ENERGY FORUM
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Working Paper Series:

The Global Energy Market:
Comprehensive Strategies to Meet
Geopolitical and Financial Risks

U.S. Energy Policy and Transportation

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THE JAMES A. BAKER III INSTITUTE FOR PUBLIC POLICY
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THE GLOBAL ENERGY MARKET:

COMPREHENSIVE STRATEGIES TO MEET GEOPOLITICAL AND FINANCIAL RISKS

THE G8, ENERGY SECURITY, AND GLOBAL CLIMATE ISSUES

PREPARED IN CONJUNCTION WITH AN ENERGY STUDY SPONSORED BY
THE JAMES A. BAKER III INSTITUTE FOR PUBLIC POLICY
AND THE INSTITUTE OF ENERGY ECONOMICS, JAPAN
MAY 2008

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ACKNOWLEDGEMENTS

The Energy Forum of the James A. Baker III Institute for Public Policy would like to thank The Institute of Energy Economics, Japan, and the sponsors of the Baker Institute Energy Forum for their generous support of this program. The Energy Forum further acknowledges contributions by study researchers and writers.

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ABOUT THE GLOBAL ENERGY MARKET STUDY

The Global Energy Market: Comprehensive Strategies to Meet Geopolitical and Financial Risks—The G8, Energy Security, and Global Climate Issues examines a variety of scenarios for the future of global energy markets. Some of these scenarios evaluate factors that could trigger a regional or worldwide energy crisis. The study assesses the geopolitical risks currently facing international energy markets and the global financial system. It also investigates the consequences that such risks could pose to energy security, pricing, and supply, as well as to the transparent and smooth operation of the global market for oil and natural gas trade and investment. By analyzing these threats in depth, the study identifies a series of policy frameworks that can be used to fortify the current market system and ensure that it can respond flexibly to the array of threats that might be encountered in the coming years. The study also looks at the impact of emerging climate policy on the future of world energy markets.

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U.S. ENERGY POLICY AND TRANSPORTATION

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INTRODUCTION

Driving is part of the American way of life, making gasoline a basic good that most Americans consume. Because households cannot easily change the automobiles they own instantaneously, the ability of consumers to substitute away from a particular level of motor fuel consumption is limited in the immediate term. In other words, gasoline demand is highly price-inelastic in the short run. Thus, large or abrupt changes in motor fuel prices can have a substantial impact on consumers' discretionary spending.

Crude oil is the primary input in the production of gasoline at refineries. Specifically, refiners purchase crude oil to produce a slate of petroleum products, determined in part by the characteristics of the crude oil feedstock and partly by the type of equipment installed at the refinery. Economic factors also play a role. For example, when gasoline prices rise, refiners will shift output if possible to meet demand so long as relative prices indicate it is profitable to do so. The price at which a refiner sells petroleum products such as gasoline is the wholesale price. The price consumers pay at the pump is a markup over the wholesale price, where the markup is a function of state and federal taxes, distribution and marketing costs, and station premiums related to the

cost of operation (property lease rates, labor costs, etc.). It is, generally, the retail price that receives so much attention from consumers and policy-makers.

The literature on gasoline prices in the United States is extensive, with much of the focus on whether or not there is evidence of collusion among market participants. Many studies investigate, in particular, asymmetry between changes in crude oil prices and changes in gasoline prices. Typically, a Δ_{oil} increase in crude oil price will result in a Δ_{gas} increase in gasoline price. Asymmetry exists when a Δ_{oil} decrease in crude oil price does not result in a Δ_{gas} decline in gasoline price. In a widely cited paper, Borenstein *et al* (1997) find that retail gasoline prices respond asymmetrically to changes in crude oil prices.[1] They also find evidence of asymmetry between crude oil prices and wholesale gasoline prices, as well as between wholesale and retail gasoline prices. These asymmetries can be attributed to factors such as short-run adjustment costs and distributors and/or retailers exerting market power.[2]

These findings have been verified and/or supported by other authors,[3] but they are not without dispute. For instance, Bachmeier *et al* (2003) perform a comparative analysis to that of Borenstein *et al* by estimating higher frequency data using a standard error correction model and find no evidence of asymmetry.[4] Balke *et al* (1998) find that examination of data in levels yields no evidence of asymmetry, while in first differences

[1] Severin A. Borenstein, Colin Cameron, and Richard Gilbert, "Do Gasoline Prices Respond Asymmetrically to Crude Oil Price Changes?," *The Quarterly Journal of Economics*, February 1997: 305-339.
[2] Stanislav Radchenko, "Oil price volatility and the asymmetric response of gasoline prices to oil price increases and decreases, *Energy Economics* 27 (2005): 708-730..
[3] See Radchenko, (2005): 708-730; Robert W. Bacon,. "Rockets and Feathers: The Asymmetric Speed of Adjustment of U.K. Retail Gasoline Prices to Cost Changes," *Energy Economics* 23 (June 1991): 211-218; Sam Peltzman, "Prices Rise Faster than They Fall," *Journal of Political Economy* 108 (June 2000): 466-502.
[4] Lance J. Bachmeier and James M. Griffin, "New Evidence on Asymmetric Gasoline Price Responses," *The Review of Economics and Statistics* 85 (3) 2003: 772-776.

it does.[5] All together, evidence of asymmetry is compelling, but not entirely clear. Resolution of the matter is important to the general public, firms in the industry, and politicians because clear evidence of asymmetry is a first step to making a case for possible impropriety, and hence to taking appropriate steps to preventing such occurrences.

Other studies choose to focus on the explanation of observed outcomes. For example, Bulow *et al* (2003), argue that the run-up in the price of gasoline in the U.S. Midwest during the spring of 2000 was not the result of collusive behavior on the part of refiners.[6] They maintain that factors such as limited refining capacity, refinery outages, disruptions in pipeline capacity, and new federally-mandated reformulation standards were the culprit. While Bulow *et al* do not contribute directly to the examination of asymmetry in price movements, their study does highlight the fact the determination of gasoline prices is complicated by the many facets of refining, distribution and marketing. This is salient because it can help to explain why examination of price alone might sometimes lead to a conclusion that markets are operating inefficiently.

This previous literature is important for a couple of reasons. One, understanding why gasoline prices behave the way they do is important to determining the appropriate policy for dealing with any ill effects of rising prices. Two, understanding the relationship between transportation fuel demand, motor vehicle stocks and consumer demands for transportation services is of the utmost importance for designing policy that will have the most effect in achieving a desired outcome, such as promoting conservation.

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[5]Nathan S. Balke, Stephen P.A. Brown, and Mine K. Yucel, "Crude Oil and Gasoline Prices: An Asymmetric Relationship?" *Economic Review*, Federal Reserve Bank of Dallas (First Quarter, 1998): 1-11.

[6] Jeremy I. Bulow, Jeffrey H. Fischer, Jay S. Creswell, Jr., and Christopher T. Taylor, "US Midwest Gasoline Pricing and the Spring 2000 Price Spike." *Energy Journal* 24 (3) 2003: 121-149.

Designing an appropriate policy aimed at lowering fuel price requires an understanding of why prices are high in the first place. The mechanics of retail gasoline prices are fairly straightforward and can be expressed as a sum of crude oil prices, refining costs, state and federal taxes, distribution and marketing costs, and station premiums related to the cost of operation (property lease rates, labor costs, etc.). In fact, research indicates that there is a stable, long-run relationship between crude oil and gasoline prices, meaning that the price of crude oil is the single most important determinant of the pump price of gasoline. Of course, crude oil only sets the baseline for gasoline price and does not explain all short-term spikes in gasoline price. Higher seasonal demand, low inventories, competition for imports, and reduced operational domestic refinery capacity (due to factors such as hurricanes, for example, which struck serious blows to the U.S. Gulf Coast refinery complex in 2005) can all lead to short-term increases in gasoline prices.

The future of U.S. oil consumption is centered squarely on future developments in the transportation sector, which represents more than two-thirds of total petroleum use. Both the U.S. Department of Energy (DOE) and the International Energy Agency (IEA) have predicted that transportation fuel will constitute up to 70 percent of future U.S. oil demand. Given the fact that the United States is by far the single largest consumer of oil globally, the future of American transportation sector policy has enormous implications for the global supply-demand balance of oil and is a major factor in considering international energy market trends.

On the supply side, many analysts are focused on the future availability of crude oil, citing “peak oil” concerns and geopolitics as culprits for current high oil prices.

Indeed, the role of national oil companies in the next few decades appears to be strengthening as resource endowments favor a concentration of oil supplies in the hands of a few countries.[7] This has raised concerns that future oil supplies may be compromised, as those countries, in some cases, lack the internal capital discipline to make the needed investments to meet projected global demands.

From 1970 to 2000, more than 40 percent of the increase in world energy supply came from within industrialized regions such as the United States, Europe and Australia—or, more specifically, Alaska, the U.S. Gulf of Mexico, and the U.K. and Norwegian North Sea. However, over the next 25 years, experts project that more than 90 percent of new oil supplies will come from more unstable regions including the Middle East, West Africa and the Former Soviet Union (FSU). The IEA estimated that more than $4.3 trillion will need to be invested to meet the increase of 30 to 40 million barrels of oil a day (b/d) the world will require beyond today's demand of 83 million b/d.[8] Fifteen percent of that added demand is projected to come from the United States alone and another 24 percent from China.

It remains to be seen whether this massive investment will materialize to meet a growing global demand for oil. During the past two decades, the U.S. oil policy has been to rely on American allies in the Persian Gulf such as Saudi Arabia, the United Arab Emirates, Kuwait, Qatar and Oman, as well as major exporters like Venezuela and Nigeria. In 1990, when Iraq invaded Kuwait, cutting off 5 million b/d of needed oil supply, several of these Persian Gulf allies increased production to make up the

[7] See "The Role of the National Oil Company in International Energy Markets," Energy Forum, James A. Baker III Institute for Public Policy at Rice University, 2007: http://www.rice.edu/energy/research/nationaloil/index.html.
[8] World Energy Outlook (Paris: International Energy Agency, 2007).

difference, limiting the effect on world oil supply and thus the price. But the internal stability of many oil producing countries looks more questionable now than it did in the 1980s and 1990s. In fact, there is a long and diverse list of oil exporting countries whose production has been stagnant or falling in recent years (despite ample reserves) as a result of civil unrest, terrorism, inefficiency, government mismanagement or corruption. Does the U.S. consumer really want to rely on unstable petro-states to provide the fuel needed for basic activities, such as traveling to work in the morning?

