Perspective

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A market and policy interpretation of recent developments in the world ethanol industry

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Abstract: The concept of an integrated world ethanol market refers more to a possibility than to a reality. Presently, the value of ethanol exchanged among countries is only a few billion dollars. But the possibility of trade is real in the aftermath of escalating gasoline prices and the worldwide investment boom in ethanol. However, the prospects for continued investment and growth during the next five or six years are uncertain. This perspective considers some important factors that will define the extent of expansion in worldwide ethanol production and trade. Specifically, the balance between impending processing plans and possible technical limits on ethanol use in gasoline is measured. Also, commercial policies, such as subsidies, tariffs, and trade preferences that influence trade are reviewed; a few policies are also evaluated; and an import policy change for the EU and USA that accommodates growing developed country markets while promoting import diversification and economic development, is discussed. © 2007 Society of Chemical Industry and John Wiley & Sons, Ltd

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World trade patterns

There are only eight countries (or country groups) that account for most of the world's ethanol trade (Table 1). The major importers are the USA, EU and Japan. The major exporters are Brazil, China, and the Caribbean countries. Worldwide, trade volume was about 1.46 billion gallons in 2006. Brazil is the dominant exporter, providing 0.91 billion gallons. And the USA is the dominant importer, buying 0.7 billion gallons.

The Caribbean countries had a slight net import position in 2006, despite a resource endowment that is conducive to ethanol trade. Total imports were 0.206 billion gallons and total exports were 0.197 billion gallons, for a net import position of 0.009 billion gallons. Generally, Caribbean countries are a transshipment station for ethanol imported from Brazil and China, dehydrated, and shipped to the USA. In this way, Brazil and China gain access to a Caribbean country's tariff exemption on ethanol imported to the USA.[1] Unfortunately, Caribbean countries do not benefit fully from ethanol market participation under this system.

World production and demand balance: 2006 and 2012

World ethanol production is poised to double over the next five years or so, according to reported production plans

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Table 1. World ethanol trade for 2006[a].

	Importers U.S.	EU	Japan (in billion gallons)	Carribean	Other	Total exports
Exporters						
Brazil	0.467	0.154	0.060	0.126	0.099	0.906
China	0.042	0.007	0.030	0.080	0.110	0.269
Carribean	0.177	0.020	0.000	0.000	0.000	0.197
Other	0.016	0.000	0.043	0.016	0.016	0.091
Total imports	0.702	0.179	0.133	0.206	0.209	1.463

[a]Lichts, 2007, various issues.

Table 2. Ethanol production and demand limits: 2006 and 2012.

Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9	Col 10
				Ethanol					
	Gasoline consumption[a]		Blend rates	Demand[b]		Output		Net surplus	
	2006	2012 RFS		2006	2012	2006[c]	2012	2006	2012
Units	(BGY[d])	(BGY)	(Ratio)	(BGY)	(BGY)	(BGY)	(BGY)	(BGY)	(BGY)
Large importers									
USA	141.23	151.72	0.10	14.12	15.17	5.25	12.58[e]	–8.88	–2.59
Canada	11.12	12.45	0.10	1.11	1.25	0.15	0.93[f]	–0.96	–0.31
Europe	46.05	47.01	0.10	4.61	4.70	1.19	1.70[g]	–3.42	–3.00
Japan	15.67	15.26	0.10	1.57	1.53	0.03	0.03	–1.54	–1.50
Large exporters									
Brazil	5.74	5.74	0.23	1.32	3.53	4.71	10.07[h]	3.39	6.54
China	14.91	15.99	0.10	1.49	1.60	0.94	0.94	–0.55	–0.66
Carribean	0.01	0.03	0.10	0.00	0.00	0.27	0.27	0.26	0.26
Others:	85.22	85.22	0.10	0.00	0.00	0.98	0.99	0.98	0.99
World Total	319.96	333.41		24.22	27.78	13.51	27.51	–10.71	–0.27

[a] Source: Energy Information Agency (2).
[b] 10% of gasoline consumption.
[c] Source: F. O. Lichts, May 5, 2007.
[d] Billion gallons per year.
[e] Source: US Renewable Fuels Association (3).
[f] Source: F. O. Lichts, May 5, 2007.
[g] Source: F. O. Lichts.
[h] See Appendix A.

(Table 2, columns 7 and 8). In 2006, worldwide output was 13.51 billion gallons. And available plant lists suggest that output will be 27.51 billion gallons when all scheduled construction is complete, probably within the next five years; a worldwide increase of 14.0 billion gallons is indicated. The USA plans to construct the most new ethanol capacity: 7.33 billion gallons. Next, Brazil has apparently scheduled a production increase of 5.36 billion gallons. The remaining increases of 1.31 billion gallons are scattered among the main trading countries.

This ethanol investment boom was triggered by escalating prices for petroleum products that pushed ethanol beyond the competitive margin.[4] For instance, these production plans were developed very rapidly during 2006 in the USA,

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as profit rates soared to the point where payback periods of one year occurred (Fig. 1). Most recently, US profit rates have declined to a moderate but respectable level, because growing ethanol demand has bid up corn input prices, and because new ethanol plant construction costs have tripled over the last five years. Brazil's ethanol investment may have started somewhat more slowly; first, sugar input prices were exceptionally high during 2005 and 2006. Second, Brazil's expansion started with excess capacity, as defined by 1997 peak production of 4.1 billion gallons, which was not surpassed until 2005. Brazil is now adding new capacity to increase production by about 0.5 billion gallons per year (BGY). Further, Brazil's production should increase steadily for several more years: according to the production plans summarized in Appendix A, there are 126 plants planned, or under construction and scheduled for completion by 2012.

Most anticipate a prolonged period of high gasoline and petroleum prices. But the uncertainty surrounding continuation of the worldwide investment boom remains; it revolves around the ethanol market's ability to absorb these new supplies without significant price declines. Generally, excesses of anticipated production over anticipated demand provide a rough measure of potential downward price pressure in the ethanol market.

