. In other words, like biofuels are treated differently, contrary to the principle of national treatment. Applying the like product clause to this situation would suggest that sugar cane-based ethanol GHG emission savings be revised to a minimum of 20 percent, the same as for corn based ethanol, rather than 50 percent. The EU provides GHG emission saving default values only for EU produced corn ethanol, therefore suggesting that suppliers from outside the EU would need to provide an actual value (Lendel and Schaus 2010) if they believe their product meets the GHG standard. However, the calculation of an actual value may not necessarily be based on the principle of national treatment. In this case, the EU default value should apply to foreign corn-based ethanol in keeping with the principle that like products, regardless of origin, should be treated equally.

The case involving the US soybean producers and the EU raises the issue of correct science given that both sides are advancing conflicting scientific evidence. Article 2 (2.2) of the WTO's Agreement on Technical Barriers to Trade (TBT) states that technical regulations may be imposed to achieve the following objectives: national security requirements; the prevention of deceptive practices; protection of human health or safety, animal or plant life or health, or the environment. However, the achievement of either one of these objectives should not be met through technical regulations which create unnecessary obstacles to international trade. The regulations must be based on scientific evidence, to prevent the imposition of regulations that have no safety-enhancing value (Gaisford and Kerr 2001). Therefore, the TBT allows regulation aimed at protecting the environment. The GHG standards under the RFS and DIR are designed to improve environmental preservation by ensuring the development of biofuels results in a net decrease rather than a net increase in GHG emissions. The TBT encourages the adoption of international standards and, where they do not exist, private standards may be used if they have been notified to other members of the WTO. Furthermore, differential treatment is allowed under Article 12 for developing country members given the special development, financial and trade needs of developing country members. As such, the technical regulations, standards and conformity assessment procedures are not to create unnecessary obstacles to exports from developing country members (Para 3).

The Articles of the GATT and TBT are rules governing the establishment of regulations to prevent unnecessary or impractical requirements of traders, which translates into protectionism for the domestic industry. The standards imposed by the US in the early 1990s concerning foreign gasoline were challenged at the WTO as Brazil believed the standards violated Articles I and II of the GATT and Article 2 of TBT. The case will be reviewed below.

8.3 WT/DS2/9

WT/DS2/9 refers to the case involving dispute between Brazil and US concerning the latter's Standards[43] for Reformulated[44] and Conventional Gasoline[45]. In 1995, Brazil challenged the US because the former believed that the Gasoline Standards, which became effective on 1 January 1995, denied national treatment to gasoline imported from Brazil. As a consequence, Brazil charged that the regulation caused harm to their interests as exports of gasoline to the United States declined sharply in the wake of the new standards, nullifying and impairing benefits due to Brazil under both GATT 1994 and the TBT. Specifically, Brazil wished to show that the regulation was inconsistent with the most-favoured-nation obligations of Article I of the GATT; national treatment

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[43] The EPA proposed a Gasoline Rule which required baselines to determine the quality of gasoline produced in 1990 for future comparison. The gasoline rule requires any domestic refiner, which was in operation for at least 6 months in 1990, to establish an individual refinery baseline, which represents the quality of gasoline produced by that refiner in 1990. In cases of lack of accurate data, refiners may use statutory baseline, although, domestic refiners were not permitted to use it. The Rule consisted of three methods by which refiners may comply with the baseline requirement of 1990. An importer which is also foreign refiner must determine its individual baseline using the three methods if it imported at least 75 per cent of the gasoline, known as the '75 percent rule'.

[44] EPA proposed that reformulated gasoline sold in the US by domestic refiners should be subjected to the requirements in the Gasoline Rule for other gasoline qualities; the parameters sulphur, olefins and T-90 are measured against each US refiners' individual 1990 baseline and must be maintained at or below the 1990 levels. However, importers could not use individual 1990 baseline, but have to comply with the levels specified in the statutory baseline for these parameters. Furthermore, in the May 1994 Proposal, the EPA amended the reformulated gasoline regulation allowing foreign importers to establish individual baselines similar to domestic refiners conditional on additional strict requirements and not applicable to conventional gasoline.

[45] EPA required domestic refiners to measure non-degradation requirements for conventional gasoline against their individual baselines while importers of foreign gasoline are assigned to the statutory baseline. In otherwords, domestic and foreign were treated as 'unlike products'.

obligations of Article III of the GATT and Article 2 of the Agreement on Technical Barriers to Trade.

The Panel conclusions were arrived at based on the following summarised findings:

1. The baseline establishment methods contained in Part 80 of Title 40 of the Code of Federal Regulations are not consistent with Article III:4[46] of the General Agreement, and cannot be justified under paragraphs (b), (d) and (g) of Article XX of the General Agreement[47].

2. Imported and domestic gasoline were like products and that since, under the baseline establishment rules of the Gasoline Rule, imported gasoline was effectively prevented from benefitting from as favourable sales conditions as were afforded domestic gasoline by an individual baseline tied to the producer of a product, imported gasoline was treated "less favourably" than domestic gasoline. The baseline establishment rules of the Gasoline Rule were accordingly inconsistent with Article III:4 of the General Agreement.

