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THE ECONOMIC COMPETITIVENESS OF U.S. ETHANOL

Prepared for the Renewable Fuels Association

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The U.S. grain ethanol industry is a highly competitive sector that continues to evolve and mature. After increasing nearly seven-fold between 2000 and 2009, total ethanol production has been relatively stable over the past four years averaging 13.4 billion gallons annually. Moreover, the ethanol industry is producing sufficient quantity to reliably supply the U.S. gasoline market with a 10 percent ethanol blend (E10) and is poised to meet demand for an E15 blend for approved motor vehicles. Reflecting this enhanced competitiveness and maturation, ethanol prices (both FOB plant and delivered at key U.S. markets) have declined, while crude oil and conventional gasoline prices remained stable or increased. Consequently:

1. U.S.-produced ethanol continues to improve its economic competitiveness relative to gasoline.
2. U.S. ethanol is routinely less expensive than anhydrous ethanol imported from Brazil.
3. But for the effects of the European Union (EU) countervailing duty and depreciation of the Brazilian real, ethanol produced in the U.S. would continue to be the most cost effective source of imported ethanol for the EU.
4. Ethanol is the most cost competitive source of octane, as well as oxygen to meet Clean Air Act requirements.

In short, U.S. ethanol has emerged as the lowest cost transportation fuel and octane source in the world over the past several years. This study addresses several issues relative to the competitiveness of American-made ethanol in three key U.S. markets: New York, Chicago and Los Angeles. This analysis uses price data covering the period of 2010 through 2013 from both public and commercial sources.[1]

[1] U.S. ethanol, RBOB, and gasoline prices were sourced from USDA/AMS, EIA, and OPIS. Brazilian ethanol prices were provided by the Center for Advanced Studies and Applied Economics (CEPEA). Trade data was sourced from the USITC Online Trade Database.

This is consistent with the period of stability mentioned earlier. Each of these issues is discussed in the following sections.

1. Ethanol costs less than gasoline in wholesale markets

Ethanol is blended with gasoline to add oxygen, enhance octane levels, and displace hydrocarbon gasoline. Typically, ethanol is splash blended with gasoline at a local terminal rack before delivery to retail stations. In the majority of the U.S., ethanol is blended with either a conventional gasoline blendstock specifically designed for blending with ethanol ("CBOB," Conventional Blendstock for Oxygenate Blending) or a blendstock used to produce gasoline compliant with USEPA regulations in designated reformulated gasoline (RFG) areas ("RBOB," or Reformulated Blendstock for Oxygenate Blending).[2] RFG is required in cities with high smog levels and is optional elsewhere. According to the USEPA, RFG is currently used in 17 states and the District of Columbia and about 30 percent of gasoline sold in the U.S. is reformulated.[3]

The three markets included in this study – New York, Chicago and Los Angeles – require RFG. Reflecting this, we have used RBOB rather than CBOB prices in our analysis. RBOB is slightly more expensive to refine than conventional regular gasoline or CBOB. For example, EIA data show that the price of RBOB at New York Harbor was 1.5 cents per gallon higher than conventional regular gasoline from 2010 through 2013. Figures 1 through 3 compare average monthly prices for RBOB, ethanol and E10 in New York, Chicago, and Los Angeles.

[2] A special RBOB formulation known as CARBOB is mandated by the California Air Resources Board.

[3] http://www.epa.gov/otaq/fuels/gasolinefuels/rfg/

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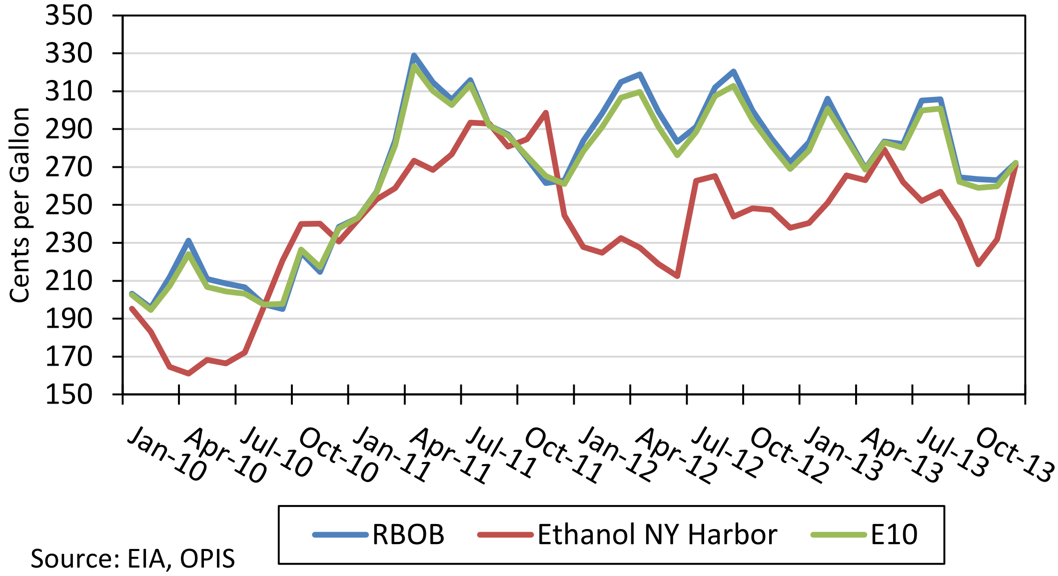
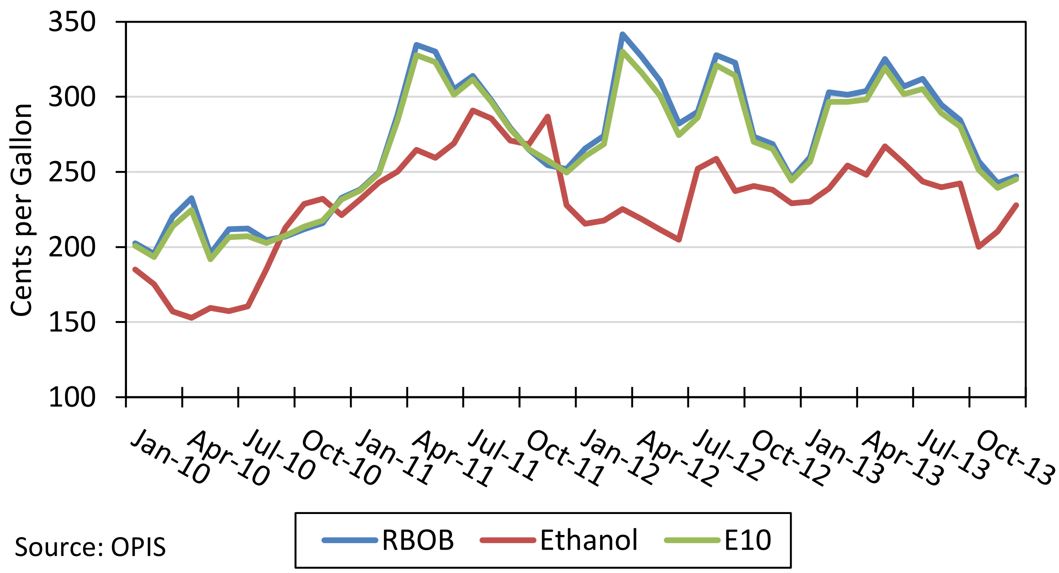
Figure 1
New York RBOB, Ethanol and E10 Prices



