Panel Discussion: The Future of Biofuel

An Economic Critique of Corn-Ethanol Subsidies

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If corn ethanol is such a wonderful product, why does it require government subsidy?[1] If ethanol is truly economically competitive with gasoline absent government preference—as many of its supporters seem to believe—then private investors will produce ethanol for the market regardless of whether government lends a hand (Tyner and Taheripour, 2008).[2] Subsidies in this case will simply result in more ethanol production than is economically efficient. If ethanol is *not* economically competitive with gasoline, then subsidies distort the market by steering investment away from economically attractive gasoline and toward economically unattractive ethanol. Consumer well-being and overall economic efficiency suffer as a consequence.

Support of ethanol subsidies and consumption mandates offer a mix of arguments to justify government intervention. Those arguments can be neatly sorted into two categories: those that forward wealth distribution claims and those that forward efficiency claims. The former arguments, although interesting, are not addressed in this paper. Ethanol may or may not transfer wealth to rural America, for instance, but preferences with regard to wealth allocation are subjective and not worth much analytic time. The latter arguments, however, are grounded in concrete claims that can be proven or disproven and are, thus, the focus of this paper.

To have any intellectual force, the argument that ethanol subsidies and consumption mandates enhance economic efficiency must begin with a discussion of market failure. Economists broadly agree that, as a general rule, leaving production and consumption decisions to market actors proves more economically efficient than leaving the same to governmental planners. Only if some unique and fundamental failure occurs that prevents gains to trade in a given market is there room for the argu-

[1] This paper is exclusively concerned with ethanol made from corn. Unless otherwise indicated, all references to ethanol are in relation to ethanol made from corn. When economists discuss ethanol subsidies, they are almost always referring to four subsidies in particular: a $0.51 per gallon blenders' tax credit afforded to refineries that use ethanol in motor fuel (known in the law as the Volumetric Ethanol Excise Tax Credit, it is scheduled to be reduced to $0.45 per gallon in 2009); a Renewable Fuels Standard that requires U.S. refiners to consume a certain amount of ethanol per year (9 billion gallons, for instance, in 2008, rising to 36 billion gallons by 2022); a 2.5 percent ad valorem tariff on ethanol imports; and a $0.51 per gallon tariff on the same. However, a number of other direct and indirect federal, state, and local subsidies afforded to the ethanol industry in aggregate are quite large but are rarely considered in the peer-reviewed literature (Hahn, 2008). That is largely because such subsidies are difficult to quantify in a satisfactory manner and because they are often afforded to other industries besides ethanol, leading to debate about whether it is appropriate to consider them as ethanol subsidies per se. The Energy Information Administration (EIA; 2008) pegs the cost of ethanol subsidies to the taxpayer at $3 billion in 2007. The best guess of the total federal subsidy afforded to the ethanol industry that year, however, is conservatively estimated at $6.9 to $8.4 billion and $9.2 to $11 billion in 2008, or $1.50 to $1.70 per gallon of gasoline-equivalent ethanol (Koplow, 2007).

[2] Tyner and Taheripour (2008) believe that ethanol production in the United States was (barely) profitable without subsidy (defined as operations clearing a 12 percent or better return on equity) for the first time in 2001. From 2002 to 2003 production returned to unprofitability absent subsidies, but from 2004 to 2007 significant profits were realized even without subsidy largely because of the de facto ban on methyl tertiary-butyl ether as a fuel additive and a surge in ethanol demand to provide those blending services. In 2008, however, production again reached the break-even point.

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ment that government intervention improves the functioning of those markets (Cowen, 1988, and Cowen and Crampton, 2003). Hence, the case for ethanol subsidies hinges on whether concrete market failures exist in transportation fuel markets.

This paper examines the claims made about alleged market failures in transportation fuel markets. Two claims in particular warrant examination: that gasoline prices are too low because they do not account for the national security costs associated with gasoline consumption and that the environmental costs associated with gasoline consumption are ignored in the pricing mechanism. Subsidy proponents argue that if gasoline prices included both the national security and environmental costs associated with gasoline consumption, ethanol would be much cheaper than gasoline and demand for the latter would grow dramatically. Alas, those costs ("externalities" in economic parlance) are not embedded in final consumer prices and thus market actors, left to their own devices, will overconsume gasoline and underconsume ethanol. Other market failures have been alleged but they are altogether less compelling than these two. A cursory examination of a few of them follows.

"BIG OIL" MARKET POWER

We occasionally hear that "Big Oil" exercises their market power to the detriment of motorists by restricting ethanol's entry into end-use fuel markets (Cooper, 2005). The oil industry's reluctance to use high blends of ethanol in gasoline absent a government mandate, build ethanol delivery infrastructure to supply service stations, or provide E85 pumps[3] are often marshaled as evidence that oil companies are unfairly strangling an economic competitor in its bed. The existence of this self-serving oil cartel is said to explain why this otherwise commercially attractive transport fuel—ethanol—requires government subsidies and consumption mandates.

Yet, as of 2007, 38 percent of the retail fuels market was composed of independent service stations, not vertically integrated franchises, and another 13 percent of grocers and other hypermarkets. Only 49 percent of retail fuel was sold by stations associated with major oil companies. Likewise, 56 percent of the refining market was composed of independent, vertically deintegrated refining companies (Lowe, 2008). Big Oil is simply incapable of keeping ethanol out of service stations if profits are to be made by selling ethanol to motorists.

Statistical analysis of market data finds no evidence that market power in the oil sector has any impact on national retail motor fuel prices, although mergers and acquisitions have likely increased fuel prices in some regions while decreasing them in others (Chouinard and Perloff, 2007, and Taylor and Van Doren, 2006). Likewise, metrics regarding market concentration in the refining sector (such as the Herfindahl-Hirschman Index) do not suggest much market power in four of the five refining Petroleum Administration Defense District regions of the United States (Du and Hayes, 2008).

The economic and regulatory hurdles to entering the refining or retail sales markets are modest. Refineries change hands frequently—as do service stations. This factor is important because many economists now believe that, if a market is theoretically contestable, market power is functionally modest to nonexistent (Baumol, 1982; and Baumol and Panzer, 1982), although actual entry may still be important in some industries (Borenstein, 1992).[4]

Finally, ethanol is delivered primarily by rail but also by truck and barge. The oil industry is in no position to block the expansion of that infrastructure or to prevent third parties from investing in dedicated ethanol pipelines (ethanol cannot move through pipelines used for oil or gasoline because ethanol is water soluble).

A variation of the above narrative holds that oil refining capacity is so tight that, absent govern-

[3] E85 is motor fuel that is 85 percent ethanol and 15 percent gasoline.

[4] Many states prohibit entry to some extent in retail fuel markets by preventing major retailers like Cosco, Sam's Club, and Wal-Mart from selling motor fuel. Likewise, zoning laws and environmental regulations have been identified as barriers to entry in some markets. Those are government failures, however—not market failures—and should be addressed by deregulation. Given the inclination of many major retailers to project "green" images to consumers, it may well be that deregulating entry would increase the availability of ethanol to consumers.

ment efforts to promote ethanol, American consumers would have suboptimal volumes of motor fuel available to them and, accordingly, higher pump prices. Thus, the argument is that ethanol increases the amount of motor fuel available—effectively adding to capacity—and serves the role that, for instance, Hamburger Helper serves in increasing the volume of food on a plate of ground beef.

The argument is superficially true. Assume, for instance, that all ethanol disappeared tomorrow. In the short run, gasoline refining capacity is relatively fixed and consumers do not respond robustly to price increases in the short term. Hence, the highly inelastic short-term supply-and-demand curves for gasoline suggest that gasoline prices would increase dramatically—14.6 percent according to a 2004 analysis circulated by the Renewable Fuels Association (Urbanchuk, 2004), a figure that would be even higher today given ethanol's larger share of the motor fuels market in 2008. Supply and demand are more elastic in the long run, so ultimately, prices would rise only 3.7 percent in the long term according to that same analysis.

What is the market failure, however, that leads industry to underinvest in refining capacity? Sometimes we are told that industry conspires to restrain refining capacity to maximize profit (Cooper, 2007). This is a variation of the previous argument about monopoly power in the oil sector. It is also an argument that, even if true, does not necessarily provide evidence of market failure. The exercise of market power may have an impact on wealth distribution (refinery owners are wealthier and everyone else is poorer), but it likely has little impact on overall market efficiency (Posner, 1999).

Many analysts believe that the lack of excess refining capacity is largely driven by the limited profits historically made by those who invest in refining. To the extent that ethanol programs significantly reduce refining profits (see Du and Hayes, 2008), the problems ostensibly addressed by ethanol subsidies may actually contribute to the existence of the underlying problem.

Other times we are told that government policies discourage the construction of new refineries and the expansion of capacity at existing facilities. Although it is unclear to what extent this is true, if government policies inhibit optimal capacity expansion it is a government failure, not a market failure, and is best remedied by direct assault on the policies in question.

The strongest study offered as evidence that ethanol subsidies have reduced motor fuel prices is by economists Xiaodong Du and Dermot Hayes at the Center for Agriculture and Rural Development at Iowa State University (Du and Hayes, 2008). Their regression analysis concludes that ethanol production has reduced retail gasoline prices by \$0.29 to \$0.40 per gallon from 1995 to 2007 because it has "prevented some of the dramatic price increases often associated with an industry operating at close to capacity" (p. 13).

