# North American Ethanol Bioenergy Policies and Their NAFTA Implications


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> *Subsidized ethanol is a very inefficient way to raise farm income. It would be much more economical to burn straight gasoline in our automobiles and pay farmers a direct subsidy equal to the amount that they would receive as a result of ethanol production* (Gavett, Grinnell, and Smith).

> *A final consideration is that legislation could be adopted that makes it less favorable to import ethanol into the US; while Congress would likely respect trade agreements that have been ratified, it is possible that more inventive legislation would be considered if imports grew and had a significant impact on the US market. Therefore, it is necessary to keep one eye on the markets and the other on the politicians as ethanol trade evolves* (Richman).

> *The closest thing to a state religion in America today isn't Christianity – it's corn. Whether liberal or conservative, Democrat or Republican, urban or rural, virtually everyone in the business of offering opinions is in firm and total agreement that America's ills, from Islamic terrorism to global warming to economic stagnation in the heartland, could be solved by a hefty dose of 200-proof grain alcohol* (Taylor and Van Doren).

> *The experience of the 1970s and 1980s taught us that if a technology is commercially viable, then government support is not needed and if a technology is not commercially viable, no amount of government support will make it so* (Lee, Ball, and Tabors).

> *Patria: tu superficie es el maíz … y los veneros del petróleo el diablo* (López Velarde).

## INTRODUCTION

Ethanol poses formidable challenges for the agenda of trade liberalization.[2] In fact, the emergence of the modern ethanol vehicle fuel industry in Brazil, the United States, and more recently in Canada, is the antithesis

[1] We gratefully acknowledged comments by Danny LeRoy, Al Mussel, Kate Tsiplova, Predrag Rajsic, Maria Klimas and Zahoor Haq on earlier versions of this paper.

[2] This chapter focuses on ethanol. Many of the conclusions, nevertheless, are valid for biodiesel, both in terms of the potential trade distorting impacts as well as with regards to the implications regarding food and hunger.

of freer trade and represents a continuation of extensive government subsidies to agriculture. Brazil and the United States are currently the largest vehicle fuel ethanol producing nations in the world. Production in Brazil expanded in the 1970s as a response to chronic balance of payments problems, admittedly exacerbated by higher nominal oil prices, but fundamentally arising from profligate monetary policies in the previous decade. The development of the Brazilian industry has been an important element of an import-substitution reaction to domestic inflation. Production of ethanol in the United States has grown rapidly in the last decade, first as a "clean" alternative to fossil fuels and more recently in an attempt to offset much-loathed "dependence" on oil imports. There is ample evidence that offshore sources of fuel ethanol either are or soon would be available to the United States at lower cost than the current grain-based domestic production systems. But it is unlikely that the current policy environment in the United States would tolerate imported ethanol any more than it is comfortable with imported oil. The growing interest in ethanol production in Mexico, while seen as an effective instrument of rural development, is also being promoted as an import substitution alternative.[3] In the United States and Canada as well as in Brazil, the development of the ethanol industry has been built on a foundation of extensive government subsidies and various forms of market intervention. Mexico, apparently learning from example, is contemplating subsidizing the development of a domestic ethanol industry.

Ethanol policy in the United States and Canada is complex, dynamic and increasingly controversial. Policy is at a formative stage in Mexico. Our overall purpose in this chapter is to assess first the prospects for international trade in ethanol with specific reference to the NAFTA countries and also to identify potential areas where trade frictions might emerge. One of the areas of potential trade conflict could be the different levels of support or other differences in policy approaches among the three NAFTA countries. We will review and compare the changing levels and instruments of support as part of our analysis. But assessing the likelihood of trade or, for that matter, trade conflict, requires going beyond comparisons of existing policies. It is important to understand the political economy of ethanol policy in the North American context in order to get a sense of whether trade or trade conflicts involving ethanol might emerge in the future. This task requires an examination of aspects of price trends in oil and gasoline markets, an examination of the available evidence on the competitiveness of ethanol as a vehicle fuel, an assessment of the various rationales for policy that have been used to justify support for the ethanol industry, and finally, a discussion of the emerging controversies surrounding ethanol policy. Ultimately, speculation about prospects for either trade or trade conflicts requires a framework for understanding of

[3] Mexico, which is a major petroleum exporter, faces a trade deficit in gasoline and other secondary petrochemical products. Estimates suggest that import savings could reach $2 billion by 2010.

the political economy of ethanol policy, particularly in the United States. We sketch the outlines of such a framework at the end of this chapter.

## ETHANOL POLICY IN CONTEXT

The extent to which biofuels are produced in a policy-dominated environment is clear from a recent International Food and Agricultural Trade Policy Council discussion paper that identifies a long list of support measures used in various countries, including fuel excise tax exemptions and rebates; production mandates of specified levels of biofuels; compulsory blending mandates with fossil fuels; government-procurement preferences and purchase mandates; local tax breaks on property taxes and/or state/provincial taxes; accelerated write-off schedules for eligible biofuels-related capital; tax exempt bonds for finance (typically in the United States); subsidized loans, loan guarantees, special capital gains exemptions, or deferrals on sale of biofuel plant and infrastructure; regulatory exemptions and waivers including environmental impact waivers; state (provincial) producer credits either for all producers or those below a certain size or having a certain organizational structure (e.g., farmers' cooperatives); state/provincial/federal subsidies towards purchase of vehicles and infrastructure that can use biofuels; environmental legislation mandating certain specific types of fuel additives (typically for fuel oxygenation) related to reducing vehicle exhausts; government purchases of surplus agricultural stocks for conversion to bioethanol (particularly wine in the EU); subsidies not normally associated directly with biofuels, such as agricultural farm supports in the US, the EU, and elsewhere; and finally, government supported R&D for biofuels ranging from basic research to technology demonstration plants. If this list doesn't represent a full employment plan for biofuel trade economists, we don't know what does.

The rationale for government support for ethanol as a vehicle fuel has taken several forms since 1978. Proponents have advocated fuel ethanol as a cleaner burning fuel than petroleum-based gasoline, as a means of increasing farm income, as an environmentally superior fuel additive relative to MTBE (methyl-tertiary-butyl ether), and as a method of reducing oil consumption or imports (in the United States), first as a balance of trade issue and more recently as an anti-terrorism policy, but also as a means of reducing greenhouse gas emissions. All of these rationales have come under attack, increasingly so as ethanol production has expanded in the last few years. So far, the policy coalition promoting ethanol policy support by governments has been reasonably successful at maintaining sufficient political momentum to advance its interests. If that momentum is sustained, our anticipation is that trade in fuel ethanol will not be regularized any time soon. On the other hand, if the increasingly pointed criticism of ethanol policy starts to produce an ethanol backlash, this could threaten the protected status of the emerging industry. But, in our view, this outcome does not lead to freer trade either, since erosion of policy support would likely trigger a contraction on both the supply and demand sides of the ethanol "market."

Current government policies supporting ethanol production, especially in the United States and more recently in Canada, are facing a growing chorus of criticism on environmental, trade, economic and distributional grounds. Lieberman; Lewis; Bovard; Taylor and Van Doren; Green; Pimental; Runge and Senauer; Koplow; and Sopuck have raised concerns about the ambiguous effect of ethanol fuel use on air quality relative to gasoline, about the limited extent to which corn-based ethanol actually displaces petroleum use, about the impact of increased ethanol production on food and feed grain prices, about the cost involved in securing the manifold putative benefits from ethanol use in vehicle fuel, and about the level of subsidization and interference with international trade in ethanol embodied in current policy. But, as Lieberman, and before him, Bovard have acknowledged, support for ethanol did not emerge from a vacuum. Politically well-positioned interests have, so far, been able to resist reform.

## Ethanol Production Trends

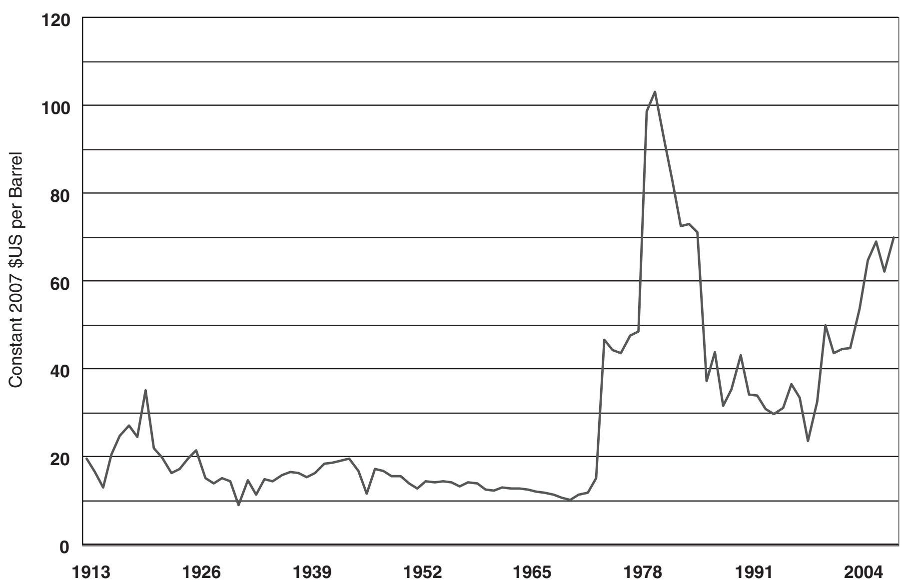
Global ethanol production is expanding rapidly. Klein and LeRoy report that global production has doubled in the last five years. World production fluctuated around the 20 billion liter per year level from 1995 to about 2001, but had risen to about 45 billion liters per year by 2005 (Klein and LeRoy). The United States is now the largest ethanol-producing nation, followed closely by Brazil, both producing about 16 billion liters per year, which amounts to over 70 percent of world production. In contrast, current Canadian production is estimated to be about 230 million liters per year and Mexican production is about 50 million liters per year. Olar et al. project Canadian production to reach two billion liters annually in the next decade, based on current policy targets.

Rapid expansion of ethanol production in the United States may be starting to put supply-side pressure on prices. The Credit Suisse "US Biofuel Outlook" anticipates a short to medium-term surplus in the US ethanol market, putting downward pressure on ethanol prices. According to their analysis, existing and soon to be operational capacity, along with the prospects of increased finished gasoline imports from the EU, are putting and will continue to put downward pressure on gasoline and ethanol prices in the United States. They estimate that supply growth will exceed demand growth in the US gasoline market by 1.2 percent for 2007-2009. In addition, they speculate about the disintegration of the political coalition supporting biofuels production, particularly as the connection between biofuel production and agricultural commodity prices comes under closer scrutiny. More recently, “BioProducts Update” (Checkmate) has projected bleak profit results for the rapidly expanding US ethanol industry in the wake of increased grain prices.