3. The baseline establishment methods found inconsistent with Article III:4 was not justified under Article XX(b) of the *General Agreement* as "necessary to protect human, animal or plant life or health". Furthermore, baseline establishment rules found to be inconsistent with Article III:4 could not be justified under Article XX(g) as a measure "relating to" the conservation of exhaustible natural resources.

4. The maintenance of discrimination between imported and domestic gasoline contrary to Article III:4 was not justified under Article XX(d) as "necessary to secure compliance

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[46] Article III (4) of the GATT states that the products of the territory of any contracting party imported into the territory of any other contracting party shall be accorded treatment no less favourable than that accorded to like products of national origin in respect of all laws, regulations and requirements affecting their internal sale, offering for sale, purchase, transportation, distribution or use. The provisions of this paragraph shall not prevent the application of differential internal transportation charges which are based exclusively on the economic operation of the means of transport and not on the nationality of the product.

[47] The measures imposed are necessary to protect human, animal or plant life or health (XX;b), secures compliance with laws or regulations which are not inconsistent with the provisions of the Agreement (XX;d), and related to the conservation of exhaustible natural resources if such measures are made effective in conjunction with restrictions on domestic production or consumption (XX;g)

with laws or regulations which are not inconsistent with the provisions of [the General] Agreement."

5. It was unnecessary, in the light of findings 2, 3, and 4, to determine whether the measure at issue was inconsistent with Articles 2.1 and 2.2 of the Agreement on Technical Barriers to Trade (TBT Agreement).

8.3.1 Recommendation

The Panel recommended that the Dispute Settlement Body request the United States bring this part of the Gasoline Rule into conformity with its obligations under the General Agreement.

8.4 Appeal

The US appealed the ruling of the Panel requiring conformity of the Gasoline Rule. The US claimed the Panel erred in the rulings regarding Article XX (g) and its interpretation of Article XX in general. The appellate body agreed with the US as they found that the Panel erred in *law in its conclusion that the baseline establishment rules contained in Part 80 of Title 40 of the Code of Federal Regulations did not fall within the terms of Article XX (g) of the General Agreement.* In addition, the Panel erred in law in failing to decide whether the baseline establishment rules contained in Part 80 of Title 40 of the Code of Federal Regulations fell within the ambit of the chapeau[48] of Article XX of the General Agreement. Nevertheless, the appellate body found that the baseline establishment rules contained in Part 80 of Title 40 of the Code of Federal Regulations failed to meet the requirements of the chapeau of Article XX of the General Agreement, and accordingly are not justified under Article XX of the General Agreement. In other words, the Panel’s ruling that the rules were unjustified under Article XX was upheld.

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[48] “Subject to the requirement that such measures are not applied in a manner which would constitute a means of arbitrary or unjustifiable discrimination between countries where the same conditions prevail, or a disguised restriction on international trade….”(GATT 1947).

8.4.1 Recommendation

The Appellate Body made a similar recommendation to the Dispute Settlement Body with a request for the United States to bring the baseline establishment rules contained in Part 80 of Title 40 of the Code of Federal Regulations into conformity with its obligations under the General Agreement.

8.5 Conclusion

The ruling is a precedent for disputes involving different treatment of foreign energy products such as biofuels. Under the RFS, different standards are established for *like products*. The EU Directive imposes capacity constraints on suppliers and is discriminatory in the establishment of default values. The inconsistencies in the standards may cause harm to developing countries exports of biofuel to the US and the EU, nullify and impair apparent benefits under both GATT 1994 and the TBT. Therefore, if the US and EU are going to attempt to exercise their privileges under Article XX, both countries will need to prove the respective sustainability standards are not "*applied in a manner which would constitute a means of arbitrary or unjustifiable discrimination between countries where the same conditions prevail, or a disguised restriction on international trade…."(* GATT 1947).

Chapter 9: Conclusion

9.1 Summary of Results

The risk of food insecurity in the form of higher food prices has prompted policymakers in the US and the EU to revise their approach to biofuel development. The US Renewable Fuel Standard (RFS) and EU Directive 2009/28/EC require long term use of renewable energy in transportation, subject to sustainability. These mandates create long term demand for biofuels which are unlikely to otherwise exist and increase the potential for trade. Developing countries, which may have a competitive advantage in biofuel production, have been interested in what opportunities may arise due to the revised biofuel mandates. The sustainability provisions of the mandates include GHG emission savings requirements and land use restrictions. It is believed that the favourable production conditions in developing countries provide an advantage in reaping the benefits from higher demand for inputs and biofuel through trade. However, the blend wall in the US and the EU's sustainability criteria may inhibit the ability of developing countries to capitalize on the trading opportunities arising as a result of the mandates.

The extent of the revisions to the US and EU mandates prompted this investigation into the likely effects on foreign suppliers, especially developing countries. A theoretical framework and empirical analysis were done using a partial equilibrium comparative static approach. Hence, the thesis explored implications for trade when the volume produced domestically or required under RFS is in disequilibrium with technical capability or use constraints in the case of the US and the impact of the sustainability criteria could have on new and existing foreign suppliers to the EU when compliance costs are considered.