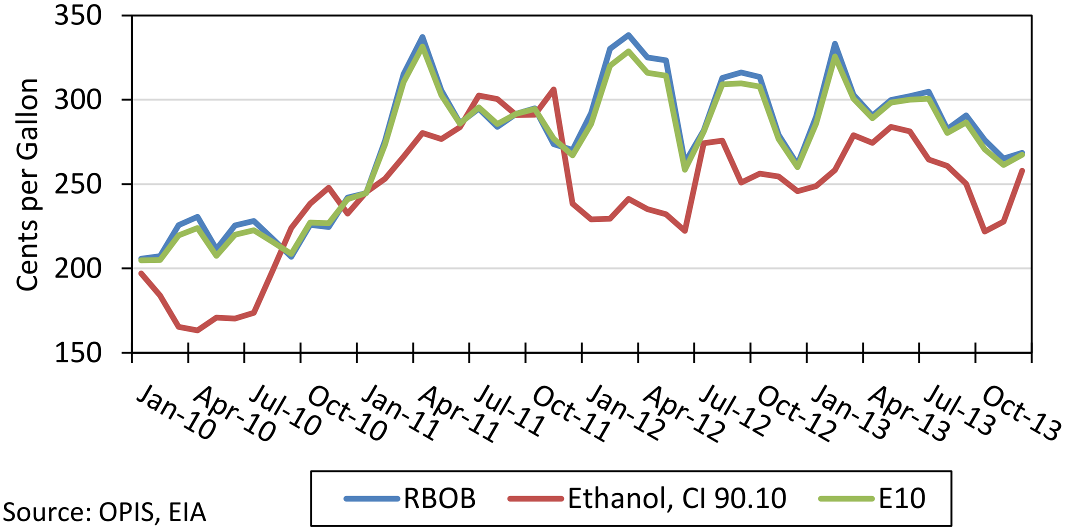
Source: EIA, OPIS

Figure 2
Chicago RBOB, Ethanol and E10 Prices



Source: OPIS

Figure 3
Los Angeles RBOB, Ethanol and E10 Prices



Source: OPIS, EIA

As can be seen in Table 1, RBOB prices are considerably higher than delivered ethanol prices in each market, with the highest difference in the Chicago market.[4] The "spread" between ethanol and RBOB has averaged 30 to 40 cents per gallon over the past four years in these three key markets, and the difference averaged more than 60 cents per gallon in 2012. Thus, ethanol blended with RBOB to produce reformulated gasoline at a 10 percent (E10) blend has reduced the cost of motor fuel to consumers. This does not include the additional downward impact ethanol has on gasoline prices as a result of extending supplies and reducing demand for crude oil.[5]

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[4] It should be noted that all or part of eight Illinois counties are required to blend ethanol with RBOB year-round. These counties represent 66 percent of the state's population. For the remainder of the state, there is a summer gasoline volatility season that limits gasoline's Reid vapor pressure (RVP) during the summer. E10 has been granted a waiver from the RVP requirement for those counties during the summer months. This means that these counties can offer E10 by blending ethanol with less expensive CBOB during the summer. Over the past several years, CBOB has been about 7 cents per gallon cheaper than RBOB in Chicago.

[5] See, for example, Hayes, Dermot J., Du, Xiaodong (May 2012) The Impact of Ethanol Production on U.S. and Regional Gasoline Markets: An Update to 2012. *Center for Agricultural and Rural Development (CARD).* http://www.card.iastate.edu/publications/dbs/pdffiles/12wp528.pdf.