## Oil and Gasoline Price Trends

One of the more durable rationales for government policy supporting ethanol is that biofuels in general can serve as an alternative to what is perceived to be increasingly scarce petroleum-based fuels. The general consensus, at least up to mid-2005, seems to have been that ethanol could not compete on price with petroleum-based gasoline. But volatility in oil and fuel markets since the summer of 2005 have cause many observers to ask if the historical relative price situation has changed. Discussion of this issue, however, continues to be confounded by the pervasive money illusion that seems to exist regarding oil and gasoline prices. During late 2005, media outlets in North America were dominated by reports of what were hailed as record oil prices. Of course, these prices reached record levels only in nominal terms. One of the artifacts of the relatively low inflation rates in North America over the last 25 years is that people have forgotten that even low rates of inflation distort nominal prices over time. Figure 4.1 reports constant dollar oil prices from 1913 to 2007. In real

**Figure 4.1:** Price of crude oil in constant (2007) dollars 1913-2007.



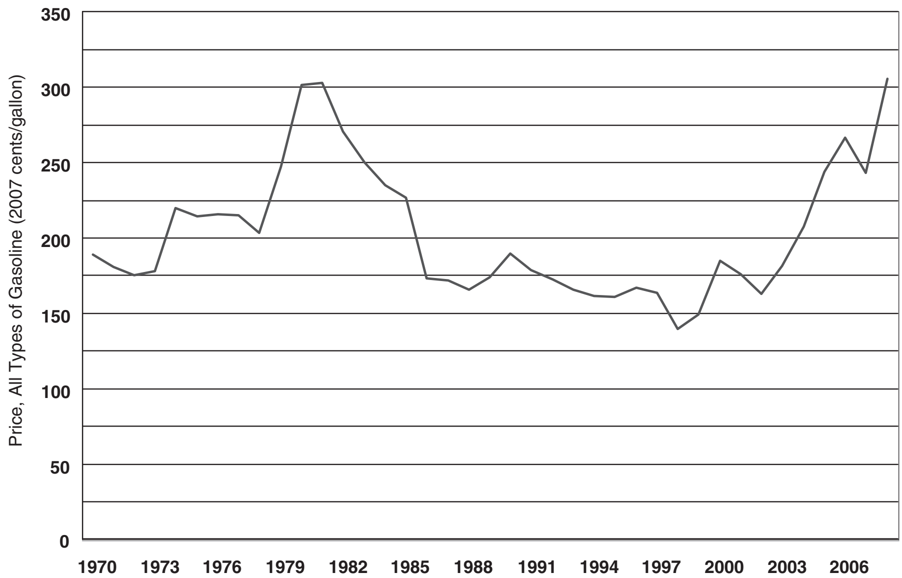

**Source:** Author’s calculations.

terms, record oil prices[4] occurred not in 2005-2006, but rather in 1981, when prices reached a peak of about $100 per barrel, in 2007 constant dollars. These prices were approximately twice the level of real oil prices during the so-called energy crisis of the early 1970s. Nominal oil prices, in 2005-2006, peaked somewhere around $77 per barrel, then retreated to the $55 per barrel range in early 2007 before rebounding to current prices in the low $60 range. What is especially noteworthy in the present context is that by the late 1990s, oil prices had fallen to the $15 range, as exploration and development on the supply side as well as conservation on the demand side, triggered by the price spike of the early 1980s came on line. Huber and Mills; Lomborg; Simon; and Adelman have studied long term trends in oil availability and concluded that recurrent anxiety about future energy supplies is misplaced. Runge and Senauer, on the other hand, based on projections from the US Energy Administration, anticipate "sustained upward pressure on oil prices." It is beyond the scope of this chapter to resolve what has proven to be the most important and most difficult question in resource economics over the past 50 years, namely, "Is energy, especially oil, becoming more scarce?". If the oil pessimists are right, and the correct answer to this question is "yes", then the rationale for ethanol production as part of an energy policy becomes stronger, at least the rationale for considering it economically as an alternative to increasingly scarce oil. On the other hand, if the petroleum optimists are correct, at least in the short to medium-term, then this would relegate ethanol into the category of ideas whose time has not yet arrived. We tend to side with the oil optimists, but we will leave this question for you, the interested reader, to examine for yourself.

The story with domestic gasoline prices in the United States and Canada appears to be even more subject to money illusion than has been the case with oil. For domestic policy reasons, retail gasoline prices follow a different trajectory in Mexico. Figures 4.2, 4.3, and 4.4 report retail gasoline prices in the United States, Canada, and Mexico, respectively, adjusted for the effects of inflation. Media reports on gasoline prices in the United States and Canada have been full of trepidation since the late summer of 2005. Dire consequences for the national economies of both countries have been anticipated with each up-tick in the retail price of gasoline. When we strip away the money illusion, however, quite a different story emerges. Retail gasoline prices in the United States and Canada have been remarkably stable, in constant dollar terms, for 25 years. There has been an upward trend in retail prices since 1999, but remember that oil prices bottomed out at about $22 per barrel in that year, measured in 2007 constant dollars. A recent Credit Suisse report,

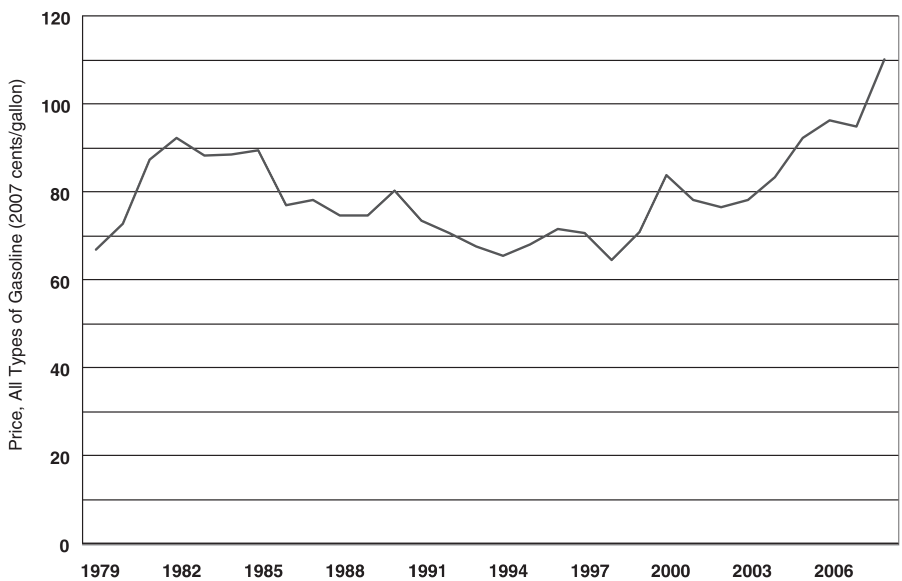
[4] In constant dollar terms, oil prices prior to 1913 were actually higher than even 1981. We have truncated our time series at 1913, however, for two reasons. First, oil played quite a different role in the global economy in the late 19th and early 20th centuries than it does today, and second, the problems associated with measuring inflation with price indexes over long periods of time make conversion of prices from 100 years ago into contemporary monetary magnitudes speculative.

**Figure 4.2:** US real gasoline prices, 1970-2007 (2007 cents/gallon).




**Source:** US Energy Information Administration.

**Figure 4.3:** Toronto real gasoline prices, 1979-2007 (2007 cents/liter).




**Source:** Statistics Canada; Ontario Ministry of Energy.

however, expresses US gasoline expenditure as a share of disposable income from January 1970 to January 2007. The ratio is relatively flat from about 1986 to 2005 and rises afterwards. The current ratio of a little over 3.5 percent, however, is still less than the value of 4.5 percent reached in 1980 and 1981.

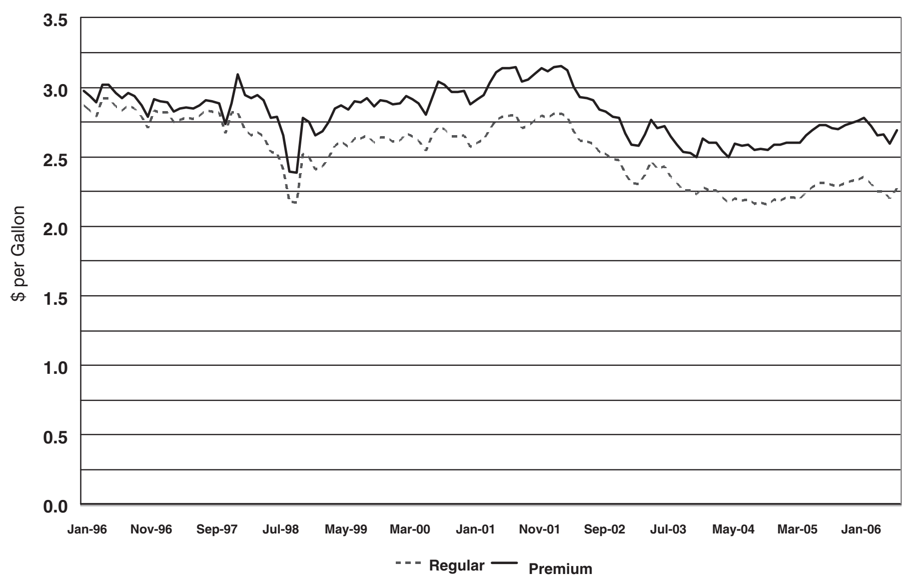
The Mexican case is somewhat different. The Mexican Constitution grants the state exclusive control over the distribution of gasoline. Prices are not market-driven, but policy-driven, and are not set by Pemex, the state oil company, but rather the Treasury Department (*Secretaria de Hacienda*). Presently the government adjusts gasoline prices monthly, based on expected inflation. What this does is effectively isolate the economy from the impact of international oil prices movements. It means that when prices are rising, Mexican users do not feel the inflationary effect. Likewise, when prices fall, Mexican users do not benefit from lower gasoline prices.

## Summary of Evidence on Production Costs for Grain-Based Ethanol

There seems to be a strong consensus in the literature that grain-based ethanol is expensive[5] relative to petroleum-based vehicle fuel –

[5] Of course, Buchanan's warning about the futility of producing objective cost of production estimates in general is still relevant.

**Figure 4.4:** Constant (July 2006) peso Mexican gasoline price (premium and regular) converted to US dollars, Jan 1996 - Jul 2006.