The growing concern about the security and availability of oil in an increasingly tense geopolitical environment sets the backdrop for current U.S. energy policy discussions. As Congress labored to create a more comprehensive energy bill in 2007, it debated topics such as fuel economy standards, alternative and sustainable fuels, and carbon emissions. The path forward with regard to carbon emissions is beginning to unfold in the United States, but the federal government has yet to fully forge a thoughtful response to climate change. In 2005, the United States emitted a total of 712 million metric tons of carbon, 412 million metric tons of which came from road petroleum use. Thus, U.S. road petroleum use and climate change policy are intimately linked. The country emits more energy-related carbon dioxide per capita than any other industrial nation,[9] and in the 1990s, the American transportation sector represented the fastest growing source of emissions of carbon dioxide of any other major sector of the U.S. economy.[10] In fact, the DOE predicts that the transportation sector will generate almost half of the projected 40 percent increase in U.S. carbon emissions by 2025.

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[9] John Byrne, et al, "American Policy Conflict in the Greenhouse: Divergent Trends in Federal, Regional, State, and Local Green Energy and Climate Change," *Energy Policy* 35 (2007): 4555-4573.

[10] Joseph Romm, "The Car and Fuel of the Future," *Energy Policy* 34 (2006): 2609-2614.

So, two natural questions to ask for the U.S. consumer are "How can we reduce our dependence on imported oil?" and "How can we reduce our total demand for oil?" President George W. Bush offered a plan to reduce gasoline use by 20 percent by 2017, mainly by substitution through expanding biofuels programs. Members of Congress as well as the 2008 presidential candidates have proposed other solutions, with some officials advocating conservation, and others promoting policies that will increase total energy supplies through the construction of new refineries, expanded development of domestic resources, and the promotion of alternative fuels. Still others say innovative automotive and fuel-system technologies can solve the problem. However, the truth of the matter is that the issues related to American gasoline supply, reliability and demand are fairly complex, and proponents of easy answers are likely glossing over the truth about the details of such ideas.

In this paper, we discuss policy options facing the U.S. transportation sector and look at the role of conservation, biofuels, corporate average fuel economy (CAFE) standards, and improved car technology in reducing the growth in U.S. gasoline demand. In our discussion, we will investigate past and current policies, such as the new 2007 U.S. Energy Independence and Security Act (EISA), and their impact on gasoline demand. We will also discuss the role that gasoline prices play in generating or discouraging demand growth and look at the determinants of gasoline prices in the United States, including such factors as the price of crude oil, the role of gasoline inventories in market stability and the rising dependence on imports to meet the seasonal increase in demand.

The potential for effective energy policy in the transportation sector is high. History has shown that improvements in efficiency in the transportation sector can serve

as a virtual source of supply, with dramatic impacts on global energy market trends. Future climate and energy security policy will focus heavily on promoting or regulating automobile efficiency.[11] In fact, new technologies, including advanced biofuels, efficient hybrids and plug-in hybrids, can displace oil demand. This paper will discuss the various policy frameworks for reducing U.S. gasoline demand, with an eye to debunking myths about quick solutions and with the goal to demystify the policy framework to a sound and comprehensive portfolio of approaches that can help the United States enhance its energy security and render its transportation sector more resilient to supply shocks and other risks.

SOME BASIC CONCEPTS AND FACTS

U.S. motor vehicles in use totaled 242 million in 2007, just under a vehicle for every person in the country, and Americans traveled about 12,000 miles per vehicle in 2006. Moreover, both vehicle stocks and miles driven have been increasing through time (see Figure 1). This has had obvious ramifications for motor fuel use, since virtually all U.S. vehicles are powered by petroleum-based fuel. As a result, despite the fact that the United States represents only five percent of the world's population, it consumes more than 33 percent of all road transportation fuel in the world. By comparison, China, even with its growing economy, has about 13 million vehicles and consumes only about five percent of all the road fuel produced in the world, despite having a population that is more than four times the size of the United States.

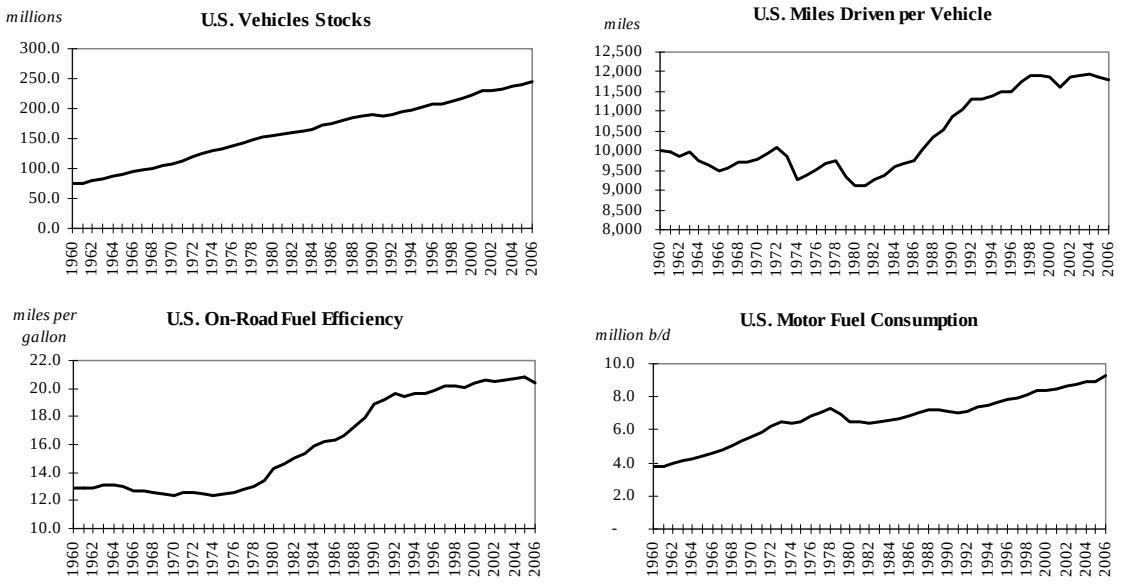
From 1995-2006, U.S. gasoline demand increased on average at about 1.7 percent per year, reflecting factors such as growing per capita income, low gasoline prices and a

[11] Note that improvements in fuel efficiency come with a cost, so policy must not promote efficiency to the point that overall transportation costs for the consumer actually increase. Thus, research and development is critical in enhancing energy efficiency in a cost-effective manner.

commensurate increase in less fuel efficient SUVs and other larger cars, and increasing urban sprawl. In fact, since 1995, the U.S. economy has expanded, in real terms at an average annual growth rate just over three percent, expanding from $8 trillion to $11.5 trillion (expressed in 2000 dollars). During most of this time, gasoline prices averaged $1.49/gallon, with average annual price only rising above $2/gallon since 2004. High incomes and low prices reduced the importance of fuel efficiency to the average consumer and encouraged growth in larger less fuel-efficient vehicles. In fact, the number of SUVs and light trucks on the road has increased from 65 million to about 100 million, representing a 3.7 percent average annual increase. This is even more pronounced when one considers the fact that the number of passenger cars only increased slightly over the same period, rising at an average annual rate of less than one percent (0.6 percent, to be exact).

In the past couple of years, rising prices have begun to have an impact on demand, with the average annual increase sharply lower than what was seen in the previous decade. From 2003 to 2004, U.S. gasoline use rose by 1.9 percent but only increased by 0.6 percent from 2004 to 2005 and one percent from 2005 to 2006. Preliminary data for 2007 indicate that motor fuel demand only increased by 0.5 percent from 2006-2007. In terms of U.S. miles driven per light duty vehicle (this includes passenger cars and SUVs), the average for 2005 was 11,853, down from 11,947 in 2004. In 2006, miles driven per vehicle continued to fall to an estimated 11,791.

Figure 1. U.S. Vehicle Stocks, Miles Driven, Fuel Use and Efficiency (1960-2006)



Source: Energy Information Administration, Federal Highway Administration, Author's Calculations

Many factors influence the demand for gasoline. Consumer income and the price of gasoline are certainly important variables, but there is wide disagreement about the size of the effect these variables have on demand. In a recently published paper, Goodwin, Dargay, and Hanly (2004) report a range of estimates for price and income elasticity that prevail in the previous literature.[12] The reported price elasticities range from -0.05 to -0.17 in the short run and from -0.10 to -0.63 in the long run. Thus, in the short run, demand is estimated to decrease between 0.05 and 0.17 percent for every one percent increase in price. The long-run elasticities are higher because they reflect price-induced changes in vehicle stock characteristics, such as fuel efficiency, as well as price-induced changes in consumer habits. The income elasticities are reported as ranging from 0.05 to

[12] P. Goodwin, J. Dargay, and M. Hanly, "Elasticities of Road Traffic and Fuel Consumption with Respect to Price and Income." *Transport Reviews* 24 (2004): 275-292.

0.62 in the short run and 0.12 to 1.47 in the long run, again being generally higher in the long run due to changing capital stocks and consumer behavior patterns.

Other important variables include miles of paved roads, vehicle stocks, fuel efficiency, and traffic congestion. Miles of paved road statistics generally are important in studies that compare gasoline demand across a range of countries at different levels of economic development. Vehicle stocks and fuel efficiency are especially important in studies that consider the basic determinants of demand using a more systematic approach. For example, if we consider that demand for gasoline is derived from the demand for transportation service, we have the following variable relationship:

$$\underset{\text{(i.e. - gallons of gasoline)}}{gasoline\ consumption} = \frac{utilization}{\underset{\text{(i.e. - miles driven per vehicle)}}{\quad}\quad efficiency\quad \underset{\text{(i.e. - miles per gallon)}}{\quad}} * \underset{\text{(i.e. - \# of vehicles)}}{vehicle\ stock} \quad .$$

In these types of studies, it is possible to model each of the right-hand-side variables as determinants of gasoline demand, with each variable itself potentially being a function of other variables. While these types of models can be complicated, they carry an advantage in that they create the ability to identify whether policies targeting efficiency, vehicle utilization or vehicle stocks will have the biggest potential for altering gasoline demand.