A hypothetical renewable fuel standard (RFS) on ethanol demand at 10% of gasoline worldwide consumption is a useful reference point for ethanol demand. The major importing countries have RFSs that vary somewhat in timing and extent of fuel market. But 10% is also a plausible demand threshold because most automobile manufacturers recommend a 10% blend for standard engines, and blending occurs with a slight reduction in car fuel economy. Higher ethanol concentrations, such as E20, E85 or pure ethanol have lower fuel economy and reduced demand prices for ethanol.[†]

Turning to the details, ethanol consumption and production estimates for each importer and exporter are given in the present (2006) and six years hence (in 2012) in Table 2. The first column defines the world's major consuming and producing countries. Then gasoline consumption is given; Column 2 contains data for 2006; the projection for 2012 in Column 3 is based on the recent growth rate of gasoline consumption in the respective country or region. Next, estimates of potential ethanol demand for the present and intermediate term future, given in Column 5 and Column 6, assume a 10% blending rate for ethanol in gasoline for all countries except Brazil (Column 4).

[†]The rate at which ethanol substitutes for gasoline depends on several factors, including the concentration of ethanol in the blended fuel. See subsequent Eqn (1) and related discussion.

[‡]The ethanol production data includes fuel and beverage use. In some countries, where vehicles can run on hydrated pure ethanol, dehydration facilities are available, or smuggling prevails, significant substitution between ethanol grades may occur.

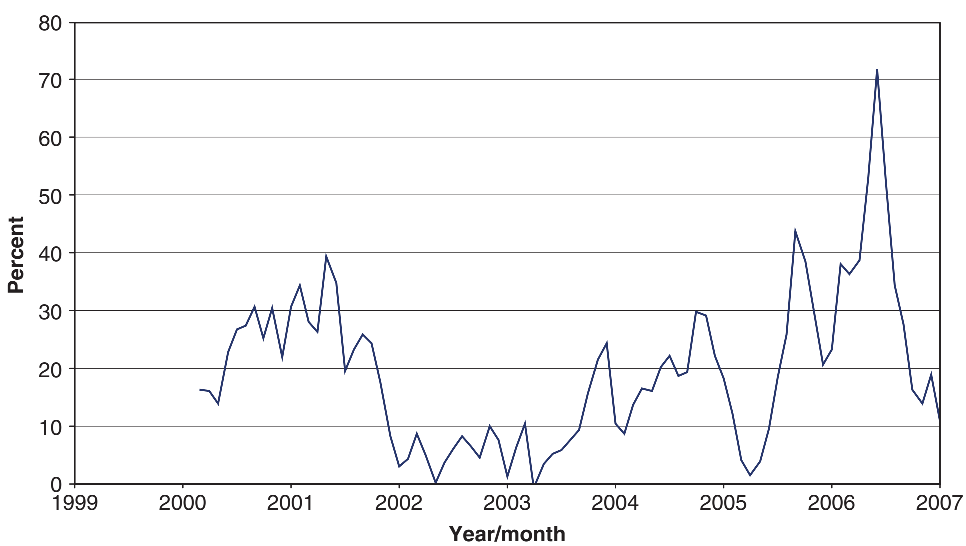

Figure 1. Monthly return on an equity investment (ROI) after taxes: corn-ethanol dry mill through 5/07.

The corresponding ethanol production numbers are in Column 7 (2006 data) and 8 (2012 estimates). The net supply for each country or region, the difference between ethanol production and potential ethanol demand, is given in Columns 9 (2006) and 10 (2012 estimate).[2]

The world net supply gap for the present and future is given at the bottom of Columns 7 and 8 in Table 2. This bottom line defines an indicator of the ethanol supply/demand balance or imbalance on the world market. Presently world ethanol production at 13.51 BGY, is 10.71 billions below the demand limit of 24.22 BGY. By 2012, however, only a small net deficit of 0.27 billion gallons still remains.

According to the 2012 estimates of world net supply, the market may view production plans mostly in balance with demand prospects. First, the impending production estimates, generally consistent with plant construction lists and a United States Department of Agriculture (USDA) forecast for the USA that is close to the US plant list, are widely known. Other major country production projections are also taken from available plant lists and plant construction announcements. Further, gasoline consumption estimates extrapolate recent growth rates for countries. Taken together with the diminished profit rate for an ethanol plant investment (Fig. 1), one might infer that the ethanol investment boom is subsiding.

Then world trade in 2012 would work toward about 7.5 BGY, the sum of 2012 deficits calculated for the major importers. The main importers would be the USA, Europe and Japan, who all import 1.5 to 3.0 BGY. Canada and China import smaller amounts, roughly 0.5 BGY. The exporters would be Brazil, the Caribbean, and African countries.

Ethanol–gasoline substitution and ethanol demand in a commodity fuel market

The prospects for reaching a 10% blending rate for ethanol in the major developed countries are good, because they all have generous consumption subsidies for the use of ethanol in gasoline.[5] Ethanol is competitive now, so expanding ethanol consumption in developing countries is a possibility. Also, fuel-economy reductions associated with even higher concentrations of ethanol in fuel means that large ethanol price reductions would be necessary to induce widespread use of E85.

To understand the nature of ethanol demand as a commodity fuel in direct competition with gasoline, a hypothetical gasoline consumer's decision to use gasoline or a gasoline-ethanol blended fuel is a good starting point. With an auto and fuel-using technology given, the market will force equality between the retail price of gasoline ($P_g^{\,r}$, in \$ gallon^{-1} g) and the retail price of a blended fuel with ethanol concentration α ($P_{e\alpha}^{\,r}$), in \$ gallon^{-1} eα) when a suitable fuel economy adjustment (f_α , in gallon eα gallon^{-1} g) is included:

$$P_g^{\,r} = f_\alpha P_{e\alpha}^{\,r} \tag{1}$$

Here subscripts g and e denote gasoline and ethanol, respectively, and superscript r denotes retail. The market is in balance when the fuel-economy adjusted prices are equal. Otherwise, consumers will substitute away from the more expensive fuel, reducing the price, and substitute toward the cheaper fuel, increasing the other price.