**Source:** Secretaria de Energia.

**Table 4.1:** Comparison of ethanol production costs.

| Country and Feedstock | OECD Estimated Production Cost for 2004[a] ($ per liter) | OECD Estimated Production Cost Adjusted[b] to Petroleum Based Gasoline Equivalent[c] ($ per liter) | OECD Estimated Breakeven Oil Price[d] ($ per barrel) |
|---|---|---|---|
| **Brazil – Sugar Cane** | 0.219 | 0.332 | 29.00 |
| **United States - Corn** | 0.289 | 0.438 | 44.00 |
| **Canada - Wheat** | 0.563 | 0.853 | 150.00 |
| **Canada - Corn** | 0.335 | 0.508 | 65.00 |
| **EU – Sugar Beet** | 0.560 | 0.848 | 95.00 |
| **Gasoline Supply Price[e] (Regional Supply Costs)** | 0.311 | 0.311 | 39.00 |

[a]OECD (Table 1, p. 11)
[b]Assuming that one liter of ethanol is equivalent to 0.66 liters of petroleum-based gasoline
[c]Authors' calculations based on OECD data.
[d]OECD (Figure 3, p. 14).
[e]National gasoline prices, net of fuel taxes, were reported as $0.384 per for the United States, $0.401 for Canada, $0.394 for Brazil, and $0.406 for the EU.

particularly if the costs are adjusted for differences in energy efficiency (see below) – and also relative to ethanol produced from sugar cane and other tropical crops. Various attempts have been made to estimate ethanol production costs for various feedstocks for various locations around the world, including Gavett, Grinnell, and Smith; Berg; Fulton, Howes, and Hardy; and the Organization for Economic Cooperation and Development (OECD). These cost comparisons generally have concluded that corn-based ethanol production could not compete on a cost basis with petroleum, which is subject to taxation from which ethanol is generally exempt, at least for oil price conditions prior to the second half of 2005. Of course, as Buchanan explained almost 30 years ago, cost of production estimation confronts challenging subjective valuation problems if we want to understand opportunity costs.

The available evidence also suggests that production of ethanol from grain corn or from feed wheat or barley is not competitive with production using sugar cane or other tropical crop feedstocks. Estimates of production costs continue to be controversial, however, for predictable reasons. Hill et al. report that ethanol production has not been competitive with petroleum-based gasoline until recent increases in the price of oil. Table 4.1 summarizes some of the findings of an OECD report that compared ethanol production costs for various feedstocks with petroleum-based fuel costs for 2004. On a per liter of gasoline equivalent basis,[6] Brazilian sugar-based ethanol was almost competitive with the supply cost (i.e, exclusive of fuel taxes) of petroleum-based gasoline for market price conditions of 2004. Corn-based ethanol production in the United States would start to become competitive with oil if oil prices rose 32 percent relative to their 2004 level. The corresponding oil prices that would make Canadian wheat and corn-based ethanol competitive with oil would be 157 and 63 percent,

[6] Conversion of ethanol quantity to gasoline equivalent assumed one liter of ethanol was equivalent to 0.66 liters of petroleum based gasoline. Other sources report higher ethanol to gasoline equivalency conversions. And ethanol also is used as an octane enhancer in gasoline.

respectively, while the corresponding oil price for EU sugar beet ethanol production would be 157 percent. Of course, oil prices did rise appreciably in 2005 and 2006, making the short-run economics of ethanol production more attractive, relative to oil, but it remains to be seen if oil prices will continue at the higher levels observed over the past two years. It seems to be generally acknowledged that oil production from the Canadian tar sands becomes profitable at about $40 per barrel. And the reserves in the Canadian tar sands are at least as large as the petroleum reserves of Saudi Arabia, suggesting that this will be an important source of supply-side pressure on prices. And ethanol feedstock prices in North America have also risen steeply in the last two years. Berg reports that raw materials account for 70 to 80 percent of ethanol production costs, so increases in grain prices would have a significant effect on the competitiveness of grain-based ethanol production.

Unfortunately, ethanol prices are difficult to obtain for Canada. There are a small number of production facilities and an even smaller number of distribution firms and publically available data do not currently exist. But US data are more readily available. The California Energy Commission reports ethanol prices as well as retail gasoline prices for the state of California for the last 18 months. The retail price of ethanol, with existing tax exemptions, fluctuated in a range from $0.45 to $0.71 per liter since late 2005, except for the period from April to July of 2006, when prices spiked to the $1.05 per liter level. Regular retail gasoline prices in California reached $0.84 per liter in the late spring and early summer of 2006, about the time of the ethanol price spike, it then retreated to the $0.68 per liter level the following winter. California regular retail gasoline prices rebounded to the mid $0.80s per liter by the late spring and early summer of 2007. Although ethanol prices in California followed the rise of retail regular gasoline prices during the summer of 2006, this has not apparently happened during the summer of 2007. One possible explanation is that the rapid expansion of ethanol production capacity in the United States over the last 12 months has begun to have an effect on prices. As we suggest elsewhere, this may be an early indication that the bloom is off the rose for profitability of investments in ethanol plants in the United States. It is important to remember as well that these prices are expressed on a per unit of volume and not a per unit of energy basis. Ethanol as vehicle fuel is widely reported to be less productive than gasoline, in the sense that a higher volume[7] of ethanol is required to propel a vehicle a specified distance compared to gasoline. Estimates of the productivity difference are varied. We have encountered estimates ranging from 1.25, that is, 1.25 liters of ethanol are required to propel a vehicle the same distance as one liter of gasoline, to a value of 1.33 reported by the Canadian Renewable Fuels Association, to a value of

[7] Of course, ethanol also serves as a substitute for MTBE, so that energy content is not the only consideration in determining its value relative to gasoline, but clearly addition of ethanol does not decrease the price at the pump.

1.6 reported by Olar et al. The price of ethanol relative to retail regular gasoline in California in the summer of 2006, $1.05 to $0.84 per liter or a 25 percent price premium for ethanol, increases to nearly 80 percent if we assume that ethanol contains 70 percent of the energy equivalent of regular gasoline. The Minnesota Department of Agriculture reports price data for ethanol and unleaded regular gasoline from 1994 to 2007 for the Minneapolis/St. Paul market. Early in the time period reported, from about 1994 to 2000, the price of ethanol was consistently about twice the retail price of gasoline. Recall from figure 4.1 that this was a period of time with relatively low world oil prices. Both ethanol and gasoline prices in Minnesota rose after 2000. The gap between the price of ethanol and the price of gasoline has fluctuated but generally decreased as a proportion of the gasoline price. However, the most recent Minnesota price data (Minnesota Department of Agriculture) indicate that ethanol is 58 percent more expensive than gasoline ($0.63 per liter for ethanol compared to $0.40 per liter of gasoline). Again, this price comparison is expressed on a volumetric basis. Applying the same assumption that we used in the California case would increase the energy equivalent price premium to over 120 percent during the winter of 2006.

## The Economic and Political Rationales for Ethanol Production

The technology to use ethanol as vehicle fuel is not new. In the early years of the automobile industry, ethanol was given serious consideration as a fuel source, until petroleum reserves were discovered and developed at a unit cost that made ethanol uncompetitive. Since the early 20th century, however, ethanol advocates have repeatedly claimed that ethanol's time has come.

Typically, support for ethanol production is presented in terms of externalities and market failures to adequately price environmental goods, national security and public welfare in general, and rural welfare in particular. We have identified six major policy rationales for ethanol production. Responding to differing clientele groups and objectives, in a number of cases the rationale tend to overlap. While this list may not be all inclusive, we do think that it adequately represents the state of the policy discussion regarding the rationale for ethanol production. Examination of each of these policy rationales is critical to the assessment of prospects for trade in ethanol. If these rationales continue to drive policy, then trade volumes are likely to be meager.

***Balance of Payments*** Brazil's ethanol program was initiated in the 1970s as a means of conserving on foreign exchange. Although it is not the major driver behind Mexico's recent decisions to develop an ethanol-based industry, estimates place foreign exchange savings from incorporating a ten percent blend into the gasoline supply as high as $2 billion. This comes from both savings on gasoline imports and substitution for MTBE. But as we intimated earlier, import substitution policies are generally applied to mask the symptoms of serious and chronic problems with national monetary policy. Countries with such problems generally don't make trade liberalization a policy priority.

***Environmental Benefits*** Kerr and Loppacher have claimed that the major policy motivation for ethanol policy in the EU, Brazil, Canada, and the United States has been to correct for the market failures associated with the use of petroleum fuel. If this view is correct, then this would place ethanol into a category of environmental goods, which are subject to different trade disciplines than, say, agricultural or industrial goods. This claim, however, is often made by assertion. Increasingly, critics of the ethanol industry have raised environmental concerns about the current and projected scale of ethanol production within North America and even globally, implying that ethanol's status as an environmental good is contentious.

The putative environmental friendliness of ethanol has several dimensions. One aspect is the claim that ethanol production reduces greenhouse gas emissions. Another aspect is that ethanol is a cleaner burning fuel than gasoline in terms of non-greenhouse gas emissions. A third dimension of the claimed environmental benefits of ethanol has to do with its ability to replace MTBE as a fuel ingredient. All of these claims, however, are controversial.

The claim of reduction in greenhouse gas emissions from ethanol use is closely related to analysis of the net petroleum displacement achieved from ethanol use. If vehicle fuel consists of a 10 percent ethanol blend, then every gallon of a blended fuel reduces petroleum use by some amount. The magnitude of the reduction in petroleum use, of course, depends on the size of the energy equivalency adjustment that we discussed earlier. However, using corn as the feedstock for ethanol production, however, means that the petroleum used directly and indirectly to produce the corn, as well as the fossil fuel energy used to process that corn into ethanol, as well as energy used in the transportation of ethanol must be taken into consideration. Of course, indirect energy use occurs in the petroleum supply chain as well.

Our view is that comparing the net energy balance of ethanol versus petroleum-based gasoline faces an unresolvable problem of infinite regress. Early advocates of ethanol claimed that every liter of ethanol used replaced 0.66 liters of petroleum-based gasoline, when adjustments are made for Btu (British thermal unit) content. Critics of ethanol responded that oil was used in the production of the corn that went into the ethanol and that an oil-equivalent of coal or natural gas was used to generate the electricity used in the ethanol plant, so these oil or oil-equivalent inputs should be charged against the ethanol to produce a net oil displacement figure. But ethanol proponents countered that oil is used in the production and transportation of oil as well, so that should be counted. But, pursuing this line of reasoning, oil was used in the production of the tractors that are used to grow the corn. And oil is used to fuel the iron ore freighters that delivered the ore to the steel plants that made the steel that went into the tractors that were used to produce the corn. Of course, being consistent, this indirect oil consumption should be charged against the oil rigs, that are also made of steel, that extract the oil from the oil fields. And then there is the fuel that is used by the employees of the tractor factory, the steel plant, the oil refinery, and the ethanol plant to drive to work. Should that be counted? As with other so-called life cycle analyses, there is no non-arbitrary stopping point for this type of analysis. So any physical estimate of net energy displacement with ethanol has to choose some arbitrary stopping point. The temptation to choose a stopping point that confirms the analyst's prior beliefs is great. Analytically, this is a familiar problem to economists. It is precisely one of the fatal flaws of the labor theory of value developed by the classical economists. The only way out of this morass is to abandon the hopeless project altogether and assess petroleum-based gasoline and ethanol on the basis of prices. On that basis, however, ethanol from grain is not a clear winner in a competition with petroleum-based gasoline. We will discuss the controversy around the net-energy balance calculations for ethanol below. In any case, as a means of reducing greenhouse gas emissions, ethanol use seems to be a high-cost means of reducing those emissions. Henke, Klepper, and Schmitz estimated costs of greenhouse gas reduction in the range of €200 to €1,000 per metric ton of $CO_2$ equivalent, which is far more expensive than readily available alternatives. Forge reports Natural Resources Canada estimates that vehicle fuel using ten percent ethanol produced from corn generates three to four percent lower greenhouse gas emissions compared to conventional fuel. Forge projects that national use of a ten percent ethanol blend fuel would reduce Canada's greenhouse gas emissions by one percent. This suggests that the reliance of the Government of Canada, as well as other governments, on ethanol production as a pivotal element of its climate change policy is, at best, ill advised.