The Du and Hayes study (2008) does not, however, support the contention that, in a hypothetical world in which ethanol production did not exist, motor fuel prices would be higher. That is because the study assumes that, without ethanol production, gasoline refining capacity would not have grown any more than it did with ethanol production. Given that total refining capacity has historically expanded to meet increased demand (Shore and Hackworth, 2004), it is likely that, absent ethanol production, capacity expansion would have occurred and fuel prices in that counterfactual world would have been no higher than they were historically. The authors acknowledge as much: "Because these results are based on capacity, it would be wrong to extrapolate the results to today's markets. Had we not had ethanol, it seems likely that the crude oil refining industry would be slightly larger today than it actually is, and in the absence of this additional crude oil refining capacity the impact of eliminating ethanol would be extreme" (pp. 13-14).

The Du and Hayes (2008) study also implicitly assumes a fixed amount of oil production. Ample anecdotal evidence, however, suggests that oil producers have responded to U.S. ethanol production by reducing investments in upstream production capacity. This seems reasonable given that ethanol consumption displaces oil consumption and projections about the same heavily affect decisions about investment in future oil production capacity. Consequently, ethanol's impact on oil prices is ambiguous.

Even if ethanol subsidies reduced motor fuel prices, it does not follow that motorists are, on balance, better off. For instance, the two Iowa State economists who produced the aforementioned estimate regarding the reduction of motor fuel prices that has followed from ethanol subsidies (Du and Hayes, 2008) also contend (in Du, Hayes, and Baker, 2008) that the total social costs associated with ethanol subsidies are greater than the aggregated benefits. Cornell economists Harry de Gorter and David Just (2007b) argue that the spread between the two is even greater than alleged by Du, Hayes, and Baker.

This should not be surprising. Subsidies for wheat, corn, soybeans, and other crops produce lower commodity prices, but very few economists argue that gains to consumers outweigh the efficiency losses imposed by those subsidies on the economy as a whole. What consumers gain is more than offset by taxes and the loss as a market actor in other sectors of the economy.

FARM SUBSIDIES

Some have argued that ethanol subsidies actually *reduce* the net burden of subsidies on the taxpayer because the higher corn prices yielded by ethanol subsidies reduce other subsidy payments that would have otherwise gone to corn farmers. This appears to be correct, at least for 2007. Reductions in loan deficiency payments to corn farmers exceeded the costs of the ethanol program by $3.45 billion in that year (Du, Hayes, and Baker, 2008).

Yet it does not follow that ethanol subsidies therefore enhance efficiency. First, the taxpayer savings identified by Du, Hayes, and Baker (2008) do not account for all of the deadweight losses associated with ethanol subsidies.[5] Total deadweight losses are, in aggregate, greater than the advertised savings to the taxpayer (de Gorter and Just, 2007b). Second, although that same study finds a net reduction in farm payments from the ethanol program, it also finds that the net total of social cost associated with the refiners' tax credit, the ethanol consumption mandate, and the ethanol tariff (absent any consideration of the alleged national security or environmental benefits of ethanol) was $780 million in 2007.

One further point should be made. The existence of farm subsidies is not a market failure—it is a government failure. In a narrow sense, ethanol subsidies may reduce the cost of farm subsidies to the taxpayer, but a far more direct and less-costly means of doing the same is simply to dismantle the farm subsidies in question.

LEVELING THE PLAYING FIELD

Ethanol proponents frequently note that government provides substantial subsidies to the oil sector. The belief is that those subsidies provide commercial advantages to oil producers and oil prices are lower as a consequence; that is, oil subsidies distort the market by encouraging excessive oil consumption. Thus, ethanol proponents believe that subsidies for ethanol, beyond simply leveling the competitive playing field, make the economy more efficient by reducing oil consumption from the inefficiently high levels promoted by subsidies to the oil sector.

The EIA pegged federal oil and natural gas subsidies at $2.15 billion in 2007 (EIA, 2008). A more ambitious tally suggests that oil subsidies, broadly defined, were $5.2 to $11.9 billion in 1995, or $1.20 to $2.80 per barrel (Koplow and Martin, 1998; the estimate does not include environmental or national security externalities and, unfortunately, has not been updated). Although laws and outlays have changed substantially since Koplow and Martin's publication (although the EIA's tally finds no appreciable change in the sum of federal oil and gas subsidies since 1999), their estimate illustrates the importance of defining subsidy beneficiaries. To wit, are subsidies programs that exclusively benefit the targeted industry (the EIA definition), or do they also include programs that benefit the recipient and other parties outside that sector of the economy (the Koplow and Martin definition)?

[5] Deadweight losses arise from the economic distortions associated with tax avoidance and changes in social and economic behavior in response to regulatory intervention. A textbook exposition of deadweight loss can be found in Rosen and Gayer (2008).

The EIA calculates that federal oil and gas subsidies outside the electricity sector total $30,000 per million British thermal units (BTUs). Biofuel subsidies outside the electricity sector, however, ($3 billion of the $3.2 billion of which are directed at ethanol via the blenders' tax credit), work out to $5.72 million per million BTU (EIA, 2008, Table 36). Using EIA figures for oil and gas subsidies and estimates of the cost of the blender's tax credit from Koplow (2007), economist Douglas Tiffany (2008) calculates that oil subsidies in 2007 were slightly less than $0.15 per gallon of gasoline while ethanol subsidies totaled $0.588 per gallon. Whether we embrace a narrow or broad definition of subsidy, the conclusion is the same; oil subsidies are relatively trivial while ethanol subsidies are relatively substantial.

Although none of the identified oil subsidies is defensible on economic grounds, they have very little if any impact on oil prices because they do not reduce marginal production costs (Metcalf, 2006). Hence, oil subsidies do not distort the market and do not disadvantage ethanol producers. There is no efficiency problem for ethanol subsidies to correct.

Ethanol subsidies, however, are more pernicious. Unlike oil subsidies, ethanol subsidies reduce marginal production costs and, as a consequence, distort price signals and thus capital allocations in the market. The ethanol subsidy "cure" in this case is far worse than the oil subsidy "disease."

NATIONAL SECURITY EXTERNALITIES

Among the most fashionable preoccupations in foreign policy circles is "energy security." Although the precise meaning of energy security is unclear, foreign policy elites have long been concerned about U.S. reliance on foreign energy (an exception is Gholtz and Press, 2007). Fear of embargoes and supply disruptions affects how Western nations deal with oil- and gas-producing states, what sort of policies are pursued in the Middle East, and even fundamental questions of war and peace.

Proponents of ethanol subsidies argue that if the price of oil included the cost of our "oil mission" in the Middle East, the wars that the U.S. military engages there to protect oil supplies, the costs associated with our need to "kiss the ring" of Middle Eastern oil producers, the economic damage by terrorists from the flow of petrodollars into their coffers, and the harm done to U.S. interests by oil-rich states like Iran, Venezuela, and Russia, then oil consumption would be far less than it is now. Alas, it is believed that those national security externalities are not embedded in gasoline prices and, as a result, gasoline consumption is heavily subsidized. Ethanol consumption is thus suboptimal and ethanol subsidies are an appropriate remedy.

Economists, however, are far less worried about the national security costs of America's reliance on oil (foreign or otherwise) (Bohi and Toman, 1996) and with good reason: Economists understand oil markets far better than do foreign policy elites. The alleged national security externalities associated with gasoline consumption are for the most part a figment of an imagination unmoored from a good understanding of market reality.[6]

Blood for Oil

Many believe that reliance on foreign oil requires the United States to militarily defend friendly exporting states and to ensure the safety of oil supply facilities and shipping lanes. Those marching under banners declaring "No Blood for Oil" seem to believe that is the case, as do most mainstream foreign policy analysts. Delucchi and Murphy (2008) offer a rigorous attempt to quantify the public dollars associated with the "oil mission." They suggest that if motor vehicles in the United States did not consume Persian Gulf oil, the U.S. Congress would have likely reduced military expenditures by $13.4 to $47 billion in 2004 (one of the

[6] Greene and Leiby (2006) argue that oil-price volatility imposes significant economic losses and that ethanol is less subject to disruption and thus offers economic advantages. Although empirical claims appear to be untrue, U.S. data from 1960 to 2005 demonstrate that corn harvests are far more variable than oil import volumes (Eaves and Eaves, 2007). Even if that were not the case, price volatility does not suggest a market failure. If ethanol were more commercially attractive because its price were more stable, refiners would take that into account when making decisions about optimal motor fuel blends. The claim that oil price volatility imposes an externality on third parties does not comport with the standard definition of market failure in that the same would hold true for all price changes anywhere in the economy (economists refer to this phenomenon as a "pecuniary externality"; Huntington, 2002).

two years examined in the analysis). If U.S. motor vehicles did not consume any oil at all, military expenditures would have, oddly enough, gone down by far less: by $5.8 to $25.4 billion in 2004. The "best guess" of this analysis is that, if U.S. gasoline consumers were forced to pay for the U.S. oil mission, gasoline prices would increase by $0.03 to $0.15 per gallon.

Simple economics, however, suggests that the oil mission—however large it may be—is unnecessary, regardless of what Congress may think. Oil producers will provide for their own security needs as long as the cost of doing so results in greater profits than equivalent investments could yield. Because Middle Eastern governments typically have little of value to trade except oil—oil revenues, for instance, are 40 to 50 percent of Iranian government revenues and 70 to 80 percent of Saudi government revenues—they must secure and sell oil to remain viable (EIA, 2006). Given that their economies are so heavily dependent on oil revenues, Middle Eastern governments have even *more* incentive than do consuming states to worry about the security of oil production facilities, ports, and shipping lanes (West, 2005).