The fuel substitution parameter f_α reflects consumers' assessment of gasoline–blend substitution when the blend has ethanol concentration α. f_α should also reflect the technical substitution of fuels when consumers are well informed. However, evidence from retail prices in Iowa, where E10 and regular gasoline are sold at the same service stations, suggests otherwise. In particular, the f_α computed from the ratio of regular and E10 prices was $f_{0.1} = 1.0$ in the five-year period ending in year 2000. For the most recent five years, retail price ratios suggest that $f_{0.1} = 1.01$.[6] In contrast, engineering studies suggest that there is a 2% fuel economy loss in shifting from regular to E10, i.e. $f_{0.1} = 1.0214$ gallon e gallon^{-1} g.[7] Underdiscounting of blended fuels may occur at low concentrations because there are several other factors that can change fuel economy by 20%. So consumers can't evaluate the effect of blended fuels.

There are some circumstances when actual substitution rates between gasoline and ethanol blends are gallon-for-gallon ($f_\alpha = 1.0$). In older cars, the fuel economy may actually increase with moderate ethanol concentrations because the engine runs rich and oxygen improves combustion.[7] Also, the substitution of ethanol for methyl tertiary-butyl ether (MTBE) in reformulated fuel markets of the USA will not reduce fuel economy because both additives have similar fuel economy properties. Generally speaking, ethanol

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competes as an additive instead of a commodity fuel at low concentrations. That is, quality attributes such as octane and oxygen, in conjunction with product quality and emission standards, define the conditions of substitution.[8,9] Indeed, there have been episodes in the USA where ethanol prices have exceeded regular gasoline prices by more than \$1.25 gallon^{-1} during the past few years, especially when MTBE production dropped and reformulated fuel demands were seasonally high.

However, as concentrations extend beyond E10 ($\alpha = 0.1$) market-wide, ethanol becomes a commodity fuel. And the prospects are that the fuel substitution rate will deteriorate more than proportionately with increases in ethanol concentration, because ethanol's lower heat content will begin to offset the octane and oxygen benefits. Accordingly, here it is assumed that E20 ($\alpha = 0.2$) used in a conventional automobile has a fuel economy loss of 5% compared to conventional gasoline (or $f_{0.2} = 1.0526$). Apparently, flexible fuel vehicles (FFVs) do better when E85 is mixed with gasoline. A study of fuel economy for several FFVs gave results for cars that mixed tanks of gasoline and E85 at low, intermediate, and high rates;[10] the grouped results are a 5% fuel economy loss ($f_{0.27} = 1.0526$) when $\alpha = 0.27$, a 19% fuel economy loss ($f_{0.62} = 1.235$) when $\alpha = 0.62$, and a 26% fuel economy loss ($f_{0.81} = 1.3514$) when $\alpha = 0.81$. Other studies using straight E85 show similar results, i.e. $f_{0.85} = 1.35$.[11]

But what do market arbitrage and declining substitution rates mean for ethanol price and demand? For demonstration, specify that the retail gasoline price is the sum of a handling margin (M) and the wholesale gasoline price (P_g):

$$P_g^{\,r} = M + P_g \tag{2}$$

Next, assume that retailers take the same handling margin, and the cost of the blended fuel is the concentration weighted average of the wholesale prices for ethanol and gasoline. Also, the ethanol subsidy (S) is subtracted from the wholesale ethanol price, because the subsidy is paid to retailers who purchase ethanol blended fuel:

$$P_{e\alpha}^{\,r} = M + (1-\alpha)\,P_g + \alpha\,(P_e - S) \tag{3}$$

For an equilibrium price relationship at the wholesale level, substitute (2) and (3) into (1), and rearrange to obtain:

$$P_e = P_g + S - (P_g + M)\,(l/\alpha), \text{ where } l = 1 - 1/f\alpha \tag{4}$$

When the fuel substitution rate is unity or the fuel economy loss is zero; and then, the ethanol price is simply the gasoline price plus the subsidy in a commodity fuel market. However, a discount defined by the ratio of the fuel economy loss and the ethanol concentration in the blend is present under most circumstances.

Now consider equilibrium ethanol price (Eqn (4)) when various ethanol concentrations prevail in the market. Figure 2 depicts the situation for a conventional automobile and an FFV that use regular gasoline in market conditions as in Iowa during the last half of 2006 – the wholesale gasoline price was \$2.08 gallon^{-1}, the marketing margin \$0.47 gallon^{-1}, and the subsidy S = \$0.50 gallon^{-1}. For the conventional auto, we assume zero fuel economy loss for ethanol concentrations up to $\alpha = 0.10$, owing to MTBE replacement and octane benefits. But $l = 0.02$ when $\alpha = 0.10$, and $l = 0.05$ when $\alpha = 0.20$, following fuel economy studies. Initially, the ethanol demand price is \$2.58, which is the wholesale gasoline price plus the subsidy. But the ethanol demand-price declines to \$2.08 at E10, and falls to about \$1.95 gallon^{-1} for E20. So replacing gasoline with E20 in a conventional auto throughout the market, means that the ethanol demand price will decline by 25%. With the FFV, the ethanol price is about the same as the gasoline price initially, at $\alpha = 0.27$. However the ethanol discount is 31.4% below the gasoline price plus subsidy reference level when the ethanol concentration in fuel approaches 80%.

The example suggests that some substantial price discounting of ethanol vs. gasoline will occur if production increases substantially and the prevailing ethanol concentration in the market extends beyond 10%. Ethanol price reductions of 25% could be expected with E20 and conventional autos, and very large price discounts could occur with further supply expansions and few FFVs. Such declines would be an incentive for adopting FFV's, but price reductions of 31% could be expected even with widespread adoption of E85 vehicles. These prospects for ethanol price reductions even with stable gasoline prices are one factor which could stem ethanol profitability and end the investment boom.

