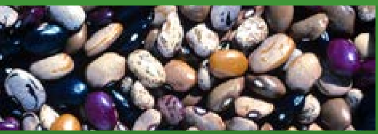
May 2013 | ICTSD Programme on Agricultural Trade and Sustainable Development



Global Biofuel Trade

How Uncoordinated Biofuel Policy Fuels Resource Use and GHG Emissions

By Seth Meyer, Josef Schmidhuber, Jesús Barreiro-Hurlé
Food and Agriculture Organization of the United Nations

ICTSD
International Centre for Trade and Sustainable Development

FAO FIAT PANIS

Issue Paper No. 48

Global Biofuel Trade

How Uncoordinated Biofuel Policy Fuels Resource Use and GHG Emissions

By **Seth Meyer, Josef Schmidhuber, Jesús Barreiro-Hurlé**
Food and Agriculture Organization of the United Nations

ICTSD
International Centre for Trade and Sustainable Development

Issue Paper 48

Published by

International Centre for Trade and Sustainable Development (ICTSD)
International Environment House 2
7 Chemin de Balexert, 1219 Geneva, Switzerland

Tel: +41 22 917 8492 Fax: +41 22 917 8093
E-mail: ictsd@ictsd.ch Internet: www.ictsd.org

Publisher and Director: Ricardo Meléndez-Ortiz
Programmes Director: Christophe Bellmann
Programme Team: Ammad Bahalim, Jonathan Hepburn

Acknowledgments

This paper has been produced under the ICTSD Programme on Agricultural Trade and Sustainable Development. ICTSD wishes gratefully to acknowledge the support of its core and thematic donors, including: the UK Department for International Development (DFID), the Swedish International Development Cooperation Agency (SIDA); the Netherlands Directorate-General of Development Cooperation (DGIS); the Ministry of Foreign Affairs of Denmark, Danida; the Ministry for Foreign Affairs of Finland; and the Ministry of Foreign Affairs of Norway.

ICTSD and the authors are grateful to all those who commented on earlier drafts of the paper, including Prof. David Blandford (Penn State University), Luiz Fernando Amaral (ICONE), Francis Johnson (Stockholm Environmental Institute), Henrique Pacini (UNCTAD) and one other anonymous reviewer.

For more information about ICTSD's Programme on Agricultural Trade and Sustainable Development, visit our website at http://ictsd.org/programmes/agriculture/

ICTSD welcomes feedback and comments on this document. These can be forwarded to Jonathan Hepburn at jhepburn [at] ictsd.ch

Citation: Mayer, Seth; Josef Schmidhuber; Jesús Barreiro-Hurlé; (2013); *Global Biofuel Trade: How Uncoordinated Biofuel Policy Fuels Resource Use and GHG Emissions*; ICTSD Programme on Agricultural Trade and Sustainable Development; Issue Paper No. 48; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

ISSN 1817 356X

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

LIST OF ABBREVIATIONS AND ACRONYMS

AMS	Aggregate Measurement of Support
AoA	Agreement on Agriculture
CAFE	Corporate Average Fuel Economy
EU	European Union
EISA	Energy Independence and Security Act
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organization
FFVs	Flex Fuel Vehicles
GHGs	Greenhouse Gases
ILUC	Indirect Land-Use Change
NPS	Non Product Specific
OECD	Organization for Economic Co-operation and Development
PS	Product Specific
RED	Renewable Energy Directive
RFS2	Renewable Fuel Standard 2
RIN	Renewable Identification Number
USDA	United States Department of Agriculture
WTO	World Trade Organization

FOREWORD

In recent years, global trade in biofuels has grown dramatically, albeit against a background of highly distorted markets for agricultural goods and for energy, and in a context of weak global governance for environmental public goods. While the development of the biofuels sector has helped generate new economic opportunities, it has also led to some unforeseen economic, social and environmental outcomes, including in the area of greenhouse gas emissions. Policy-makers in various countries are currently exploring how best to reform current policies and targets so as to improve environmental outcomes, while ensuring coherence with broader public policy goals such as the need to reduce poverty, enhance food security and expand access to energy and improved technologies.

This paper, by FAO experts Seth Meyer, Josef Schmidhuber and Jesús Barreiro-Hurlé, describes and analyses global intra-industry trade in biofuels arising from environmental legislation that has been developed separately in different markets and jurisdictions, and puts forward proposals and recommendations for addressing some of the environmental impacts resulting from this phenomenon. We hope that, as such, it provides a useful contribution to the ongoing debate about how government policies in this area can best contribute to achieving environmental objectives related to greenhouse gas emissions, without compromising other public policy goals such as food security.

Ricardo Meléndez-Ortiz
Chief Executive, ICTSD

ABSTRACT

In recent years we have seen significant volumes of bilateral trade of physically identical ethanol between the United States of America and Brazil driven by their different biofuel policies. The trend emerged in 2010, and accelerated in the second half of 2011, with large quantities of ethanol crossing paths in bilateral trade between the two countries. While this two-way or intra-industry trade of homogenous products is not a new phenomenon, it is typically explained by factors such as seasonality or cross-border exchanges caused by transportation cost differentials. However, we find that traditional market factors do not explain the notable volumes of bilateral trade in ethanol between the US and Brazil. Instead, this trade appears to be driven by differential and uncoordinated environmental policy. The conclusion is that the uncoordinated environmental legislation is inducing the product differentiation that invites arbitrage between the two countries, resulting in the two-way trade of an otherwise physically homogenous product; in so doing, additional fossil energy is consumed in the bilateral trade of ethanol along with the associated emissions of greenhouse gases (GHGs) from transport. Transport, as a result of the individual policies, also raises the price of biofuels to consumers which may suppress the displacement of fossil fuels. Both of these unintended consequences work in direct conflict with stated environmental objectives of many biofuel programmes.

The potential for intra-industry trade in biofuels could be further stimulated by evolving legislation within the European Union (EU). With tighter environmental constraints on biofuel production written into EU policy, the potential competition for certain classes of renewable fuels increases and could extend its reach from ethanol to biodiesel and/or the underlying feedstocks in the EU, the US and Brazil. This would create additional opportunities for counter-productive arbitrage among the three regions. We highlight one negative consequence of uncoordinated biofuel policy and propose options for mitigation through the use of a “book and claim” system under which each country could continue to pursue its own policy objectives while acting in a coordinated fashion to reduce costs and GHG emissions.

Keywords: ethanol, biofuels, biofuel policy, mandates, trade

JEL CODES: F14 Q17 Q18 Q41 Q48 Q58

INTRODUCTION

The year 2010 introduced a new phenomenon into the global biofuels economy: the bilateral trade of bioethanol between Brazil and the United States of America; the most important producers, consumers and traders of ethanol. Brazilian ethanol is produced primarily from sugarcane, while the US produces ethanol primarily from maize, but the resulting ethanol products are physically indistinguishable. Ethanol intra-industry trade, as the phenomenon is known, remained small in volume until the end of 2010 and therefore went unnoticed or was discarded as irrelevant in the global context. However, the large increases in ethanol intra-industry trade between the two countries seen during 2011 make this phenomenon difficult to ignore. Here we pose the question regarding its underlying causes and the associated economic and environmental costs, and we assert that under current policies, intra-industry trade is likely to increase to unsustainable levels increasing costs to consumers and greenhouse gas emissions.

1. INTRA–INDUSTRY TRADE IN FOOD AND AGRICULTURE – COMMON EXPLANATIONS

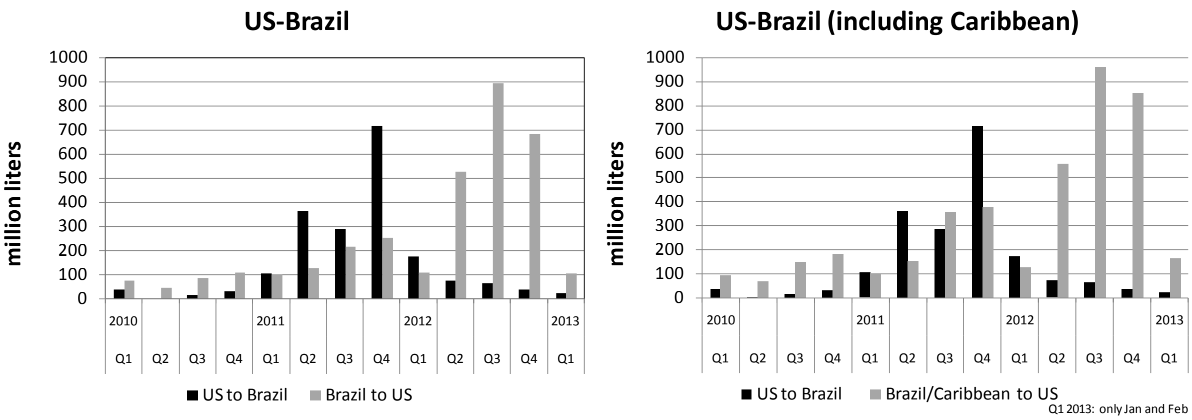
While the bilateral trade of differentiated goods, from cars to cheese, is common, the trade literature also offers some explanations for the less common exchange of undifferentiated products. In this section we examine these reasons and provide evidence that eliminates them as drivers for US-Brazil trade in ethanol since 2010.