Traffic congestion is another potentially important variable. In a recent paper, Small and Van Dender (2007) examine the effects of increasing congestion in the United States.[13] As a key part of their analysis, they consider the effect that increased fuel efficiency has on the demand for motor fuel. More specifically, if higher fuel efficiency lowers the cost per mile for driving, to what extent does this encourage an increase in

[13] Kenneth A. Small, and Kurt Van Dender, "Fuel Efficiency and Motor Vehicle Travel: The Declining Rebound Effect," *Energy Journal* 28 (1), 2007:25-51.

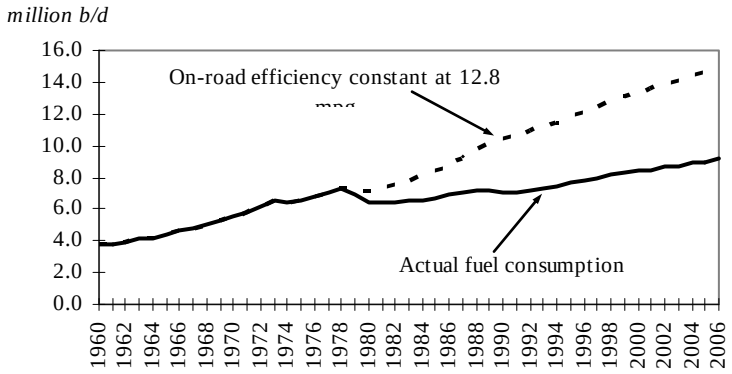
driving, or the so-called “rebound effect”? This is important because the rebound effect counters, to some extent, the reductions in fuel consumption that come about as a result of greater fuel efficiency. They estimate that the elasticity of vehicle miles traveled with respect to the cost per mile is on the order of -0.05 in the short run and -0.21 in the long run. Thus, a *ceteris paribus* increase in fuel efficiency would lower the cost per mile, thereby increasing miles traveled. They also find that “a 10 percentage-point increase in urbanization reduces the rebound effect by about 0.25 percentage points”. This is important because it indicates that the phenomenon of urban sprawl actually increases the rebound effect. Thus, in many regions of the southern United States, where cities such as Los Angeles, Houston and Atlanta notoriously sprawl for miles from the city center, fuel efficiency increases may have a more muted impact in lowering gasoline demand, especially when compared to the effects in more densely-populated cities.

AUTOMOBILE EFFICIENCY: PAST AND PRESENT

In the wake of the oil embargo imposed by the Organization of Petroleum Exporting Countries (OPEC) in the early 1970s, the U.S. government took steps to reduce crude oil demand and hence dependence on imports. One policy measure undertaken as part of the Energy Policy and Conservation Act of 1975 (EPCA75) was the adoption of CAFE standards. CAFE standards are the sales-weighted average of all fuel economies, expressed in miles per gallon (mpg), in a given manufacturer’s fleet of new vehicles sold in a given year. The EPCA75 called for a standard of 18 mpg for new passenger cars in model year 1978, rising to 27.5 mpg by the mid-1980s. Up until 2007, U.S. CAFE standards were aimed to have all new passenger cars get an average of 27.5 mpg and new light trucks (including sport utility vehicles, or SUVs) get an average of 22.2 mpg for

model year 2007. The standard for new light trucks was just recently increased (from 20.7 mpg), while the standard for the passenger car fleet has been constant since 1990.

Figure 2. U.S. Fuel Use (Actual and On-road Efficiency Constant at 1977 levels)



Source: Energy Information Administration, Author's Calculations

Improvements in fuel efficiency that were realized from the late 1970s through 1990s, catalyzed by mandates and consumer demands for lighter vehicles, resulted in considerable fuel savings. In fact, U.S. gasoline consumption would have been considerably higher than it is now absent those improvements. Figure 2 indicates what fuel consumption would have been had efficiency remained constant at 1977 levels (at 12.8 mpg) and miles driven increased as indicated in Figure 1. Also indicated is actual fuel consumption. The increase in on-road fuel efficiency to about 20 mpg by the early 1990s has acted as a virtual source of supply. Efficiency improvements facilitated an increase in miles driven without an increase in actual fuel use.

The average annual growth rate of motor fuel demand from 1977 through 1992 was only 0.1 percent. This occurred despite a two percent average annual growth rate in the stock of motor vehicles and one percent average annual increase in miles driven (see Figure 1 for data on vehicle stocks, miles driven and motor fuel demand). Thus, between

1977 and 1992, there were more cars on the road and those cars were being driven greater distances, but fuel demand was virtually unchanged. This was the result of an almost 70 percent increase in fuel efficiency.

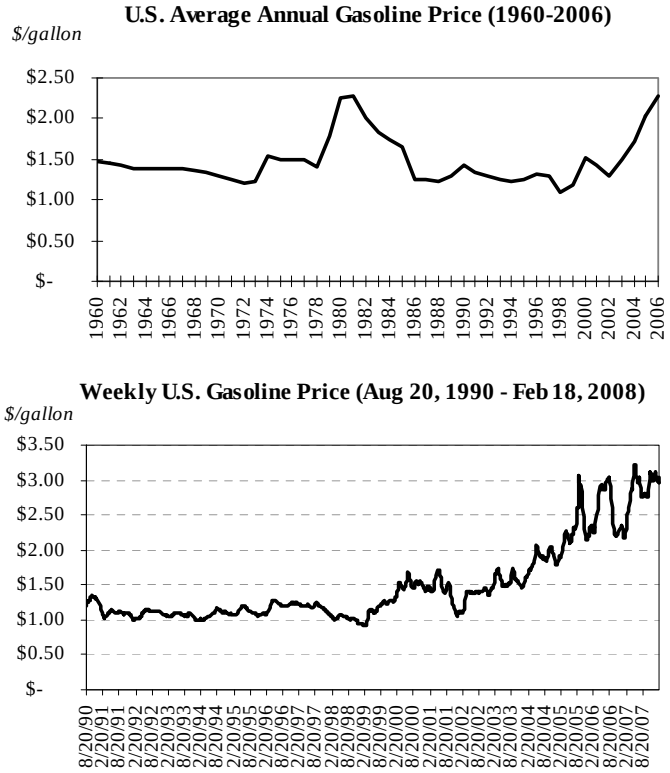
Since 1992, U.S. motor fuel demand has increased substantially. From 1992-2006, motor vehicle stocks increased at an average annual rate of 1.82 percent and miles driven increased at an average annual rate of 1.91 percent. During this period, unlike the period from 1977-1992, the increases in miles driven and vehicle stocks translated into an average annual increase in fuel demand of 1.86 percent. The key difference between the period spanning 1977 to 1992 and the period spanning 1992 to 2006 is what happened to vehicle fuel efficiency. Specifically, while on-road fuel efficiency increased substantially in the earlier period, it has hovered virtually unchanged over the last 15 years.

It is important to note that on-road fuel efficiency is substantially lower than the mandated CAFE standard. For example, according to the Federal Highway Administration, U.S. on-road fuel efficiency for all motor vehicles is 17.3 mpg, with passenger cars averaging 22.6 mpg and light trucks (i.e. SUVs, pickups and vans) averaging 16.8 mpg. The disparities between the CAFE mandates and the actual on-road efficiencies arise for several reasons. One, CAFE standards apply to new vehicles only, with older vehicles produced under a different set of mandates. It takes, on average, about eight to 10 years for a motor vehicle to be retired from use, so that many older, less fuel-efficient vehicles remain on the road. Two, consumer driving habits can create differences between actual fuel efficiency and the fuel efficiency reported by the Environmental Protection Agency (EPA). For example, stop-and-go driving, as in rush-hour traffic, will typically result in much lower fuel efficiency than a vehicle's "window

sticker" indicates. Three, alternative vehicle credits contribute to lower actual on-road fuel efficiency. Automakers receive CAFE credit for manufacturing flexible fuel vehicles, even if that vehicle, once sold, runs primarily on gasoline. Thus, a vehicle's fuel efficiency may be rated well above the current CAFE regulation even though its actual on-road efficiency is well below the mandated minimum. This means that even though the automaker is technically in compliance with the CAFE mandate, overall realized on-road fuel efficiency can actually be lower than what was mandated because of the effects of the flexible fuel vehicle credits. These credits allow a manufacturer to sell more cars that are below the officially mandated level for new vehicles by claiming the credits from sales of flexible fuel vehicles that in practice are being operated with gasoline, not ethanol.

Another important fact concerns SUVs and other light trucks. Relatively low gasoline prices through the 1990s (see Figure 3) meant very little emphasis was placed on the fuel cost of driving. Thus, the value of greater fuel efficiency to consumers was substantially diminished, and the number of SUVs and other light trucks on the road increased dramatically through the 1990s. In fact, SUVs increased to roughly 40 percent, up from only 15 percent in 1975, of all passenger vehicles on the road today. This shift in vehicle stock composition has actually contributed to stagnation in the overall on-road fuel efficiency for passenger vehicles since the early 1990s. Moreover, it is a major factor in explaining why gasoline demand in the United States has risen so rapidly in the past 15 years.