In short, whatever security our military presence provides (and many analysts think that our presence actually *reduces* security; see Jervis, 2005) would be provided by incumbent producers were the United States to withdraw. That Saudi Arabia and Kuwait paid for 55 percent of the cost of Operation Desert Storm suggests that keeping the Strait of Hormuz free of trouble is certainly within their means.

The same argument applies to al Qaeda threats to oil production facilities. Producer states have such strong incentives to protect their oil infrastructure that additional Western assistance to do the same is probably unnecessary. Although terrorists do indeed plot to disrupt oil production in Saudi Arabia and elsewhere, there is no evidence to suggest that producer-state security investments are insufficient to protect their interests.

The U.S. oil mission is thus best considered a taxpayer-financed gift to oil regimes (and, perhaps, the Israeli government) that has little, if any, effect on the security of oil production facilities or, correspondingly, the price of oil. One may support or oppose such a gift, but our military expenditures in the Middle East are not necessary to remedy a market failure.

Foreign Policy Distortions

Many foreign policy analysts believe that U.S. oil imports are dependent on friendly relationships with oil-producing states. The fear is that unfriendly regimes might not sell us oil—a fear that explains why former Federal Reserve Chairman Alan Greenspan supported the two Gulf Wars against Iraq (Woodward, 2007). Others believe, however, that maintaining good relations with oil producers interferes with other foreign policy objectives—such as the defense of Israel and the pursuit of Islamic terrorists—and increases anti-American sentiment in oil-producing states with unpopular regimes (Scheuer, 2007 and 2008). The problem with this argument, however, is that its fundamental premise is incorrect. Friendly relations with producer states neither enhance access to imported oil nor lower its price (Adelman, 1995).

Selective embargoes by producer nations on some consuming nations are unenforceable unless all other nations on Earth refuse to ship oil to the embargoed state or a naval blockade is used to prevent oil shipments into the ports of the embargoed state. That is because, once oil leaves the territory of a producer, market agents—not agents of the producer—dictate where the oil goes, and anyone willing to pay the prevailing world crude oil price can have all he or she wants. The 1973 Arab oil embargo is a perfect case in point. U.S. crude oil imports actually increased from 1.7 million barrels per day (MBD) in 1971 to 2.2 MBD in 1972, 3.2 MBD in 1973, and 3.5 MBD in 1974 (EIA, 2004). Instead of buying from Arab members of the Organization of the Petroleum Exporting Countries (OPEC), the United States bought from non-Arab oil producers. The customers displaced by the United States bought from Arab members of OPEC. Beyond the modest increase in transportation costs that followed this game of musical chairs, the embargo had no impact on the United States (Fried, 1988, Parra, 2004, and Adelman, 1995). In short, all that matters for the majority of consumers is how much oil is produced for world markets, not from whom the oil was initially purchased.

Do oil-producing nations allow their feelings toward oil-consuming nations to affect their production decisions? Historically, the answer has been "no." The record strongly indicates that oil-producing states, regardless of their feelings toward the industrialized West, are rational economic actors. After a detailed survey of the world oil market since the rise of OPEC, oil economist M.A. Adelman concluded, "We look in vain for an example of a government that deliberately avoids a higher income. The self-serving declaration of an interested party is not evidence" (Adelman, 1995, p. 31). Philip Auerswald of George Mason University agrees, stating "For the past quarter century, the oil output decisions of Islamic Iran have been no more menacing or unpredictable than Canada's or Norway's" (Auerswald, 2007, p. 22).

If energy producers are wealth maximizers, what do we make of countries that are selling oil and natural gas to others at below-market rates? For instance, Russia sold oil to Cuba at below-market prices during the Cold War; Russia has long sold natural gas to Ukraine at below-market prices but has ended its natural gas subsidy to Georgia as relations have soured; and China sells oil to North Korea at low rates and used this as leverage to induce North Korea to bargain over its nuclear weapons program.

Two conclusions seem reasonable. First, sellers have leverage in natural gas markets that is not possible in oil markets because oil can be transported easily, whereas natural gas is shipped through pipelines. Buyers have few near-term alternatives if natural gas sellers reduce shipments. As liquefied natural gas gains market share, however, natural gas markets will look increasingly like world crude oil markets, and the ability of Russia or other states to extract concessions from consumers will dissipate.

Second, the Russia-Cuba and China–North Korea cases involve poor countries receiving foreign aid in the form of low-priced oil. We are unaware of any wealthy Western countries receiving such in-kind aid from oil-producing countries.

What if a radical new actor were to emerge on the global stage? For example, if the House of Saud were to fall and the new government consisted of Islamic extremists friendly to Osama bin Laden, the new regime might reduce production and increase prices. But that scenario is by no means certain given that Iran—despite all its anti-Western rhetoric—has not reduced oil output.[7]

Regardless, the departure of Saudi Arabia from world crude oil markets would probably have about the same effect on domestic oil prices as the departure of Iran from world crude oil markets in 1978. The Iranian revolution reduced oil production by 8.9 percent, whereas Saudi Arabia accounts for about 13 percent of global oil production today. Oil prices increased dramatically after the 1978 revolution, but those higher prices set in motion market supply-and-demand responses that undermined the supply reduction and collapsed world oil prices eight years later (Adelman, 1995). The short-term macroeconomic impacts of such a supply disruption would actually be less today than they were then, given the absence of price controls on the U.S. economy and our reduced reliance on oil as an input for each unit of gross domestic product (Dhawan and Jeske, 2006, Walton, 2006, and Fisher and Marshall, 2006).

So while it is possible that a radical oil-producing regime might play a game of chicken with consuming countries, producing countries are very dependent on oil revenue and have fewer degrees of freedom to maneuver than consuming countries. Catastrophic supply disruptions would harm producers more than consumers, which is why disruptions are extremely unlikely. The best insurance against such a low-probability event is to maintain a relatively free economy where wages and prices are left unregulated by government. That would do more to protect the West against an extreme production disruption than anything else in government's policy arsenal.

Oil Profits for Terrorists

Does Western reliance on oil put money in the pocket of Islamic terrorists? To some degree, yes. Does that harm Western security? Probably not—at least, probably not very much.

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7 While it is true that oil production in Iran was about twice as high under the Shah than it has been under the Islamic Republic, almost all analysts agree that this reflects the damage to the oil infrastructure during the 1980-88 war with Iraq, the "brain drain" that has occurred in response to the revolution, and poor state management of Iranian oil assets—not the intentional result of state policy.

Before we go on, it is worth noting that only 15.5 percent of the oil in the world market is produced from nation-states accused of funding terrorism (Lundberg Survey, 2006). Hence, the vast majority of the dollars we spend on gasoline do not end up on this purported economic conveyer belt to terrorist bank accounts.

Regardless, terrorism is a relatively low-cost endeavor and oil revenues are unnecessary for terrorist activity. That a few hundred thousand dollars paid for the 9/11 attacks suggests that the limiting factors for terrorism are expertise and manpower, not money.

This observation is strengthened by the fact that there is no correlation between oil profits and Islamic terrorism. In Taylor and Van Doren (2007), we estimated two regressions using annual data from 1983 to 2005: the first between fatalities resulting from Islamic terrorist attacks and Saudi oil prices and the second between the number of Islamic terrorist incidents and Saudi oil prices. In neither regression was the estimated coefficient on oil prices at all close to being significantly different from zero.[8]

During the 1990s, inflation-adjusted oil prices and profits were low. But the 1990s also witnessed the worldwide spread of Wahhabi fundamentalism, the buildup of Hezbollah, and the coming of age of al Qaeda. Note too that al Qaeda terrorists in the 1990s relied on help from state sponsors such as Sudan and Afghanistan—nations that are not particularly known for their oil wealth or robust economies.

Producer states do use oil revenues to fund ideological extremism. Saudi financing of madrassas and Iranian financing of Hezbollah are good examples. But given the importance of those undertakings to the Saudi and Iranian governments, it is unlikely that they would cease and desist these activities simply because oil profits were down. They certainly were not deterred by meager oil profits in the 1990s.[9]

The futility of reducing oil consumption as a means of improving national security and energy independence is illustrated by the fact that states accused of funding terrorism earned $290 billion from oil sales in 2006 (Lundberg Survey, 2006). Even if that sum were cut by 90 percent, that would still leave $29 billion at their disposal—more than enough to fund terrorism given the minimal financial needs of terrorists.

Rents to Bad Actors

When oil prices are high, so too are oil profits for inframarginal (low-cost) producers. Even if those profits do not find their way to international terrorists, they prop up many regimes we find distasteful. Oil producers in the Second and Third worlds often use their robust flow of petrodollars to squelch human rights at home and to menace neighbors abroad. Many foreign policy elites argue that oil consumption thus harms our national security by strengthening these bad international actors (Lugar and Woolsey, 1999, and Council on Foreign Relations, 2006).

It is unclear to what extent oil profits are associated with human rights abuses or militaristic activity. Examples abound: Relatively long-lived regimes with terrible human rights records—such as North Korea—have no oil revenues to speak of, and this is the case even within the same socioeconomic region. Denuding Iran and Libya of oil revenues might produce a government that looks a lot like Syria, and denuding Venezuela of oil revenues might produce a government that looks a lot like Cuba. After all, most of the "bad acting" petrostates that foreign policy elites worry about yielded unsavory regimes even when oil revenues were a small fraction of what they are today.