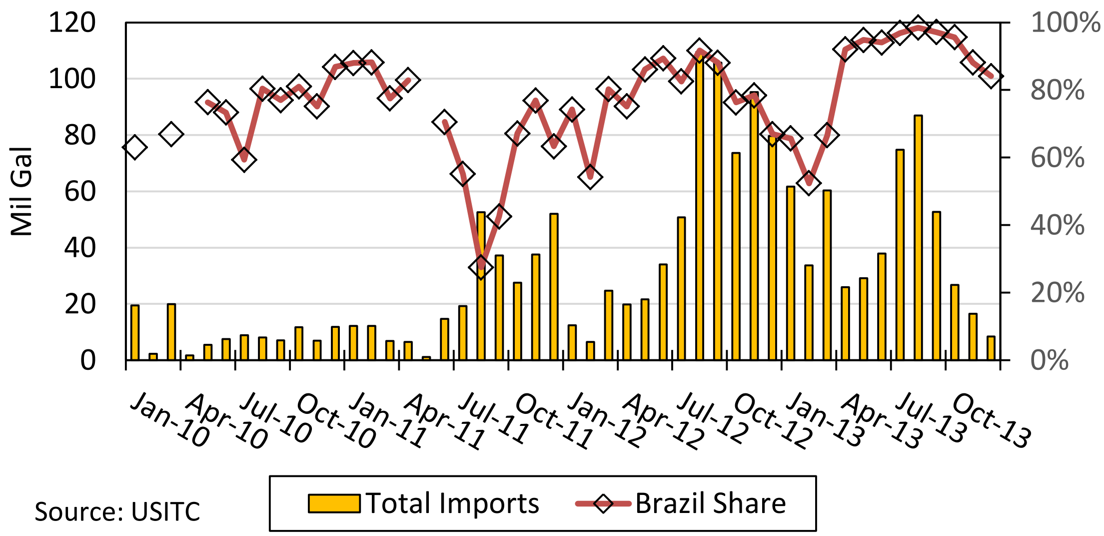
Table 1
Difference between RBOB and Ethanol Prices
(Cents per Gallon)

	New York	Los Angeles	Chicago
2010	16.7	23.8	26.2
2011	13.3	11.6	21.7
2012	60.8	57.5	65.0
2013	29.2	33.1	48.3
Average	30.0	31.5	40.3

2. Ethanol produced in the U.S. is less expensive than anhydrous ethanol imported from Brazil.

The U.S. typically imports a relatively small amount of ethanol, with Brazil serving as the major supplier. Figure 4 portrays the quantity of fuel ethanol[6] imported by month and the share of imports accounted for by Brazil. Most ethanol imported from countries "other than Brazil" is actually Brazilian hydrous ethanol that is dehydrated in other countries and re-exported to the U.S.

Figure 4
U.S. Fuel Ethanol Imports

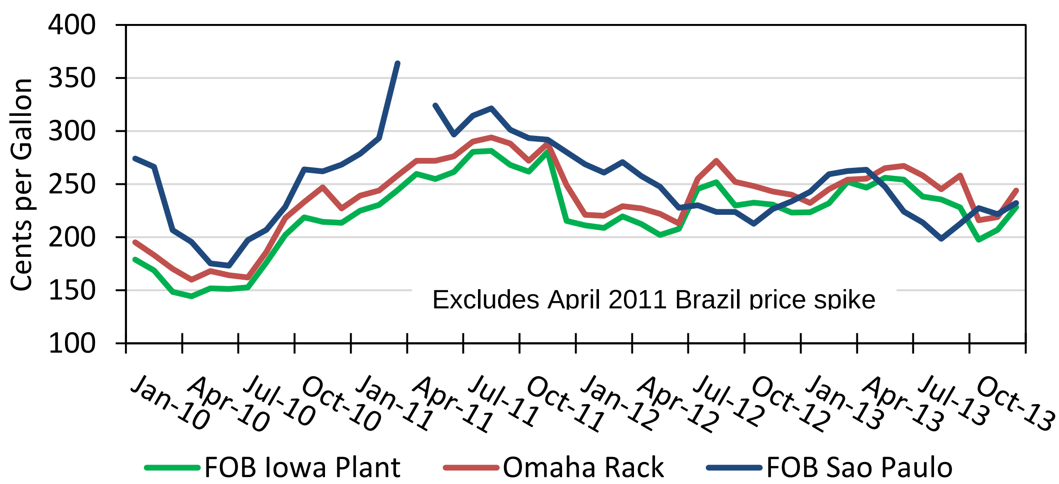


Source: USITC

[6] Source: USITC Interactive Tariff and Trade Database. HTS 220710610 and 2207106090. EIA reports the volume of U.S. imports of fuel ethanol by country of origin. USITC reports imports by country of origin and port of entry in customs value, volume, CIF value, and landed duty-paid value. These data can be used to calculate a landed-duty price.

The price of ethanol at the plant in the U.S. and Brazil is closely tied to the price of feedstock (corn in the U.S. and sugar in Brazil). Figure 5 compares the price of ethanol received at an Iowa ethanol plant, with the Omaha terminal rack price, and the FOB price in São Paulo, Brazil. In the past, Brazilian sugarcane ethanol was less expensive to make than corn-based ethanol produced in the U.S. However, record sugar prices in 2010, 2011 and 2012 caused by drought in Brazil pushed sugarcane ethanol prices above U.S. levels from January 2010 through mid-2012. While world sugar prices have declined from their 2010 peak, they remain considerably higher than typical pre-2009 levels. Brazilian ethanol prices soared to $1.50 per liter ($5.66 per gal) in April 2011 due to concerns that the demand for ethanol in Brazil would outstrip the ability of the industry to produce.[7] This price spike was an anomaly and prices returned to more "normal" levels within two months.