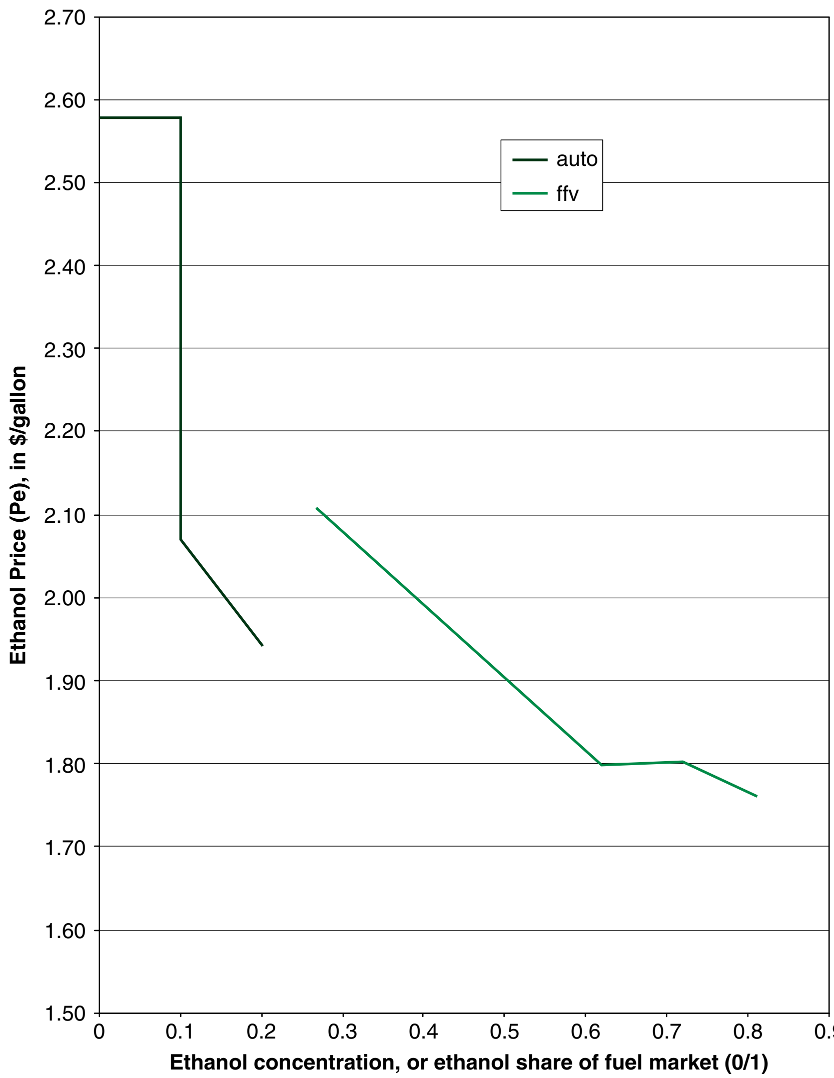

Figure 2. Ethanol demand, given wholesale gasoline price (P_g = 2.08), retail margin (M = 0.47) and consumer subsidy (S = 0.5).

Trade policies and their effects

There are some circumstances that could shift ethanol demand and sustain the investment boom beyond present plans. For instance, technology that improves E85 fuel economy onto a par with gasoline would expand ethanol demand to the entire gasoline market without price declines. Further, the USA is discussing renewable fuel standards for the next decade or so that are considerably higher than the estimate of 2012 ethanol consumption presented here. Without new sources of domestic supply, any substantial demand expansion would turn the EU or the USA into a major deficit area. Then import policies would become a significant determinant of world trade volume.

If an episode of growing EU or US ethanol demand does occur, then ethanol import policies of the EU and USA may be important determinants of market adjustment. The EU has an import duty of \$.73/gallon (denatured). Further, the EU allows many developing countries, including 79 ACP (African, Caribbean, and Pacific) countries duty-free imports of ethanol. Similarly, the USA has a tariff-quota policy for ethanol; the import duty on ethanol is \$0.57 gallon^{-1}, and an exemption for CBI (Caribbean Basin Initiative) countries permits duty-free ethanol imports up to 7% of current US

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production.[4] Generally, Caribbean countries do not have enough ethanol production to meet their duty-free import limitation, without resorting to the dehydration/transshipment scheme.

Tariff quotas are a policy that became widely used after the Uruguay Round of the General Agreement on Tariffs and Trade (GATT).[12] To understand how the present system of sugar import polices affect trade, consider an analysis of the joint effects of a tariff, trade preferences, and quota on ethanol importers. This hypothetical analysis explicitly considers the American trade (country A for USA, country B for Brazil, and countries C for Caribbean). However, a similar analysis holds for the EU trade preference system.

In panel (a) of Fig. 3, the excess supply curve for exporting countries C is ES_c up to the quota volume, q^*. At higher volumes, country C's excess supply curve shifts upwards, to $ES_c^{\,t}$ because it must pay the import duty (t). In contrast, exporting country B must pay the tariff from the beginning, as defined by an upward shift in the excess supply curve to $ES_b^{\,t}$ in panel (b). Hence, the excess supply curve of both the Caribbean and Brazil ($ES_a^{\,t}$, in Panel (c)) includes several segments; in phase I, only countries C supply without paying the import duty, t; in phase II, C continues to supply without paying t and country B supplies and pays t upon entry into country A; in phase III, C exactly fills the quota while B expands exports while paying the tariff; in phase IV, C and B both pay t. The excess supply curve for the EU system of preferences eliminates phase III, but is the same otherwise.