The claim that oil revenues increase the threat posed by such regimes to their neighbors seems reasonable enough, but again, the extent to which this is true is unclear. Pakistan is a relatively poor country with few oil revenues but it has still managed to build a nuclear arsenal and is constantly on the precipice of war with India. Impoverished, oil-poor Egypt and Syria have at various times been

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[8] Unit root tests suggested that fatalities and Saudi oil prices had unit roots but terrorist incidents did not, so the former were first differenced before the regressions. Even after first differencing, autocorrelation existed, so autoregressive terms were added to each regression, which further weakened the insignificant relationships.

[9] Although little is known about funding trends associated with Iranian support for Hezbollah, the Iranian government probably spends no more than $25 to $50 million on Hezbollah a year (Cordesman, 2006). Less is known about Saudi contributions to Islamic extremism (Prados and Blanchard, 2004).

the most aggressive anti-Israeli states in the Middle East. Russia launched its war with Chechnya before oil revenues engorged its treasury.

While I have little doubt that—all other things being equal—a rich bad actor is more dangerous than a poor bad actor, the marginal impact of oil revenues on "bad acting" might well be rather small. That unsavory petrostates have been fully capable of holding on to power, oppressing their people, and menacing their neighbors during a decade associated with the lowest inflation-adjusted oil prices in history (the 1990s) suggests that nothing short of rendering oil nearly valueless will have any real effect on regime behavior.

For the sake of argument, however, let us assume that there is some incremental benefit associated with reducing oil revenues to bad-acting oil producers. Unfortunately, we have only very blunt and imperfect instruments at hand to achieve that end. Policies that might reduce oil consumption would reduce oil demand—and thus, reduce revenues—for *all* oil producers, regardless of whether they are bad actors. Producers in the North Sea, Canada, Mexico, and the United States (which collectively supplied 20.1 million barrels of oil per day in 2006, or 24 percent of the world's crude oil needs that year) would be harmed just as producers in Venezuela, Iran, Russia, and Libya (which collectively supplied 20.3 million barrels per day in 2006) (EIA, 2007).

Given bad acting aplenty in 1998 with the lowest real oil prices in world history, it is unlikely that even the most ambitious policies to reduce oil consumption would have much effect on bad acting. Accordingly, there is good reason to doubt that the foreign policy benefits that might accrue from anti-oil policies would outweigh the very real costs that such policies would impose on both consumers and innocent producers. There are certainly better remedies available to curtail bad behavior abroad.

The Ethanol Remedy

If significant national security externalities *did* exist and were, as a result, significantly affecting gasoline prices, the most direct and efficient remedy would be a tax on oil imports. That would get gasoline prices "right" and lead to optimal motor fuel consumption patterns. Countervailing ethanol subsidies are an extremely inefficient means of remedying the problem given the deadweight losses and inefficiencies associated with most forms of subsidy. They also substitute prospective market judgments regarding appropriate motor fuel consumption with political judgments that are unlikely to prove correct.

Regardless, ethanol production cannot displace significant amounts of gasoline consumption (Akinci et al., 2008). Even if the entire U.S. corn harvest were dedicated to ethanol production, only 3.5 percent of current gasoline consumption would be displaced (Eaves and Eaves, 2007). All available cropland in the United States would have to be dedicated to corn production if all U.S. vehicles were powered by fuel composed of E85 ethanol. By 2036, all rangeland and pastureland would have to be added to that total to maintain adequate production. By 2048, all land outside of urban centers would be required for corn production (Dias de Oliveira, Vaughan, and Rykiel, 2005). Thus, no matter one's opinions about the dangers of oil dependence (foreign or otherwise), corn ethanol cannot displace enough oil to matter.

ENVIRONMENTAL EXTERNALITIES

Many believe that gasoline consumers are being subsidized because they are not required to compensate third parties for the air pollution associated with gasoline consumption. If those environmental externalities were "internalized" via regulation or taxes, gasoline prices would be far higher, gasoline consumption would be consequently lower, and ethanol production would be far greater. Ethanol subsidies are defended as the second-best means of improving market efficiency.

There are three difficulties with this argument. First, it is very unclear how large the externalities are in monetary terms, making it impossible for analysts to know whether interventions to correct those externalities are actually improving or worsening market efficiency. The best available evidence, however, suggests that the air emissions externalities are probably so low that internalizing them via the first-best policy avenue—a pollution tax—would not affect gasoline prices enough to significantly affect the motor fuels market. Second, ethanol's environmental advantages relative to gasoline are greatly overstated. The negative environmental externalities associated with ethanol may well be even greater than those associated with gasoline.[10] Even if they are not, ethanol's environmental advantages are almost certainly not large enough (in monetarized terms) to significantly alter the fuel mix in motor fuels markets. Third, ethanol subsidies are an extremely inefficient means of addressing the environmental externalities of gasoline; far better means of addressing this market failure exist.

Conventional Air Pollutants

It is unclear to what extent there are uninternalized externalities associated with conventional air pollutants from gasoline. A recent review of the peer-reviewed literature suggests that monetized damages from the same might range from $0.016 to $0.184 per mile, which translates into $0.36 to $4.20 per gallon (Parry, Walls, and Harrington, 2006). A frequently cited "best guess" regarding the cost of the conventional air emissions generated by gasoline consumption is $0.16 per gallon (Parry and Small, 2005).

The biggest problem with the above exercises—beyond the uncertainty associated with the human health impacts of exposure to small doses of potentially dangerous air contaminants—is that these studies do not consider the extent to which existing regulation imposes costs on gasoline consumption and the extent to which those costs function as a tax. If, for instance, the conventional air emissions externality were $0.16 per gallon but regulatory policy reduced emissions to where they would have been had a $0.16 per gallon tax been imposed in a world without regulation, then there would be no externality: The consumer would, in a sense, be paying for the pollution costs associated with gasoline consumption (albeit indirectly). Accordingly, the above calculations provide limited guidance to policymakers seeking to promote optimal gasoline prices (Nye, 2008).

Regardless, ethanol is a poor remedy for whatever externalities may exist in this arena. A review of the academic literature finds that, when evaporative emissions are taken into account, ethanol in fuel blends sold on the market today

- increases emissions of total hydrocarbons, nitrogen oxides, nonmethane organic compounds, and air toxics (particularly acetaldehyde, formaldehyde, ethylene, and methanol) relative to conventional gasoline; but
- decreases emissions of carbon monoxide (Niven, 2005; other studies broadly consistent with Niven's findings include von Blottnitz and Curran, 2007, and U.S. Environmental Protection Agency [EPA], 2007).

We pause here to note that carbon monoxide emissions are only a very modest problem in the United States today. Because few areas of the United States violate federal air quality standards for carbon monoxide, ethanol provides little benefit on that front. The other pollutants at issue, however, worsen urban smog and the concentration of dangerous air toxics—far more serious human health matters.

Ethanol proponents often argue that stronger ethanol blends—like E85—are cleaner. Those contentions are not consistent with the reviews of the literature cited above. Nor are they consistent with a recent study concluding that universal use of E85 would increase ozone-related mortality, hospitalization, and asthma by 9 percent in Los Angeles and 4 percent in the United States as a whole relative to a world in which the auto fleet were powered entirely by conventional gasoline (Jacobsen, 2007).

Air Toxics

The above studies explicitly consider toxic air emissions in their analyses, but a recent paper for

[10] Although I only examine conventional air and greenhouse gas emissions in this paper—the main environmental advantages that subsidy proponents allege for ethanol—ethanol has a number of other environmental disadvantages relative to gasoline. The main issues include groundwater contamination (Niven, 2005), water resource use and surface water pollution (National Research Council, 2008; Donner and Kucharik, 2008; and Nassauer, Santelmann, and Scavia, 2007), soil erosion (Patzek, 2004), and habitat destruction (Nassauer, Santelmann, and Scavia, 2007, and Dias de Oliveira, Vaughan, and Rykiel, 2005). Whatever advantages ethanol may have with regard to air emissions (which I believe to be, at best, nonexistent) must outweigh the environmental harms it creates.

the Energy Future Coalition (Gray and Varcoe, 2005) argues that the environmental costs of gasoline-related air toxic emissions total approximately $250 *billion* per year. Although their paper has received little attention in academic circles, it has received modest attention in policy circles, so a brief discussion is in order.

Gray and Varcoe (2005) argue that the direct harms from the various toxic emissions from aromatics in gasoline total about $64 billion a year. But those aromatics also contribute to the formation of particulate matter (PM) in the atmosphere, and the harms from PM that can be traced back to aromatic gasoline emissions are said to equal at least $200 billion a year. Gray and Varcoe round the total sum to $250 billion a year (which was equal to about $1.78 a gallon in 2005) and argue that "leveling the playing field" would justify an equivalent subsidy to the ethanol industry.

The $64 billion estimate for the *benefits* associated with reducing aromatic emissions, however, is derived from the *costs* associated with reducing toxic air emissions in the industrial sector. Yet there is little reason to believe that the costs of emission controls equal the benefits from the same. Gray and Varcoe (2005) justify this leap of faith by citing EPA contentions that the benefits from the regulation of industrial air toxic emissions have in the past exceeded the costs of doing so. But even if the EPA is correct, there is no reason to assume that the cost of reducing toxic air emissions from point sources x years ago has relation to the costs (or benefits) of reducing toxic air emissions from automotive tailpipes today.