Another aspect of the claim of environmental benefit is that ethanol is an alternative to MTBE in the formulation of gasoline. MTBE has been phased out through a combination of regional bans on its use and the expiration of a legislative shield from liability for its use. Johnson and Libecap's discussion of the history of the debate over the relative environmental demerits of ethanol versus MTBE, however, suggests to us that discerning the truth on this issue is not easy.

Frequently, estimates of the potential environmental benefits and costs do not take into consideration the impact of promoting plantings on marginal land and/or additional water use requirements.[8] An inappropriate choice of crops and technologies can result in negative environmental effects.

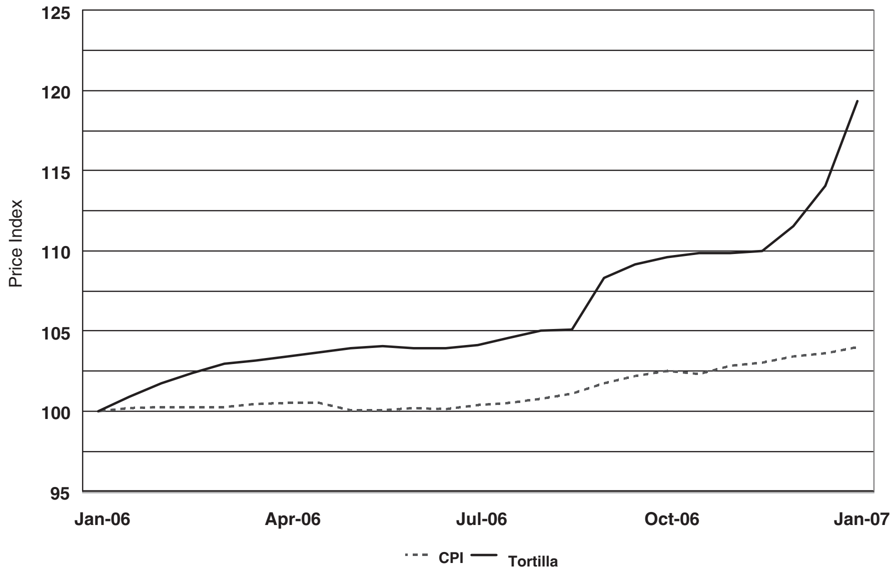
***Farm Income Support and Rural Development*** A long-standing rationale for ethanol production in the United States and Canada is that ethanol increases demand for grains, which increases the price of grains, benefitting grain farmers. Gavett, Grinnell, and Smith, among others, have suggested that ethanol subsidies are an inefficient way of transferring income to farmers, however. Of course, higher grain prices, especially higher feed grain prices, are a mixed blessing at best for the agricultural sector, as these higher prices translate into higher livestock feeding costs (Centre for International Economics) and increased crop acreage in response to ethanol demand-driven grain price increases puts pressure on wildlife habitat (Avery). Mexican and Canadian corn farmers have also benefited from the higher prices for corn on the US market while livestock producers face higher costs for their feed and consumers pay more for their tortillas in Mexico, as figure 4.5 illustrates. Note from figure 4.6, that the burden of increased corn prices falls more heavily on low-income households. Furthermore, as Klein and LeRoy have recently concluded, higher grain prices are quickly capitalized into higher land prices. Another rural development argument that has been offered in support of the ethanol industry is that farmer-investors, as owners of small-scale regional ethanol production facilities, can benefit from profits in ethanol production as well as from higher grain prices. This too, however, may be a short-run phenomenon. Rationalization of ethanol production into larger and larger plant sizes seems to be underway in the United States. There is evidence that economies of size exist in ethanol production, at least up to a plant size of about 150 million liters of production per year.

In Mexico the thrust of the ethanol program is sugar cane. The current rationale is that it will support rural welfare by creating more jobs from expanding sugar cane production and investment in local processing plants. Because of the concern about the availability of corn for human consumption, there is a movement underway to modify the existing legislation to withdraw support from corn-based ethanol.

Sopuck estimates that provincial ethanol support measures in Manitoba cost about $Cdn75,000 per job "created." And none of the advocacy of ethanol as a farm support and rural development policy makes the claim that there is a net gain overall from the subsidization and promotion of ethanol production. Ethanol subsidies, and the marginal excess burden

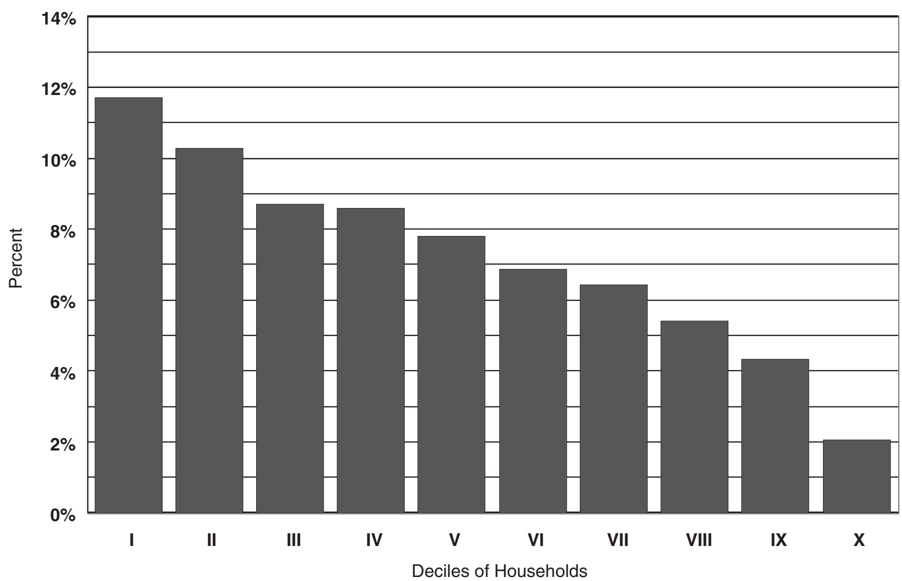
[8] The issue of environmental damage and sustainability, for example, is of particular concern for the production of biodiesel from palm oil.

**Figure 4.5:** Index of consumer level tortilla prices and the overall CPI in Mexico: Jan 2006 = 100.




**Source:** Author's calculations.

**Figure 4.6:** Share of household expenditure used for corn products in Mexico.




**Source:** Author's calculations.

created when the taxes are raised to finance them, impose costs elsewhere in society. So the apparent farm income and rural development benefits are, in reality, income and wealth transfers from other sectors of the economy. In Mexico, because of the importance of corn in the diet of Mexican consumers, one would be particularly hard pressed to make the case that there is an overall net benefit to society from higher corn prices to farmers.

***Reduce Reliance on Oil Imports – the Energy Balance Controversy***

The current primary rationale for ethanol policy in the United States is that ethanol production will reduce demand for imported oil. For Canada and Mexico, however, as net oil exporters, this rationale does not have much relevance, although as pointed out previously, Mexico is an importer of secondary petrochemical products. As in the case of the greenhouse gas reduction rationale, the imported oil argument hinges on the net energy gains (or losses) realized with grain-based ethanol production, and is subject to the same criticism (See discussion above). Pimental has recently estimated that ethanol production from corn in the United States uses 30 percent more energy than is present in the ethanol. Hill et al. have recently concluded that ethanol production from corn in the United States generates 25 percent more energy than it consumes, although almost all of the net gain is attributed to the energy credit estimated for the dried distillers' grains, a byproduct of ethanol production. Olar et al. summarize a number of studies on net energy estimates for ethanol. They conclude that there is a slight upward trend in these values for more recent estimates, but the variability of available estimates is quite high. Sopuck also summarizes estimates of net energy balance for corn-based ethanol production and also presents his own estimates. His summary of nine previous studies, which includes two sets of results produced by Pimental, gives and average positive net energy balance of about 1,100 Btu per liter. Sopuck's own estimate is about 5,500 Btu per liter.

Several practical factors contribute to the variability of estimates of the net energy balance of ethanol production from corn, in addition to the analytical problems discussed previously. First, corn yield is influenced by weather, disease, insects, and operator error. This means that there is variability in output from any given combination of land, fuel, seed, fertilizer, and pesticide products applied to a particular stand of corn. Depending on growing conditions, a given level of fossil fuel input results in a range of corn, and hence corn energy outputs. Second, corn is grown using a wide range of production systems, systems that vary, among other ways, in the level of fossil fuel used. There is no provenance provided with each bushel of corn that arrives at the ethanol plant documenting the nature of the production system used to produce that corn. So no one really knows what energy inputs have been applied. So these inputs are estimated or assumed. And there continues to be controversy about estimates of inputs used in corn production. For example, extension personnel in Ontario have claimed for some time that farmers are applying fertilizer at rates that exceed the profit maximizing level of nitrogen use. On the other hand, aggregate data on total nitrogen use and nutrient budget calculations suggest that the quantity of nitrogen removed in the form of grain corn, at a provincial level, is reasonably close to balanced with total nitrogen fertilizer inputs. Depending on which data one uses, the net energy balance from corn-based ethanol in Ontario would be quite different. A third factor has to do with the treatment of byproducts from ethanol production. Some of the most recent estimates reporting small positive energy balances from ethanol produced from corn charge some of the corn production energy inputs against the byproducts. In fact, the magnitude of the positive energy balance is approximately equal to this byproduct attribution. Economically, this is problematic. Ethanol and the byproducts are joint products. Production economists have long recognized that allocation of production costs over joint products in a non-arbitrary way is not possible. Some arbitrary rules have been developed, such as cost allocation based on share of revenue. If we used recent relative prices for Dried Distillers' Grains (DDGs) and Ethanol, assuming an ethanol yield of 10.26 liters of ethanol per bushel of corn (2.7 US gallons), which would be worth about $6.75, assuming a price of $2.50 per gallon, and DDGs output of about 17 lbs. (7.7 kg) per bushel of corn input, which would be worth approximately $0.62 at current prices, this would result in 91 percent of the corn energy budget being allocated to the ethanol and nine percent to the DDGs. But this ratio may overstate the share of revenue derived from DDGs in the future as ethanol capacity expands putting downward pressure on DDG prices. In any case, our 91 percent to nine percent ratio is a much lower energy input allocation than has been used in studies that have found a net energy gain from ethanol.