Figure 3. Real (2000$) U.S. Gasoline Prices (1960-2006)



Source: Energy Information Administration

Largely in response to consumer outcry due to steadily increasing prices (see Figure 3), President George W. Bush proposed an ambitious target to reduce the growth in U.S. gasoline use by 20 percent over the next 10 years in his 2007 State of the Union address. The president noted that the nation was "addicted to oil" and added that U.S. dependence on imported oil makes it "more vulnerable to hostile regimes, and to terrorists who could cause huge disruptions of oil shipments, raise the price of oil, and do great harm to our economy." The president's plan called for modernization of CAFE standards for SUVs and other light trucks to reduce projected annual gasoline use by 8.5 billion gallons, representing a five percent reduction in projected gasoline demand. The president also outlined in his program an increase in the supply of renewable and

alternative fuels, which is to be achieved by setting "mandatory fuels standards" to require 35 billion gallons of renewable and alternative fuels in 2017, roughly displacing 15 percent of projected annual gasoline use in that year. With higher CAFE standards and increases in the supply of alternative fuels, the result would be a total reduction in projected annual gasoline use of 20 percent.[14]

Through late 2007, CAFE standards for light trucks have been increased twice in recent years using an attribute-based, size-related method. The president's 2007 plan called on Congress to authorize the Secretary of Transportation to apply the same kind of method to passenger cars as opposed to legislating a numeric target for fuel economy. In its statement regarding the proposal, the White House asserted that "the President's plan will help confront climate change by stopping the projected growth in carbon emissions from cars, light trucks and SUVs within 10 years." According to White House calculations, the plan would remove about 175 million metric tons of carbon dioxide emissions or the equivalent of emissions from 26 million automobiles. The plan would supplement the DOE target goal (under the Energy Policy Act of 2005), requiring 30 percent of 2004 U.S. transportation fuel consumption be displaced with biofuels by 2030. Renewable and alternative fuels are defined by the White House as corn ethanol, cellulosic ethanol, biodiesel, methanol, butanol, hydrogen, and alternative fuels.[15]

The 2007 EISA, passed on December 18, 2007 and signed by President George W. Bush, raises CAFE standards to 35 mpg by 2020, with first improvements required in passenger fleets by 2011. The new 35 mpg standard for new passenger cars by 2020 that

[14] White House, "President Bush Delivers State of the Union," January 23, 2007. http://www.whitehouse.gov/stateoftheunion/2007/

[15] White House, "President Bush Delivers State of the Union," January 23, 2007. http://www.whitehouse.gov/stateoftheunion/2007/

is mandated under the 2007 energy bill is a step in the right direction. However, it will likely only be able to ameliorate the projected *increase* in U.S. oil imports over the next 10 years, and it is not likely to reduce American oil imports from current levels.[16]

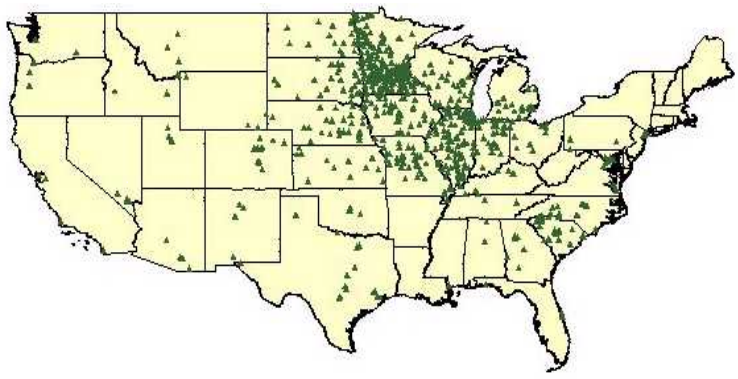
Given the mandated schedule for the phase-in of the new fuel standards, on-road efficiency of all motor vehicles should reach about 20.5 mpg by 2017, assuming new vehicle purchases represent about 6.5 percent of the entire fleet each year (which is the average for the past few years). This would reduce oil demand in the transportation sector in the United States by about 9.5 percent, putting U.S. motor fuel demand in 2017 at 12 million b/d instead of the 13.3 million b/d previously projected for 2017. However, this is still about 0.8 million b/d higher than U.S. motor fuel use in 2006. By 2020, the new standards would put U.S. gasoline demand at 11.6 million b/d, 2.3 million b/d below previously projected levels but 0.3 million b/d above 2006 demand levels. In total, between now and 2020, the new CAFE regulations could push oil use about 2.3 million b/d lower than what was previously projected, assuming the average rate of new vehicle purchases experienced in recent years.

The 2007 bill failed to close the loophole on how flexible fuel vehicles (FFVs) are treated under current CAFE standards. The loophole gives automakers a CAFE credit for vehicles that can run on 85 percent ethanol fuel (E85). The credit allows automakers to produce a greater number of vehicles that get below the mandated mileage standard (in the case of the 2007 bill, which would be more vehicles under the mandated 35 mpg). Furthermore, an increase in the number of ethanol-fueled vehicles may actually lower on-

[16] Note that CAFE standards only establish a floor, or minimum, for vehicle fuel efficiency. Raising the floor only affects overall fuel efficiency if auto manufacturers are forced to significantly improve the fuel efficiency of the vehicles they are currently producing. Thus, raising the minimum will only result in an improvement in actual on-road fuel efficiency (which was about 17.3 mpg in 2005) if automakers' fleets are currently near the minimum standard.

road fuel efficiency because ethanol yields considerably lower fuel efficiency than gasoline. Under the current fuel economy regulations, a fleet credit of up to 1.2 mpg is applied if automakers produce vehicles that can run on both conventional gasoline and a gasoline mixture containing up to E85.

Figure 4. Distribution of E85 Refueling Stations



Source: Ford Motor Company

The renewable fuels credit is problematic because very few E85 refueling stations actually exist, so the FFVs being used to earn this credit for automakers actually operate on gasoline the majority of the time. Current U.S. ethanol production is concentrated in the Midwest region and the distribution system in other parts of the country is not well-developed or even non-existent, which creates some difficulty in expanding ethanol use. As of December 2007, there were about 1,300 E85 ethanol fueling stations in the United States and more than 35 percent of them were located in two states, Minnesota and Illinois.[17] Figure 4 indicates the distribution of E85 refueling stations.

[17] See U.S. Department of Energy, Alternative Fuels and Advanced Vehicles Data Center: "Alternative Fueling Station Total Counts by State and Fuel Type." http://www.eere.energy.gov/afdc/fuels/stations_counts.html (Dec.06, 2007).

Figure 5. Projected motor fuel use and fuel efficiency (2006-2030)

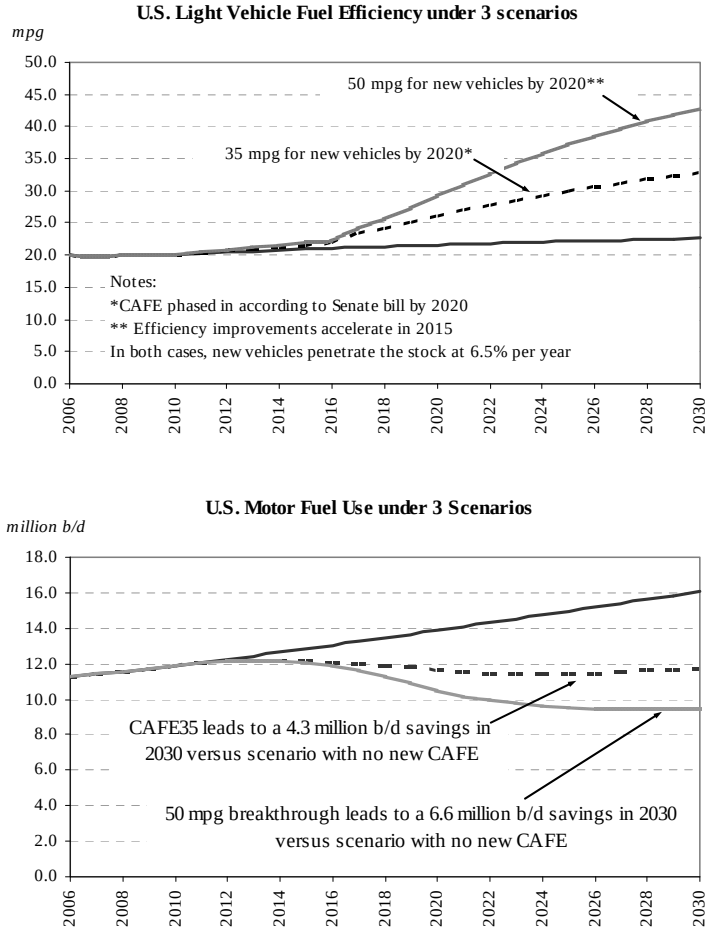
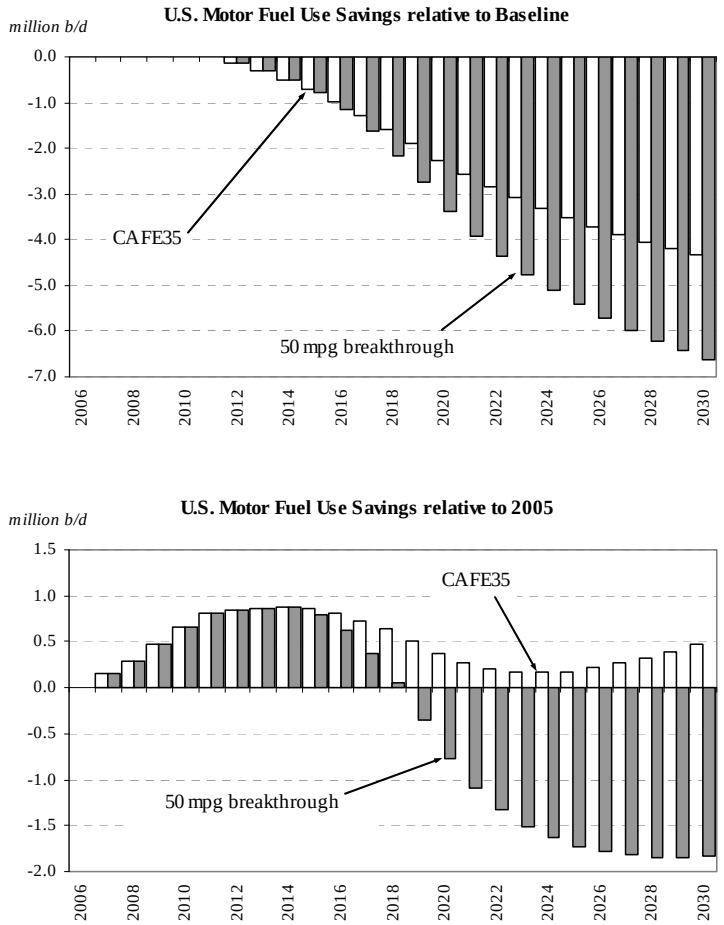


Figure 5 depicts motor fuel use and fuel efficiency through 2030 under three different assumptions. In the first scenario, or the "business-as-usual" case, motor fuel consumption is projected assuming efficiency improvements occur slowly over time, such that on-road fuel efficiency rises by about 10 percent from 2006 through 2030. The second case, CAFE35, depicts motor fuel use under the new 2007 CAFE mandates. In constructing the simulations, it is assumed that new vehicle purchases represent about 6.5 percent of the fleet in each year (the average rate from recent years), so that the higher fuel efficiencies associated with newer vehicles phase in over time. In addition, the

"rebound effect" discussed above is also included. Thus, as efficiency increases, the cost per mile decreases and vehicle miles driven increases, serving to slightly offset the efficiency gains. The third case uses the same basic assumptions, but allows a breakthrough that pushes the fuel efficiency of new vehicles to 50 mpg by 2020, which could come about if, for example, plug-in hybrid vehicles are successfully marketed. Figure 6 depicts the fuel *savings* (relative to the "business-as-usual" case) that will result from implementation of a 35 mpg efficiency standard as well as the savings if new vehicles could average 50 mpg by 2020.