Gray and Varcoe's (2005) estimate for the costs associated with PM formation that can be traced back to gasoline aromatics likewise emerges from a problematic set of assumptions. They posit that 40 percent of all $PM_{2.5}$ is carbon based and then assume that half of this mass (when adjusted for population exposures) can be attributed to gasoline emissions.[11] The latter claim appears to be incorrect; their own footnote suggests that only 4 to 33 percent of $PM_{2.5}$ can be traced back to tailpipe emissions.

Using the benefit estimates associated with ambient PM concentration reductions from the recently established off-road diesel fuel regulations, Gray and Varcoe (2005) arrive at about $200 billion in benefits. It is unclear, however, how they trace those costs to aromatic tailpipe emissions from the total universe of motor vehicle tailpipe emissions.

Gray and Varcoe (2005), however, well understand the limitations of their analysis: "We emphasize that these are, necessarily, speculative estimates, based on various heuristic assumptions that cannot easily be proven (or refuted, given basic uncertainties)" (p. 52). Normally, claims that cannot be proven or disproven are called "opinions" or, alternatively, "religious beliefs." Let us posit that we should not use either as the basis for public policy.

If Gray and Varcoe (2005) were familiar with the literature on tailpipe emissions, they would not need such analytic contortions. A review of the literature finds that the environmental costs associated with toxic air emissions from gasoline is likely $0.087 to $1.62 billion annually in 1991 dollars, a tiny fraction of the $64 billion estimate laboriously forwarded by Gray and Varcoe (McCubbin and Delucchi, 1996). While it is unclear to what extent harm from $PM_{2.5}$ can be traced back to gasoline aromatics, the published literature suggests that the environmental costs associated with *all* particulate emissions from motor vehicle tailpipes (not just the aromatics targeted by Gray and Varcoe) is $16.7 to $266.4 billion. The authors who reviewed that literature, however, note that "We are uneasy with this result, even as an upper-bound" (McCubbin and Delucchi, 1996, p. 212) because it is heavily weighted by one study in the literature (Pope et al., 2002) and that study is both anomalous and methodologically problematic (Schwartz, 2006). Likewise, a recent study (Hill et al., 2009) examines the emissions of greenhouse gases (GHGs) and $PM_{2.5}$ from gasoline and corn ethanol. It finds that, for each billion gallons of ethanol-equivalent fuel, gasoline emissions cost $469 million and corn ethanol emissions $472 to $952 million.

There is little reason to accept the $250 billion externality estimate by Gray and Varcoe (2005) and to reject the more careful work in the peer-reviewed literature cited above. Even were we to

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[11] $PM_{2.5}$ means particles less than 2.5 micrometers in aerodynamic diameter.

do so, however, it is worth remembering that the toxic air emissions associated with ethanol are even greater than the toxic air emissions associated with conventional gasoline. Hence, even if Gray and Varcoe were correct, it does not justify countervailing subsidies for ethanol.

Greenhouse Gas Emissions

It is difficult to know for certain how ethanol compares with gasoline with regard to GHG emissions because the data required to perform a satisfactory energy life-cycle analysis simply do not exist. Four fundamental problems exist (Delucchi, 2004 and 2006).

First, limited field and facility data are available. Aggregated data are thus required to fill in the holes, and many data points are based on estimates, not observations. Unfortunately, those estimates are frequently only loosely grounded in reality (Liska et al., 2009).

Second, some important disagreements about methodology cannot be easily resolved. For instance, how far back in the production chain should we go in the course of tallying energy inputs? What is the best way to disentangle the energy inputs and GHG outputs associated with ethanol production from the energy inputs and GHG outputs associated with other coproducts (primarily distillers' grains for livestock feed) associated with ethanol production?

Third—and most important—dynamic variables can significantly affect the life-cycle analysis but are generally completely ignored in the literature because they are difficult to model properly. For instance, how and to what extent will the contemplated policy change prices for millions of goods and services (both directly and indirectly), and how will those price changes affect consumption patterns and, thus, GHG emissions?[12] Answering such complex questions requires a rather sophisticated global general equilibrium model, but none have been produced or used in the life-cycle analyses of ethanol that have appeared in the literature.

Fourth, even if done well, the life-cycle models produce findings that are less relevant to policymaking than advertised. For example, what exact policy is being suggested by the life-cycle analysis and is that policy realistic? How does the execution of that policy impact the dynamic economic factors mentioned above? What are the opportunity costs of the contemplated policy? What are emissions at the margin in response to policy-induced change?

Nonetheless, dozens of studies and several computer models exist to partially inform analysis (for instance, Liska et al., 2009; Adler, Del Grosso, and Parton, 2007; Wang, Wu, and Hong, 2007; Groode and Heywood, 2007; Hill et al., 2006; Farrell et al., 2006; Nielsen and Wenzel, 2005; and Patzek, 2004).[13] The best is a recent study from researchers at the University of Nebraska (Liska et al., 2009). That analysis used the most recent data available on individual facility operations and emissions, observed corn yields, nitrogen fertilizer emissions profiles, and coproduct use; all of which prove important because of improved energy efficiencies associated with ethanol production over the past several years. The authors found that the total life-cycle GHG emissions from the most common type of ethanol processing facility in operation today are 48 to 59 percent lower than gasoline, one of the highest savings reported in the literature. Even without subtracting the GHG emissions associated

[12] "Whatever the exact magnitude of these price effects, they are potentially important enough that they ought to be taken seriously in an evaluation of the impact of transportation policies on climate. There is no way to escape this conclusion. We cannot dismiss the effects because they occur outside of the U.S., or outside of the transportation sector, because in an analysis of global warming, we care about all emissions, everywhere. We cannot dismiss price effects on the grounds that a policy will not really affect price, because in principle even the smallest change has a nonzero probability of leading to a nonzero effect on price. (In any event, if the price effects are really so small, then the policy must be so unimportant or ineffective as to have no affect on climate worth worrying about anyway.) And we certainly cannot argue that all such price effects are likely to be substantially 'similar' for all policies, and hence of no importance in *comparison* of alternatives, because this clearly is not the case" (Delucchi, 2004, p. 10).

[13] I am interested only in those studies that attempt to quantify GHG emissions, not in those studies exclusively concerned with the net energy balance of ethanol. The latter issue is theoretically interesting but it asks a question that is not particularly relevant for policy analysis. Even if ethanol has a negative energy balance (more energy inputs were required to produce ethanol than is yielded by ethanol on combustion), if the energy inputs were relatively abundant but the energy displaced by ethanol were relatively scarce, ethanol could have a net negative energy balance but still prove profitable and efficient. Likewise, if the energy inputs have modest GHG emissions but the energy being displaced by ethanol had significantly larger GHG emissions, a negative energy balance might still translate into a net reduction of GHG emissions.

with ethanol coproducts (which accounted for 19 to 38 percent of total system emissions), ethanol would still present GHG advantages relative to gasoline.

Although the study by Liska et al. (2009) appears to offer the best current analysis on this question, many problems remain, rendering policy analysis problematic. First, the study examines only a subset of corn production operations and ethanol processing facilities: dry-mill ethanol processors fired by natural gas in six Corn Belt states. Together, those facilities accounted for 23 percent of U.S. ethanol production in 2006. This approach makes the study stronger because the authors are not forced to rely as heavily on estimates and aggregated analysis, but the downside is that the study ignores a large number of older, less-efficient ethanol processing facilities and thus cannot be used to assess the GHG balance of the ethanol industry as a whole. While the findings may well point to where the industry will be in the future as older, less-efficient facilities lose market share and are upgraded or retired (Groode and Heywood, 2007), the bankruptcies that are shuttering many newer facilities at present caution against certainty on this point.

Second, estimates regarding emissions are still relied on to some degree, and one of those estimates in particular—the estimate pertaining to the release of nitrous oxide (N_2O) from fertilizer use in corn production—is problematic. Although the study comports with convention in that it relies on emission estimates offered by the Intergovernmental Panel on Climate Change (IPCC, 2006), a recent study (Crutzen et al., 2007) finds that the IPCC estimates pertaining to N_2O release from fertilizer does not comport with the observed data. Crutzen et al. (2007) find that N_2O emissions from fertilizers used in biofuel production are three to five times greater than assumed by the IPCC and that, if we use those higher emissions in the ethanol life-cycle models (as Crutzin et al. did using the openly accessible EBAMM model constructed by Farrell et al., 2006), "the outcome is that the production of commonly used biofuels, such as biodiesel from rapeseed and bioethanol from corn (maize), can contribute as much or more to global warming by N_2O emissions than cooling by fossil fuel savings" (p. 389). Given that the lead author of the study—Paul Crutzen—is a Nobel laureate chemist who has specialized in fields related to atmospheric science, his findings cannot be lightly dismissed.

Third, Liska et al. (2009) acknowledge the importance of the impact of ethanol production on crop prices and, thus, on global land-use patterns, but they do not account for the GHG emissions associated with those changes. Those emissions are substantial, and no life-cycle analysis of ethanol can credibly ignore them.