Ethanol trade and price formation with a tariff and unfilled quota is shown in panel c. Equilibrium is defined by country A's excess demand (ED_a) . The intersecting point with the excess supply curve ($ES_a^{\,t}$) defines the equilibrium price and imports for country A at P_a and M_a. Notice that imports consist of exports from countries C (X_c) and from country B (X_b). It is very important to notice that countries C exporters receive the relatively high country A price for their exports ($P_c = P_a$). In contrast, country B's price (P_b) is below the import price by the amount of the import duty.

Trade and price formation under free trade is also shown (in blue) in panel (c). Now the intersection of country A's excess demand with the free trade excess supply curve (ES_a) defines country A's equilibrium price and imports at $P_a^{\,e}$ and $M_a^{\,e}$. Both exporters receive the same price, which is the same as the importing country price ($P_c^{\,e} = P_b^{\,e} = P_a^{\,e}$). Finally, exporting country prices and tariff-free excess supply curves define the free trade export levels at $X_c^{\,e}$ and $X_b^{\,e}$, in countries C and country A.

The distribution of benefits and costs to market participants within countries associated with adopting a free trade are defined by the two equilibrium price and trade

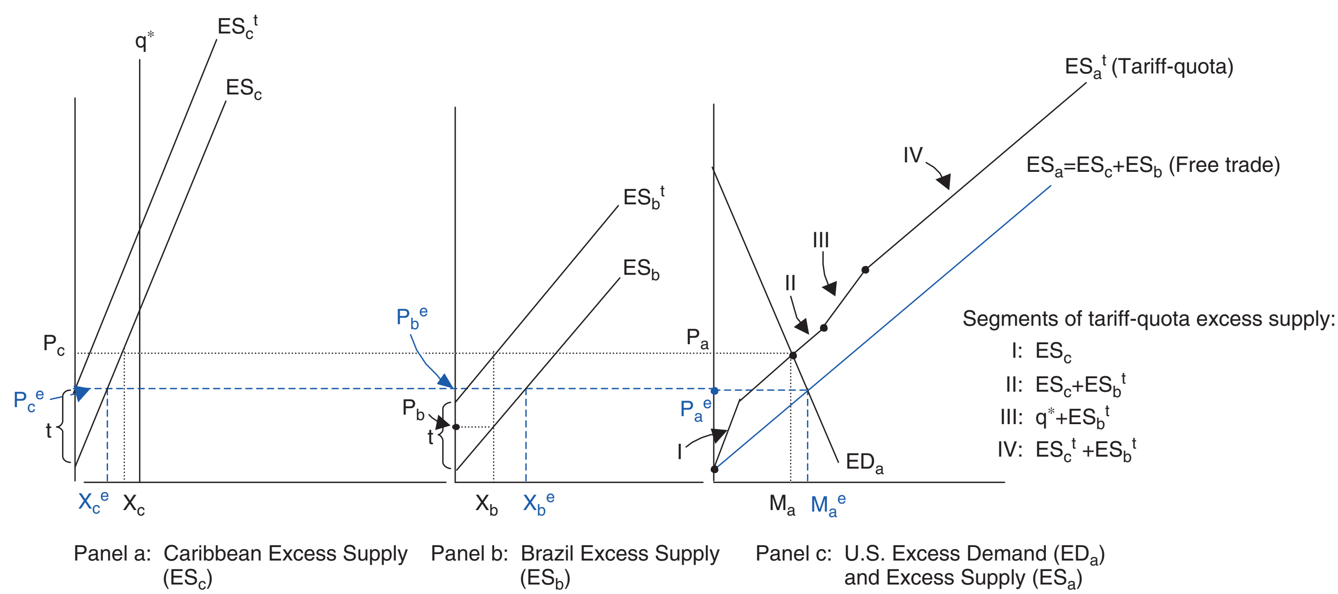

Figure 3. USA–Brazil–Caribbean ethanol trade and price equilibrium: US tariff with an unfilled quota versus free trade.

outcomes. It is well known that country A gains because it imports more and pays a reduced price. Similarly, country B gains from exporting more at a higher price. However, less attention is paid to the third country effects on countries C. Specifically, economic losses are incurred in countries C because the export volumes and export prices both fall.

Presently, it appears that the USA would leave the present policy in place through domestic demand expansions; the US congress has removed measures to repeal the ethanol import duty from proposed legislation twice in the last year. Thus, the import market would likely adjust by an outward shift in the import demand curve, probably into phase III of the excess supply curve, where the quotas of countries C are filled. Relatively higher profits in countries C would be an incentive for investment in these countries, and could shift their excess supply curve outwards for more third country exports. At the same time, the quota exemption would likely shift outward, as US production increases to fill part of the domestic demand expansion.

Lastly, a policy change that gradually increased the quota exemption, q^*, from 7% of US production to, say 8%, is an alternative policy path to free trade. Eventually, when the exemption is granted to all market participants, there would be no import duty.

Conclusions and implications

A 10% upper limit on ethanol blending in gasoline may define the segment of the ethanol market that is highly price-competitive with gasoline. Further, worldwide production may balance with ethanol demand over the next six years as scheduled ethanol plants come on line. The corn and sugar markets may be absorbing ethanol production plans for the 2007 crop year with receding commodity prices. But erosion of ethanol processing profits could still occur, partly because ethanol plant costs have risen substantially in the major producing countries. Further expansion may also be limited by substantial ethanol price discounting against gasoline.

However, three potential events could induce further investment. First, ethanol blending in the gasoline of developing countries could grow, because ethanol is a competitive gasoline additive in the present petroleum-product prices. Second, significantly larger ethanol mandates are widely discussed in the USA. Third, automobile engines that reduce fuel economy reductions associated with E85 or pure ethanol could widely extend ethanol demand.