Figure 6. Projected motor fuel use savings (2006-2030)



Note that in each of the cases where fuel efficiency of new cars is increasing, the on-road efficiency takes some time to approach the efficiency of new vehicles. This is a function of the long life of existing vehicle stocks. Specifically, consumers consider many things when determining whether or not to trade in their older vehicle for a new one, and fuel cost is but one of those factors. Of course, there are factors that can accelerate or decelerate the diffusion of the higher efficiency vehicles into the market, which would alter the pictures in Figure 5 and 6. Specifically, if gasoline prices continue to increase, consumers will be encouraged to increase fuel efficiency in order to lower the fuel cost of driving. This could accelerate the adoption of the newer, more fuel-efficient vehicles, and increase the near-term aggregate fuel savings by increasing the on-road fuel efficiency of the aggregate vehicle stock more quickly. Likewise, if gasoline prices fall, the rate of adoption of new technologies could slow, which would reduce aggregate fuel savings. In any case, price and expectations of future price are certainly key determinants of future fuel use and could alter the patterns seen in Figures 5 and 6.

The importance of the rate of new vehicle diffusion into the existing on-road fleet cannot be understated. If the new CAFE standards are phased in differently than currently planned, or new vehicle purchases accelerate or decline to a rate that differs from past years, the impact could be substantially different.

Further improvements in vehicle efficiency beyond those imposed by the new CAFE standards could also be potentially very important in the future. If, for example, a major breakthrough in car technology and innovation were to occur such that new vehicle fuel efficiency accelerated after 2015 to an average of 50 mpg by 2020, the implications would be substantial, even if no other regulatory policies are enacted. If new cars could

achieve 50 mpg by 2020, fuel consumption would be substantially lower in 2020 than it is today and would continue to fall beyond 2020 as the higher-efficiency new vehicles would diffuse more broadly into the vehicle fleet.

BIOFUELS

The 2007 EISA is the first serious national energy legislation passed in decades aimed to achieve even the modest conservative goal of holding gasoline demand flat over the next 15 to 20 years. This is to be achieved through a combination of energy efficiency improvements (see above) and expanded production of ethanol and renewable fuels. Ethanol production, in particular, is targeted to reach 15.2 billion gallons a year or close to 1 million b/d by 2012.

The 2007 EISA increases the Renewable Fuels Standard (RFS) to nine billion gallons of renewable fuels annually by 2008, which is to progressively increase to a 36 billion gallon renewable fuels annual target by 2022, of which 16 billion is slated to come from cellulosic ethanol. The bill specifies that 21 billion gallons of the 36 billion must be "advanced biofuel" which has up to 50 percent less greenhouse gas emissions than the gasoline or diesel fuel it will replace. "Advanced biofuels" include ethanol fuel made from cellulosic materials, hemicellulose, lignin, sugar, non-corn starch and wastes, and biomass-based biodiesel, biogas, and other fuels made from cellulosic biomass.

Moving to ethanol as a means of enhancing energy security is not without its difficulties. In fact, in order for ethanol to simply prevent gasoline demand from rising over the next 10 years, absent the new CAFE standards, it will take an additional 1.9 million b/d of ethanol production, which is more than six times higher than U.S. production in 2006 and represents about a sustained 16 percent per year increase. Ethanol

production rose 19 percent between 2005 and 2006 and is projected to rise at an even faster rate from 2006 to 2007. However, continuing to grow domestic ethanol production at this pace over the next five to 10 years will prove highly challenging, as food and other agricultural prices have skyrocketed recently in response to this new demand for corn.

The combined effect of biofuels and new CAFE mandates can be significant. If it is possible to use biofuels to replace a more manageable 0.5 million b/d of conventional gasoline use in the next ten years, then biofuels along with higher fuel efficiency could result in demand for conventional gasoline in 2018 being flat relative to 2005. Further increases in biofuels production and use along with greater improvements in fuel efficiency could serve to reduce U.S. motor fuel consumption. Of course, a countervailing effect is the fact that burning of biofuels as a transport fuel is generally about 25 percent less efficient than gasoline. Thus, replacing 0.5 million b/d of gasoline consumption amounts to about 0.625 million b/d of ethanol use. Basically, biofuels use must increase by enough to offset the reduction in fuel efficiency.

Outside of the fuel complex, increased use of ethanol carries some potential adverse effects. Current levels of ethanol production have already led to increases in corn-based food prices, and analysts worry that in drought conditions in the Midwest the consequences of ethanol production on food costs could be quite severe. A related issue is the concern that expanded use of ethanol could closely link food prices with energy commodity prices. Since the latter have been shown to have a negative relationship with macroeconomic health, greater use of ethanol could provide an additional channel through which rising energy prices can adversely affect the economy. Environmentally, some studies show that the impact of increased use of fertilizers and irrigation use on

ecosystems along the Mississippi River and in the Gulf of Mexico could be drastic, potentially expanding the so-called dead zone in the Gulf of Mexico.[18]

One other important point is that expanding biofuels use will not result in U.S. energy independence. Rhetoric making that claim is factually ridiculous. Furthermore, "energy dependence" as defined may not even be a worthwhile goal. For example, if achieving energy independence means relying on very high-cost forms of energy when suitable low-cost sources of supply are available internationally, then economic well-being and consumer welfare could be compromised by favoring self-sufficiency over free trade. Simply put, eliminating 12 million b/d of oil imports is not plausible. To achieve U.S. oil independence by replacing gasoline with ethanol would require approximately 10 times the current amount of *worldwide* biofuels production.

CONSERVATION

Encouraging energy conservation through increased use of public transportation or other means also has a role in American energy policy. To hold U.S. gasoline demand at 2005 levels by 2020, without considering the new CAFE mandates for fuel efficiency, each vehicle would have to be driven about 63 miles less per week by 2020, which amounts to about a 25 percent decrease in miles driven. While this is likely difficult to achieve in most cases, adopting practices such as car-pooling, using public transportation, or telecommuting at least one day a week could go a long way toward achieving such a reduction.

[18] Susan Powers, P.J.J. Alvarez, and D. Rice, "Increased Use of Ethanol in Gasoline and Potential Groundwater Impacts," State of California. UCRL-AR-145380, 2001; and "Quantifying Cradle to Grave Life Cycle Impacts associated with Fertilizer used by Corn, soybeans and stover production," NREL/TP-510-35700, May 2005.

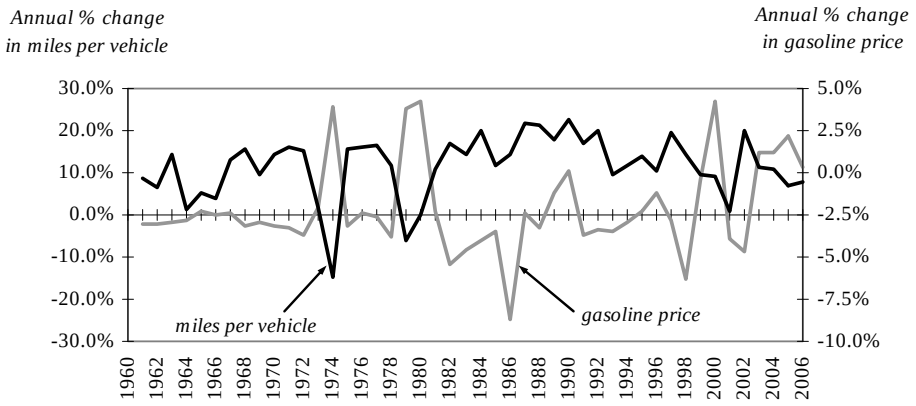
If, however, we consider the new CAFE mandates, given the CAFE35 projections in Figure 5 above, the miles-driven reduction through conservation that is required to simply hold gasoline demand to 2005 levels by 2020 is much smaller. In fact, it only amounts to about six miles per week, or a mere 2.2 percent decrease in miles driven. Anything greater could actually lower demand relative to 2005 by 2020. Again, however, we must caution that this number may be larger or smaller depending upon the rate of diffusion of the newer, more fuel-efficient vehicles. Nevertheless, the combined effect of higher fuel efficiency and conservation can make achieving a particular fuel-use target much more achievable.

One of the most important drivers of consumer efforts to conserve fuel is the fuel price. From Figure 1, we see that the increase in gasoline price in the late 1970s and early 1980s coincides with a decrease in miles driven. Figure 7 indicates the percentage change in miles driven in a given year along with the percentage change in fuel prices. While other factors also matter, such as income, population, congestion and fuel efficiency, it is clear that a negative correlation exists between fuel price and miles driven, especially during periods of extreme price movement, such as in 1974, 1978-1981, and in recent years.