Figure 5
Ethanol Producer Prices, U.S. and Brazil



Source: USDA, NE Energy Office, CEPEA

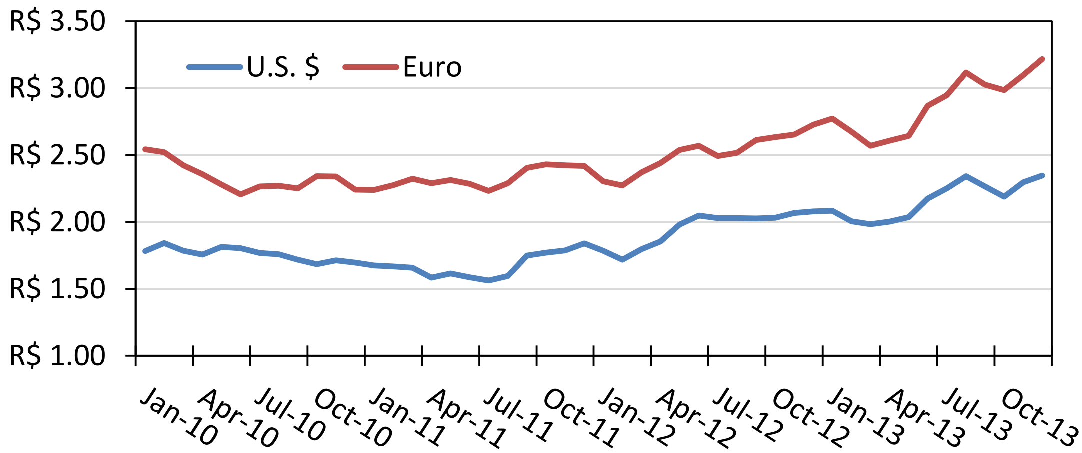
The price of ethanol at principal markets reflects producer costs and transportation costs. In the U.S., most ethanol moves by rail (80- to 100-car unit trains) from Midwest plants to both coasts. The primary transportation cost for U.S. ethanol is for rail transport, which is largely based on distance.

[7] Stephan Nielsen. "Brazil Ethanol at Record High, Price May Rise Again in 2012, Archer Says". Bloomberg. April 15, 2011. http://www.bloomberg.com/news/2011-04-15/brazil-ethanol-at-record-high-price-may-rise-again-in-2012-archer-says.html

Ethanol from Brazil is moved to U.S. ports by ocean tanker. The costs of waterborne freight reflect cost, insurance and freight (CIF) charges. The landed price of ethanol in U.S. markets is calculated by dividing the landed duty-paid value of fuel ethanol from Brazil by the quantity of imports. This price reflects the Brazilian producer price, exchange rates, duties, and CIF charges.

Exchange rate policy is one key factor that has affected the competitiveness of Brazilian ethanol both in the U.S. and EU. As shown in Figure 6, the real has depreciated by nearly 32 percent against the U.S. dollar and 28 percent against the euro between January 2010 and December 2013 and 49 percent and 41 percent, respectively, since mid-April 2011. The effect of this is to reduce the price of Brazilian ethanol in terms of dollars and euros and improve the relative competiveness of Brazilian ethanol. Still, even with depreciation of the real, U.S. ethanol has been more cost competitive than Brazilian ethanol in key U.S. and world markets over the past several years.

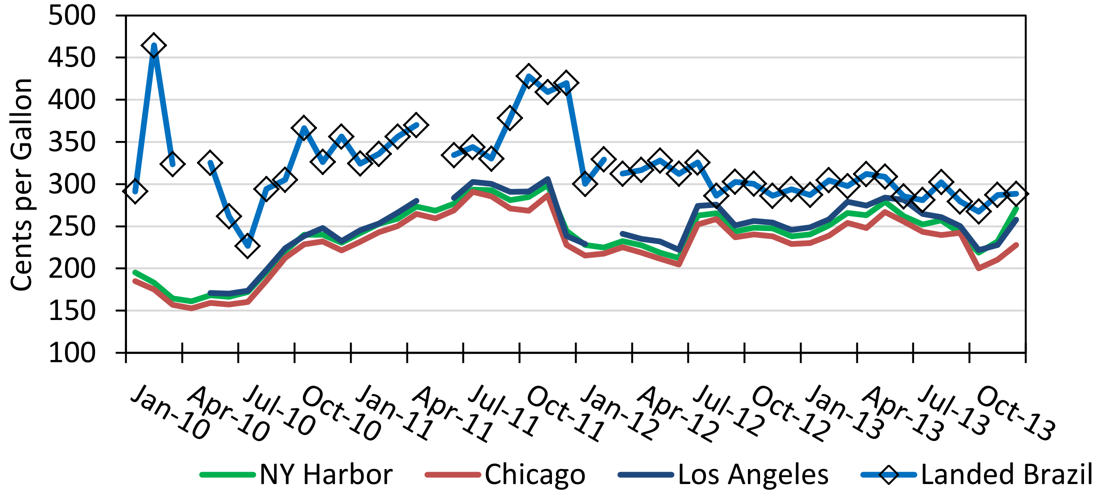
Figure 6
Brazilian Real Versus U.S. Dollar and Euro



Source: Federal Reserve Board

Figure 7 compares the delivered cost of fuel ethanol in key U.S. markets to landed duty-paid Brazilian ethanol at all ports by month, and Table 2 summarizes differences between landed Brazilian ethanol and delivered U.S. ethanol by year.