In addition to the net energy balance question, the limited capacity of available cropland in the United States, to say nothing of the opportunity cost of the feed and food grain uses of grains currently grown on that cropland, caps potential import replacement at a relatively low level. And even projected growth of ethanol production in the United States would not put much of a dent in oil consumption. US gasoline consumption in 2004 exceeded 500 billion liters. Even doubling current US ethanol production would only constitute about six percent of 2004 gasoline consumption. Hill et al. have estimated that if all US corn and soybean acreage was devoted to ethanol and biodiesel fuel production, this would meet only 12 percent of gasoline and six percent of diesel fuel demand.

***The Infant Industry Argument*** The infant industry argument has been proposed as a rationale for government support for the ethanol industry in the United States, Canada, and most recently in Mexico. The essence of this argument is that new industries, or industries that are new in a particular jurisdiction, need government support to overcome learning and technology development costs if they are to compete internationally with established firms on the world stage. There are several long-standing criticisms of this argument. First, and this is the main point of Lee, Ball, and Tabors in the quotation at the beginning of this paper, is that we have tried this before and it didn't work. A more general criticism of the infant industry argument is that the children, having grown up in such an artificial and protected environment, never grow up. They need perpetual protection. Finally, in the case of grain-based ethanol, it is difficult to see how, biophysically, very much growing up is possible. This is not a new technology. Costs are dominated by biologically determined input-output ratios. This point is driven home in the Center for Agricultural and Rural Development (CARD) study (Tokgoz et al.) which states that under present price levels "the demand for fuels with greater than ten percent ethanol will be small in the next ten years without a change in government policy (p.2)."

Advocates of grain-based ethanol production sometimes, when confronted with this criticism, retreat to "well, grain-based ethanol is just a stepping stone to cellulose-based ethanol production." Interestingly the CARD study, when referring to the possibility of switchgrass, concludes that "in the Corn Belt [switchgrass] will make economic sense only if it receives an additional subsidy that is not provided for corn-based ethanol (p.41)." Of course, the policy coalition that sustains ethanol policy has nothing to gain and much to lose from cellulose-based ethanol. And it seems to be generally accepted that cellulose-ethanol is a long way from commercial scale operation.

***Ethanol as Part of an Overall Renewable Energy Program*** The interest in ethanol is often part of a large effort to develop alternative and renewable sources of energy. Among the other alternatives include geothermic energy, wind, and waves. Ethanol, along with biodiesel, for many of the reasons listed above, has attracted most of the public's attention and budget outlays. This has effectively turned energy policy into "ethanol," and to a lesser extent "biodiesel," policy, to the detriment of the development of alternative renewable energy sources. Likewise, the focus on ethanol and biodiesel is politically attractive. The message is that energy conservation is secondary. Funding for energy conservation programs, including research and subsidies, pales in comparison to the resources going to the development of ethanol and biodiesel-based industries. Consumers in the well-to-do nations are being told that they can essentially continue their energy spending/wasting lifestyles since there are and will be readily available alternative energy sources.

But alternative energy sources are not just alternatives to oil, but also to one another. One of the "others" is ethanol production from tropical crops in equatorial climates. And the critical question for any alternative energy system is "are we there yet?"

## General Issues

***Is Differential Taxation a Subsidy?*** Policy support for the ethanol industries in United States and Canada takes many forms. In Mexico there has yet to be official support forthcoming for biofuels, although Congress recently passed a bill that signals the intent to support biofuels – and particularly ethanol. Capital and operating grants and concessional loans are being widely used in Canada. Import tariffs protect domestic firms in the United States and Canada. Differential application of excise taxes on fuel is also used.[9] Some analysts, for example, Koplow, include the US excise tax exemption as part of their subsidy calculations. In fact, Koplow concludes that the excise tax exemption is the largest subsidy directed toward ethanol production in the United States. But is a tax exemption a subsidy? Differential tax rates on goods may be perceived to be unfair and may raise controversial distributional issues. They may promote market distortions. They may be inconsistent with obligations of WTO members or NAFTA signatories, but, in our view, it is incorrect to view differential taxation as subsidization. If a government levies a tax of X percent on product A and does not tax product B, it has not subsidized product B. It has not taken wealth or income from taxpayers or consumers and handed it over to producers of product B. To treat differential taxation as a subsidy is to assume that the government owned an entitlement in the tax revenue, not the producer, and that, by failing to collect its entitlement, it conveyed a subsidy to producers of product B.

***Food versus Fuel*** The tradeoff between grain production for feed and food versus production for fuel has become more visible in the last 18 months. Various livestock industry groups have raised concerns about the effect of increased ethanol production on feed grain costs for some time. To support what are assumed to be higher long-run corn prices the CARD study (Tokgoz et al.) concludes that the livestock industry will cutback production in order to pass on the higher costs to consumers.[10] But the increase in corn prices[11] in particular, over the last 18 months has precipitated a more general concern, not just within North America,

[9] Because an important component of prices at the gas pump is state taxes, this is a particularly attractive policy to promote ethanol use in US cornbelt states.

[10] The increased use of corn for fuel in North America, along with the anticipated contraction in livestock production, will have important consequences for future commodity trade flows, opening the way to potentially new trade disputes.

[11] Klein and LeRoy report an increase of 86 percent in US corn prices, of 32 percent in US soybean prices, and of 39 percent in US oat prices, as well as increases of 54 and 59 percent in Canadian feed barley and feed wheat prices, respectively, between 1 March 2006 and 1 March 2007.

but globally. According to a recent estimate, around 15 percent of last year's US corn crop was used for ethanol production. If we assume a short-run supply elasticity of 0.5, a new source of demand of this magnitude could increase prices by 30 percent. Changes in corn prices have not gone unnoticed in land markets. A survey by the Federal Reserve Bank of Chicago reports that the value of "good" land in the corn and soybean growing states of Illinois and Iowa grew by seven percent and 16 percent respectively during the first quarter of 2007. The key driver in this reversal from the situation last year, according to the Bank is "the expectation that the higher corn and soybeans prices relative to a year ago will be sustained by continued growth in demand for these crops, particularly to make biofuels."

As figures 4.5 and 4.6 illustrated earlier, the food versus fuel debate takes added relevance in the Mexican context. Mexico is one of the few countries where corn and corn products directly play an important part in the consumer diet. According to the United Nations Food and Agricultural Organization data, in 2004, the average Mexican consumed 308.3 grams of corn per day making it the most important food product in terms of volume (FAOSTAT). Likewise, the Mexican National Statistics Institute (Instituto Nacional de Estadística, Geografía e Informática) reported that for the average Mexican household, six percent of the total food bill is for corn and corn products, e.g., tortillas (INEGI). For the poorest households, the percentage of the food bill spent on corn and corn products reaches 12 percent.

As figure 4.5 reports, by the beginning of 2007, tortilla prices had risen 19.4 percent compared with the level one year earlier. The overall Consumer Price Index (CPI) grew by four percent over the same period. Fearing both the political repercussions from consumer discontent over higher corn and tortilla prices and the impact of high prices on efforts to control inflation, the government cajoled the industry into holding the line on tortilla prices. They also authorized emergency corn imports, i.e., outside the NAFTA-based quota system. At the same time, they offered to make additional funds available to support corn production in the country. While one would think that higher corn prices would facilitate the transition to an open market in 2008 under the NAFTA, the short-run reaction of the government has been to turn its back on market mechanisms, and to take a step backwards to quasi-price controls and extensive support to corn production.

Globally, Runge and Senauer project that the accompanying price increases from the use of food products to produce biofuels will "exacerbate world hunger." Rather than the 23 percent decline in the number of hungry people in the world that they projected in 2003, they are now predicting that the number of chronically hungry in the world will rise by 600 million more in 2005 than the previous estimates.

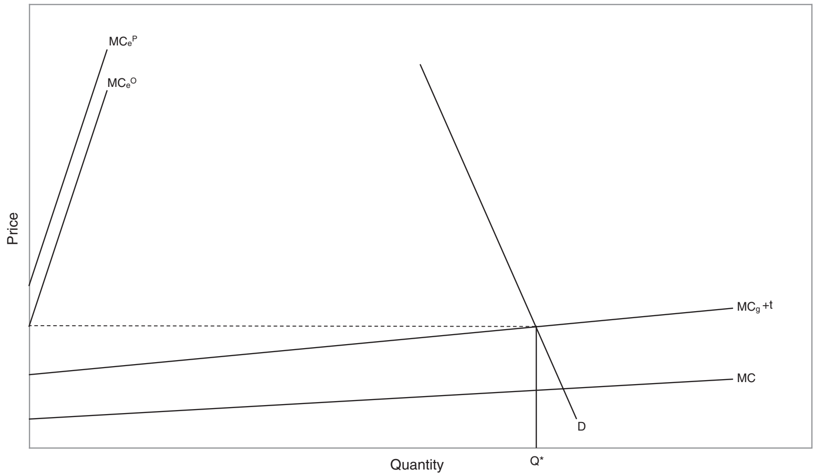
Underlying the impact of the use of food products for biofuel production is the question of whether or not there is enough land available to produce both the world's food and fuel needs. The answer, of course, depends on a number of assumptions, including changes in productivity. It also revolves around the extent to which ethanol or biodiesel are included in the fuel mix, as well as the choice of feedstock. Calculations by the Mexican Secretary of Energy estimate that to achieve a ten percent ethanol blend level in gasoline would require one million hectares of corn production. Because Mexico is already a net importer of food products, without a change in technology, we have to conclude that land used for production of crops destined to produce ethanol would mean that Mexico's food trade deficit would increase.

## THE ECONOMIC ANALYTICS OF THE ETHANOL AND GASOLINE MARKETS

Certain aspects of current ethanol support policy in Canada and the United States are represented in a series of supply and demand diagrams, presented as figures 4.7, 4.8, and 4.9. Figure 4.7 illustrates the approximate relative positions of the demand for fuel (D) and the marginal costs of petroleum based gasoline (MCg) and ethanol (MCe) in North American markets. The superscript O or P on the marginal cost schedule for ethanol distinguishes between an optimistic (O) and a pessimistic (P) cost comparison with petroleum based gasoline. The retail supply of gasoline is represented as MCg + t where t represents the tax. Demand for vehicle fuel, D, is drawn as relatively inelastic. Of course, the marginal cost of gasoline, exclusive of taxes, does fluctuate, although, as we showed earlier, not generally to the extent commonly perceived. In any case, this implies that the MCg + t schedule does move up and down. Fuel ethanol is generally exempt from excise and other taxes, but based on what we have seen, is not able to compete on a cost basis with retail gasoline, which is taxed. The marginal cost of ethanol is more steeply sloped than the marginal cost of gasoline, owing to the limited land base and the impact of grain use for ethanol on grain prices. For the optimistic ethanol cost scenario, (O), ethanol is close to being competitive, on a price basis, with gasoline. For the pessimistic scenario, (P), the marginal cost of untaxed ethanol lies above the retail price of gasoline.