In general, since the early 1980s, the number of miles driven per vehicle has been increasing. This trend owes a lot to the fact that end-user motor fuel prices have been fairly low and stable and income growth has been quite robust. While policy-makers would generally not want to adversely influence income growth, there are measures they could use to reduce miles driven by encouraging conservation. One such measure is a tax on motor fuels. Taxes in the United States are significantly lower than in Japan and many

countries in Europe. High taxes have been a major factor discouraging growth in motor fuel use in those countries, as compared to the United States. Higher taxes have encouraged European consumers to conserve through greater use of public transportation, more dense urban living (by discouraging urban sprawl), and wider adoption of smaller, more fuel-efficient vehicles. This has contributed to lower fuel use in those countries.

Figure 7. Gasoline price and Vehicle Miles Driven



Source: Energy Information Administration, Federal Highway Administration, Author's Calculations

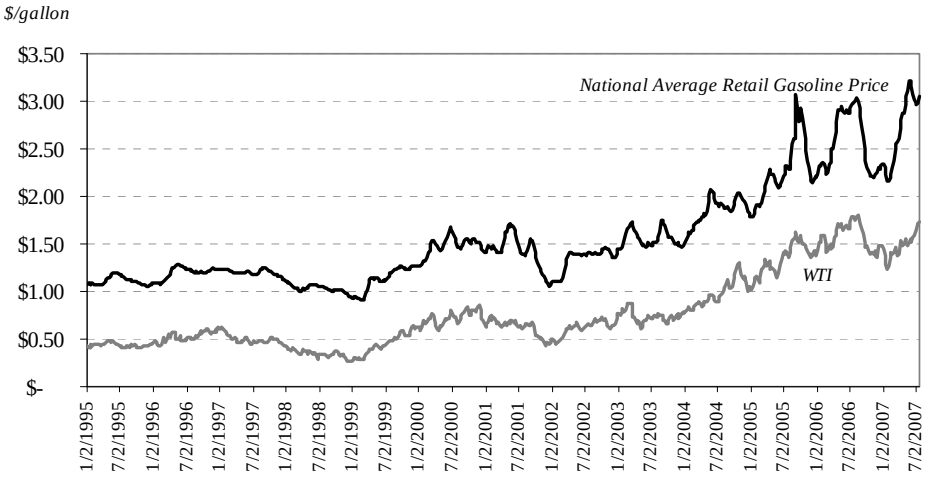
MORE ON THE DETERMINANTS OF GASOLINE PRICES

The primary influence on the recent rise in gasoline prices has been the increase in crude oil prices. In fact, research indicates that there is a stable long-run price relationship between crude oil and gasoline.[19] Figure 8 provides visual evidence of the relationship between prices because, in general, when the price of crude oil rises the price of gasoline also increases. Statistically, if there is a *cointegrating* relationship between

[19] See Kenneth B. Medlock III, "U.S. Gasoline Price in the Long and Short Run," Energy Forum Working Paper, James A Baker III Institute for Public Policy, Rice University (2007). It should be noted that the existence of a long-run cointegrating relationship between the price of crude oil and the price of gasoline is well established. In fact, many studies use the long-run relationship between gasoline and crude oil prices as a starting point to investigate other matters (see, for example, Borenstein et al. (1997) Radchenko (2005), Bacon (1991), Peltzman (2000), Balke et al. (1998)).

the price series, then there exists a stable long-run relationship between the price series, where the "long run" is unencumbered by phenomena such as refinery capacity constraints, inventory problems and short-run adjustment costs that may occur due to things such as seasonal changes in formulation standards.

Figure 8. Weekly WTI and U.S. Retail Gasoline Price (Jan 2, 1995 – July 16, 2007)



Source: Energy Information Administration

To establish the existence of a stable long-run relationship between the prices we must first establish they are integrated of the same order and then establish they are indeed cointegrated. Augmented Dickey Fuller (ADF) tests reveal that each of the three price series is integrated of order one.[20] If the series are then cointegrated, it is possible to use OLS to estimate a long-run relationship between the wholesale price of gasoline, $p_{GAS,t}$, and the price of crude oil, $p_{OIL,t}$, of the form

$$p_{GAS,t} = a_0 + a_1 p_{OIL,t} + e_t \qquad (1).$$

[20] Augmented Dickey Fuller tests indicate that each of the variables is $I(1)$. AIC tests were used to select optimal lag length in the ADF tests. Results are: $p_{GAS} \Rightarrow$ ADF = -1.623 (3 lags); $p_{RETAIL} \Rightarrow$ ADF = -1.749 (3 lags); $p_{OIL} \Rightarrow$ ADF = -0.435 (2 lags).

Similarly, the long-run relationship between retail, $p_{RETAIL,t}$, and wholesale gasoline prices can be estimated as

$$p_{RETAIL,t} = b_0 + b_1 p_{GAS,t} + u_t \qquad (2).^{21}$$

Following the method of Engle and Granger (1987), the residuals from equations (1) and (2), $\hat{e}_t \left(= p_{GAS,t} - \hat{a}_0 - \hat{a}_1 p_{OIL,t}\right)$ and $\hat{u}_t \left(= p_{RETAIL,t} - \hat{b}_0 - \hat{b}_1 p_{GAS,t}\right)$, are found to be stationary, so that the prices are indeed cointegrated.[22] This, in turn, implies the estimates of the parameters a_0 and a_1 in equation (1) and b_0 and b_1 in equation (2) are super consistent. The estimation results are reported in Table 1.

Table 1. Estimation results of cointegrating equations

Equation	Parameter Estimates (standard errors in parentheses)	R^2
(1)	$p_{GAS,t} = \underset{(0.0078947)}{-0.0058778} + \underset{(0.0002265)}{0.028043}\, p_{OIL,t}$	0.9609
(2)	$p_{RETAIL,t} = \underset{(0.0070065)}{0.630628} + \underset{(0.0071759)}{1.072006}\, p_{GAS,t}$	0.9728

Source: Medlock (2007)

Equations (1) and (2) imply a set of long-run equilibrium prices, which are reported in Table 2. It is important to note that these results are specific to U.S. *Gulf Coast* wholesale gasoline prices and *national average* retail prices. Thus, regional

[21] Equations (1) and (2) together imply a relationship between crude oil prices and retail gasoline prices of the form $p_{RETAIL,t} = c_0 + c_1 p_{OIL,t} + v_t$, where $c_0 = b_0 + b_1 a_0$ and $c_1 = b_1 a_1$. This is estimated as $p_{RETAIL,t} = \underset{(0.0090618)}{0.6135744} + \underset{(0.00026)}{0.030408}\, p_{OIL,t}$ with an $R^2 = 0.9564$. In fact, F-tests verify that the parameter estimates of c_0 and c_1 are not statistically different from $b_0 + b_1 a_0$ and $b_1 a_1$, respectively.

[22] ADF tests reveal this to be the case. ADF tests of stationarity of the residuals on equations (1) and (2) reveals: (1) ADF = -7.375 (3 lags); (2) ADF = -8.497 (2 lags). Each is significant at the one percent level. Robert E. Engle, and Clive W.J. Granger, "Cointegration and Error Correction: Representation, Estimation, and Testing," Econometrica 55, March 1987: 251-76.

differences may exist. In addition, the prices in Table 2 indicate the gasoline price U.S. consumers *ought* to *on average* expect to pay for a given price of crude oil. However, if the price of crude on a particular day in May is $90 per barrel, it is very possible, indeed likely, that the national average retail price of gasoline will be above $3.33 per gallon. The answer lies in market fundamental forces. In particular, summertime demands are typically higher than normal, which tends to lift price relative to its long run average. If there are any added constraints, such as refinery outages, below normal inventories, or other supply chain disruptions, then the price will deviate even higher.

Table 2. Long-run price relationships

Crude Oil ($/bbl)	Wholesale Gasoline ($/gallon)	Retail Gasoline ($/gallon)
$10.00	$0.27	$0.92
$20.00	$0.55	$1.23
$30.00	$0.84	$1.53
$40.00	$1.12	$1.83
$50.00	$1.40	$2.13
$60.00	$1.68	$2.43
$70.00	$1.96	$2.73
$80.00	$2.24	$3.03
$90.00	$2.52	$3.33
$100.00	$2.80	$3.63
$110.00	$3.07	$3.93
$120.00	$3.36	$4.23

Source: Medlock (2007)

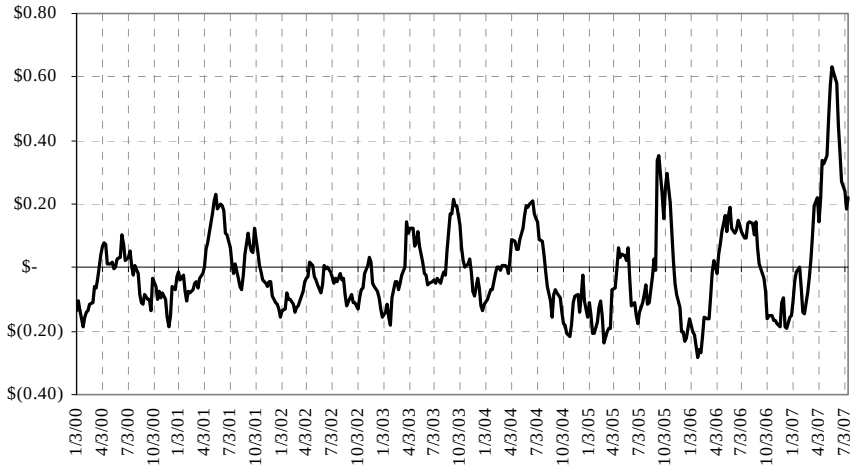
The above analysis verifies that the price of gasoline will tend to increase when the price of crude oil rises, which makes sense because, after all, crude oil is refined to make gasoline. In the short run, however, there are particular factors that influence the gasoline market that are not necessarily related to the price of crude. Such factors include variations in demand, inventories, refinery capacity, and expectations about future market conditions, and these factors can temporarily bring gasoline prices out of line with

historical relationships to crude oil price levels. The price consumers pay at the pump is a markup over the wholesale price, where the markup is a function of state and federal taxes, distribution and marketing costs, and station premiums related to the cost of operation (property lease rates, labor costs, etc.).