Figure 7
Delivered Ethanol Prices



Source: USITC, OPIS

Table 2
Difference between Landed, Duty-Paid Brazilian Ethanol and
U.S. Ethanol at Key Markets
(Cents per Gallon)

	Landed Brazilian Ethanol	U.S. Ethanol					
		NY Harbor	Diff to Brazilian	Chicago	Diff to Brazilian	Los Angeles	Diff to Brazilian
2010	313.6	194.9	118.7	185.6	128.0	197.1	116.5
2011	381.1	272.3	108.8	262.3	118.8	277.9	103.2
2012	300.1	237.5	62.6	229.1	71.0	245.6	54.5
2013	291.2	252.8	38.4	238.2	53.0	259.1	32.1
Average	321.5	239.4	82.1	228.8	92.7	244.9	76.6

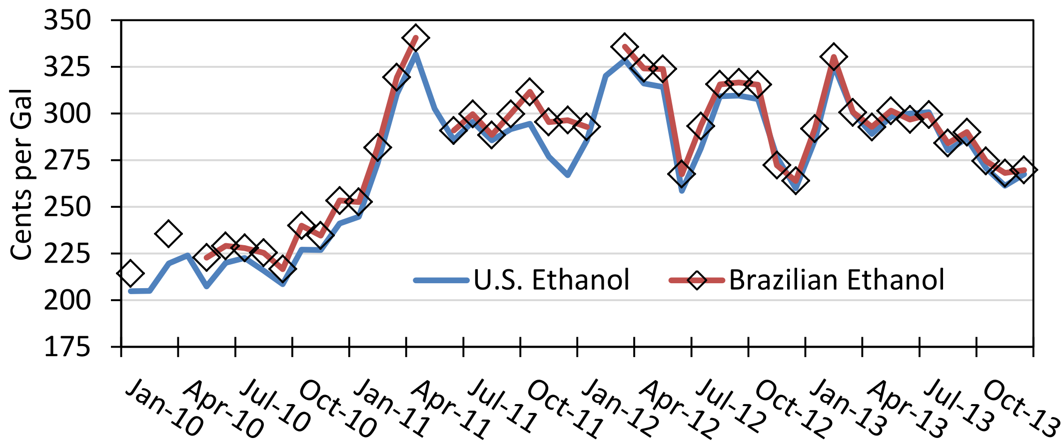
As can be seen in Figure 7 and Table 2, Brazilian ethanol landed in the U.S. was between 77 cents per gallon and 93 cents per gallon more expensive than U.S. ethanol in major U.S. markets.

Of particular note is the difference between the price of ethanol imported from Brazil and U.S. ethanol in California reflected by the Los Angeles ethanol price.

California's Low Carbon Fuel Standard (LCFS) requires fuel suppliers to incrementally reduce the carbon intensity of the state's motor fuel, culminating in a 10 percent reduction by 2020. Sugarcane ethanol is given a favorable carbon intensity score under the LCFS, meaning a blend of 10 percent sugarcane ethanol with 90 percent CARBOB generally results in meaningful reductions to the overall carbon intensity of the gasoline blend. Thus, California has imported relatively large volumes of Brazilian ethanol to meet the LCFS. Through its carbon intensity scheme, the LCFS has created "pull demand" for Brazilian ethanol that otherwise would be uneconomical to import. In 2009, before the LCFS existed, less than 6 percent of total U.S. ethanol imports entered through California ports, according to U.S. customs data. By 2012, 18 percent of U.S. imports entered though California, and in 2013 the share of U.S. imports entering through the state hit 34 percent.

Over the past four years, Brazil supplied nearly 78 percent of the fuel ethanol imported by California. El Salvador was the only other major source of imported fuel ethanol in California, accounting for 19 percent of imports. However, it is likely that this product also originated in Brazil as hydrous ethanol and was simply dehydrated in El Salvador and re-exported. Despite the favorable treatment for Brazilian sugarcane ethanol under the LCFS, some sources of U.S. corn ethanol have remained viable in the California marketplace over the past few years. As shown in Figure 7 and Table 2, U.S. corn-based ethanol is less expensive for California blenders than imported Brazilian ethanol. The impact of using imported Brazilian ethanol on California consumers is clearly illustrated in Figure 8, which compares the price of E10 in Los Angeles made with U.S. ethanol with E10 made with Brazilian ethanol. Use of Brazilian ethanol in place of U.S. ethanol theoretically raised the price of E10 for California consumers by 8 cents per gallon over the past four years.

Figure 8
Price Comparison of California E10 with U.S. and Brazilian Ethanol (excluding taxes)



3. Ethanol produced in the U.S. is competitive with Brazilian ethanol in the EU

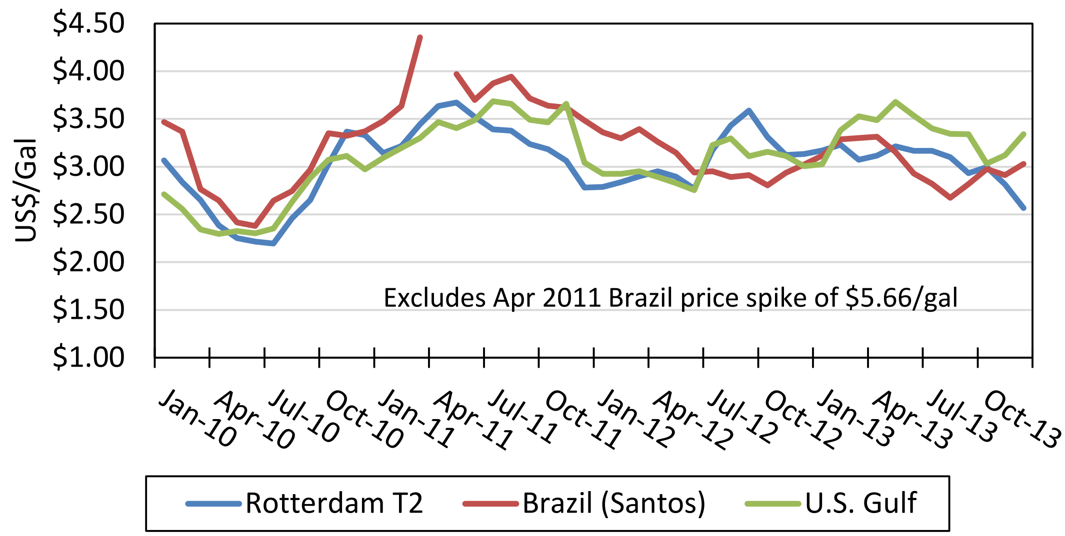
The U.S. and Brazil have historically been the major exporters of fuel ethanol to the EU. The EU protects its domestic industry with a tariff of €0.19 per liter (currently $0.99 per gallon) on un-denatured ethanol for non-beverage use and €0.10 per liter ($0.52 per gallon) on denatured ethanol. Following an anti-subsidy and anti-dumping investigation, the EU imposed an anti-dumping duty of €62.9 per metric ton ($0.26 per gallon) on imports of ethanol from the U.S. in early 2013. U.S. exports of non-beverage ethanol to the EU increased nearly threefold between 2010 and 2011, reaching more than 290 million gallons, of which nearly 80 percent was denatured ethanol for fuel use. As a consequence of the investigation and subsequent implementation of the countervailing duty, U.S. exports to the EU fell to 168 million gallons in 2012 and 26.4 million gallons in 2013.