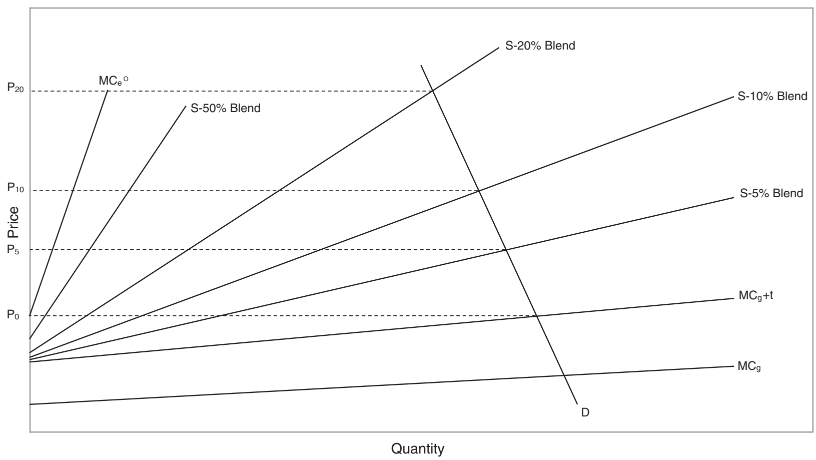
Figure 4.8 extends figure 4.7 and illustrates the effect of blending requirements on fuel supply and on retail fuel prices. In Figure 4.8, the ethanol portion of blended fuel is exempted from tax. Even modest blending requirements have potentially significant impacts on retail prices, given the limited production capacity of domestic farmland to

**Figure 4.7:** The demand for vehicle fuel and the supply of gasoline and ethanol.




**Notes:** $MC_e^P$ = Marginal cost of ethanol (pessimistic view); $MC_e^O$ = Marginal cost of ethanol (optimistic view); $MC_g$ = Marginal cost of gasoline; $MC_g$+t = Marginal cost of gasoline plus tax; D = Demand for gasoline/ethanol.

**Figure 4.8:** The potential effects of ethanol blending requirements on vehicle fuel prices.




**Notes:** $MC_e^O$ = Marginal cost of ethanol (optimistic view); S-50% Blend = Supply of 50% blend ethanol; S-20% Blend = Supply of 20% blend ethanol; S-10% Blend = Supply of 10% blend ethanol; S-5% Blend = Supply of 5% blend ethanol; $MC_g$ = Marginal cost of gasoline; $MC_g$+t = Marginal cost of gasoline plus tax; D = Demand for gasoline/ethanol.

produce ethanol feedstock, relative to current continental levels of vehicle fuel use.

Figure 4.9 illustrates the possibility of ethanol imports from Brazil, which, based on the information available to us, we believe would be competitive with retail unblended gasoline on a price basis in the United States at the present time. However, the import duty currently applied largely precludes this from happening.[12] Even if import duties were removed, however, we have represented the import supply curve from Brazil as relatively steep, given the size of the US domestic fuel market relative to Brazil's capacity to export. So removing trade barriers to Brazilian imports would not provide much price relief from the effects of blending requirements.

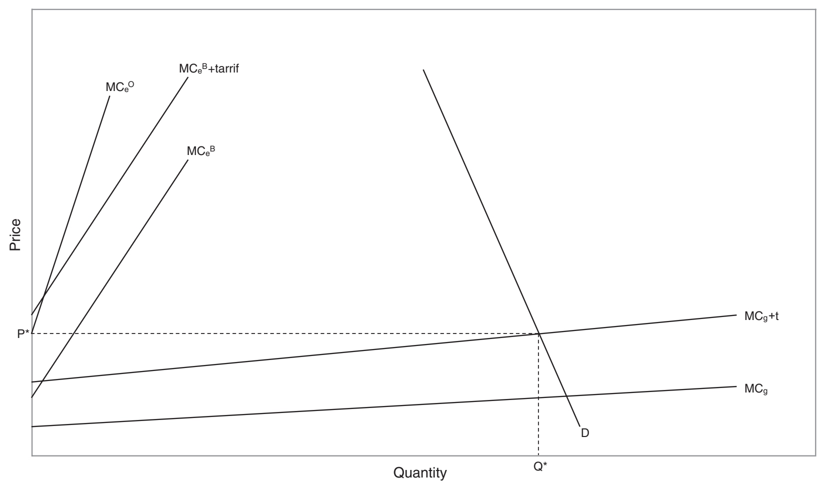
## NATIONAL POLICIES

### Canada

The main federal policy initiatives promoting ethanol production are an import duty of C$0.10 per liter imposed on imports from non-NAFTA

[12] We have seen some evidence that small amounts of Brazilian ethanol in fact do enter the US market under the current tariff regime, but this may be due to imbalances between regional requirements and production or to limited availability of infrastructure.

**Figure 4.9:** The potential competitive impacts of Brazilian ethanol imports.




**Notes:** $MC_e^O$ = Marginal cost of ethanol (optimistic view); $MC_e^B$ = Marginal cost of Brazil-produced ethanol; $MC_e^B$+tarrif = Marginal cost of Brazil-produced ethanol plus tarrif; $MC_g$ = Marginal cost of gasoline; $MC_g$+t = Marginal cost of gasoline plus tax; D = Demand for gasoline/ethanol.

countries, a C$0.10 per liter federal excise tax exemption dating from 1992, capital grant or concessional loan programs, starting with the Ethanol Expansion Program in 2003 and currently through the Biofuels Opportunities for Producers and the ecoAgricultural Biofuels initiatives announced in the most recent budget, a federal fuel procurement preference, and a recently announced target of five percent ethanol in national gasoline consumption by 2010. The recent federal budget also announced that the C$0.10 excise tax exemption is to be replaced by a C$0.10 producer incentive payment "where industry requires support to remain profitable." Under the Ethanol Expansion Program, loan amounts ranged from C$0.08 to C$0.20 per liter of capacity, assuming a 25 percent marginal excess burden. There were seven loans totaling $CDN 78.2 million approved under the program for a total additional capacity of about 750 million liters per year. Repayment terms for these loans are lenient, since repayments are contingent on net return targets. If these loans are treated as grants and amortized over five years, the subsidy would range from C$0.02 to C$0.04 per liter. If we assume that the principal will be repaid and the subsidy is the interest rate, say, at eight percent real, then the subsidy ranges from C$0.005 to C$0.013 per liter.

Provincial policies vary. Walburger et al. report provinces exempt ethanol from provincial fuel taxes. This exemption ranges from C$0.09 per liter in Alberta to C$0.20 per liter in Quebec. In Ontario, the largest producing province, the exemption was C$0.147 per liter, but this was phased out when minimum blending requirements were introduced. In the case of Quebec, the exemption is up to 130 percent of the current C$0.152 per liter tax. British Columbia, Saskatchewan, Manitoba, and Quebec stipulate that the provincial tax exemption only applies to ethanol produced within the province.

In addition to federal and provincial government support, municipal governments have promised property tax reductions as well as attractive terms for real estate acquisition in efforts to attract ethanol plants in Canada. The process has resembled, at the level of smaller rural municipalities, the rivalry of larger urban centers for professional sports franchises.

## Mexico

Until just recently, when Congress passed the bioenergy law, Mexico had no real policy towards biofuels generally, let alone ethanol. At the end of April the Congress passed a bioenergy law.[13] As discussed above, the main focus was on the support of bioeneregy development to stimulate rural

[13] For the law to go into effect it has to be published in the Mexican equivalent of the Federal Registry. As of this writing it has yet to be published, leading to speculation that it will undergo further modifications.

development. In fact, a major criticism of the law is that it does not fully contemplate the role of energy-related institutions in the development and distribution of a biofuels market. While the bill was still in Committee in the Congress there was talk of a ten percent blending requirement. The final version did not set a specific blending target, nor overall use targets for biofuels, except in so far as it would serve as an oxygenation agent in existing fuels. Some law-makers are considering proposing changes in this recently passed law. These may include specific and quantifiable blending requirements or biofuel use targets. The law, as it now stands, is vague on the specifics of support. It does, however, contemplate support for bioenergy products, including capital subsidies for processing facilities.

The policy environment for fuel has its foundation in the Mexican Constitution. The state is granted the exclusive right to petroleum resources including refining, distribution, and sale of gasoline. The production of ethanol, according to a number of sources, is not the exclusive right of the state, nor is the sale of 100 percent ethanol by private individuals or companies limited to the state. If the ethanol is blended with gasoline, however, the state assumes the exclusive right to distribute the blended fuel.[14]

Gasoline is subject to a value added tax (VAT). The recently passed Bioenergy Law does not contemplate a special tax regime for ethanol blended fuels. This suggests that ethanol blended fuels would be subject to the same tax structure as non-ethanol-based fuels.

As indicated above, the price for gasoline in Mexico is set by the government according to a fixed formula which is presently based on expected inflation. The Bioenergy Law does not consider a special pricing regime for biofuels. This, again, would suggest that ethanol blended fuels would be subject to the same price structure as non-ethanol-based fuels.

## The United States

Zhang, Vedenov, and Wetzstein trace the recent growth of the ethanol industry in the United States to the provisions of the 1990 Clean Air Act amendments, even though ethanol had been subject to fuel tax exemptions since the 1978 Energy Tax Act. The 1990 Clean Air Act amendments required minimum oxygen content standards. Ethanol and MTBE emerged as substitute fuel additives used to comply with the oxygen standards. Due to cost considerations, however, ethanol was not able to realize a significant share in the fuel additive market until MTBE began to be phased out for environmental and human health reasons. The relatively rapid withdrawal of MTBE created substantial new demand for ethanol. Berg divides the post-1990 history of ethanol production in

[14] The state does franchise the distribution of gasoline to private individuals.

the United States into three sub-periods, attributing modest growth in output between 1990 and 1998 to the oxygenate requirements of the Clean Air Act amendments, more rapid growth between 1998 and 2005 to the growing concerns about MTBE and the projected 30 plus percent growth between 2005 and 2012 to the Renewable Fuels Standards of 2005. Runge and Senauer identify an earlier boost to ethanol production in the United States, when demand increased in response to the phase out of lead in gasoline in the 1970s and 1980s.

Koplow's recent synopsis of federal and state government support measures for ethanol is the most detailed and comprehensive analysis available. An earlier survey by MacDonald of the California Energy Commission also compared state level policies in the United States. Yacobucci has also reviewed current US policy. The main elements of US federal policy are a federal excise tax exemption, income tax credit that has ranged from $0.51 per gallon ($0.134 per liter) to $0.54 ($0.142 per liter), an ad valorem import duty of 2.5 percent as well as a supplemental import duty of $0.54 per gallon ($0.142 per liter), a small producers' (originally up to 30 million gallons per year production, but later raised to 60 million gallons per year) income tax credit of $0.10 per gallon ($0.026 per liter), and under the Energy Policy Act of 2005, a renewable fuels standard mandating minimum blend requirements for ethanol in gasoline nationally. Koplow; MacDonald; Yacobucci; and others have also documented the wide range of state level programs, which include fuel tax exemptions, support payments and blending requirements as well. The history of blending requirements is complex, beginning with the Clean Air Act Amendments of 1990, which established an oxygenate standard which created demand for ethanol and MTBE as fuel additives. The Energy Policy Act of 2005 dropped the oxygenate standard from the 1990 Amendments and instituted the national Renewable Fuel Standard, setting requirements of 15.1 billion liters of ethanol in 2006, increasing to 28.4 billion liters by 2012. In addition, the Energy Policy Act did not contain an expected liability protection provision for MTBE manufacturers, further accelerating the shift toward ethanol.