A worldwide agricultural model constructed by Searchinger et al. (2008) finds that the increases in crop prices that follow the increased demand for ethanol will induce a global change in the pattern of land use. Those land-use changes produce a surge in GHG emissions that is dissipated only by conventional life-cycle emissions savings many decades hence. Although the study modeled ethanol production increases that were beyond those mandated in existing law, "the emissions from land-use change per unit of ethanol would be similar regardless of the ethanol increase analyzed" (p. 1239).

While critics of Searchinger et al. (2008) rightly point out that (i) the agricultural model employed in the study was crude, (ii) much is unknown about the factors that influence global land-use decisions, (iii) improved yields are reducing the amount of land necessary to meet global crop demands, and (iv) any land additions to crop production do not need to come from forests or other robust carbon sequestration sinks (Renewable Fuels Association, 2008), none of those observations is sufficient to reject the basic insight forwarded in Searchinger et al. (2008). If ethanol demand increases corn and other crop prices beyond where they otherwise would have been, profit incentives will induce investors to increase crop production beyond where production would otherwise have been. If that increased production comes in part from land-use changes relative to the baseline, then significant volumes of GHG will likely be released and those emissions will threaten to swamp the GHG savings found elsewhere in the life-cycle analysis. Even if the upward pressure on crop prices as a consequence of ethanol consumption is more than offset by downward price pressures following from other factors, crop acreage retirement will not be as large as might otherwise have been the case and terrestrial sequestration will be lower as a consequence. Every link in that chain of logic is unassailable.

Changing global land use is but one of the many impacts that ethanol might have on hundreds of industrial sectors worldwide. The work of Searchinger et al. (2008) is ultimately unsatisfying because it is only a crude and partial consideration of those impacts, many of which might indirectly affect global land-use patterns. For instance, if ethanol consumption reduces the demand for—and thus the price of—crude oil in global markets, how much of those "booked" reductions in oil consumption will be offset by increased demand induced elsewhere by the lower global crude oil prices that follow (known as a "rebound effect" in economics)? How might that rebound effect influence all sorts of GHG emissions vectors? None of these types of questions are asked in ethanol GHG life-cycle analyses, but they are clearly crucial to the analysis.

To summarize, a narrow, conventional consideration of the GHG emissions associated with ethanol suggests that ethanol reduces climate change harms relative to gasoline. If the IPCC has underestimated N_2O emissions from fertilizer—as appears to be the case—then ethanol probably is *at best* a "wash" with regard to GHG emissions. Even if that is not the case, consideration of secondary and tertiary emissions impacts strongly suggests that most, if not all, advertised GHG gains are lost in the changes in land-use patterns that follow increases in ethanol production relative to the baseline. Other changes in anthropogenic emissions—positive and negative—would almost certainly follow as well, but existing models do not bother to search for them and thus we do not know enough to say much beyond this with confidence.

First versus Second-Best Remedies

If there are in fact uninternalized environmental externalities associated with gasoline consumption, the most direct and efficient remedy is to impose a tax on emissions (or a cap-and-trade program that functions like a tax) to correct prices accordingly. Countervailing ethanol subsidies are a much less-efficient remedy because they create deadweight losses, do not correct gasoline prices or ethanol prices for environmental externalities, and impose a market share for ethanol that might not have arisen in equilibrium.

One might argue that emissions taxes on conventional pollutants in motor fuel markets are impractical and/or unlikely and that ethanol is a necessary second-best alternative. But even if so, tighter regulation of motor fuel emissions is almost certainly more efficient than ethanol subsidies *if* government intervention is warranted. This is particularly true given that ethanol has substantial air emissions of its own. Nondiscriminatory emission regulations that apply regardless of fuel source are a far more defensible intervention.

Price internalization exercises to address GHG emissions, however, are not only conceivable, they are probable in the near term given the current political makeup of Washington and voter sentiment. Once a federal cap-and-trade program is in place, ethanol proponents will lose the argument that gasoline prices are suboptimal because they do not consider the cost of GHG emissions. Of course, one might always argue that the permit prices yielded from such a regime are too low to adequately reflect the damages, but a recent "best guess" about those damages based on the literature suggests that the uninternalized GHG externalities associated with gasoline amount to only about $0.05 per gallon (Parry and Small, 2005).

If the displacement of gasoline with ethanol is in fact among the most cost-effective means of reducing GHG emissions, ethanol producers should be able to prove that fact in a carbon-constrained, cap-and-trade market without government subsidy. But even if we posit the lowest-bound estimate for total ethanol subsidies and divide that figure by the GHG savings reported in Wang, Wu, and Hong (2007; a 19 percent reduction of total life-cycle GHG emissions relative to gasoline), we find that $300 of subsidy is necessary to displace a metric ton of GHG emissions from gasoline. "Based on historical prices for carbon offsets, this same investment could have purchased 90-120 times as much displacement on the CCX [Chicago Climate Exchange], the most appropriate benchmark for the U.S. carbon market. Even on the more expensive ECX [European Climate Exchange], the subsidies could have purchased 11 metric tonnes of offsets" (Koplow, 2007,

p. 35). If we instead use the high end of the GHG savings reported in Liska et al. (2009) those figures could be cut by two-thirds—still yielding costs that could not be sustained if market actors, rather than political actors, were deciding how best to respond to a carbon-constrained world.

THE POLITICAL ECONOMY OF SUBSIDY

Although there has long been a debate about the merits of ethanol subsidies, most parties in the discussion accepted without question the idea that subsidizing ethanol reduces oil consumption. How much, of course, was open to debate. Yet a rigorous examination of the existing subsidies in place by Cornell economists Harry de Gorter and David Just (2007a) finds that one of those subsidies—the blenders' tax credit—actually *subsidizes* gasoline consumption within the context of the current regulatory regime.

The conclusion is counterintuitive but the analysis is sound. The explanation is as follows. By itself, the blenders' tax credit ensures that ethanol is often cheaper than gasoline from the refiners' perspective. Refiners will thus compete to secure that ethanol, which results in the price of ethanol being "bid up" until it is above the market price of gasoline by at least $0.51 per gallon (the size of the tax credit). In a world with the blenders' tax credit at the 2006 level, retail fuel prices are lower by 1.9 percent ($2.32 per gallon rather than $2.36 per gallon). Ethanol production increases from 653 million gallons to 6.67 billion gallons while gasoline production declines from 141.2 billion gallons to 135.7 billion gallons. The credit serves as an ethanol consumption subsidy with most of the benefits going to ethanol producers and the remainder to motorists.

By itself, the Renewable Fuel Standard (which mandates specified levels of ethanol consumption) produces motor fuel costs that are a weighted average of the cost of ethanol and the cost of gasoline. In a world with the consumption mandate at the 2006 level, retail fuel prices are 0.48 percent lower ($2.31 per gallon rather than $2.32 per gallon). Ethanol production increases from 6.67 billion gallons (assuming a nonbinding mandate in the form of the ban on methyl tertiary-butyl ether as a fuel additive) to 10 billion gallons while gasoline production falls from 135.7 billion gallons to 132.5 billion gallons. The mandate, like the credit, serves as an ethanol production subsidy with almost all of the benefits captured by ethanol producers.

When a tax credit is added to a consumption mandate, however, there is no incentive for refiners to bid up the price of ethanol; the mandated demand for ethanol ensures that ethanol (even with the tax credit) is more costly than gasoline. Because competition in the refining sector is relatively intense, refiners cannot capture the full benefit of the tax credit. Instead, it is passed on to consumers. Using the 2006 blenders' tax credit, this produced retail fuel prices 1.42 percent lower than they would have been without the tax credit but with the mandate: $2.31 per gallon rather than $2.34 per gallon. Ethanol production increases a wee bit—from 9.99 billion gallons to 10 billion gallons—but gasoline production *increases* even more—from 132.1 billion gallons to 132.5 billion gallons. The combined policies are, in effect, a direct gasoline consumption subsidy with all of the benefits captured by motorists.

Such analyses highlight the difficulty of accepting claims about the impact of ethanol production on foreign oil imports or GHG emissions without careful consideration of the indirect impact that subsidies have on the market. Unfortunately, this is an exercise rarely performed in the literature pertaining to the advertised benefits of ethanol (and, implicitly, government preferences for the same).

CONCLUSION

Why should taxpayers subsidize ethanol? The most commonly offered rationales—that ethanol reduces harm caused by our reliance on foreign oil and a host of air pollution problems—do not hold up to scrutiny. Foreign oil dependence is not a substantial foreign policy or economic problem, and ethanol offers little remedy for any problems that might exist. Environmental gains are likewise unclear. The balance of the evidence suggests that ethanol worsens conventional air pollution and offers no net reductions in GHG emissions. In fact, there is good reason to believe that GHG emissions might well go up as we displace gasoline in favor of ethanol.

Even if we were to accept the national security and environmental benefits claimed most frequently for ethanol in the literature, in 2012 ethanol subsidies would still cost $3 billion more than the monetized benefits delivered (Hahn, 2008).

Other justifications for subsidy have even less merit. There is little evidence to suggest that "Big Oil" is strangling ethanol for competitive advantage or that ethanol on balance reduces motor fuel prices by any consequential amount. Ethanol subsidies may in some periods reduce net federal subsidies to corn producers, but the deadweight losses associated with ethanol subsidies more than offset this savings to the taxpayer. Finally, they do not "level the playing field." In fact, they distort the playing field and produce inaccurate price signals which, in turn, lead to less economic efficiency and, by force, less overall wealth creation.