Figure 9 compares the price of T2 ethanol (duty paid) at Rotterdam reported by Platt's with Brazilian and U.S. ethanol delivered at Rotterdam between 2010 and 2013.[8] The Brazilian delivered price was calculated by adding an ocean freight rate of $62.50 per metric ton ($0.187 cents per gallon) and the EU

[8] The Rotterdam price is an amalgam of imports from all sources weighted by their share of trade. As such the Rotterdam will follow the U.S. and Brazilian prices but may not be a mathematical average of the two prices.

tariff for denatured ethanol (expressed in US$ at prevailing exchange rates) to the Santos FOB price. The U.S. price is calculated using the U.S. Gulf Coast ethanol price reported by OPIS and adding a shipping cost of $52.50 per metric ton ($0.157 per gallon)[9] and the EU tariff for denatured ethanol plus the anti-dumping tariff.

Figure 9
Ethanol Delivered to the EU



As can be seen in Table 3, the duty paid price of U.S. ethanol delivered at Rotterdam was less expensive than Brazilian ethanol in 2010, 2011 and much of 2012. However, the anti-dumping duty imposed by the EU against American ethanol combined with the devaluation of the real made U.S. ethanol more expensive than Brazilian ethanol in 2013.

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[9] Ocean shipping costs were extracted from trade press reports. Ocean rates vary over time reflecting ship availability and bunker fuel costs. The rates used in this analysis are treated as representative rather than exact rates for any period. The cost to ship ethanol from U.S. Gulf ports is lower than the cost from Santos, Brazil reflecting the shorter distance from the Gulf to Rotterdam.

Table 3
Ethanol Prices Delivered to EU
(U.S.$/Gal)

	Rotterdam T2	U.S. Gulf	Santos Brazil	Diff U.S. v. BZ
2010	$2.70	$2.63	$2.95	-$0.32
2011	$3.30	$3.41	$3.98	-$0.57
2012	$3.07	$3.02	$3.08	-$0.06
2013	$3.05	$3.35	$3.03	$0.32

4. Ethanol is the most cost competitive source of octane, as well as oxygen to meet Clean Air Act requirements.

The prohibition of lead in gasoline in 1995 forced refiners to look to other sources of octane. Alternative sources of octane include ethanol, MTBE (methyl tertiary-butyl ether), and alkylates. MTBE is a chemical compound that is manufactured by the chemical reaction of methanol and isobutylene. Alkylates are produced by refineries by combining light hydrocarbons such as propylene and isobutene. Most automobile engines require fuel with octane ratings of 87 to 93 to avoid knocking. Nearly all gasoline blendstock produced by refiners today is 84 octane and lacks sufficient octane to meet minimum posted levels in most states. The way blenders achieve the 87 octane minimum is to blend in higher octane additives. Ethanol has a high octane rating of 113, MTBE has an octane rating of 110 and alkylates have octane ratings in the 90 to 98 range. Blenders can add 10 percent ethanol to an 84 octane blendstock to achieve the minimum 87 octane level. In order to reach the same octane level blenders would have to use 11 percent MTBE and 13 percent alkylates. Due to its favorable price and high octane rating, refiners have shown a preference for ethanol in recent years.