Aggregation or classification issues in trade data: In some instances, trade flow classifications may simply not be fine enough to differentiate between what are in fact different products. Denatured and un-denatured alcohol (ethanol) are measured at the HS-4 level (HS 2207) which may include other non-fuel alcohol products. The prior historical trade in these classes for products other than anhydrous ethanol had been insignificant. The vast majority of this trade is fuel ethanol in both directions.

Seasonality. Annual trade statistics may simply mask the common phenomenon that countries sometimes exchange large quantities of an otherwise homogenous product to accommodate off-season consumer needs and match deficits through an intra-year exchange of goods. Trade may exploit seasonality between the hemispheres. If seasonality were a driver, trade flows would exhibit an off-season/on-season pattern during the year, perhaps related to maize and sugar harvest periods when feedstocks are abundant, thus compensating for changing domestic supplies. Observed ethanol trade flows in recent quarters, however, suggests that intra-industry trade flows were rising and falling simultaneously or pro-cyclically, rather than intermittent or counter-cyclically (Figure 1), particularly if Brazilian exports to the US via Caribbean[1] countries are included (Figure 1, second pane). Data for 2012 shows a different pattern but this is related to supply constraints in the US due to the drought (see below).

Border trade. This phenomenon relates to large countries sharing a long physical border, or lacking efficient internal transport channels between supply and demand regions, that may find it profitable to exchange homogenous products across borders rather than within their own borders due to lower transportation costs. The costs of shipment of ethanol between the two countries is greater than the shipment costs between ethanol production and consumption centres within the United States, although potentially high internal ethanol shipping costs in Brazil should be examined.[2] Discounting these reasons for ethanol intra-industry trade, we pursue the idea that ethanol intra-industry trade is due to policy induced attributes of ethanol[3] which differ in US and Brazilian policy.

Figure 1: Quarterly bilateral ethanol trade between Brazil and the United States 2011-2013, with and without exports through the Caribbean countries



Source: Global Trade Information Services (GTIS)

2. INTRA–INDUSTRY TRADE AS A POLICY–INDUCED PHENOMENON OF PROCESS DIFFERENTIATION

The stated objectives of US biofuel policy have been wide-ranging, from domestic energy production and self-sufficiency, to the desire to address global concerns such as the reduction of GHGs, to reasons that fall into the realm of pure agricultural and farm income support.

Ethanol subsidies in the United States at the federal level were introduced in the Energy Tax Act of 1978 through an ethanol exemption from the gasoline excise tax worth the equivalent of $0.40 per gallon (~$0.11 per litre). This was motivated by OPEC oil embargos of the 1970s and a desire to reduce energy consumption and import dependence.[4] In 1980 a $0.54 per gallon (~$0.14 per litre) duty on imported alcohol was imposed.[5] The duty made no explicit distinction concerning the imported fuel's production process or feedstock. Subsequent amendments to the Clean Air Act in 1990, and the expressed impact of motorfuel consumption on air quality, saw the beginning of a shift in renewable fuels policy toward environmental concerns. In 2005, the Energy Policy Act (United States Public Law 109–58) added quantitative mandates of 4 million gallons of renewable fuel consumption per year in 2006, rising to 7.5 billion gallons (28.4 billion litres) by 2012 in addition to the blenders' tax credit and import tariff. The ethanol industry was given a further boost as the fuel oxygenate MTBE (methyl tertiary butyl ether) was eliminated due to its role as a groundwater pollutant with ethanol becoming the de-facto replacement. This substantially boosted demand and resulted in a rapid expansion of the industry through early 2007.

The Energy Policy Act of 2005,while setting quantitative blending mandates, also began the practice of differentiating renewable fuels based on feedstocks or production practices, for example, defining cellulosic biofuel and allowing 1.0 gallon of cellulosic biofuel to count as 2.5 gallons of renewable fuel (such as ethanol made from maize) in meeting a quantitative mandate. The mandate system was further differentiated and expanded in the Energy Independence and Security Act of 2007 (EISA) (United States Public Law 110-140).

While numerous reasons are stated for the expansion of biofuel policy, the primary instrument that is currently applied in the US (mandated usage) contains elements of environmental legislation and aims at fostering environmentally friendly, carbon-saving production processes. Essentially all biofuel classifications are determined by feedstocks and production process rather than the final product (Table 1). This policy differentiation creates the potential for differential wholesale pricing of biofuels based on their classification and creates the opportunity for arbitrage with countries which may have different classification schemes or no classification schemes at all. Stated differently, biofuel policies that aim to affect production processes and induce environmentally friendly and carbon-saving processes have led to a differentiation at the product level that can induce exchanges of ethanol, an otherwise physically homogenous good, through unnecessary carbon-releasing and environmentally unfriendly trade. In this process, transportation fuel is wasted in the name of resource-saving policies and transportation costs increase final costs to consumers, thereby suppressing renewable fuel demand. Given the complexity of the policy framework, a review of existing biofuel policy and how it supports ethanol intra-industry trade is in order.

Table 1: Summary of EISA provisions for renewable fuel classification

Mandate	**GHG Reduction minimum**	**Feedstocks, fuels and processes**
Cellulosic Biofuel (S)	60%	Derived from cellulose, hemi-cellulose or lignin from Renewable Biomass (from existing lands in production): Dedicated crops, crop residues, planted trees and residues, algae, yard waste and food waste
Bio-based Diesel (B)	50%	Distillate replacements produced from: Vegetable oil, animal fats, waste grease, animal waste and byproducts, excluding co-processing with petroleum
Advanced Fuels (A)	50%	*(all of above and)* ***Sugar, Starch other than maize***, bio-based diesel from co-processing with petroleum, butanol, biogas
Renewable Fuels (T)	20%	*(all of above and)* ***Ethanol from maize starch***

Source: Authors' interpretation based on EISA 2007 legislation

3. US BIOFUEL POLICY AND THE POTENTIAL FOR INTRA–INDUSTRY TRADE WITH BRAZIL

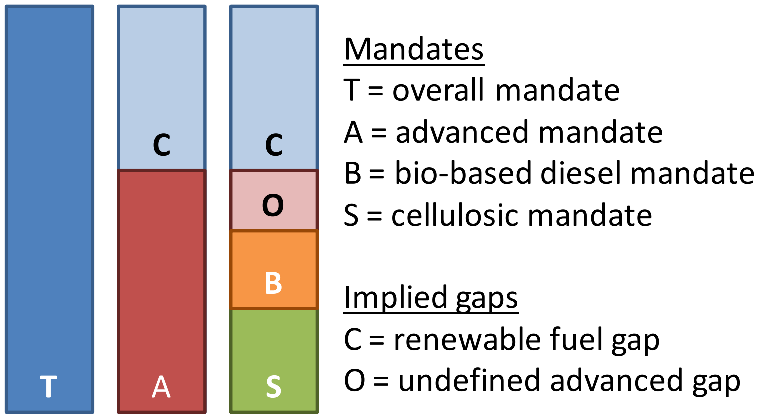
The blenders' credits which subsidized the blending of ethanol at the rate of $0.45 per gallon expired at the end of 2011 and the $1.00 per gallon blenders credit for biodiesel is set to expire at the end of 2013. What remains is the mandate system known as the Renewable Fuel Standard 2 (RFS2) established in the Energy Independence and Security act of 2007. The RFS2 further segmented biofuels (Table 1) and mandated volumes were greatly expanded (Table 2). The four classes of mandates are delineated by fuel type, the reduction in lifecycle GHG emissions relative to a base for gasoline or diesel transport fuels, feedstocks and manufacturing process. The mandates (renewable fuel, advanced biofuel, bio-based diesel and cellulosic biofuel) are not individual compartmentalized mandates but quantitative minimums nested within the overall renewable fuel mandate (Figure 2).