Whatever problems exist in motor fuel markets are better remedied by direct interventions to address identified problems. Ethanol subsidies are extremely poor remedies for those alleged problems.

REFERENCES

Adelman, M.A. *The Genie Out of the Bottle: World Oil Since 1970*. Cambridge, MA: MIT Press, 1995.

Adler, Paul R.; Del Grosso, Stephen J. and Parton, William J. "Life-Cycle Assessment of Net Greenhouse-Gas Flux for Bioenergy Cropping Systems." *Ecological Applications*, April 2007, *17*(3), pp. 675-91.

Akinci, Berk; Kassebaum, Paul G.; Fitch, Jonathan V. and Thompson, Robert W. "The Role of Biofuels in Satisfying U.S. Transportation Fuel Demands." *Energy Policy*, September 2008, *36*(9), pp. 3485-91.

Auerswald, Philip. "The Irrelevance of the Middle East." *American Interest*, May/June 2007, *2*(5), p. 22.

Baumol, William J. "Contestable Markets: An Uprising in the Theory of Industrial Structure." *American Economic Review*, 1982, *72*(1), pp. 1-15.

Baumol, William J. and Panzer, John C. *Contestable Markets and the Theory of Industrial Structure*. New York: Harcourt Brace Jovanovich, 1982.

Bohi, Douglas R. and Toman, Michael A. *Economics of Energy Security*. Norwell, MA: Kluwer Academic Publishers, 1996.

Borenstein, Severin. "The Evolution of U.S. Airline Competition." *Journal of Economic Perspectives*, Spring 1992, *6*(2), pp. 45-73.

Chouinard, Haley H. and Perloff, Jeffrey M. "Gasoline Price Differences: Taxes, Pollution Regulations, Mergers, Market Power, and Market Conditions." *B.E. Journal of Economic Analysis and Policy*, 2007, *7*(1), pp. 1-26.

Cooper, Mark. "Over a Barrel: Why Aren't Oil Companies Using Ethanol to Lower Gasoline Prices?" Consumer Federation of America, May 2005; www.ethanolrfa.org/objects/documents/113/consumerstudy.pdf (accessed January 29, 2009).

Cooper, Mark. "Big Oil vs. Ethanol: The Consumer Stake in Expanding the Production of Liquid Fuels." Consumer Federation of America, July 2007; www.consumerfed.org/pdfs/Ethanol.pdf (accessed January 29, 2009).

Cordesman, Anthony H. "Iran's Support of the Hezbollah in Lebanon." Center for Strategic and International Studies, July 15, 2006.

Council on Foreign Relations. *National Security Consequences of U.S. Oil Dependency*. Washington, DC: Council on Foreign Relations Press, October 2006.

Cowen, Tyler, ed. *The Theory of Market Failure: A Critical Examination*. Fairfax, VA: George Mason University Press, 1988.

Cowen, Tyler and Crampton, Eric, eds. *Market Failure or Success: The New Debate*. Cheltenham and Northampton, UK: Edgar Elgar, 2003.

Crutzen, P.J.; Mosier, A.R.; Smith, K.A. and Winiwarter, W. "N2O Release from Agro-Biofuel Production Negates Global Warming Reduction by Replacing Fossil Fuels." *Atmospheric Chemistry and Physics Discussions*, 2007, *7*, pp. 11191-205.

de Gorter, Harry and Just, David R. “The Law of Unintended Consequences: How the U.S. Biofuel Tax Credit with a Mandate Subsidizes Oil Consumption and Has No Impact on Ethanol Consumption.” Working Paper 2007-20, Cornell University, September 2007a (updated February 2008).

de Gorter, Harry and Just, David R. “The Welfare Economics of an Excise-Tax Exemption for Biofuels and the Interaction Effects with Farm Subsidies.” Working Paper 2007-13, Cornell University, September 2007b (updated January 2008); http://aem.cornell.edu/research/researchpdf/wp0713.pdf.

Delucchi, Mark A. “Conceptual and Methodological Issues in Lifecycle Analyses of Transportation Fuels.” Paper prepared for the U.S. Environmental Protection Agency Office of Transportation and Air Quality, UCD-ITS-RR-04-45, October 2004.

Delucchi, Mark A. “Lifecycle Analyses of Biofuels.” Draft Report, Institute for Transportation Studies, University of California, Davis, UCD-ITS-RR-06-08, 2006.

Delucchi, Mark A. and Murphy, James J. “U.S. Military Expenditures to Protect the Use of Persian Gulf Oil for Motor Vehicles.” *Energy Policy*, June 2008, *36*(6), pp. 2253-64.

Dhawan, Rajeev and Jeske, Karsten. “How Resilient Is the Modern Economy to Energy Price Shocks?” Federal Reserve Bank of Atlanta *Economic Review*, Third Quarter 2006, *91*(3) pp. 21-32.

Dias de Oliveira; Marcelo E.; Vaughan; Burton E. and Rykiel, Edward J. “Ethanol as Fuel: Energy, Carbon Dioxide Balances, and Ecological Footprint.” *BioScience*, July 2005, *55*(7), pp. 593-602.

Donner, Simon D. and Kucharik, Christopher J. “Corn-Based Ethanol Production Compromises Goal of Reducing Nitrogen Export by the Mississippi River.” *Proceedings of the National Academy of Sciences*, March 18, 2008, *105*(11), pp. 4513-18.

Du, Xiaodong and Hayes, Dermot J. “The Impact of Ethanol Production on U.S. and Regional Gasoline Prices and on the Profitability of the U.S. Oil Refinery Industry.” Working Paper 08-WP 467, Center for Agricultural and Rural Development, Iowa State University, April 2008.

Du, Xiaodong; Hayes, Dermot J. and Baker, Mindy. “A Welfare Analysis of the U.S. Ethanol Subsidy.” Working Paper 08-WP 480, Center for Agricultural and Rural Development, Iowa State University, November 2008.

Eaves, James E. and Eaves, Stephen. “Neither Renewable Nor Reliable.” *Regulation*, Fall 2007, *30*(3), pp. 24-27.

Energy Information Administration. *Annual Energy Review 2004*. Washington, DC: U.S. Department of Energy, 2004.

Energy Information Administration. “Country Analysis Briefs”; www.eia.doe.gov/emeu/cabs/contents.html (accessed November 14, 2006).

Energy Information Administration. “International Petroleum Monthly.” May 8, 2007.

Energy Information Administration. “Federal Financial Interventions and Subsidies in Energy Markets 2007.” SR/CNEAF/2008-01, April 2008.

Farrell, Alexander E.; Plevin, Richard J.; Turner, Brian T.; Jones, Andrew D.; O’Hare, Michael and Kammen, Daniel M. “Ethanol Can Contribute to Energy and Environmental Goals.” *Science*, January 27, 2006, *311*(5720), pp. 506-08.

Fisher, Eric and Marshall, Kathryn G. “The Anatomy of an Oil Price Shock.” Federal Reserve Bank of Cleveland *Economic Commentary*, November 2006.

Fried, Edward. “Oil Security: An Economic Phenomenon,” in Edward Fried and Nanette Blandin, eds., *Oil and America’s Security*. Washington, DC: Brookings Institution, 1988, pp. 56-59.

Gholtz, Eugene and Press, Daryl G. “Energy Alarmism: The Myths That Make Americans Worry About Oil.” Policy Analysis 589, Cato Institute, April 5, 2007.

Gray, C. Boyden and Varcoe, Andrew R. “Octane, Clean Air, and Renewable Fuels: A Modest Step Toward Energy Independence.” *Texas Review of Law & Politics*, Fall 2005, *10*(1), pp. 10-62.

Greene, David L. and Leiby, Paul N. "The Oil Security Metrics Model: A Tool for Evaluating the Prospective Oil Security Benefits of DOE's Energy Efficiency and Renewable Energy R&D Programs." ORNL/TM-2006/505, prepared by the Oak Ridge National Laboratory for the U.S. Department of Energy, May 2006.

Groode, Tiffany A. and Heywood, John B. "Ethanol: A Look Ahead." LFEE Working Paper 2007-02 RP, Laboratory for Energy and the Environment, Massachusetts Institute of Technology, June 2007.

Hahn, Robert W. "Ethanol: Law, Economics, and Politics." Working Paper 08-02, Reg-Markets Center, American Enterprise Institute, January 2008.

Hill, Jason; Nelson, Erik; Tilman, David; Polasky, Stephen and Tiffany, Douglas. "Environmental, Economic, and Energetic Costs and Benefits of Biodiesel and Ethanol Biofuels." *Proceedings of the National Academy of Science*, July 25, 2006, *103*(30), pp. 11206-10.

Hill, Jason; Polasky, Stephen; Nelson, Erik; Tilman, David; Huo, Hong; Lindsay, Ludwig; Neumann, James; Zheng, Haochi and Bonta, Diego. "Climate Change and Health Costs of Air Emissions from Biofuels and Gasoline." *Proceedings of the National Academy of Science*, February 10, 2009, *106*(6), pp. 2077-82.

Huntington, Hillard. "Energy Disruptions, Interfirm Price Effects and the Aggregate Economy." OP 51, Energy Modeling Forum, Stanford University, September 2002.

Intergovernmental Panel on Climate Change: Eggleston; Simon; Buendia, Leondro; Miwa, Kyoko; Ngara, Todd and Tanabe, Kiyoto, eds. "2006 IPCC Guidelines for National Greenhouse Gas Inventories." National Greenhouse Gas Inventories Programme, 2006.