Significant import demand expansions in the USA or EU could also occur, especially if the ethanol-using technology of automobiles becomes more efficient, or if large US ethanol mandates are not accompanied by the development of a domestic biomass-ethanol industry. Some popular discussion of policies to accommodate these circumstances has emphasized elimination of import duties. But there are adverse third country effects on countries in Africa and the Caribbean that have the resource base to participate fully in the world ethanol trade.

Import-accommodating policy changes may become useful over the next six years. For instance, we anticipate that the worldwide net surplus for 2012 will be some what negative, at –0.27 BGY in Table 2. Hence, expansions of trade preferences might usefully be incorporated into the policy change. Then a moderate tariff reduction, or perhaps an extension of trade preferences to countries that are already exporting, could be added after Caribbean quotas are filled.

A policy of long-term commitment to trade preferences as part of a strategy to achieve free trade could promote import diversification for the USA and EU, and encourage economic development in some of the world's poorest countries. If the expectation of such a policy replaced today's zealous free trade rhetoric, then ethanol investment in the Caribbean and African countries would probably increase because investors would cease discounting expected profits for the possibility of trade preference elimination. The USA could also discourage dehydration facilities that use Brazil's ethanol as a means to a trade preference. Finally, an extensive World Bank interest in ethanol investments in Caribbean and African countries might also help.

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Appendix A: Plant construction projects in brazil and implied ethanol capacity

Table A1 is a compilation of the ethanol plant construction projects that have been reported by F.O. Lichts newsletter for Brazil during the April 2005 to May 2007 period. For each reported plant, the sugarcane crush capacity is given. Individual reports specified whether the plant would jointly produce sugar and ethanol, or specialize in ethanol. The estimate of impending production capacity specified the fraction of sugarcane that would be devoted to ethanol production as 100% for specialized plants, and 60% for combined refined sugar/ethanol plants. Also, an ethanol yield of 25 gallons of ethanol per tonne of sugarcane was used – this estimate is somewhat higher that today's industry average in Brazil, on the notion that cane variety improvements and new processing technology will be incorporated in these new plants.

A few other conventions of this summary are also worth noting. First, some individual reports gave a schedule of increases over a time period, in which case the final time period and cane input estimate are used in Appendix Table A. Second, estimates made in 2005 for completion in 2006 were also included, that many plants take longer than anticipated, and that mid-year adoption would not be reflected in annual production data. There are 126 sugarcane processing plants shown in the table. Of these, 43 planned to specialize in ethanol, while the remainder would be joint sugar/ethanol plants. Finally, 12 of the reports did not specify a location, possibly indicating an early planning stage.

The estimate of capacity for Brazil is 5.36 billion gallons of ethanol. These plants are under construction, or recently began production since the end of the 2006 calendar year. These plants were scheduled for completion before 2012.

Table A1.

Investment units	Company	Complete	Location	Ethanol mil gal	Crush mil ton	Ethanol share	Ethanol mil litre	Sugar mil tonne	Comments	Plants
	Agro Industrial Santa Juliana	2007	Santa Juliana, Minas Gerais	30.00	1.20	1.00	100.00			1
40 mil $	Grupo Uniales	2007	Suzanopolis	25.00	1.00	1.00	100.00			2
200 mil R	Grupo Bellodi	2007	Pereira Barreto	21.00	1.40	0.60				3
100 mil R	De Biasi	2007	Pongai, Sao Paulo	22.50	1.50	0.60				4
		2011		22.50	1.50	0.60				
100 mil R	CFM Leachman	2008	Pontes Gestal, Sao Paulo	22.50	1.50	0.60			10,000 ha pasture	5
150 mil R	Usina Vale do Rosario	2006	Frutal, Mining Δ	37.50	2.50	0.60	80.00	1.00		6
100 mil R	Energitica Santa Elisa	2006	Columbia, Sao Paulo	21.00	1.40	0.60				7
	Vale de Verdo (Finance)	2007?	Itumbiana, Goias	27.00	1.80	0.60				8
	Flavio Wallauer		Ponta Pora, Mato Grosso do Sul	30.00	2.00	0.60	100.00	0.12	2.4 mln 50kg	9
300 mil R	Monteverde Energetica			26.42	1.06	1.00	100.00	0.12		10
440 mil R	Coruripe/ Petrobus	2009	Carneirinho	50.00	2.00	1.00				11
		2010	Uniao	50.00	2.00	1.00				12
900 mil R	Grupo Farias	2010		135.00	9.00	0.60				13
100 mil R	Cargill/Caragiel (expansion)	2008	Cerasa, Sao Paulo	24.00	1.60	0.60				14
	Cerradinho II	2006	Potirendaba, Sao Paulo	45.00	3.00	0.60				15
400 mil R	Sao Martinho	2008	Quirinopolis, Goias	80.00	3.20	1.00				16
120 mil R	Barcellos/ Pessoa	2009	Valparaisio, Sao Paulo	37.50	2.50	0.60				17
150 mil R	Unialco	2011	Dourados, Mato Grosso do Sul	27.00	1.80	0.60	100.00			18