Table 2: US biofuel mandates in EISA 2007 legislation

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
	(million gallons)													
Renewable fuels (T)	11100	12950	13950	15200	16550	18150	20500	22250	24000	26000	28000	30000	33000	36000
of which advanced fuels (A)	600	950	1350	2000	2750	3750	5500	7250	9000	11000	13000	15000	18000	21000
of which cellulosic biofuels (S)	0	100	250	500	1000	1750	3000	4250	5500	7000	8500	10500	13500	16000
of which bio-based diesel (B)	500	650	800	1000	1280	1280	1280	1280	1280	1280	1280	1280	1280	1280
Renewable fuel gap (C) = (T-A)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Undefined advanced gap (O) = (A-1.5*B-S)	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Source: EISA 2007 legislation

Figure 2: Graphic Representation of the nested mandate structure under EISA of 2007 legislation



Source: Authors' interpretation

The cellulosic biofuel (S) and bio-based diesel (B) mandates set *minimum* quantities of these two types of fuels to be consumed. Cellulosic biofuels, not restricted to cellulosic ethanol, are defined by a biomass feedstock used to derive fuel from the cellulose, hemicellulose or lignin to produce a fuel which reduces GHGs emissions by at least 60 percent. Bio-based diesel is a distillate replacement made from feedstocks such as vegetable oils or animal fats that reduces GHG emissions by at least 50 percent. The overarching advanced fuel mandate (A) is greater than (or equal to) the sum of the cellulosic and bio-based diesel mandates creating an undefined advanced gap (O=A-B-S) for other advanced fuels (O) used to meet the larger advanced fuel mandate.[7] Advanced fuels, which can be blended to exploit the undefined advanced fuel gap, are characterized by their feedstock and GHG reduction scores. They must reduce GHG emissions by at least 50 percent: they explicitly *include* ethanol made from sugarcane and explicitly *exclude* maize starch ethanol. This advanced mandate is nested in a larger over-arching renewable fuels mandate (T). The nesting creates a renewable fuel gap (C=T-A) for which maize starch ethanol qualifies (Table 2 and Figure 2). As they are minimums, over production in each category can be used to meet the larger, less restrictive mandate. That is to say advanced fuels, for example sugarcane-based ethanol, blended in excess of the advanced mandate, could be used to satisfy the total renewable fuels mandate, crowding out maize starch ethanol, but the reverse is not true. This creates a hierarchy among the fuels based on the mandate classification while the physical product, in this case ethanol, is indistinguishable (Thompson *et al.*, 2009).

The legislated mandates shown in Table 2 show that while current mandate volumes allow for a dominant share of the total mandate to be met by maize ethanol (C), this volume grows more slowly than the overall mandate (T) and the implied need for advanced (A) and specifically cellulosic biofuels (S) continues to expand rapidly. In 2013, maize ethanol can compete for 83 percent of the total mandate volume. By 2015, the maximum volume that maize ethanol can count toward the mandates stops growing; by 2020, it can access only 50 percent of the mandate volumes, and the share continues to fall.

As the different biofuels are basically indistinguishable for consumers they cannot be priced differently at retail[8], and thus the additional benefits are translated into price incentives via an electronic tracking system of traceable mandate obligations. The electronic classification instrument used for tracking mandate compliance, the Renewable Identification Number (RIN), is what differentiates the renewable fuels in the wholesale market. The RIN identifies the highest of the four classifications the renewable fuel can qualify for, the volume and the vintage of production. The RIN is obtained by the producer for each batch of fuel created and registered with the EPA tracking system. The RIN must accompany the fuel, and can only be separated from the fuel when blended. Thus, the wholesale price of the biofuel reflects the embedded value of the RIN. Once the renewable fuel is blended, RINs can be separated and used for compliance or sold to other blenders to meet their obligation in lieu of their own physical blending, much like a "book and claim" system (Schmitz, 2007). It is possible, and even likely, that each class of RIN will have a different price in the compliance market and so although fuels may be physically identical, at the wholesale level they can have different prices based on mandate compliance (Thompson *et al*., 2011). This differentiation through RIN classification of the commodity by process or inputs versus physical characteristics opens the door for arbitrage where a physically identical product is cross shipped between countries or trade is reorganized based on different compliance systems.

It is generally assumed that much of the implied advanced gap (O) of the RFS2 would have to be sourced from imported sugar-cane ethanol or through additional use of bio-based diesel above its own mandate, as no other competitive fuels currently exist in the United States (FAPRI, 2012; OECD/FAO, 2012). The size of the undefined advanced gap is likely to influence both the volume of US imports of ethanol from Brazil and volume of ethanol the US sends back to Brazil.

4. THE SHORTFALL IN CELLULOSIC BIOFUELS AND THE POTENTIAL FOR RAPID GROWTH IN TRADE

The Environmental Protection Agency (EPA), faced with inadequate productive capacity to meet the cellulosic biofuel mandate as legislated for 2010-2013, was forced to reduce the mandate significantly while *choosing* to leave the total and advanced mandate in place. In reality, production has never exceeded 1 percent of the original target in a given year. The shortfall in cellulosic ethanol coupled with the EPA decision to maintain the other mandates means that the size of the implied undefined advanced gap has grown and even created the need for undefined advanced fuels in 2011 (Table 4). This prompted US ethanol imports from Brazil, and plentiful supplies of maize starch ethanol in the US prompted increased ethanol exports, much of this to Brazil where domestic production of sugar-cane ethanol lagged behind domestic demand.

Table 3: Adjustments to the US cellulosic biofuel mandates by the Environmental Protection Agency (EPA)

	2010	2011	2012	2013
	(million gallons)			
Cellulosic biofuel mandate in EISA-2007	100	250	500	1000
Cellulosic biofuel mandate set by EPA waiver	6,5	6,6	8,65	14
	(percent)			
EPA quantity as a % of EISA legislation	6,5	2,6	1,7	1,4

Source: US Environmental Protection Agency Rule Making for EISA 2007 Legislation

Setting aside any shortfall in cellulosic production, the potential (mandate-driven) market for imported ethanol in the US, through the undefined advanced gap (O), is set to grow to 3.08 billion gallons by 2022 (Table 2). If cellulosic ethanol production continues to lag expectations and the EPA continues with its current policy of maintaining the other mandates while reducing the cellulosic mandate, the situation quickly becomes untenable. For exposition, if it is assumed that 25 percent of the cellulosic mandate can be met, the potential need for advanced fuels, would grow to 15.08 billion gallons by 2022 (Table 4). This volume exceeds total annual ethanol production in Brazil in recent years and is clearly large enough to distort trade significantly between the two markets.

Table 4: Actual and projected waived cellulosic mandate level and resulting new undefined advanced gap in million gallons

	2009	2010	2011	2012	2013	2014	2015
	(million gallons)						
Waived cellulosic mandate (SW)	0	25	25	33	250	438	750
New undefined advanced gap (OW) = (A-1.5*B-SW)	0	0	125	467	580	1393	2830
	2016	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
	(million gallons)						
Waived cellulosic mandate (SW)	1063	1375	1750	2125	2625	3375	4000
New undefined advanced gap (OW) = (A-1.5*B-SW)	4268	5705	7330	8955	10455	12705	15080

Source: Authors' interpretation and outlook for implementation of EISA 2007

5. ETHANOL DEMAND AND THE BLEND WALL

While the scenario in Table 4 outlines a situation where the US could import over 15 billion gallons of ethanol from Brazil, the ability of the US market to absorb such large volumes of ethanol on top of a presumed 15 billion gallons of maize ethanol is uncertain. Until recently, ethanol blending rates in the US for conventional vehicles were capped at 10 percent blends (E10). The number of flex fuel vehicles (FFVs) which can take up to 85 percent ethanol is limited, and most of the existing E85 dispensing locations are concentrated in the Midwest, away from the population centres on the coasts. With motorfuel demand between 140 and 150 billion gallons annually and ethanol disappearance in the US exceeding 14 billion gallons in 2011 with minimal sales of E85, the 10 percent blend market is approaching saturation (Thompson *et al.*, 2012). Recent rulings by the EPA allow cars produced in the year 2001 or later to use up to 15 percent blend ethanol fuels but impediments remain. There is no physical difference between the cars produced before 2001 and those produced after that date, so ensuring that consumers do not dispense inappropriate fuel, either inadvertently or purposefully, is difficult to monitor and retailers have expressed concern about liability in such circumstances. Many new car warranties also specify a limit of E10 even today. There are also a limited number of dispensing options on consumer pumps and there may simply not be enough “room at the pump” to dispense both E10 and E15. All of these obstacles have worked to constrain E-15 dispensing and use, limiting the outward movement of the blend wall (Wisner, 2012). Further declines in motorfuel use through increased Corporate Average Fuel Economy (CAFE) standards, which vehicle manufacturers must adhere to, or consumer response to higher fuel prices only exacerbate the problem by shrinking the fuel market and increasing the needed blending rates, as the mandates are in fixed volumes.

The presence of the blend wall will also shape the competition to fill the implied advanced gap. Imported ethanol will need to be absorbed into the motorfuel supply, driving up compliance costs and pushing down the value of ethanol in the retail market. This will push excess US ethanol production, beyond that which can be allocated towards the implied renewable fuel gap, out into the export market as opposed to being consumed domestically. The blend wall may also allow for excess biodiesel (quantities beyond that needed to meet its own mandate (B)) to compete more effectively with imported sugar-cane ethanol in filling the undefined advanced gap (O) as the constraints on the consumption chain in the distillate market are less binding. Biodiesel prices and their associated RIN price may then play a role in the speed and extent of intra-industry trade in ethanol between the United States and Brazil. The US use of biodiesel to fill part of the undefined advanced gap may not eliminate the cross trade but may simply change the product mix exchanged. The US may choose to import some of its biodiesel needs from South America and return ethanol to those markets. Brazil also has an expanding minimum blend rate for biodiesel[10], further complicating the potential exchange of ethanol and biodiesel between the two countries.