Jacobsen, Mark Z. "Effects of Ethanol (E85) Versus Gasoline Vehicles on Cancer and Mortality in the United States." *Environmental Science and Technology*, April 18, 2007, *41*(11), pp. 4150-57.

Jervis, Robert. "Why the Bush Doctrine Cannot Be Sustained." *Political Science Quarterly*, Fall 2005, *120*(3), pp. 351-77.

Koplow, Douglas. "Biofuels—At What Cost? Government Support for Ethanol and Biodiesel in the United States: 2007 Update." Global Studies Initiative of the International Institute for Sustainable Development, October 2007.

Koplow, Douglas and Martin, Aaron. *Fueling Global Warming: Federal Subsidies to Oil in the United States*. Washington, DC: Greenpeace, June 1998.

Liska, Adam J.; Yang, Haishun S.; Bremer, Virgil R.; Klopfenstein, Terry J.; Walters, Daniel T.; Erickson, Galen E. and Cassman, Kenneth G. "Improvements in Life Cycle Energy Efficiency and Greenhouse Gas Emissions of Corn Ethanol." *Journal of Industrial Ecology*, January 21, 2009.

Lowe, John E. Testimony before the U.S. Senate Judiciary Committee hearing on "Exploring the Skyrocketing Cost of Oil." May 21, 2008.

Lundberg Survey, Inc. "Fatally Flawed Premise: Why Anti-Oil Weapon in War on Terror Won't Work." *Energy Détente*, November 30, 2006, *27*(11).

Lugar, Richard G. and Woolsey, R. James. "The New Petroleum." *Foreign Affairs*, January/February 1999, *78*(1), pp. 88-102.

Metcalf, Gilbert E. "Federal Tax Policy Towards Energy." NBER Working Paper 12568, National Bureau of Economic Research, October 2006.

McCubbin, Donald R. and Delucchi, Mark A. "The Social Costs of the Health Effects of Motor Vehicle Air Pollution," in "The Annualized Social Cost of Motor Vehicle Use in the United States, Based on 1990-1991 Data." Report 11. UCD-ITS-RR-93-3(11), Institute for Transportation Studies, University of California, Davis, August 1996, pp. 169-209.

Nassauer, Joan Iverson; Santelmann, Mary V. and Scavia, Donald, eds. *From the Corn Belt to the Gulf: Societal and Environmental Implications of Alternative Agricultural Futures*. Washington, DC: Resources for the Future, 2007.

National Research Council of the National Academies Press. *Water Implications of Biofuel Production in the United States*. Washington, DC: National Academies Press, 2008.

Nielsen, Per H. and Wenzel, Henrik. "Environmental Assessment of Ethanol Produced from Corn Starch and Used as an Alternative to Conventional Gasoline for Car Driving." Institute for Product Development, Technical University of Denmark, June 2005.

Niven, Robert K. "Ethanol in Gasoline: Environmental Impacts and Sustainability." *Renewable & Sustainable Energy Reviews*, December 2005, *9*(6), pp. 535-55.

Nye, John V.C. "The Pigou Problem." *Regulation*, Summer 2008, *31*(2), pp. 32-37.

Parra, Francisco R. *Oil Politics: A Modern History of Petroleum*. London: I.B. Tauris, 2004.

Parry, Ian and Small, Kenneth. "Does Britain or the United States Have the Right Gasoline Tax?" *American Economic Review*, September 2005, *95*(4), pp. 1276-89.

Parry, Ian W.H.; Walls, Margaret and Harrington, Winston. "Automobile Externalities and Policies." Discussion Paper 06-26, Resources for the Future, June 2006.

Patzek, Tad. "Thermodynamics of the Corn-Ethanol Biofuel Cycle." *Critical Reviews in Plant Sciences*, 2004, *23*(6), pp. 519-67. July 22, 2006, online version; http://petroleum.berkeley.edu/papers/patzek/CRPS416-Patzek-Web.pdf.

Pope, C. Arden et al. "Lung Cancer, Cardiopulmonary Mortality, and Long-Term Exposure to Fine Particulate Air Pollution." *Journal of the American Medical Association*, March 6, 2002, *27*(9), pp. 1132-41.

Posner, Richard A. *Natural Monopoly and Its Regulation*. Washington, DC: Cato Institute, 1999.

Prados, Alfred B. and Blanchard, Christopher M. "Saudi Arabia: Terrorist Financing Issues." RL32499, CRS Report for Congress, Congressional Research Service. December 8, 2004, online version.

Renewable Fuels Association. "Understanding Land Use Change and U.S. Ethanol Expansion." November 20, 2008.

Rosen, Harvey and Gayer, Ted. *Public Finance*. Eighth Edition. New York: McGraw-Hill, 2008.

Scheuer, Michael. *Imperial Hubris: Why the West Is Losing the War on Terror*. Washington, DC: Potomac Books, 2007.

Scheuer, Michael. *Marching Toward Hell: America and Islam after Iraq*. New York: Free Press, 2008.

Schwartz, Joel A. "Comments on the EPA's Proposal to Tighten the Fine Particulate Matter Standard." Testimony before the U.S. Environmental Protection Agency, EPA-HQ- OAR-2001-0017, April 17, 2006.

Searchinger, Timothy; Heimlich, Ralph; Houghton, R.A.; Dong, Fengxia; Elobeid, Amani; Fabiosa, Jacinto; Tokgoz, Simla; Hayes, Dermot and Yu, Tun-Hsiang. "Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land-Use Change." *Science*, February 29, 2008, *319*, pp. 1238-40.

Shore, Joanne and Hackworth, John. "Challenging Times for Making Refinery Capacity Decisions." Presentation at the National Petroleum Refiners Association, Energy Information Administration, March 2004; www.eia.doe.gov/pub/oil_gas/petroleum/presentations/2004/npra2004/npra2004_files/frame.htm.

Taylor, Jerry and Van Doren, Peter. "Economic Amnesia: The Case against Oil Price Controls and Windfall Profit Taxes." Policy Analysis 561, Cato Institute, January 12, 2006.

Taylor, Jerry and Van Doren, Peter. "Don't Increase Federal Gasoline Taxes—Abolish Them." Policy Analysis 598, Cato Institute, August 7, 2007.

Tiffany, Douglas G. "Economic Consequences of Corn Ethanol as a Fuel Source." Presented at the Federal Reserve Bank of St. Louis; Washington University in St. Louis Wiedenbaum Center for the Economy, Government, and Public Policy; and International Center for Advanced Renewable Energy and Sustainability conference *Economics of Ethanol*, November 14, 2008.

Tyner, Wallace and Taheripour, Farzad. "Biofuels, Policy Options, and Their Implications: Analysis Using Partial and General Equilibrium Approaches."

Journal of Agriculture & Food Industrial Organization, 2008, *6*(20), pp. 1-18.

Urbanchuk, John M. "Ethanol and Gasoline Prices." LECG, May 26, 2004; www.ethanolrfa.org/resource/facts/consumers/documents/EthanolandGasolinePrices-LECG.pdf (accessed January 28, 2009).

U.S. Environmental Protection Agency. *Regulatory Impact Analysis: Renewable Fuel Standard Program*. EPA 420-R-07-004, 2007.

von Blottnitz, Harro and Curran, Mary Ann. "A Review of Assessments Conducted on Bioethanol as a Transportation Fuel from a Net Energy, Greenhouse Gas, and Environmental Life-Cycle Perspective." *Journal of Cleaner Production*, 2007, *15*(7), pp. 607-19.

Walton, David. "Has Oil Lost the Capacity to Shock?" Bank of England *Quarterly Bulletin*, Spring 2006, *46*(1), pp. 105-14.

Wang, Michael; Wu, May and Hong, Huo. "Life-Cycle Energy and Greenhouse Gas Emission Impacts of Different Corn Ethanol Plant Types." *Environmental Research Letter*, 2007, *2*(2).

West, J. Robinson. "Saudi Arabia, Iraq, and the Gulf," in Jan Kalicki and David Goldwyn, eds., *Energy Security*. Washington, DC: Woodrow Wilson Center Press, 2005, pp. 197-218.

Woodward, Bob. "Greenspan: Ouster of Hussein Crucial for Oil Security." *Washington Post*, September 17, 2007, p. A3.

The Future of Biofuels

Rick Tolman

CORN SUPPLY AND DEMAND

According to the U.S. Department of Agriculture (USDA), U.S. corn growers produced 12.1 billion bushels of corn in 2008, the second-largest crop ever. This harvest reflects the increasing ability of growers to produce higher yields, measured in bushels per acre (bu/acre), due to improvements in agronomic practices and biotechnology that improve the corn seed itself. The 2008 national average yield, 153.9 bu/acre, is the second-largest on record.

As high as this yield is (by comparison, the 1988 yield was only 84.6 bu/acre), many in the corn industry expect it to nearly double well before mid-century. In fact, many growers who take part in the National Corn Growers Association (NCGA) National Corn Yield Contest routinely score yields much higher than the national average.

Since 1994, corn productivity per acre has accelerated as a result of advances in marker-assisted breeding, biotechnology, and improved farming practices. Growers are harvesting considerably more corn without significantly increasing acreage. Based on past performance, average production per acre is projected (following a 15-year trend) to hit 180 bu/acre by 2015. Some seed

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Federal Reserve Bank of St. Louis *Regional Economic Development*, 2009, *5*(1), pp. 97-102.