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Table A1. Continued

Investment units	Company	Complete	Location	Ethanol mil gal	Crush mil ton	Ethanol share	Ethanol mil litre	Sugar mil tonne	Comments	Plants
180 mil R	Unialco	2009	Suzanopolis, W. Sao Paulo	18.00	1.20	0.60			Financing pending	19
		2009	Penalto, Sao Paulo	45.00	3.00	0.60			Financing pending	20
?	Tereos SA (Acucar Guariani)		Cardoso, W. Sao Paulo	45.00	3.00	0.60				21
	Nova America	?	Maracai	12.00	0.80	0.60				22
50 mil R	Grupo Tratorag	2009	Dourados, Mato Grosso do Sul	25.00	1.00	1.00	80.00			23
120 mil R	Viralcool	2006	Castilho, Sao Paulo	17.50	0.70	1.00				24
50 mil $	Carlos Lyra	2007	Conceicao, Minas Gerais	34.35	1.37	1.00	130.00			25
12 mil $	Carlos Lyra	2007	Volte Grande	52.50	2.10	1.00	46.00			26
	Biago/ Junqueira		Pontes Gestal, Sao Paulo	45.00	3.00	0.60				27
			Ouroeste, Sao Paulo	45.00	3.00	0.60				28
			Guaraci, Sao Paulo	45.00	3.00	0.60				29
			Itapagipe, Minas Gerais	45.00	3.00	0.60				30
			Frutal, Minas Gerais	45.00	3.00	0.60				31
	Grupo Balbo		Mining ∆, Minas Gerais	37.50	2.50	0.60	40.00	0.18		32
	Biagi		Lins, Sao Paulo	13.50	0.90	0.60				33
	Grupo Bellodi	2007	Pereira Barreto	21.00	1.40	0.60	50.00			34
	Dasa	2007	Ibirapoa, Bahia	37.50	1.50	1.00	130.00			35
150 mil R	Grupo Grendene	2008	Valparaiso, Sao Paulo	30.00	2.00	0.60				36
130 mil R	Brazcana	2010	Parana	00.40	0.02	1.00	1.50			37
	Cooperativu Integrada		NortePioneiro, Parana	50.00	2.00	1.00				38

(*continued overleaf*)

Table A1. Continued

Investment units	Company	Complete	Location	Ethanol mil gal	Crush mil ton	Ethanol share	Ethanol mil litre	Sugar mil tonne	Comments	Plants
240 mil $	Infinity Bioenergy		Espirito Santo (2 mills)	45.00	3.00	0.60				39
	Nova America	2008	Caarapo, Matto Grosso do Sul	22.50	1.50	0.60				40
7 mil R	Neutral do Brazil		Rio Grande do Sul	4.23	0.17	1.00	16.00			41
200 mil R	Grupo Unialco	2011	Vale do Parana, Sao Paulo	30.00	2.00	0.60				42
50 mil $	Globex		Sao Paulo	30.00	2.00	0.60				43
200 mil R	Energetica, Santa Elisa	2011	Goias	75.00	5.00	0.60				44
450 mil R	Maity Bioenergy	2010?	Palmao, Tocantin	60.00	2.40	1.00				45
			Apareuda, Tocantin	60.00	2.40	1.00				46
			Pedro Alfonso, Tocantin	60.00	2.40	1.00				47
180 mil R	Equipar	2010	Brejo Alegre, Sao Paulo	60.00	4.00	0.60				48
300 mil R	Grupo Cerradinho	2011	Chapadao do Ceu, Goias	60.00	4.00	0.60				49
170 mil R	Grupo Pitangueiras	2012	Frutal, Minas Gerais	30.00	2.00	0.60				50
	Usina Agrisa	2011	Expansion	0.26	0.01	1.00	80.00			51
700 mil R	Grupo Itamarati	2011	Mato Grosso do Sul	100.00	4.00	1.00				52
	Grupo Balbo	2010	Usina Uberabusa, Minas Gerais	40.00	1.60	1.00	155.00			53
200 mil R	Grupo Tenorio	2011	Nova Ponte, Minas Gerais	45.00	3.00	0.60				54
100 mil R	Grupo Ipiranga	?	Iacanga, Sao Paulo	37.50	1.50	1.00				55
	EQM		Confresa, Mato Grosso	9.25	0.37	1.00	35.00			56
140 mil R	Globorr Industria e Comercio	?	Sao Luiz Gonzaga, Rio Grande do Sul	15.00	1.00	0.60	100.00			57

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Table A1. Continued

Investment units	Company	Complete	Location	Ethanol mil gal	Crush mil ton	Ethanol share	Ethanol mil litre	Sugar mil tonne	Comments	Plants
280 mil R	Noroeste Bioenergetica		Son Luig Gonzaga, Rio Grande do Sul	50.00	2.00	1.00	160.00			58
	Grupo Carlos Lyra	2008	Uberaba, Minas Gerais	60.00	4.00	0.60	150.00			59
20 mil R	Grupo Tabu		Caapora, Parana	5.28	0.21	1.00	20.00			60
144 mil R	Santo Angelo	2011	Verissimo	30.00	2.00	0.60				61
	Coinbra	2008	Rio Brillhante, Mato Grosso do Sul	20.00	0.80	1.00				62
150 mil R	Crystalsev	2012	Santa Victoria, Mining ∆	30.00	2.00	0.60				63
150 mil R	Vale do Rosario	2008	Frutal, Minas Gerais	37.50	2.50	0.60	80.00			64
105 mil R	Columbo of Sao Paulo			22.50	1.50	0.60				65
	Grupo Triunfo	2006	Juliana, Minas Gerais	37.50	1.50	1.00				66
200 mil R	Grupo Maedo	2010	Goias	75.00	5.00	0.60				67
80 mil $	Evergreen	2008	?	50.00	2.00	1.00				68
	Grupo Moema	2006	Itapagipe, Minas Gerais	37.50	1.50	1.00				69
60 mil R	Usina Alcool Verde		Capixaba	15.85	0.63	1.00	60.00			70
300 mil R		2011	Campos dos Goytacazes, Rio de Janeiro	30.00	2.00	0.60				71
99 mil R	Santa Terezinha	2007	Terra Rica	22.50	1.50	0.60				72
	Grupo Encalso		Itapura, Sao Paulo	37.50	2.50	0.60				73
170 mil R	CAVDP	2009	Santa Vitoria, Minas Gerais	37.50	2.50	0.60				74
21 mil R	Grupo Tavares de Melo		Passo Tempo, Mata Grosso do Sul	7.50	0.50	0.60				75

(*continued overleaf*)