The intra-industry trade between Brazil and the US is unlikely to be a litre for litre, and the ratio of trade is likely to fluctuate from year to year based on relative feedstock prices (sugar and maize), the blend wall, transportation costs and oil prices. Shipping costs are ultimately borne by motorfuel consumers in both countries. The relative elasticities under policy effects, or how consumer demand responds to changes in the increase in price from transportation costs, will determine who pays for the transport and, ultimately, the number of ethanol ships passing on the high seas. The more restrictive the policies are in Brazil, in terms of blending requirements, the greater the intra-industry trade is likely to be. This can be incredibly context dependent as well. In a market situation where the ethanol blend requirement in Brazil is not binding (consumers demand more than the minimum requirement) but in the US, the advanced mandate is binding (consumers would like to purchase more but are constrained by the legislation), the lack of demand flexibility (elasticity) in the US market, means US consumers are likely to pick up most of the cost of transport and little ethanol may return to Brazil in cross-trade.

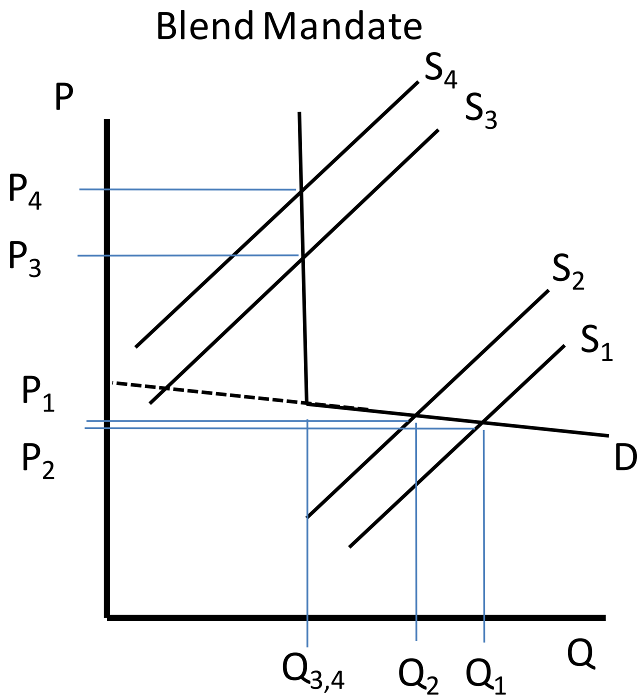
6. BRAZIL POLICY AND RESPONSE

The 1973 oil embargo and the associated jump in oil prices came at a time when Brazil was importing over 80 percent of its domestic fuel consumption and low international sugar prices were putting significant economic pressure on producers (Hira and de Oliveira, 2009). The National Alcohol Program (Proálcool) was established in 1975 with the goal of improved foreign exchange and rural and agricultural development. Ethanol was promoted through heavy market intervention including fixed pricing, obligatory purchases and tax reductions on ethanol and neat fuel cars that consume pure ethanol (E100). Minimum blends were established for ethanol-gasoline blending, which required no immediate action for car manufacturers; however, the ongoing market intervention spurred the sale of neat vehicles throughout the 1980s (UNICA, no date). Increasing sugar prices, lower petroleum prices and an increase in the fixed sales price of ethanol significantly stressed the industry; during the first half of the 1990s Brazil was an importer of ethanol (Rosillo-Calle and Corez, 1998). In 1993, the Brazilian government passed a law mandating that all gasoline would be blended at 20 – 25 percent ethanol inclusion rates. By the end of the 1990s, both anhydrous and hydrous ethanol prices had been liberalized along with gasoline and sugar markets, although ethanol still maintained a tax advantage relative to gasoline.

In 2004, the sale of FFVs took off in Brazil as the government provided the same tax breaks for the purchase of FFVs as it did for neat vehicles. The expansion of FFVs was rapid: they represented the majority of automobiles and light duty vehicle sales by 2005, and more than 90 percent of the sales by 2008. Currently, ethanol entering the motorfuel market in Brazil is consumed in two ways: first as pure ethanol (E100) by the ageing fleet of neat fuel vehicles, whose sales numbers have plummeted; second, blended with gasoline in the FFV fleet that dominates current vehicle sales. Consumers with FFVs are able to use blender pumps when purchasing fuel and select the ethanol inclusion rate between the policy minimum and the FFV's technical maximum based on relative prices of ethanol and gasoline. The FFVs allow for a wide range of ethanol inclusion with the 20 – 25 percent policy blending requirement acting as a floor; consumers may be very responsive to prices until the blend minimum or the technical blend maximum become constraining. Consumers with neat fuel vehicles will be unresponsive to ethanol prices in the short run (they cannot substitute away from alcohol fuels) but they are likely to shift to other vehicles when replacing existing ones. The blending rate minimums support ethanol consumption but do not discriminate between feedstock or process in blending. The blending minimums then provide a mechanism to drive intra-industry trade.

In a stylized comparative static exercise (Figure 3) we can see that when US policy draws in ethanol imports from Brazil to satisfy the advanced mandate, ethanol market prices will rise prompting Brazil to re-import ethanol to satisfy market or legislative demand. The determinant of replacement volume depends on the position of available domestic supplies relative to consumer demand and mandated quantities (based on prescribed blending rates). The shift in supplies available for domestic consumption can occur either through production shortfalls or from increased trade demand. If the market equilibrium in Brazil is such that the blend mandate is not binding (reflected by S1-D in Figure 3), an increase of imports from the US would reduce domestic supply from S1 to S2 with consumers being able to reduce their consumption of ethanol in Brazil by cutting the inclusion rate at the pump for FFVs, and much of the adjustment in the Brazilian ethanol market may come through reduced domestic demand (Q1-Q2) resulting in a small price change (P1-P2) that may be insufficient to draw in large quantities of foreign ethanol to replace the exported volume. If the domestic blend mandate is more constraining (S3-S4), effective demand will be less responsive (Q3-Q4) and ethanol prices will rise (P3-P4), inducing greater imports from abroad, with the US as the likely supplier as seen in 2011.

Figure 3: Brazilian ethanol market behaviour



Source: Authors' elaboration

7. INTERSECTION WITH EUROPE'S RENEWABLE ENERGY DIRECTIVE (RED)

The discussion of policy-induced intra-industry trade has thus far been limited to the main elements of US and Brazilian policies. However, even though the EU has been a minor importer of Brazilian (or for that matter US) ethanol due to its focus on biodiesel as the main component of the biofuels mix (covering over 80 percent of the biofuel consumption in 2011 [USDA FAS, 2011]) recent developments in EU policies and transportation fuel market factors have the potential to boost ethanol demand in the future, increasing biofuel trade flows between the EU, US and Brazil.