Figure 9 illustrates the historical departure of retail gasoline price from its implied long-run equilibrium with crude oil price. It is apparent from the figure that the deviation demonstrates some seasonal behavior. This is consistent with the notion that as gasoline markets tighten (that is, demand rises in the face of a fixed production capacity, as is the case during the spring and summer) the gasoline price will rise relative to crude oil. One striking feature of Figure 9 is the fact that the magnitude of the deviations appears to be growing over time. This is symptomatic of U.S. demand outgrowing domestic refinery capabilities, leaving the domestic market to rely increasingly on gasoline imports to balance.

In the short term, temporary demand and supply factors can cause gasoline prices to rise substantially. Given the shortage in refinery capacity in the United States, these short-run departures have been growing larger and more frequent. Demand has grown steadily, but U.S. refinery capacity has not kept pace. Thus, the U.S. market has become increasingly dependent on foreign gasoline imports. At the same time, growing demand elsewhere in the world means increased competition for gasoline, which, in turn, drives up the price to attract imports during high U.S. demand periods.

Figure 9. Deviations from long-run equilibrium (Jan 2, 2000 – July 16, 2007)



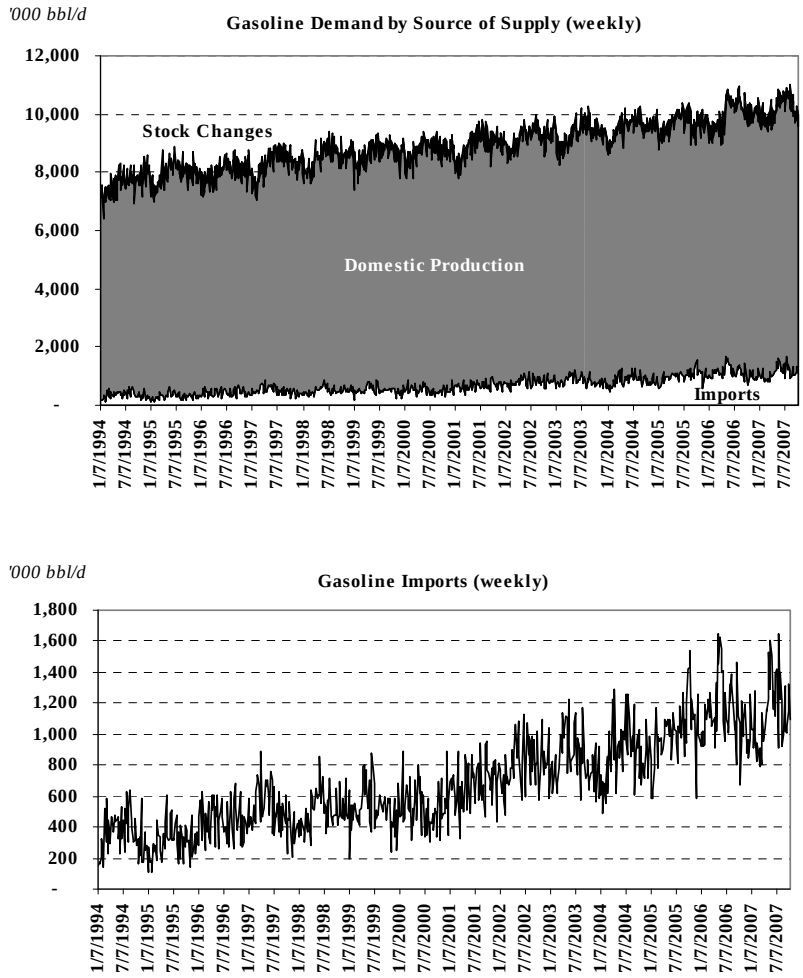
Note: Figure data are constructed as the actual retail gasoline price minus the long run equilibrium retail gasoline price implied by equations (1) and (2).

In general, U.S. gasoline demand in the summer is higher than in other times of the year, especially around the summer holidays, such as the Memorial Day and Labor Day holidays, and to a lesser extent the Fourth of July. Existing refinery capacity in the United States is not capable of producing enough gasoline to meet this higher demand. Thus, the United States relies on gasoline that has been stored during times of lower demand and on imports to meet the seasonal increase. If demand rises, and inventory is not sufficient or there is difficulty in importing gasoline, then prices can rise especially high, particularly because demand in the short run is fairly unresponsive to changes in price. This has been happening with increasing frequency in the United States over the past few years. In 2007, demand peaked in the summer (August) at about 9.7 million b/d, and refinery output of gasoline that same month was about 9.2 million b/d.

Imports, refinery capacity and capacity utilization are also very important factors in determining the price of gasoline. When capacity is tight (or low) markets will place a

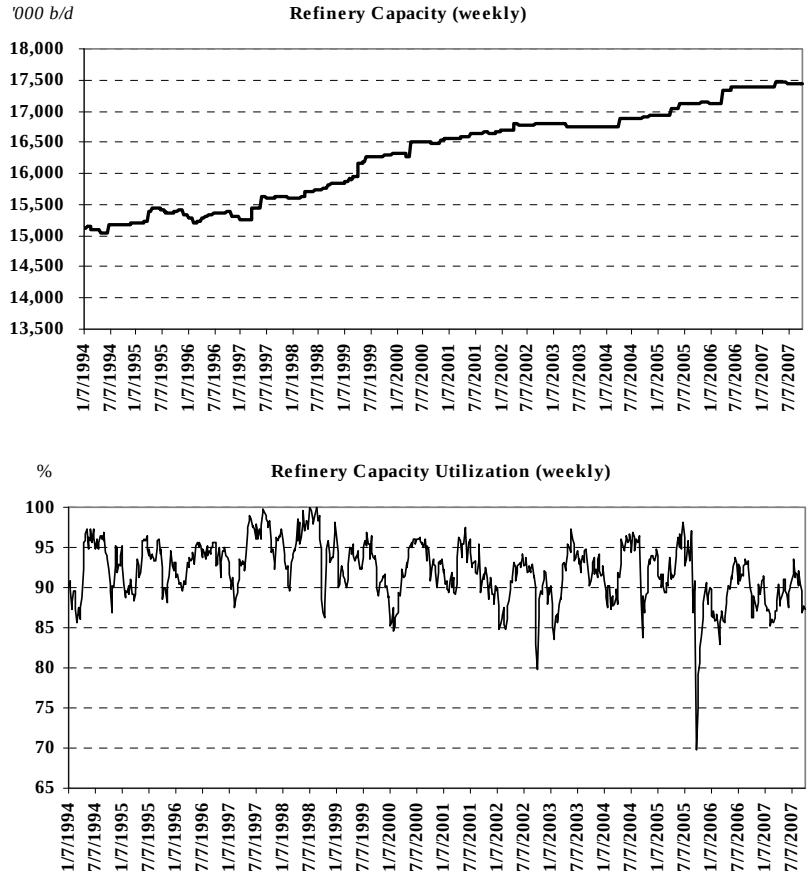
premium on gasoline, reflecting scarcity of available supply. Figures 10 and 11 summarize these points graphically.

Figure 10. Demand by source of supply and imports (Jan 7, 1994 – Oct 12, 2007)



Source: Energy Information Administration and author's own calculations

Figure 11. Refinery capacity and utilization (Jan 7, 1994 – Oct 12, 2007)



Source: Energy Information Administration and author's own calculations

Given the tight refining capacity situation in the United States, especially in high demand periods, we might expect gasoline prices to be higher and likely more volatile with increasing frequency. Hurricanes Katrina and Rita, which struck the U.S. Gulf Coast in 2005, only served to make matters worse by temporarily disabling a large proportion of U.S. refinery capacity. For the first time in three decades, American drivers found empty signs on gasoline pumps across the U.S. Gulf Coast and up the Eastern Seaboard. Still today, the U.S. fuel delivery system remains vulnerable to severe storms and other weather-related disruptions. Thus, in the event of an active hurricane season, it is likely

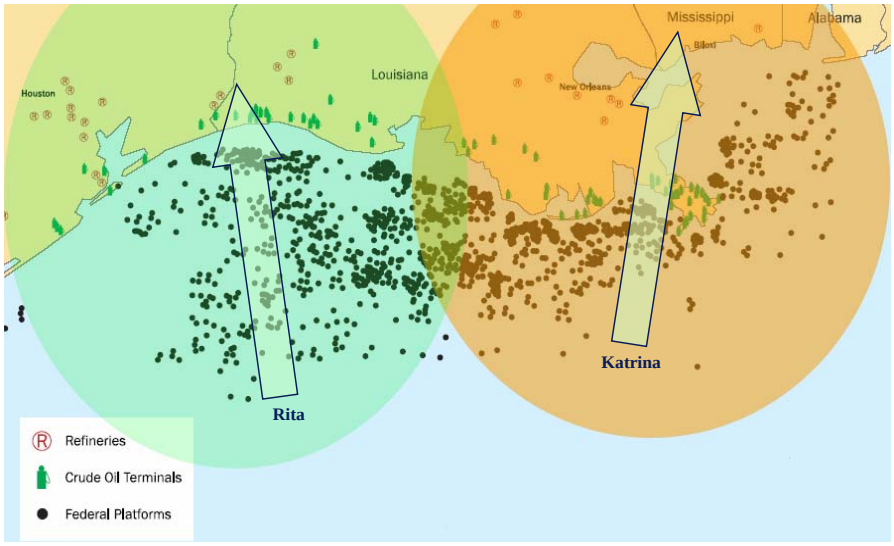
that gasoline prices will rise well above their long-run equilibrium with crude oil for a short period of time.

The hurricane season of 2005 highlighted the vulnerability of the U.S. gasoline market to short-term weather-related disruptions. In the aftermath of Hurricane Katrina, which made landfall in southeast Louisiana and the Louisiana/Mississippi state line on August 29, 2005, Gulf Coast refinery production of finished gasoline (PADD 3) fell by 700,000 b/d versus year-earlier levels. Hurricane Rita made landfall in Texas on September 24, 2005, and resulted in a substantial, additional loss of refining capability. For the week ending September 30, finished gasoline production was down by 1.4 million b/d versus levels of a year earlier. Seventy-five days after the hurricanes, more than 90 million barrels of crude oil and more than 175 million barrels of refined products had been lost from the market. By December 2005, close to 750,000 b/d of U.S. refining capacity was still affected by the aftermath of the hurricanes, and much of this capacity was not brought back online until the end of March 2006.