Koplow's compilation and analysis of US biofuel subsidies includes not only import tariffs, renewable fuel blending standards, and excise tax exemptions, but also includes procurement preferences and input subsidies for capital, feedstocks, water, land, and labor. Kaplow treats reduced levels of excise taxes on ethanol or on inputs used in ethanol production as subsidies. He also includes the negative effect of US agricultural policies on world grain prices as one of his categories of input subsidies. His overall estimate of support for ethanol production ranges from $1.42 to $1.87 per gallon ($0.37 to $0.49 per liter) of gasoline equivalent, when he applies 2006 programs to 2006 production levels. If the ongoing benefits of programs from earlier years are incorporated in the calculations, his estimates rise to $1.44 to $1.96 per gallon ($0.38 to $0.51 per liter) of gasoline equivalent. The bulk of this support, however, comes from his estimate of the federal excise tax credit, which is responsible for about 50 percent of his subsidy estimates. About 20 percent of Koplow's subsidy estimate is attributable to blending requirements.

Other trade-related aspects of US ethanol policy include the Caribbean Basin Initiative (CBI), under which ethanol produced in a Caribbean country with a specified level of local feedstock enters the United States at concessional duties. Up to 60 million gallons, or seven percent of US production is duty free. Bovard; and Elobeid and Tokgoz have discussed the evolution of this policy, however, and suggest that the opportunity for Caribbean countries to export ethanol to the US market is more apparent than real. There has been, nevertheless, increasing interest recently by Brazilian investors to use the CBI countries as a point of final processing of Brazilian ethanol. This essentially would allow Brazilian product to enter the US market duty free. In addition to the Caribbean Basin Initiative, ethanol from NAFTA countries enters the United States duty free, subject to country of origin.

US policies, including proposals for inclusion in the upcoming Farm Bill, also include a number of support elements. These include budgetary support for actions ranging from loan guarantees for biofuel plants, to grants for biobased energy technologies and products, as well as funding for educational programs. Of particular interest is a proposal to fund feasibility studies for the construction of dedicated ethanol pipelines. This responds to the problems of transporting ethanol. To the extent that feasibility studies lead to ethanol infrastructure, it will create a set of vested interests that will work against competing energy alternatives, including trade-based initiatives.

## Policy Comparisons

Table 4.2 summarizes and compares the main policy measures used to promote ethanol production and consumption in the NAFTA countries. Support has been converted to $/liter units to facilitate comparison. Several interesting points of comparison between Canada and the United States can be seen. First, federal support for ethanol seems to play a more significant role in the United States, as well as in Mexico, than it does in Canada compared to state and provincial support, respectively. The main exception is Minnesota, which looks more like a province than a state. Second, provincial commitments to ethanol are more broadly distributed in Canada than appears to be the case in the United States, where support is highest in midwestern grain producing states. Ironically, Canadian grain producers have already received substantial benefits, in the form of higher grain prices, as a consequence of US ethanol policy.

**Table 4.2:** Comparison of ethanol support policies in Canada, Mexico, and the US[a].

| | Canada[b] | | Mexico | United States | |
|---|---|---|---|---|---|
| **Category of Support** | **Federal** | **Provincial** | **Federal** | **Federal** | **State[c]** |
| ***Import Duties*** | $0.09/liter[d] | Not Applicable | $0.63/liter[e] | $0.142/liter | Not Applicable |
| ***Excise Tax Exemptions and Income Tax Credits*** | $0.09/liter | Alberta $0.081/liter<br>British Columbia $0.13/liter<br>Manitoba $0.30/liter[f]<br>Ontario $0.132/liter[g]<br>Quebec $0.18/liter<br>Saskatchewan $0.135/liter | Not contemplated in Bioenergy Law | $0.134/liter | Illinois[h] $0.079/liter<br>Iowa $0.003/liter<br>California $0.079/liter<br>Indiana[i] $0.03/liter |
| ***Capital Grants/ Concessional Loans*** | Ethanol Expansion Program[j] up to $0.03/liter | Ontario Ethanol Growth Fund up to $0.09 per liter of capacity | Ad hoc support from Federal Agricultural Infrastructure Fund | | |
| ***Operating Grants*** | 2007 Budget $0.09/liter[k] | Alberta $0.126/liter<br>Ontario up to $0.099/liter | | | Minnesota $0.053/liter<br>Texas $0.053/liter<br>Wisconsin $0.053/liter |
| ***Blending Requirements*** | 5 percent by 2010 | Alberta<br>British Columbia<br>Manitoba 8.5 % in 2005<br>Ontario rising to 10% by 2010<br>Quebec<br>Saskatchewan | No target given, but government will make effort to use blended fuel | | Minnesota 10 percent |

[a] Data in this table were derived from various sources, including Walburger et al.; Koplow; MacDonald; and various government press releases.
[b] A US$ to C$ exchange rate of C$1.00 to US$0.90 was assumed.
[c] Reported calculations are for the ten largest ethanol consuming states.
[d] Scheduled to be phased out in 2008 and replaced with an equivalent "incentive payment."
[e] Refers to denatured ethanol from countries where no trade treaty exists. Imports from Canada and the US are duty free as long as they are not sugar-based ethanol which has benefited from the Sugar Reexport Program.
[f] In Manitoba, fuel ethanol is exempted from a C$0.20/liter excise tax and the excise tax on ten percent blend fuel is reduced by C$0.015/liter on the gasoline portion. Since, in a ten percent blend, nine liters of gasoline are mixed with each liter of ethanol, the reduction in provincial excise tax is C$0.20 per liter for the ethanol exemption plus C$0.135 for the tax reduction on the gasoline in the blended fuel, for a total exemption of C$0.335/liter. The exemption on the ethanol portion will be reduced to $0.135/liter from 2007 to 2010 and to $0.09/liter from 2010 to 2013.
[g] The exemption has been replaced by a provincial blending requirement.
h Illinois reduces the sales tax on E10 and above blends from 6.25 to five percent. If the retail price of gasoline is $2.50 per gallon inclusive of sales tax at 6.25 percent, then this would fall to $2.47/gallon at a five percent tax rate. The $0.03/gallon reduction is gained for having 0.10 gallons of ethanol, so the tax reduction is $0.30/gallon of ethanol, or $0.079/liter.
[i] State income tax credit.
based ethanol which has benefited from the Sugar Reexport Program.
[f] In Manitoba, fuel ethanol is exempted from a C$0.20/liter excise tax and the excise tax on ten percent blend fuel is reduced by C$0.015/liter on the gasoline portion. Since, in a ten percent blend, nine liters of gasoline are mixed with each liter of ethanol, the reduction in provincial excise tax is C$0.20 per liter for the ethanol exemption plus C$0.135 for the tax reduction on the gasoline in the blended fuel, for a total exemption of C$0.335/liter. The exemption on the ethanol portion will be reduced to $0.135/liter from 2007 to 2010 and to $0.09/liter from 2010 to 2013.
[g] The exemption has been replaced by a provincial blending requirement.
[h] Illinois reduces the sales tax on E10 and above blends from 6.25 to five percent. If the retail price of gasoline is $2.50 per gallon inclusive of sales tax at 6.25 percent, then this would fall to $2.47/gallon at a five percent tax rate. The $0.03/gallon reduction is gained for having 0.10 gallons of ethanol, so the tax reduction is $0.30/gallon of ethanol, or $0.079/liter.
[i] State income tax credit.

Recent Canadian policy initiatives, by virtue of the small share of the North American corn market produced in Canada, are likely to have such small additional price effects as to defy measurement.

Apart from comparative support levels, this brief summary of biofuels policies in the NAFTA countries illustrates several important points. First, the ongoing expansion and even the existence of a corn-based ethanol industry is contingent on government support. The matrix of policies at the federal, provincial, and state levels is complex and dynamic. Second, the policy rationale for supporting ethanol has changed frequently since 1978. Ethanol has been promoted on environmental, economic, and geopolitical grounds. Third, the dramatic increase in ethanol production over the past two or three years has galvanized critics of current policy and challenged virtually all aspects of the rationale for government involvement in the biofuels market.

## Potential Trade Issues

International trade in ethanol does occur, but the level and even the direction of trade is volatile. Berg describes the Brazilian ethanol net trade position as "erratic." For example, Elobeid and Tokgoz report that in the fall of 2005, Brazilian ethanol, inclusive of import duties and transportation costs, was available in the US market for $2.07 per gallon ($0.54 per liter), compared to the US domestic price of $2.47 per gallon ($0.65 per liter). Brazil exported 19.7 million liters of ethanol to the United States in October and 10.2 million liters in September 2005, but did not export anything to the US market in August of that year. Gallagher et al. report a brief episode of US ethanol exports to Brazil, in 2000, when sugar prices drove up the cost of Brazilian ethanol to a level about equal to the landed price of US ethanol. Schmitz, Schmitz, and Seale report that Brazil imposed a 30 percent import duty on ethanol in 2001, presumably as a precaution against recurrence of this type of spontaneous international exchange ever happening again. Laney estimates that Brazil currently exports about 3 billion liters of fuel ethanol per year, which amounts to about 19 percent of its production.

In spite of the limited current experience with international trade in ethanol, a recent discussion paper from the International Food and Agricultural Trade Policy Council and also Kerr and Loppacher have argued that WTO disciplines do apply to biofuels, and, given the rapid growth in global production of these commodities, the need for clarification of the extent to which obligations under the WTO have implications for national biofuels policies is becoming more acute. The Council compares current biofuel mandates in the United States and Japan to the domestic capacity to produce biofuels relative to national fuel demand and concludes that trade will be inevitable. They identify three issues that need to be clarified in the application of WTO rules to this pending trade: 1)the determination of whether ethanol should be treated as an agricultural, an industrial, or an environmental good; 2) the determination of how ethanol subsidies should be treated in terms of existing categories of WTO subsidy rules; and 3) the assessment of compliance of domestic rules with WTO standards on technical barriers to trade. Kerr and Loppacher also consider clarification of whether fuel ethanol is an industrial, agricultural, or environmental good to be a critical trade issue. They also identify implications of the EU/US dispute over biotechnology as an impediment to EU/US trade.

On the US side, net imports of ethanol since 1992 have generally been small relative to national production and consumption. Data reported by Berg indicate that net US ethanol imports amounted to a little over two percent of domestic consumption in 1994, which was the highest share for the 1992-2003 period. In 2003, the import share was only 0.3 percent.