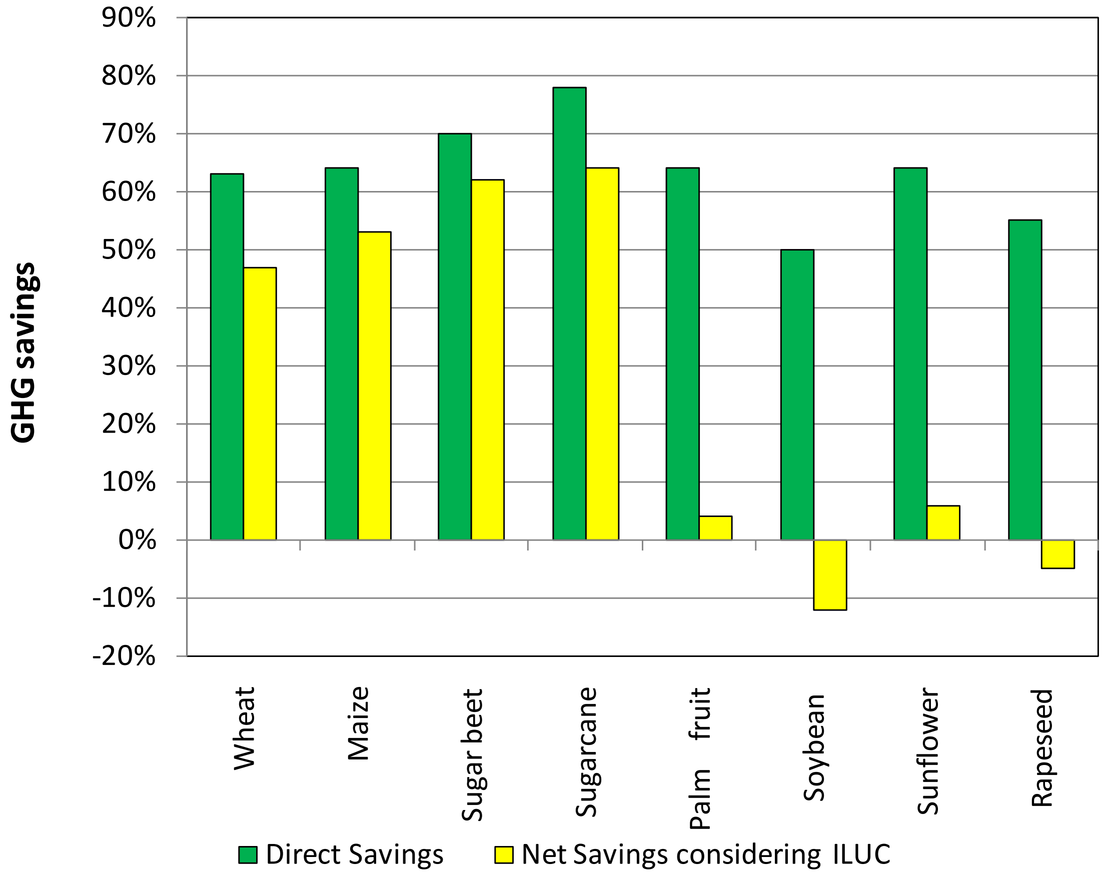
8. EU POLICIES

The EU policy framework to promote renewable energy sources for transportation dates from 2003 and to the Directive 2003/30/EC, which foresaw a non-binding target of 5.75 percent market penetration for renewable transportation energy by 2010. While an exact impact assessment of Directive 2003/30/EC is not available, preliminary estimates suggest that the target will be or has been missed (Sorda *et al.*, 2010; EC, 2012). In response to the low uptake, the renewable energy in transport targets (RED) were extended to 2020, increased to 10 percent and made binding as part of the climate change and energy package of 2009.[11] While the new package's targeting for renewable energy in transport allows different renewable energy sources (i.e. renewable electricity, hydrogen, biofuels, and other second- generation and non-land based biofuels) to count towards the overall 10 percent target, the actual implementation of the Directive has focused mainly on biofuels (Klessman *et al.*, 2011). The latest projections by member countries for their National Renewable Energy Action Plans show that 88 percent of the target will be covered by traditional biofuels (Beurskens *et al.*, 2011, Pacini *et al.*, 2013), and within biofuels, three-quarters will come from biodiesel.[12]

The climate change package also established minimum targets for GHG emission reductions. These foresee savings of 35 percent compared to fossil fuels during their life cycle up to 2017, rising to 50 percent savings by 2018 and to even 60 percent for installations starting production after 2017.[13] The climate change package also included sustainability criteria which would require verification schemes for the achievement of the GHG reduction targets. Tax exemptions and quotas provide the main incentives to reach these targets (EC, 2012).

The need to take GHG-saving requirements into account opens two possible cases: one in which potential savings include the effects of indirect land-use change (ILUC) and the other where savings are defined through their direct impacts only. Figure 4 summarizes the saving potential for a range of biofuel feedstocks and suggests that the impacts are vastly different, depending on ILUC and on whether the feedstock is used for biodiesel or ethanol production. Excluding ILUC, essentially all feedstocks, regardless of whether they are used for biodiesel or bioethanol, would clear the 50 percent GHG reduction hurdle. Disregarding possible blendwall limits for biodiesel (see below), this would suggest a continuation of current trends for feedstock use and biofuel production. Including ILUC, in contrast, (e.g. as reported by Laborde (2011)) would essentially eliminate all traditional biodiesel feedstocks under the climate change package of the RED. Other things being equal, such a scenario would suggest the EU would have to undergo a massive shift from biodiesel to ethanol and, within the ethanol use, the EU would have to source its needs from feedstocks that provide enough GHG-saving potential. In practice, only cane-based ethanol would qualify and only Brazil has the potential to supply these extra quantities. Projections by Laborde (2011) show that to meet the mandate by 2020, the EU would need to import sugarcane equivalents from Brazil to the tune of 6 500 ktoe, thus inducing an increase in land devoted to sugarcane of under 500 000 hectares if import tariffs for ethanol[14] remain in place and close to 1 million hectares if trade is liberalized.

Figure 4: EU Biofuel GHG reduction scoring



Source: Laborde, D. (2011).

Considering an average yield for Brazil of 96.7 tonnes per hectare this implies that the EU27 would be importing between 48 and 96 million tonnes of Brazilian sugar-cane equivalents, which would imply 3.5 billion million litres (920 million gallons) when transformed into ethanol.[15,16] In practice, such increases in ethanol imports may fail to materialize fully simply because the fleet composition in the EU, with its strong focus on diesel vehicles, would not allow these quantities to be absorbed. Such a shift would require an increase in blend rates for ethanol to more than 45 percent, i.e. a shift the EU car fleet is not prepared for technically. As such, a massive increase in imports of cane-based ethanol by the EU may also increase the need for Brazil to cover its own mandatory blending requirements, spurring Brazil's own import needs. These, in turn, could only be covered by US maize ethanol exports to Brazil.

Current EU biofuel policy within the Renewable Energy Directive (RED) remains in flux as a result of a recent European Commission determination to include indirect land-use change (ILUC) to calculate GHG savings and to cap "food commodity" feedstocks at 5 percent of the 10 percent renewable energy in transport target by 2020. While both the US and EU will now include ILUC calculations, they arrive at significantly different scores and apply different criteria for fuels to qualify for compliance. In the EU, the inclusion of ILUC eliminates most biodiesel products from RED compliance, but qualifies most ethanol products. EU ethanol production will then compete with potentially cheaper imports. The current policy, which would require actual trade in ethanol to satisfy the mandate, involves the implementation of sustainability criteria using a mass balance system as opposed to a book and claim system (Article 18 of the RED). This was put in place to assure that the biofuels targets promoted additional production of sustainable biofuels. If the US imports significant volumes of ethanol from Brazil to meet its advanced mandate, excess US ethanol produced from maize may find its way into European markets to meet up to half of the target of 10 percent renewable energy in the transport sector.[17] Idled EU biodiesel capacity could then be redirected to export markets.

9. BIOFUEL TOURISM ISN'T EXCLUSIVELY INTERNATIONAL

Independent policies between government entities which result in little net gain in biofuel use are not restricted to national governments. Under California Executive Order S-1-07[18], the California Air Resources Board (CARB) has implemented the Low Carbon Fuel Standard (LCFS) which rates individual fuels based on their GHG reduction score and sets a target for the reduction of GHG emissions.[19] The policy requires the fuel to be consumed within California, but the RINs associated with the fuel can still be used to comply with the nation-wide RFS2. Renewable fuels can therefore be counted both towards the LCFS and RFS2 as long as the fuel is consumed within the state; however, differences in GHG reduction scores between California and the EPA will affect production processes or fuel types. Under RFS2 threshold levels, there is no incentive to further improve the GHG reduction score once the renewable fuel pathway exceeds the desired mandate. Under the LCFS, in theory, each improvement in the pathway would be accompanied by a larger GHG reduction score which would increase the value of the fuel in California. However, the impact of the LCFS in decreasing US GHG emissions is muted by the fact that a single unit of fuel can be used to comply with both state and national regulations.

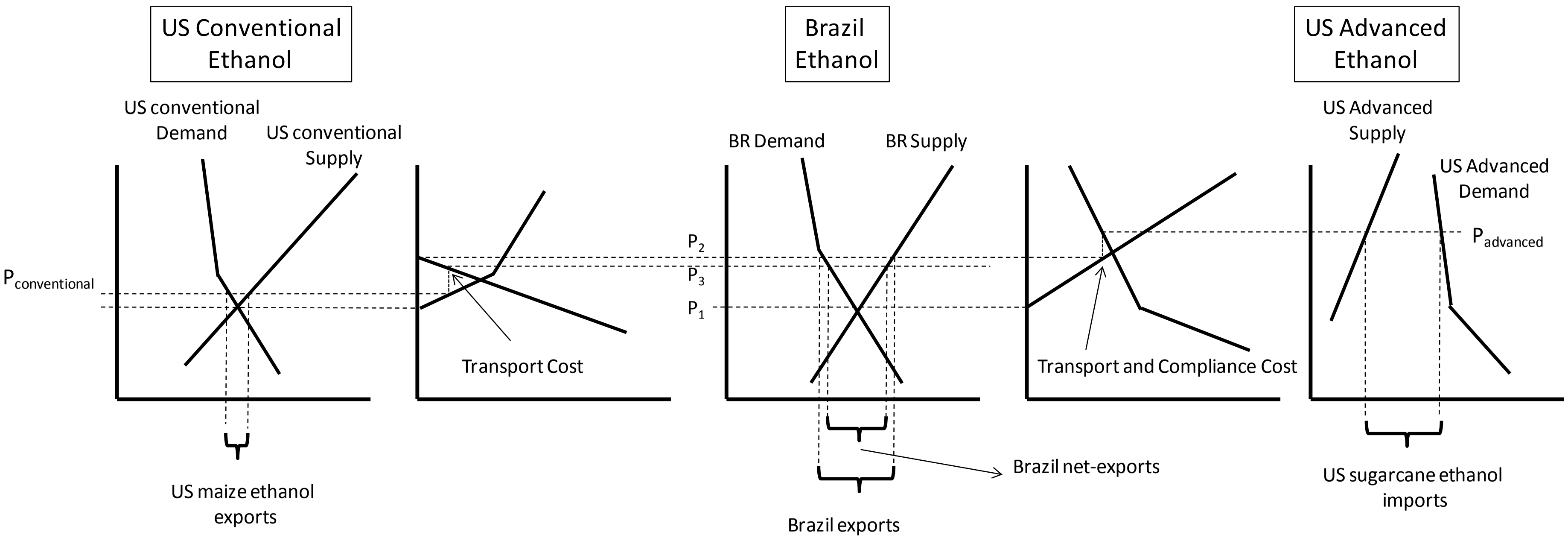
Brazilian imports may be diverted to California ports to comply with the LCFS, with the RINs generated then traded to other states. Biodiesel could be produced and consumed in the Midwest and the RINs traded to California blenders for compliance with the RFS2 in isolation; however, with the overlapping LCFS policy, the biodiesel — and not the electronic credits — must travel to California, reducing some of the GHG savings by the need to transport the fuel. While California GHG emissions would fall under the LCFS rule, the fact that RINs are likely to be generated and could be sold to the other 49 states would lower their GHG savings and the net effect on GHG emissions would be uncertain once transport of the biofuels is considered. The consumer cost of renewable fuels could rise due to the need to transport the renewable fuel to California (Kaufman et al 2009) and Californians will bear a larger share of the national cost for meeting the mandate obligations under RFS2 while simultaneously complying with the LCFS.