Table A1. Continued

Investment units	Company	Complete	Location	Ethanol mil gal	Crush mil ton	Ethanol share	Ethanol mil litre	Sugar mil tonne	Comments	Plants
130 mil R	Brazcana	2010	Parana	37.50	1.50	1.00	120.00			76
400 mil R	Nova America	2010	Navirai, Mato Grosso do Sul	60.00	4.00	0.60				77
	Nova America	2009	Caarapo, Mato Grosso do Sul	60.00	4.00	0.60				78
1.14 bil R	Tavares de Melo		Maracaju, Mato Grosso do Sul	105.00	7.00	0.60				79
			Sidrolandia, Mato Grosso do Sul	105.00	7.00	0.60				80
220 mil R	Tavares de Almeida/ Tejofran/Zogbi	2009	Rio Pardo, Sao Paulo 2008	30.00	2.00	0.60				81
150 mil R	Crystalsev	2012	Santa Vitoria, Minas Gerais 2012	22.50	1.50	0.60				82
205 mil R	Grupo FLE	2010	Ituiutaba, Minas Gerais 2014	34.87	1.39	1.00	132.00			83
200 mil $	Nova America	2017	Caarapo, Mato Grosso do Sul	30.00	4.00	0.30	130.00			84
	Usina Santa Isabell									
	Acucar Guarani		Tanabi, Sao Paulo							84
400 mil R	Energetica Santa Elisa	2010	Campina Verde, Minas Gerais	12.50	0.50	1.00	40.00			85
	Energetica Santa Elisa	2010	Uberlandia, Minas Gerais	37.50	2.50	0.60				86
	Energetica Santa Elisa	2010	Monte Alegre, Minas Gerais	22.50	1.50	0.60				87
123 mil R	Biagi	2007	Lins, Sao Paulo	21.25	0.85	1.00	80.00			88
		2007	Iguatemi, Mato Grosso	30.00	2.00	0.60				89
	Alcopar of Parana	2007	Eldarado, Mato Grosso	30.00	2.00	0.60				90

Table A1. Continued

Investment units	Company	Complete	Location	Ethanol mil gal	Crush mil ton	Ethanol share	Ethanol mil litre	Sugar mil tonne	Comments	Plants
	Moema Group	2008	Minas Gerais	30.00	2.00	0.60				91
	Moema Group	2008	Minas Gerais	30.00	2.00	0.60				92
350 mil R	CNAA	2008	Ituiutaba, Minas Gerais	37.50	2.50	0.60				93
	CNAA	2008	Campina Verde, Minas Gerais	37.50	2.50	0.60				94
500 mil. $	Equipav	2009	Capadao do Sul, Mato Grosso do Sul	112.50	4.50	1.00				95
		2010	Chapadao do Ceu, Gois	112.50	4.50	1.00				96
	Equipav	2008	Brejo Alegre, Sao Paulo	67.50	4.50	0.60				97
1200 mil R	Grupo Farias (joint Chinese)		Maranhao	125.00	10.00	0.50				98
			Maranhao	125.00	10.00	0.50				99
			Pernambuco	125.00	10.00	0.50				100
130 mil $	Clean Energy Brazil/ Usaciga		Expansion	7.50	0.50	0.60				101
450 mil R	Sucral/ Greentech	2011	Selvira, Mato Grosso do Sul	50.00	2.00	1.00				102
		2011	Inocencia, Mato Grosso do Sul	50.00	2.00	1.00				103
610 mil R	Usina Itamarati		Bataguassu, Mato Grosso do Sul	60.00	4.00	0.60	220.00	0.20		104
200 mil $	Adecoagro	2008	Angelica, Mato Grosso do Sul	30.00	2.00	0.60				105
200 mil $	Adecoagro	2009	Angelica, Mato Grosso do Sul	30.00	2.00	0.60				106
162 mil $	Bertin	2010	Dourados, Mato Grosso do Sul	57.50	2.30	1.00				107
	Cosan		Jatai, Goias	42.00	2.80	0.60				108
650 mil $	Cosan		?	49.50	3.30	0.60				109
			?	49.50	3.30	0.60				110

(*continued overleaf*)

Table A1. Continued

Investment units	Company	Complete	Location	Ethanol mil gal	Crush mil ton	Ethanol share	Ethanol mil litre	Sugar mil tonne	Comments	Plants
			?	49.50	3.30	0.60				111
200 mil $	Central de Alcool Lucelia	2009	Tupa, Sao Paulo	37.50	2.50	0.60				112
			Mato Grosso do Sul	37.50	2.50	0.60				113
80 mil $	Slane Company	2008	Tangara, Mato Grosso	30.00	2.00	0.60				114
84 mil $	Bioenergetica	2009	Tuipaciguoia, Minas Gerais	18.00	1.20	0.60				115
850 mil R	Usinao Nova Energia	no details	Minas Gerais	49.95	3.33	0.60				116
	Transcap Alcohol e Acucar		Minas Gerais	49.95	3.33	0.60				117
	Distillaria Sao Benedito		Minas Gerais	49.95	3.33	0.60				118
188 mil $	Nova America	2010	Navirai, Mato Grosso do Sul	60.00	4.00	0.60				119
		2009	Caarpo, Mato Grosso do Sul	60.00	4.00	0.60				120
	Grupo Sao Martinho	2010	Quirinopolis, Goias	25.00	1.00	1.00	94.50			121
103 mil $	Vale do Parana/World Bank finance		Suzanopolis, Sao Paulo	30.00	2.00	0.60	180.00			122
400 mil E	Coimex & Espirito Santo	2011	Montanha, Sao Paulo	22.50	1.50	0.60				123
200 mil R	Bernardo & Laurenco Biagi	2009	Lins, Sao Paulo	46.25	1.85	1.00	120.00			124
200 mil R	Bernardo & Lourenco Biagi	2005	Ribeirao Preto, Sao Paulo	80.00	3.20	1.00	28.00			125
22 mil R	Usina Itaiquara de Acucar e Alcool	2011	Passos, Minas Gerais	9.51	0.38	1.00	36.00			126
	Usina Pitagueiras/ Queiroz	2011	?	50.00	2.00	1.00				127
			Total	5360.77						

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