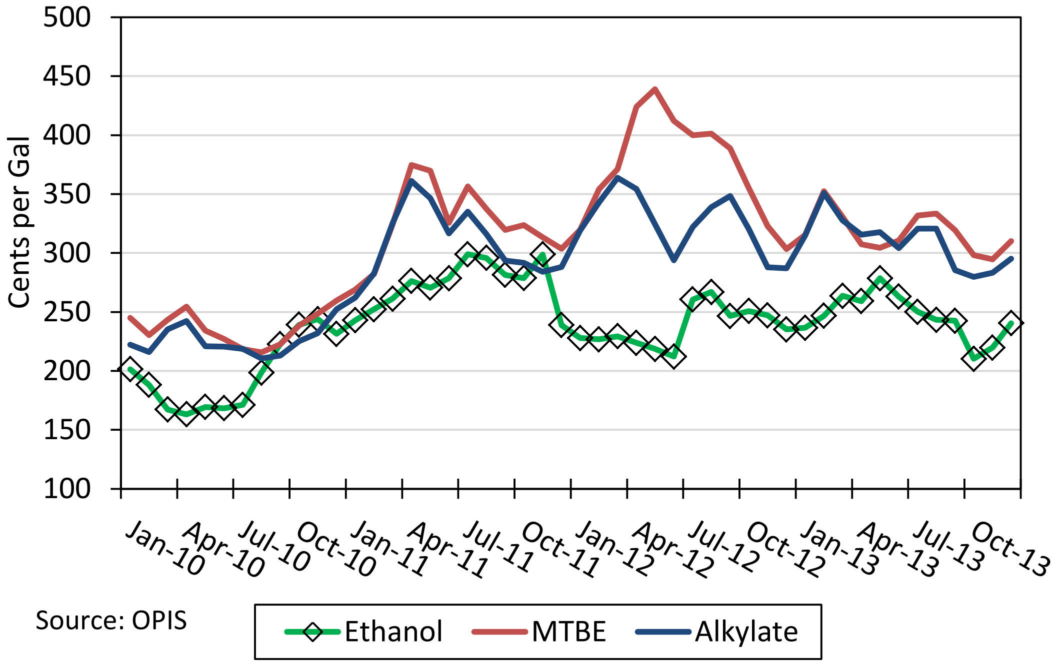
Federal Clean Air Act Amendments of 1990 required gasoline refiners to incorporate oxygen to produce cleaner-burning motor fuel to reduce emissions of carbon monoxide and ozone-forming compounds in the atmosphere. As mentioned earlier, gasoline reformulated with an oxygenate (RFG) is required in cities with high smog levels and is optional elsewhere. According to the USEPA, RFG is currently used in 17 states covering about 30 percent of gasoline sold in the U.S. Currently ethanol is the primary source of oxygen for refiners.

MTBE and alkylates also add oxygen to gasoline. MTBE was widely used by refiners until it was found in drinking water sources in a number of states and several passed legislation to ban its use. The Energy

Policy Act of 2005 failed to provide MTBE producers and refiners with protection from liability for costs for contaminated water supplies and the product was voluntarily removed from the market in 2006.[10] Alkylates can be used as a replacement for MTBE and as an alternative to ethanol, but again the higher octane rating and lower cost of ethanol makes it preferable to alkylates.

As shown in Figure 10 and Table 4, ethanol is significantly less expensive than MTBE or alkylates (priced at the U.S. Gulf Coast). The prices of MTBE and alkylates increased in 2011 in response to higher petroleum prices.

Figure 10
Prices of U.S. Gulf Coast Ethanol, MTBE and Waterborne Alkylate



Source: OPIS

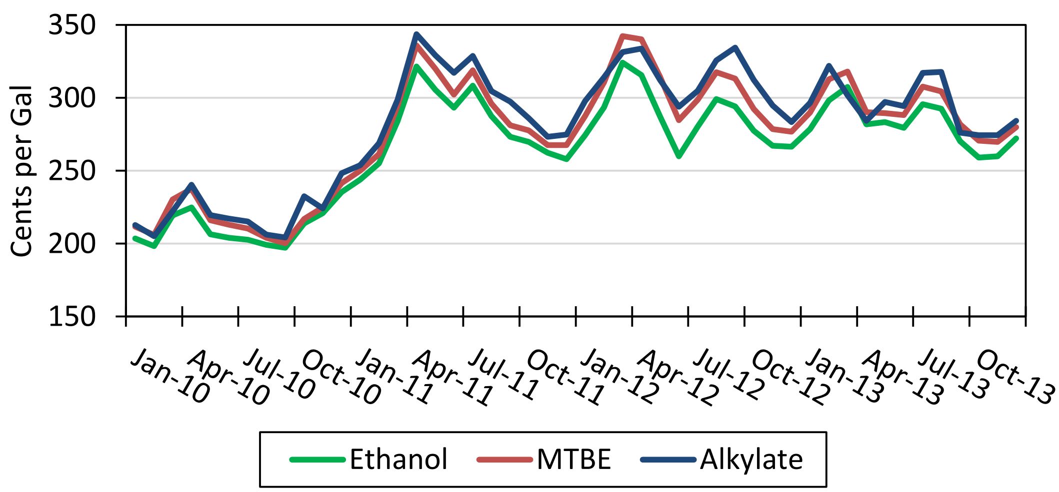
[10] McCarthy, James E. and Mary Tiemann. "MTBE in Gasoline: Clean Air and Drinking Water Issues" (2006). Congressional Research Service Reports. Paper 26.

Table 4
Differences between U.S. Gulf Coast MTBE, Alkylate and Ethanol
(Cents per Gallon)

	Ethanol	MTBE	Difference	Alkylate	Difference
2010	197.0	236.5	39.4	225.7	28.7
2011	272.9	325.0	52.1	308.6	35.7
2012	237.1	374.3	137.1	325.2	88.1
2013	246.2	317.4	71.2	309.7	63.5
Average	238.3	313.3	75.0	292.3	54.0

The most effective way of demonstrating the impact of alternative octane and oxygenate use is to compare the price of E10 in each of the three markets using ethanol, MTBE and alkylate.[11] This is illustrated in Figures 11 through 13 and Table 5.

Figure 11
E10 Price at New York Harbor using Alternative Octane and Oxygenates



[11] This analysis assumes an equivalency between ethanol, MTBE and alkylates. The 1990 Clean Air Act required a 2 percent oxygen requirement for RFG that was the equivalent of 11.7 percent by volume of MTBE or 5.8 percent of ethanol. The Energy Policy Act of 2005 removed the 2 percent oxygen requirement in favor of a nationwide renewable fuel standard.