Berg projects growth in world ethanol trade from a 2005 volume of about 1.4 billion liters annually to over eight billion liters per year by 2012. This growth is dominated by projected imports by Japan. He does not project much growth for ethanol imports into the United States.

Most recently a concern has been raised in some circles in Mexico about the possibility of "dumping" DDGs onto the Mexican market, with the effect of depressing corn prices faced by local farmers. As discussed previously, when valuing DDGs, one runs into the classic problem of assigning costs to joint products. The probability of successfully arguing a dumping case against DDGs we consider to be minimal, at best. Nevertheless, it is interesting to contemplate the possible trade disputes arising from corn-based ethanol production.

***Biotechnology*** Kerr and Loppacher have identified differing national treatments of biotechnology as a potential future trade tension for ethanol. The concern to increase productivity to respond to the demand for agricultural feedstock for the production of ethanol has given new life to supporters of biotechnology, particularly the use of genetically modified (GM) crops. The argument is that GM technology to enhance productivity already exists and the future depends on the extent that GM research and adoption is supported. This has especially been the case in Mexico, where compared with Canada and the US, the use of GM technology has been significantly limited. With regards to trade, it is not clear whether countries that prohibit or limit GM agricultural imports will also use this to limit ethanol or biodiesel which uses GM feedstock.

***Lack of Transparency*** The market for commodity ethanol has been expanding rapidly in the United States and Canada, driven by a complex array of policy measures at the federal, state, provincial, and even the municipal level. Compiling current information on the effective level of support for this dizzying array of programs is a daunting task, made more challenging by the rapid rate of policy change and by the possibility of subsidy stacking. Actions of competing jurisdictions have come to resemble the behavior of rival cities hoping to host the Olympic games or to be future homes to professional sports teams. The economic implications of the comparison are not encouraging. Even something like obtaining reliable price data for ethanol is problematic in Canada, making trade and market analysis speculative ventures.

***Provincial and State Production Preferences and National Treatment Principle*** Offers of provincial support for ethanol producers from the governments of British Columbia, Saskatchewan, Manitoba, and Quebec that explicitly favor ethanol produced in the province from feed stock grown in the province would appear to be contrary to the national treatment principle embodied in the WTO and the NAFTA.

***Potential for International Trade Liberalization*** Although we will argue later that the realistic prospects for trade liberalization in ethanol are not bright, some analytical work has been done to assess the impact of liberalization on world prices and national production and consumption levels. Elobeid and Tokgoz modeled the effect of removing US barriers to ethanol imports. They used a multi-market partial equilibrium market model that linked ethanol markets with the sugar and feed grain markets. Their model was calibrated for 2005. Their results indicate that unilateral liberalization by the United States, consisting of dropping the duty rate of 2.5 percent as well as the levy of $0.54 per gallon ($0.142 per liter), leads to a rise in world ethanol prices (23.9 percent), a decrease in the domestic US ethanol price (13.6 percent), a reduction in US domestic ethanol production (7.2 percent) and an increase in US consumption (3.6 percent). In the model, US net imports of ethanol double.

However, there are several reasons to believe that trade liberalization in ethanol or other biofuels will not happen any time soon. First, the two leading ethanol producing nations, Brazil and the United States, have made large and, in the case of Brazil, long-standing commitments to developing a domestic ethanol industry for reasons that fly in the face of the venerated principle of comparative advantage. The United States is pursuing a biofuel development import substitution policy to reduce dependence on imported oil. It is unlikely that advocates of this policy would see much advantage to swapping dependence of foreign oil for dependence on foreign ethanol. Neither country currently shows any inclination to reverse course on domestic support policies and embrace free trade in biofuels. Second, saturation of the domestic vehicle fuel market with ethanol has not been reached in either Brazil or the United States. The modest level of current Brazilian ethanol exports seems to have found an attractive outlet in the EU. The limited domestic capacity of the United States to produce ethanol relative to domestic fuel requirements means that it is unlikely to enter the export market any time soon. Furthermore, as Kerr and Loppacher have explained, the long-standing tension between the EU and the United States on biotechnology has effectively closed the EU market to US corn-based ethanol. Given the high priority on directing domestic production to domestic use in both countries, it would be unlikely that either nation would mount a WTO complaint on the other's trade barriers. Ethanol consumption is projected to expand substantially in Japan over the next ten years and the Japanese market will likely be an attractive destination for south and south-east Asian ethanol and biodiesel production, reducing the probability of a WTO challenge against US trade barriers from that region.

Within the NAFTA, Canadian production will be hard pressed to fill the blending requirements announced recently at the federal level and there is very little ethanol production in Mexico. The limited policy on biofuels does not contemplate exports of ethanol as a policy objective. There are some projects in the pipeline that do consider the possibility of exporting ethanol to the US market. Because Mexican produced ethanol would enter the US duty free under the NAFTA, Mexican ethanol producers would be able to take advantage of the US price structure for ethanol. This would imply that they would be secondary beneficiaries of the ethanol subsidy in the US While the completion of these projects may result in some ethanol being exported to the US, the overall impact on the US market will likely be minimal. If anything, it will probably be more political than economic. Because, as indicated above, in order to achieve a ten percent blending target, Mexico will need to dedicate approximately one million hectares to grow crops for ethanol instead of food, a massive movement of ethanol from Mexico to the US is highly unlikely. So, there will be little in the way of international pressure on the United States through its trade agreement obligations.

## PUBLIC CHOICE ANALYSIS OF THE EMERGING ETHANOL INDUSTRY IN THE UNITED STATES AND CANADA

Both the prospects for regularized international trade in ethanol, as well as assessment of the likelihood of trade disputes arising from that prospect are contingent on future developments in the policy environment, especially in the United States and Brazil, since they are currently the leading ethanol producers. The current policy approach in both countries mitigates against regularization of international trade, to put it mildly. But policies can change. Actual outcomes of policy processes are notoriously difficult to predict. Perhaps understanding the dynamics of those processes somewhat better is the best thing economists can hope to contribute.

Yandle has developed a public choice- based explanation for the existence of what, on the surface, might appear to be paradoxical coalitions that he had observed in environmental policy development in the United States. In several different contexts, Yandle observed environmental groups and industry groups both supporting, albeit sometimes in different ways, the development of US federal environmental regulations. Yandle calls his explanation the "Baptists and Bootleggers" theory. This metaphorical label refers to a quasi-hypothetical situation where a local government is considering a ban on retail alcohol sales on Sundays. The Baptists, according to Yandle, support a ban on moral grounds. People should be at church on Sundays, not reveling in bars. A ban on retail alcohol sales would strengthen the moral fiber of the community, or something like that. Bootleggers, on the other hand, might very well support a ban, but for more prosaic reasons. Closing retail alcohol outlets on Sundays, to the bootleggers, removes some of their competition from the market. Of course, the bootleggers, being bootleggers after all, have no intention of abiding by the proposed ban. But they suspect that licensed retail outlets will comply rather than lose their permits to sell alcohol on the remaining six days of the week. This increases the demand for bootleggers' products on Sundays, probably making higher prices possible.

Ethanol support policy in the United States and Canada has attracted a series of Baptist and bootlegger coalitions over the last 30 years. The composition of these coalitions has changed over time, just as the leading rationale for ethanol production has changed. Early on, environmental groups were generally supportive of ethanol, first as a means of phasing out lead in gasoline, later as an alternative to MTBE under the US oxygenate requirements. But more recently, particularly as the net energy issue and the environmental impacts of corn production have become more prominent, environmental groups have become at best lukewarm to ethanol promotion and some have joined the chorus of critics. Corn farmers have been staunch members of the ethanol political coalition, for obvious reasons. Joining corn farmers, large-scale ethanol producers, Archer Daniels Midland, according to Bovard and others, being the most prominent, have played a critical role politically in sustaining support for the industry.

Farmers, environmentalists, and large-scale agribusiness – we will leave it as an exercise for the interested reader to assign groups into Yandle's categories, since this designation is not our primary interest. We think that there is an implication of Yandle's theory that even Yandle has not recognized. Economists generally argue that cartels are inherently unstable. Members of a cartel might agree to a common course of action, but the incentive for individual cartel members to cheat is strong, and, if cheating becomes widespread, the desired gains from cartel behavior are not realized. Political coalitions are like cartels, in some respects, but Baptist and bootlegger coalitions have a unique characteristic that enables them to survive longer than other types of political coalitions or economic cartels. Baptist and bootlegger coalitions can defend themselves against criticism better than other types of political coalitions. The "Baptists", by taking the putative high moral ground, can help the coalition forestall criticism. Their cause is righteous. They are acting altruistically for the good of the community. People who would criticize the coalition can be painted as unenlightened. Also, the "Baptists", by making a moral-looking argument, can forestall economic criticism, by pitting concerns about costs relative to benefits of a policy against a "do the right thing" proposition.

The apparent durability of Baptist and bootlegger coalitions has important implications for one of the main themes of this paper – that practical trade liberalization in biofuels in North America should not be expected any time soon. None of the parties in the current coalition has a compelling interest in expanding international trade in biofuels and it is unlikely that any parties external to this coalition will be able to mount an effective campaign to change existing policy. Johnson and Libecap's insightful examination of the policy process that yielded US ethanol policy confirms many aspects of Yandle's theory. Their documentation of the political reaction to Gavett, Grinnell, and Smith's economic assessment of fuel ethanol is a particularly revealing narrative about the durability of the kinds of cartels analyzed by Yandle. The ability of the ethanol coalitions to manage information flows, which is a focal point of Johnson and Libecap's analysis, is critical to cartel durability and to maintaining policy momentum. For that matter, Gavett, Grinnell, and Smith's discussion of the development of ethanol policy in the United States up to 1986 also confirms Yandle's theory and is still worth reading today.

## CONCLUSIONS AND IMPLICATIONS

The evidence suggests that in the North American market, under existing conditions, grain-based ethanol-based biofuels are not economically viable without extensive government support. Likewise, in Mexico, internationally competitive ethanol from sugar cane would require government intervention to achieve important changes in the institutional structure governing the sugar industry. While current US and Canadian government policy supports ethanol production and use, our view is that the current policy approaches do not adequately evaluate and adjudicate negative environmental and social impacts. Emerging literature examining the development of ethanol policy in the United States reveals that serious consideration of environmental and social impacts of biofuel promotion and consideration of trade obligations were never really on the agenda. The direction of policy support works against freer trade and, for that matter, the operation of genuinely free markets, generally. Arguments of energy security, in particular, serve to justify these policies. If the market is indeed seriously inefficient at pricing nonrenewable energy, and we suggest that diagnosis by assumption has all too often gone unchallenged on this question, then that would suggest that some measures of government intervention might be needed. Wolf's caveat is still relevant, however. We need to be more aware that the policy cure may be worse than the market failure disease. Up to this point, the emphasis has been on supporting the development of renewable energy sources and not aggressive measures to discourage the use of nonrenewable energy. It is not yet clear that either emphasis, however, is really justified.

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