10. POLICY DRIVEN INTRA–INDUSTRY TRADE EFFECTS AND SOLUTIONS

While the intersection of Brazilian and US biofuel policy provides the necessary condition for intra-industry trade of physically identical but policy differentiated biofuels, other factors will determine if and to what extent this will happen. Figure 5 graphically illustrates the adjustments that must occur in the Brazilian market and the two differentiated US markets. The figure approximates the conditions found during the latter part of 2011 when mandated demand in the US conventional ethanol market was (marginally) not binding and imports from Brazil represented the low-cost advanced biofuel option with a strongly binding US advanced mandate and the Brazilian minimum blending requirement was also (marginally) binding. In effect Brazil cleared the ethanol market by supplying to the US advanced biofuel market while making up for those exports through imports of maize ethanol from the US market. This results in policy induced trade between the two countries, which also incur transportation costs (and associated GHG emissions). It drives up ethanol prices in Brazil, the extent of which depends critically on the size of domestic supplies relative to Brazil's own blending mandate and where domestic demand sits relative to that mandate (as discussed in Figure 3). With higher Brazilian ethanol prices, the US conventional ethanol market may then send supplies back to Brazil, incurring additional transportation costs and releasing GHG emissions, but moderating some of the ethanol price impacts of US policy in the Brazilian ethanol.

The net result is higher ethanol prices in Brazil, higher conventional ethanol prices in the US, lower advanced ethanol prices in the US (than in the absence of trade) and additional transportation costs. The actual volume of trade and the size of the price changes will depend on a wide range of factors. As an example of just one of these, the price of oil will influence market demand relative to mandated quantities. If oil prices move higher, this potentially pushes demand for ethanol beyond mandated quantities (depending on how constraining the US blend wall may be) and increases the value of maize ethanol relative to gasoline in both the US and Brazilian markets. With both US and Brazilian markets operating on a more elastic portion of the demand curve, all else equal, this would likely reduce the ratio of intra-industry trade between the two countries as US import demand to fill the advanced mandate would not induce such a large price change in Brazil, limiting the response by US exporters.

Figure 5: A supply and demand representation of how the Brazilian ethanol market clears the US advanced biofuel and conventional biofuel markets, including transportation costs.



Source: Authors' interpretation

Sugarcane and maize yields also play a critical role in determining the ratio of intra-industry trade but their yields are likely to have opposing effects on the volume of ethanol trade. Above trend sugarcane yields are likely to increase available supplies of ethanol in Brazil, expanding supplies relative to their own policy-induced needs and thus reduce the need to replace exports drawn out by US policies. Conversely, low maize yields in the US are likely to lead to a binding total mandate in the US and reduce "excess" supplies of maize starch ethanol which could be shipped to Brazil in exchange for mandate-driven imports.[20] This describes the market situation with the onset of drought in the United States in the summer of 2012. Figure 2 shows a surge in Brazilian shipments of ethanol to the United States while US exports to Brazil shrink noticeably. Imports continued to come into the United States to satisfy the expanding undefined advanced gap, not because of the US drought. The quantities imported are roughly that necessary to cover the mandate (undefined advanced gap). Meanwhile, US exports back to Brazil slowed due to a combination of plentiful Brazilian domestic supplies and surging maize prices in the US which reduced US export competitiveness in Brazilian ethanol markets.

Relative demand and supply elasticities in the two markets (as influenced by policies and the blend wall which will make such demand highly non-linear) and the market context (oil and feedstock prices) will ultimately determine the volume of ethanol exchanged. The size of the advanced mandate market in the US is set to expand rapidly in the next decade, making intra-industry trade much more likely and at substantially larger volumes.

11. THIS TRADE IN ETHANOL BRINGS WITH IT BOTH CONSUMER COSTS AND GHG EMISSIONS

While an important motivation of biofuel policies is to reduce GHG emissions associated with the use of motorfuel, there is potentially significant efficiency loss in meeting that objective. The transport of ethanol between Brazil and the US generates additional GHG emissions, and those flows identified as policy driven intra-industry trade work against this stated biofuel policy objective. At a minimum, motorfuel consumers in the US will incur the shipping costs from Brazil. At $0.08 cents per litre, by 2022 this could be $4.5 billion annually just in transport costs for the imported ethanol, not counting for any return trade. Ultimately the cost of transportation, both the US imports from Brazil and any fuel returned to Brazil, must be borne by motorfuel consumers in both countries. The transport of Brazilian sugarcane ethanol to the US for distribution also emits 3.2 gCO2e/MJ or approximately 12 percent of the total emissions from consuming the fuel in the US.[21] Similar emissions could be prevented on the volume of ethanol exported from the US to Brazil.[22] A system of tradable obligations for both the United States and Brazil (and, according to the same arguments, the EU) could avoid the transportation costs and reduce GHG emissions beyond those generated by the uncoordinated policies of each country. The reduction in transportation would tie the markets more closely together which under certain regimes could reduce feedstock price volatility (sugar, maize and oilseeds).

While a change in individual country policies could potentially yield greater efficiency, a tradable system of obligations between countries, similar to that employed in the United States or the "book and claim" system as proposed but not implemented in the EU, could potentially increase the efficiency of *current* policies in achieving GHG reduction goals at lower costs for consumers. The US already implements a compliance system for certifying imported ethanol from Brazil that would facilitate this interaction of policies between the two countries, and thus minimal additional costs would be associated with program implementation in the US. The RINs created when the ethanol is produced in Brazil would still be created but then only those RINs would be required in the US for compliance with the RFS2, eliminating the need to transport the physical ethanol.

In order to avoid double counting in Brazil, obligations toward its blending minimum would be converted to a RIN system. In this system, the Brazilian sugarcane ethanol, which had RINs sent to the US for its mandate compliance could not be counted toward Brazilian blending minimums, now based on holding sufficient RIN volumes to equal 20 percent of the volume of fuel sold and not based on the physical blending of every individual gallon of motorfuel at a minimum of 20 percent. If Brazil needed additional ethanol beyond the unobligated physical sugarcane ethanol on-hand to meet its blending minimum it could obtain conventional RINs from the United States, again eliminating the need to transport physical ethanol. The physical quantity of ethanol consumed by the Brazilians could deviate from the blend minimum but the minimum net-consumption across both countries would remain constrained by individual country policies.[23]

12. CONCLUSIONS

Current uncoordinated policies in the United States, Brazil and the European Union encourage intra-industry trade of physically homogeneous biofuels which is in contradiction with policy objectives of reducing greenhouse gas emissions. The implementation of the European Union RED may encourage additional US intra-industry trade with Brazil or further exchange of ethanol and biodiesel among the three countries based in part on differential GHG scoring based on feedstocks, fuels and processes. The scope for intra-industry trade only increases with the expansion of US mandates, in particular the advanced mandate, over the next decade, given the advanced biofuels mandate is set to increase rapidly and the prospects for meeting this through cellulosic ethanol production remain limited. Medium-term limits in consumption (blend-wall) in the US for ethanol and for both ethanol and biodiesel in the European Union (even trade motivated by a mass balance system) are likely to contribute to the expanding intra-industry trade. Intra-industry trade — and even trade motivated by a mass balance system as in the EU — could be eliminated, costs reduced and GHG emissions lowered by a inter-country book and claim system that would allow for multi-country objectives in the use of biofuels while improving the efficiency of government programs for consumers and for the reduction of GHG emissions. The intra-industry trade we have seen to date remains the “tip of the iceberg” as policy mandated quantities expand. Existing policies may appear unsustainable, through high costs or politically sensitive volumes of imports. We suggest that if blending or consumption mandates for biofuels are going to be an enduring part of energy policies there is an opportunity for a more efficient system that respects differing national objectives in biofuel use through a ‘book and claim’ system.