Figure 12
E10 Price at Chicago using Alternative Octane and Oxygenates

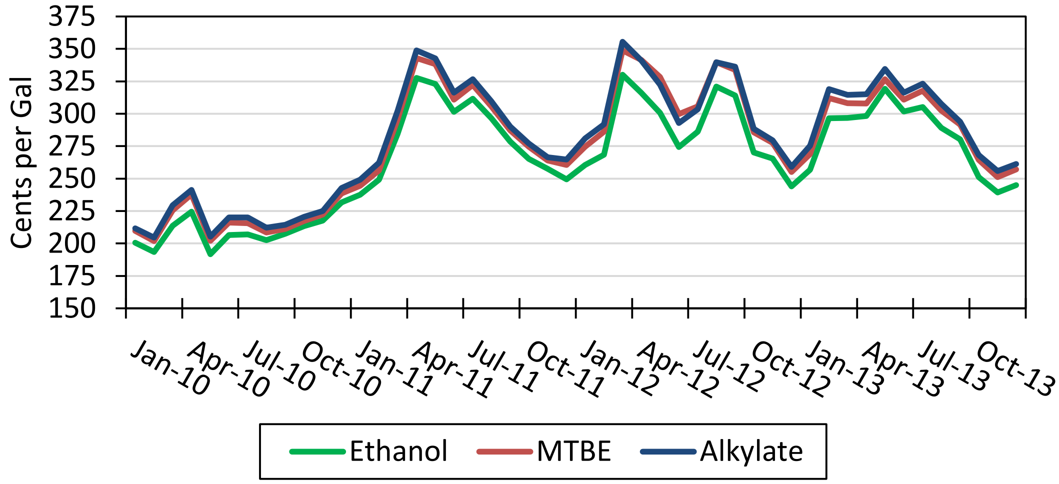
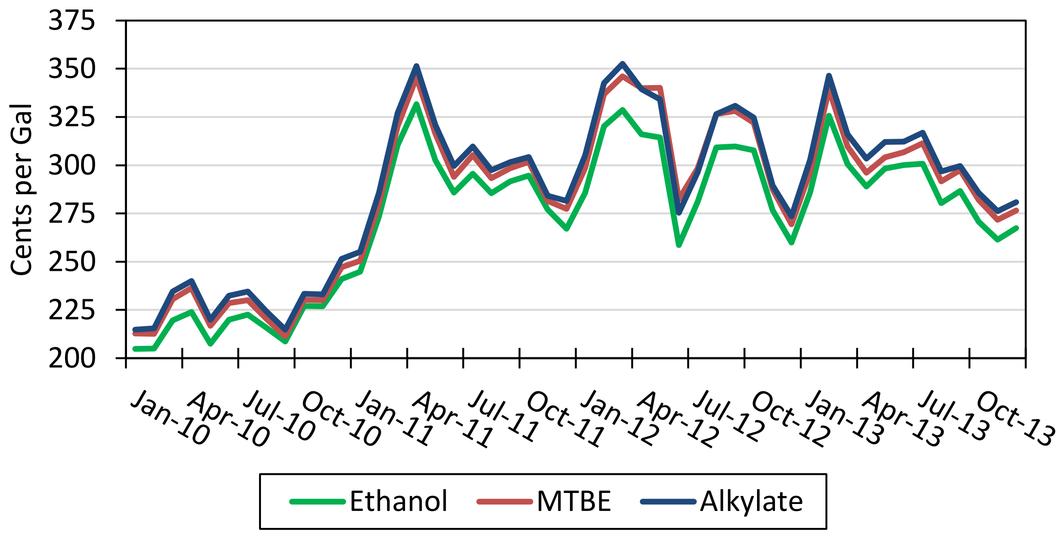


Figure 13
E10 Price at Los Angeles using Alternative Oxygenates



The price of E10 is calculated on the basis of 90 percent RBOB and 10 percent ethanol in each market as reported by OPIS. The price for alternative oxygenates is based on the RBOB price in each market and the U.S. Gulf Coast price of MTBE and alkylate plus a 7 cents per gallon transportation margin. As can be seen in Table 5, gasoline blended with 10 percent ethanol has, in theory, been about 11 cents per gallon less expensive than gasoline that uses MTBE for octane/oxygen, and 16 cents per gallon less expensive than gasoline using alkylate to meet octane/oxygen needs.

Table 5
Difference between E10 and Gasoline Blended with MTBE and Alkylates for Octane/Oxygen
(Cents per Gallon)

	Gasoline with MTBE differential to E10			Gasoline with Alkylate differential to E10		
	New York	Chicago	Los Angeles	New York	Chicago	Los Angeles
2010	7.2	8.0	7.0	10.2	11.4	10.5
2011	9.2	10.1	8.7	17.8	14.5	13.2
2012	18.1	18.8	17.3	25.0	20.2	18.6
2013	10.3	11.6	9.7	13.5	17.1	15.2
Average	11.2	12.1	10.7	16.6	15.8	14.4

Conclusion

A review of market prices and trade data confirms that U.S.-produced ethanol is an exceptionally competitive additive and fuel source in each of the three largest motor fuel markets in America. Moreover, ethanol made in the U.S. is generally less expensive than ethanol imported from Brazil, particularly for California motorists. Historically, U.S. ethanol exported to the EU has been highly price competitive relative to Brazilian ethanol. However, the countervailing duty imposed by the EU in 2013 has eroded this advantage. When the duty expires in 2017, the U.S. is expected to regain its competitive position in the EU marketplace. In sum, this analysis shows that U.S. ethanol has been the lowest cost transportation fuel and octane source in the world in recent years. This competitive advantage is expected to increase further, as U.S. ethanol and feedstock producers adopt new technologies and crude oil prices continue to trend higher.