The US and EU mandates can be viewed as inelastic demand for biofuels, which leads to no effect of the tariff rate on the volume of imports to satisfy the mandate as shown in the US case study. In addition, the US is faced with a blend wall which is a constraint on demand for biofuels and imports of biofuels by extension. The compliance costs associated with the EUs sustainability criteria may cause a contraction in supply, thus acting as a barrier to trade.

The estimated value of trade as a result of the RFS and DIR is USD$35.3 billion. The value of trade available through the RFS is estimated at USD$65.7 billion, but is reduced to USD$18.8 billion because of the blend wall. For suppliers to the EU, the potential benefit to developing countries as a result of the EU DIR is estimated at USD$16.5 billion. The ability of foreign suppliers to reap these earnings is subjected to the sustainability provisions of the mandates. It is believed that the favourable conditions in most developing countries affords producers in these countries a production advantage which could be used to exploit the export opportunities arising from the US RFS and the EU DIR to the benefit of all parties involved in the trading of biofuels.

The implications of the mandates for developing countries include sugar cane-based ethanol reducing GHG emissions at a higher rate than corn-based ethanol. In addition, the conventional or corn-based ethanol requirement is now essentially capped under the RFS. Therefore, corn-based ethanol is not a substitute for cellulosic or advanced ethanol. Partial provision of the advanced and cellulosic ethanol mandates by the domestic industry reduces the value of trade for developing countries.

The sustainability standards for GHG emissions under the US and EU mandates are different. The verification of GHG emission levels may lead to each side advancing their own *correct science*. Under the RFS, different standards are established for *like products*. The EU Directive imposes capacity constraints on suppliers and is discriminatory in the establishment of default values. The inconsistencies in the standards may cause harm to developing country exports of biofuel to the US and EU, nullifying and impairing apparent benefits under both GATT 1994 and the TBT. Therefore, if the US and EU wish to exercise the privileges under WTO Article XX, both countries will need to prove the respective sustainability standards are not "*applied in a manner which would constitute a means of arbitrary or unjustifiable discrimination between countries where the same conditions prevail, or a disguised restriction on international trade…."(* GATT 1947).

The thesis provides a theoretical framework and empirical analyses of the US RFS and EU 2009/28/EC. The belief of inevitable benefits for developing countries as a result of the mandates may be unfounded based on the results presented in the thesis.

9.2 Limitation of study

The study focuses on the requirement for the final product under the EISA. The EISA impacts the type of biomass and the manner in which renewable biomass is produced by both domestic and foreign suppliers that may have trade effects but are not explored in the thesis. The modeling of the EU mandate only examines the impact on biodiesel/final product, although trade in inputs is significant for the EU. For the EU case study, the thesis covers only biodiesel satisfying the mandate whereas the Directive explicitly states renewable fuels with the expectation that other renewable fuels, apart from biofuels, will contribute to achieving the renewable fuels target. The models are built on the assumption that importation is the preferred option for policy makers in the US and EU. However, revision of mandates may be likely in cases where energy independence is the primary objective of pursuing green energy. In other words, importing of energy may not be the preferred option. Crude estimates for compliance were calculated due to the lack of data on the various forms of compliance under the EU's Implementation Plan. Given the forms of compliance recognized by the EU, it is believed that compliance costs are case sensitive. The lack of data available for post sustainability market conditions, given the timelines for US RFS and EU DIR of 2022 and 2020 respectively, did not allow for an econometric approach. Therefore, published elasticities and point data were used for the analysis. The methodology for the study is comparative static with a comparison of two points, the current state of the market and the year of expiration of the mandates. A dynamic analysis of the mandates on an annual basis would have been informative, but given the constraints on time and resources, the dynamic approach was not feasible.

9.3 Future Research

The thesis investigates the potential trade issues that may arise under the mandate for the end product. Future research could involve modeling the effect on biomass producers from a trade perspective. Studies may explore potential trade implications for feedstock producers desirous of supplying raw materials destined for biofuel production overseas, for example, Malaysia. The far reaching monitoring associated with the mandates provides an opportunity to do research on traceability for biofuels in the interest of reducing prices of food. The cross-over into traceability may allow the investigation of the price effects or premiums for the final product, creating another dimension in the nexus of agriculture and energy.

9.4 Conclusion

The contribution of this thesis includes an assessment of the US and EU mandates design in a trade context. The disconnection between technology and biofuels policy is highlighted by the work undertaken in the thesis. Although, the thesis is limited empirically due to the lack of data, the work provides insights into the new realities of compliance for those that wish to export biofuels. The thesis differs from other studies using partial equilibrium as it explores the implications for trade when the volume produced domestically or required under RFS is in disequilibrium with technical capability or use constraints in the case of the US. For the EU, the thesis illustrates the increasing effect of the compliance costs associated with the EU on imports. There has been considerable discussion regarding the opportunities for developing countries to capitalize on the move to an increased role for biofuels in developed countries. This thesis clearly shows that while the current biofuels mandate policies of the EU and US create opportunities for developing countries to supply their markets, these poorly designed and thought out policies may well lead to less opportunities for developing countries than may have been expected.

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