ENDNOTES

1 During this period, the US imposed a $0.54 per gallon tariff on ethanol that was waived for Caribbean nations. Much of the ethanol from the Caribbean had its origins in Brazil.

2 Unit train price from Southwest Iowa to the Los Angeles Basin in California was $0.13 per gallon in 2007 (USDA, 2007). Transport costs from Brazil to the US were 0.18 Brazilian Reals per litre which, using an exchange rate of 2.15 Reals per dollar was approximately $0.32 per gallon (Crago *et al.*, 2010)

3 In consumer demand literature this refers to a credence attribute, i.e. one that consumers cannot evaluate even after purchasing and consuming a product (Roosen et al., 2007).

4 The gasoline excise tax was $0.04 per gallon and when blended at a required 10 percent a credit of up to $0.40 per gallon of ethanol could be claimed.

5 Ethanol Import Tariff of 1980.

6 As defined in the Energy Policy Act of 1992.

7 The implied advanced gap calculation is complicated by the fact that the biodiesel mandate is in physical gallons but each physical gallon qualifies as 1.5 gallons toward the advanced and total mandates. Therefore the gap is calculated as (advanced mandate – cellulosic mandate – bio-based diesel mandate*1.5) or zero, whichever is greater.

8 Consumers can only observe ethanol and biodiesel content, not its classification by mandate, unless a specific labelling scheme is put in place. However, evidence from consumer demand surveys do not show a high willingness to pay for biofuels (Gracia *et al.*, 2011).

9 http://www.afdc.energy.gov/fuels/ethanol_locations.html.

10 The blend rate was 5 percent in 2011 and expected to rise to 10 percent in 2014.

11 The Climate and Energy package implied the revision of three main pieces of EU legislation: the Renewable Energy Directive (Directive 2009/28/EC), the ETS Directive (Directive 2009/29/EC) and the Fuel Quality Directive (Directive 2009/30/EC).

12 Biofuels originating from primary forest, highly biodiverse grasslands, protected territories or carbon-rich areas are excluded.

13 21 649 kilotonnes of oil equivalent (ktoe) of biodiesel (65.9%) and 7 307 ktoe of ethanol (22.2%) out of a total of 32 859 ktoe of renewable energy in total transportation needs.

14 19.2 euro cents per litre or about 85 US cents per gallon.

15 Considering 73.71 litres of ethanol per tonne of sugarcane.

16 These figures also include the impact of increasing the current blending mandate in Brazil from 20 percent to 35 percent.

17 While both sugarcane ethanol and maize ethanol would qualify equally toward the 10 percent inclusion of renewable energy in the transport sector, the higher GHG reduction score for sugarcane ethanol would give it additional value toward meeting the overall 20 percent GHG emissions reduction target for the energy sector.

18 http://www.arb.ca.gov/fuels/lcfs/eos0107.pdf

19 http://www.arb.ca.gov/fuels/lcfs/lcfs.htm

20 Imports by the US to fill the implied advanced gap (O) will compete with biodiesel, in excess of its own mandate (B), which will be influence by the presence of the ‘’blend wall’,’ which will also influence the value of additional maize ethanol in the domestic (US) market relative to Brazilian markets where blend wall constraints are far more limited.

21 Taking care not to count local distribution which would still have to occur http://www.arb.ca.gov/fuels/lcfs/092309lcfs_cane_etoh.pdf

22 It is not clear to the authors if the possibility of cross-trade has been included in the life-cycle analysis for renewable fuel GHG reduction scoring or even how one might allocate such emissions.

23 A Brazilian RIN system would impose some additional compliance costs, but could also improve domestic market efficiency by removing the need to use the same blend in every gallon of gasoline, thereby taking advantage of any geographic pricing differences (arising through differences in ethanol transportation) in the country to adjust blend ratios above the required minimum.

REFERENCES

Beurskens, L., Hekkenberg, M. & Vethman, P. (2011). Renewable Energy Projections as Published in the National Renewable Energy Action Plansof the European Member States. European Research Centre of the Netherlands (ECN) and European Environmental Agency (EEA), Petten.

Crago, C.L., Khanna, M., Barton, J., Giuliani, E. & Amaral, W. (2010). Competitiveness of Brazilian Sugarcane Ethanol Compared to US Corn Ethanol. Poster prepared for presentation at the Agricultural & Applied Economics Association 2010, AAEA,CAES, & WAEA Joint Annual Meeting, Denver, Colorado, July 25-27, 2010

Energy Policy Act of 2005, Public Law 109–58 (2005).

Energy Independence and Security Act of 2007, Public Law 110–140 (2007).

European Commission (EC) (2012). EU Energy in Figures – Pocketbook 2012. Publications Office of the European Union, Luxembourg.

European Union Commission 2012 http://ec.europa.eu/energy/renewables/targets_en.htm

Food and Agricultural Policy Research Institute (FAPRI). (2012). "US Biofuel Baseline and Impact of E-15 Expansion on Biofuel Markets." FAPRI-MU Report 02-12. 2012.

Gracia, A., Barreiro-Hurlé, J. & Pérez y Pérez, L. (2011). Consumers' willingness to pay for biodiesel in Spain. European Association of Agricultural Economics 2011 Congress "Change and Uncertainty Challenges for Agriculture, Food and Natural Resources", 30 August to 2 September, Zurich (Switzerland).

Hira, A. & de Oliveira, L.G. (2009). No substitute for oil? How Brazil developed its ethanol industry. *Energy Policy*, 37: 2450-2456.

Kaufman, J., Thompson, W. & Meyer, S. (2009). "Implications of the Low Carbon Fuel Standard for State and National Ethanol Use," University of Missouri, Department of Agricultural Economics Working Paper No. AEWP 2009-05.

Laborde, D. (2011). Assessing the land use consequences of European biofuels policies. Report by ATLASS Consortium for DG TRADE under Framework Contract TRADE/07/A2, Brussels.

OECD/FAO. (2012). OECD-FAO Agricultural Outlook 2012-2021, OECD Publishing and FAO. http://dx.doi.org/10.1787/agr_outlook-2012-en

Roosen, J., Marette, S., Blanchemanche, S. & Verger, P. (2007). The effect of product health information on liking and choice. *Food Quality and Preference*, 18, 759–770.

Rosillo-Calle, F. & Cortez, L.A.B.. (1998). Towards ProAlcool II—a review of the Brazilian bioethanol programme, *Biomass and Bioenergy*, Vol.4(2), pp 115-124.

Schmitz, N. (2007). Certification to ensure sustainable production of biofuels. Biotechnology Journal, 2: 1474–1480. doi: 10.1002/biot.200700176

Sorda, G., Banse, M. & Kemfert, C. (2010). An overview of biofuel policies across the world, *Energy Policy*, 38: 6977-6988.

Thompson, W., Meyer, S. & Westhoff, P. (2009). "Renewable Identification Numbers are the tracking Instrument and Bellwether of US Biofuel Mandates", EuroChoices, 8(3): 43–50.

Thompson, W., Meyer, S. & Westhoff, P. (2011). What to conclude about biofuel mandates from evolving prices for renewable identification numbers? *American Journal of Agricultural Economics*, 93(2): 481–487.

Thompson, W., Meyer, S., P. Westhoff, & Whistance, J. (2012). "A Question Worth Billions: Why Isn't the Conventional RIN Price Higher?." FAPRI-MU Report 12-12, FAPRI, University of Missouri, Columbia, Missouri, December .

Sugar Cane Industry Association of Brazil (UNICA) (no date). Ethanol-powered automobiles statistics. Light vehicle sales [http://english.unica.com.br/dadosCotacao/estatistica/] Accessed 31/10/2012

USDA FAS. (2011). EU-27 Annual Biofuels Report, GAIN Report NL1013, USDA, The Hague.

USDA. (2007). Ethanol transport backgrounder. US Department of Agriculture, Agricultural Marketing Service, Transportation and Marketing Programs Transportation Services Branch, Washington DC. [http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5063605] Accessed 31/10/2012.

Wisner, R. (2012). Ethanol exports: a way to scale the blend wall? Renewable Energy & Climate Change Newsletter February 2012. Agricultural Marketing Resource Centre, Iowa State University.

SELECTED ICTSD ISSUE PAPERS

Agriculture Trade and Sustainable Development

US Farm Policy and Risk Assistance: The Competing Senate and House Agriculture Committee Bills of July 2012. By Carl Zulauf and David Orden. Issue Paper No. 44, 2012.
Net Food-Importing Developing Countries: Who They Are, and Policy Options for Global Price Volatility. By Alberto Valdés and William Foster. Issue Paper No. 43, 2012.
Trade Policy Responses to Food Price Volatility in Poor Net Food-Importing Countries. By Panos Konandreas. Issue Paper No. 42, 2012.
Trade Policy Options for Enhancing Food Aid Effectiveness. By Edward Clay. Issue Paper No. 41, 2012.
Possible Effects of Russia's WTO Accession on Agricultural Trade and Production. By Sergey Kiselev and Roman Romashkin. Issue Paper No. 40, 2012.

Competitiveness and Development

Una Evaluación De La Ayuda Para El Comercio En La Práctica. By Ricardo Paredes. Issue Paper No. 24, 2012.
Evaluating Aid for Trade on the Groung: Lessons from Nepal. By Ratnakar Adhikari, Paras Kharel and Chandan Sapkota, Issue Paper No. 23, 2011.
Evaluating Aid for Trade on the Ground: Lessons from Cambodia. By Siphana Sok, Cambodochine Dao, Chandarot Kang and Dannet Liv. Issue Paper No. 22, 2011.
Evaluating Aid for Trade on the Ground: Lessons from Malawi. By Jonathan Said, John McGrath, Catherine Grant and Geoffrey Chapman. Issue Paper No. 21, 2011.
Evaluating Aid for Trade Effectiveness on the Ground: A Methodological Framework. By Ratnakar Adhikari. Issue Paper No. 20, 2011.
EU Climate Policies and Developing Country Trade Vulnerability: An Overview of Carbon Leakage-Sensitive Trade Flows. By ICTSD. Issue Paper No. 19, 2011.

Dispute Settlement and Legal Aspects of International Trade

Conflicting Rules and Clashing Courts. The Case of Multilateral Environmental Agreements, Free Trade Agreements and the WTO. By Pieter Jan Kuijper. Issue Paper No.10, 2010.
Burden of Proof in WTO Dispute Settlement: Contemplating Preponderance of the Evidence. By James Headen Pfitzer and Sheila Sabune. Issue Paper No. 9, 2009.
Suspension of Concessions in the Services Sector: Legal, Technical and Economic Problems. By Arthur E. Appleton. Issue Paper No. 7, 2009.

Fisheries, International Trade and Sustainable Development

The Importance of Sanitary and Phytosanitary Measures to Fisheries Negotiations in Economic Partnership Agreements. By Martin Doherty. Issue Paper No. 7, 2008.
Fisheries, Aspects of ACP-EU Interim Economic Partnership Agreements: Trade and Sustainable Development Implications. By Liam Campling. Issue Paper No. 6, 2008.

Innovation, Technology and Intellectual Property

Fast-tracking Green Patent Applications: An Empirical Analysis. Issue number 37. By Antoine Dechezleprêtre, February 2013.
Unpacking the International Technology Transfer Debate: Fifty Years and Beyond. Issue Paper No. 36 by Padmashree Gehl Sampath and Pedro Roffe, 2012. Realizing the Potential of the UNFCCC Technology Mechanism. Perspectives on the Way Forward. Issue Paper No. 35 by John Barton, Padmashree Gehl Sampath and John Mugabe, 2012.
Bridging the Gap on Intellectual Property and Genetic Resources in WIPO's Intergovernmental Committee (IGC). By David Vivas-Eugui. Issue Paper No. 34, 2012.
The Influence of Preferential Trade Agreements on the Implementation of Intellectual Property Rights in Developing Countries. By Ermias Tekeste Biadgleng and Jean-Christophe Maur. Issue Paper No. 33, 2011.
Intellectual Property Rights and International Technology Transfer to Address Climate Change: Risks, Opportunities and Policy Options. By K. E.
Maskus and R. L. Okediji. Issue Paper No. 32, 2010

Trade in Services and Sustainable Development

Facilitating Temporary Labour Mobility in African Least-Developed Countries: Addressing Mode 4 Supply-Side Constraints. By Sabrina Varma. Issue Paper No.10, 2009.
Advancing Services Export Interests of Least-Developed Countries: Towards GATS Commitments on the Temporary Movement of natural Persons for the Supply of Low-Skilled and Semi-Skilled Services. By Daniel Crosby, Issue Paper No. 9, 2009.

Environmental Goods and Services Programme

Market Access Opportunities for ACP Countries in Environmental Goods. By David Laborde, Csilla Lakatos. Issue Paper No. 17, 2012
Facilitating Trade in Services Complementary to Climate-friendly Technologies. By Joy Aeree Kim. Issue Paper No. 16, 2011.
Deploying Climate-Related Technologies in the Transport Sector: Exploring Trade Links. By Rene Vosenaar. Issue Paper No. 15, 2010

Trade and Sustainable Energy

International Transport, Climate Change and Trade: What are the Options for Regulating Emissions from Aviation and Shipping and what will be their Impact on Trade? By Joachim Monkelbaan. Background Paper, 2010.
Climate Change and Trade on the Road to Copenhagen. Policy Discussion Paper, 2009.

Regionalism and EPAs

Questions Juridiques et Systémiques Dans les Accords de Partenariat économique : Quelle Voie Suivre à Présent ? By Cosmas Milton Obote Ochieng.Issue Paper No. 8, 2010.
Rules of Origin in EU-ACP Economic Partnership Agreements. By Eckart Naumann. Issue Paper No. 7, 2010
SPS and TBT in the EPAs between the EU and the ACP Countries. By Denise Prévost. Issue Paper No. 6, 2010.

Global Economic Policy and Institutions

Multilateral Negotiations at the Intersection of Trade and Climate Change: An overview of Developing Countries' Priorities in UNCSD, UNFCCC and WTO Processes. By Manual A. J. Teehankee, Ingrid Jegou, Rafael Jacques Rodrigues. Issue Paper No. 2, 2012.

These and other ICTSD resources are available at http://www.ictsd.org www.ictsd.org

ICTSD's Programme on Agricultural Trade and Sustainable Development aims to promote food security, equity and environmental sustainability in agricultural trade. Publications include:

- Agricultural Domestic Support and Sustainable Development in China. By Ni Hongxing. Issue Paper No. 47, 2013.
- The 2012 US Farm Bill and Cotton Subsidies: An assessment of the Stacked Income Protection Plan. By Harry de Gorter. Issue Paper No. 46, 2012.
- Potential Impact of Proposed 2012 Farm Bill Commodity Programs on Developing Countries. By Bruce Babcock and Nick Paulson. Issue Paper No. 45, 2012.
- US Farm Policy and Risk Assistance. The Competing Senate and House Agriculture Committee Bills of July 2012. By Carl Zulauf and David Orden. Issue Paper No. 44, 2012.
- Net Food-Importing Developing Countries: Who They Are, and Policy Options for Global Price Volatility. By Alberto Valdés and William Foster. Issue Paper No. 43, 2012.
- Trade Policy Responses to Food Price Volatility in Poor Net Food-Importing Countries. By Panos Konandreas. Issue Paper No. 42, 2012.
- Trade Policy Options for Enhancing Food Aid Effectiveness. By Edward Clay. Issue Paper No. 41, 2012.
- Possible Effects of Russia's WTO Accession on Agricultural Trade and Production. By Sergey Kiselev and Roman Romashkin. Issue Paper No. 40, 2012.
- Post-2013 EU Common Agricultural Policy, Trade and Development: A Review of Legislative Proposals. By Alan Matthews. Issue paper No. 39, 2011.
- Improving the International Governance of Food Security and Trade. By Manzoor Ahmad. Issue Paper No. 38, 2011.
- Food Reservesin Developing Countries: Trade Policy Options for Improved Food Security. By C. L. Gilbert, Issue Paper No. 37, 2011.
- Global Food Stamps: An Idea Worth Considering? By Tim Josling, Issue Paper No. 36, 2011.
- Risk Management in Agriculture and the Future of the EU's Common Agricultural Policy. By Stefan Tangermann, Issue Paper No. 34, 2011.
- Policy Solutions To Agricultural Market Volatility: A Synthesis. By Stefan Tangermann, Issue Paper No. 33, 2011.
- Composite Index of Market Access for the Export of Rice from the United States. By Eric Wailes. Issue Paper No. 32, 2011.
- Composite Index of Market Access for the Export of Rice from Thailand. By T. Dechachete. Issue Paper No. 31, 2011.
- Composite Index of Market Access for the Export of Poultry from Brazil. By H. L. Burnquist, C. C. da Costa, M. J. P. de Souza, L. M. Fassarella. Issue Paper No. 30, 2011.

About the International Centre for Trade and Sustainable Development, www.ictsd.org

Founded in 1996, the International Centre for Trade and Sustainable Development (ICTSD) is an independent think-and-do-tank based in Geneva, Switzerland and with operations throughout the world, including out-posted staff in Brazil, Mexico, Costa Rica, Senegal, Canada, Russia, and China. By enabling stakeholders in trade policy through information, networking, dialogue, well-targeted research and capacity-building, ICTSD aims to influence the international trade system so that it advances the goal of sustainable development. ICTSD co-implements all of its programme through partners and a global network of hundreds of scholars, researchers, NGOs, policymakers and think-tanks around the world.