During the 2005 hurricanes, a surge in gasoline imports following the easing of environmental restrictions on U.S. gasoline specifications helped ameliorate supply dislocations. These imports served to mitigate the effects of reduced refinery capacity. Between the end of September and the end of October 2005, gasoline imports were 476,000 b/d higher than the previous year, a 56 percent increase. The United States borrowed gasoline from European strategic stocks (the United States has no strategic gasoline stocks of its own) and refiners and traders purchased foreign gasoline on open markets.

The hurricanes of 2005 affected not only refinery capacity, but also negatively influenced deliverability of product. In the immediate aftermath of Hurricane Katrina, the forced shutdown of two main gasoline transport pipelines (Plantation pipeline and Colonial pipeline) from the U.S. Gulf Coast to the Eastern Seaboard created temporary outages at retail stations from Florida up all the way to Canada. Shortages and gasoline lines were reported in parts of South Carolina, Florida, South and North Dakota, Massachusetts, New York, New Jersey, Georgia, Arkansas, Texas, Louisiana, and Kentucky. Retail prices as high as $6.99/gallon were reached in certain markets in the aftermath of the hurricane-spurred gasoline crisis.

Figure 12. Katrina and Rita: A Path of Destruction



The events of 2005 highlighted the possible dangers of having so much U.S. refining capacity concentrated in one geographical region that is vulnerable to weather-related disruptions. The area stretching from Corpus Christi, Texas to Lake Charles, Louisiana is home to 27 percent of U.S. refining capacity. The Houston/Beaumont/Port Arthur area alone represents 20 percent of U.S. refining capacity. On the production end,

the U.S. Gulf of Mexico provides 25 percent of U.S. domestic crude oil production and 20 percent of U.S. domestic natural gas output. This heavy geographic concentration of American oil refining and energy production means that similar or worse disruptions are possible in the future.

Total refinery production capacity in the United States in 2006 was 17.4 million b/d, up from 15.6 million b/d in 1990. Although no new refineries have been constructed, expansions at existing facilities have occurred resulting in an increase in capacity of more than 10 percent. These refineries produce not only gasoline (about 46 percent of annual refinery output), but also other petroleum products such as heating oil and other distillates (~25 percent), residual fuel oil (~four percent), jet fuel (~10 percent) and other products (~15 percent). Production of each fuel is somewhat seasonal, with gasoline production ramping up to prepare for the summer driving season and heating oil output rising as the winter approaches. Currently, refineries in the United States produce an annual average of 8.8 million b/d of gasoline with capabilities to increase output somewhat during peak demand periods. In sum, domestic gasoline production is about 95 percent of demand annually.

Some oil company executives have claimed that ethanol programs discourage refinery investment, but the fact is that ethanol has very little to do with the decision to build a new refinery. Since ethanol is simply replacing the gasoline additive MTBE in the United States as a component in gasoline to produce a cleaner fuel, it is not at this point really competing with gasoline as a commodity product.

Refining has not historically been a very profitable business. In fact, through much of the 1990s, refining profit margins were not sufficiently large to generate much

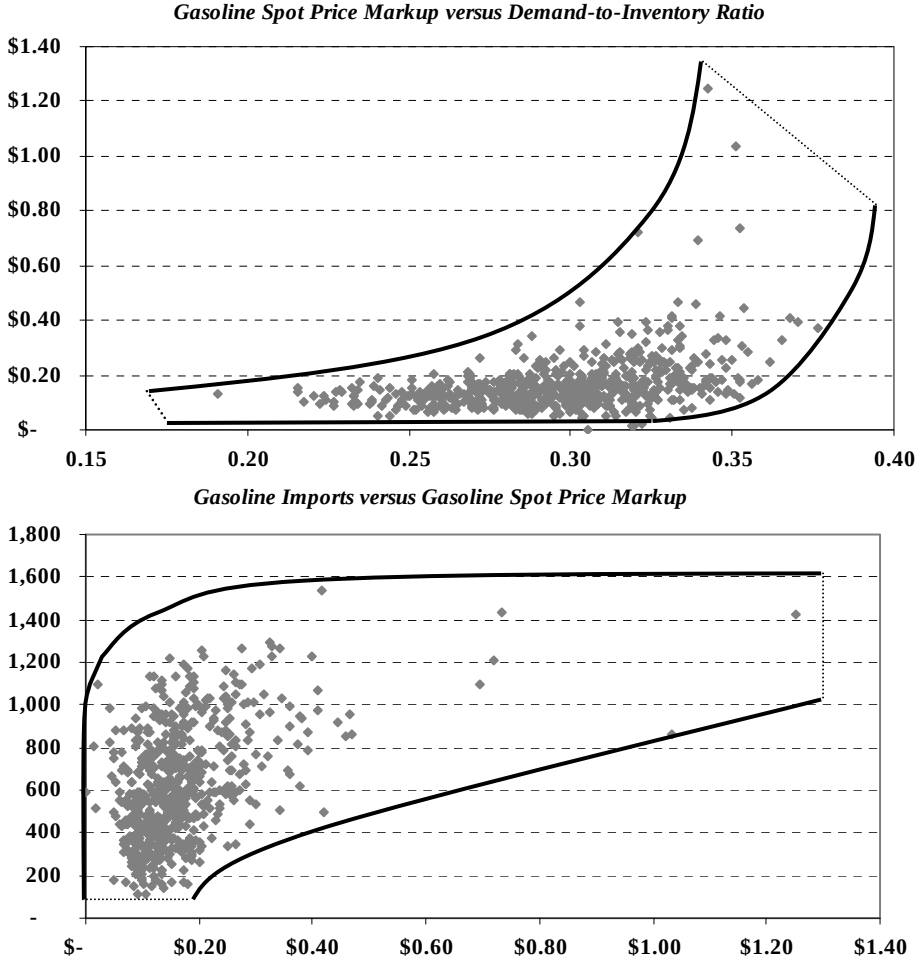
interest in the construction of new facilities. However, the less expensive route of expanding capacity at existing facilities did occur, as the phenomenon known as "capacity creep" resulted in more than 1.5 million b/d of additional capacity in the last 15 years. If too many new refineries are built, the fear among industry investors is that refining margins would very quickly return to their low historical norm, and render the capacity investment unprofitable, especially in light of today's very high construction costs in the energy industry.

Given the rapid growth globally for transportation fuels, refinery capacity has become very highly valued, with existing capacity just barely keeping pace with demand. If demand growth has consistently outpaced projected construction of refinery capacity around the globe for many years, then it is hard to see how investors would likely lose money on the construction of a new domestic refinery. That is why some companies, notably Marathon and ConocoPhillips, are making such investments. While the government has offered locations and hinted at various incentives to encourage refinery construction in the United States, continued capacity creep may still be the preferred avenue for many energy companies simply because it places less capital at risk.

As demand has risen, the United States has ceased to be self-sufficient in its refined products manufacturing capability, and imports of gasoline have risen to peaks as high as one million b/d. Historically, gasoline inventories have been built on a seasonal basis with the approach of the summer driving season and depleted as the summer drew to a close. This is to be expected as inventories are used to meet seasonal increases in demand and are replenished during periods when demand is low. But as indicated in the figures above, year-on-year demand has grown steadily while inventories have not.

Absent significant increases in refinery capacity or improvements in product management, the latter of which would facilitate "just-in-time" production, this should result in larger swings in price as time progresses. As discussed above, U.S. gasoline manufacturing capability has not kept pace with demand growth, and gasoline imports have been required to make up the difference, rising on an average annual basis by about 500,000 b/d with peak imports even higher.

Figure 13. Gasoline spot price, demand-to-inventory ratio and gasoline imports



Note: The gasoline spot price markup over crude oil price tends to rise as the demand-to-inventory ratio rises (panel 1). This reflects scarcity of supply. In turn, gasoline imports tend to increase when the spot price markup increases. As domestic resources become constrained, an increase in price relative to crude oil price will make it profitable for foreign gasoline supplies to reach the U.S. market.

Source: Energy Information Administration and authors' own calculations

Price increases associated with high demand-to-inventory ratios will encourage increased imports (see Figure 13). The industry's inability to raise carrying capacity along with persistent annual increases in overall end-user demand has resulted in an increase in the gasoline spot price markup over crude oil, leaving consumers with the bill. This pattern, which has been accelerating in recent years, begs the question "Why have rising prices not encouraged an increase in inventory capacity?" It also highlights the need to revisit U.S. gasoline inventory management policies. Such policies could carry a public benefit of protecting consumers and the U.S. economy from the negative effects of extreme swings in gasoline prices.

Hurricanes Katrina and Rita exposed the difficulties of allowing the U.S. refining industry to operate like Dell Computer with just-in-time inventories. On-hand stocks of gasoline are needed to protect consumers from sudden outages and extreme events. One possible policy fix would be to regulate the minimum level of mandatory refined product inventories. Such a system exists in Europe and has allowed Europe the flexibility to provide gasoline to the United States during the production shortfalls that occurred following Katrina and Rita, preventing worse dislocations. A U.S. government program reserving the right to use for strategic national emergency releases the extra mandated supplementary industry refined product stocks of five percent or 10 percent of each refining company's average customer demand would ensure needed supplies of gasoline in inventory to weather any disruption of consumer supplies.

The U.S. federal government and/or forward position states should also consider strategic stockpiles of motor fuel to be used to supplement supplies during evacuations from severe storms to prevent fuel outages along key evacuation routes such as the

outages experienced during hurricanes Rita and Katrina. Regional gasoline demand in the U.S. Southwest was at least twice normal levels during the evacuation of Gulf Coast residents. For the days leading up to Hurricane Rita's Sept. 24, 2005 landfall, the evacuation of some three million people pushed gasoline demand to an estimated 45 million gallons per day—about two times higher than normal. Distribution systems in storm-affected areas need to be shut down for safety reasons, meaning that alternative supplies must come by truck from unaffected areas that are contiguous with affected zones.

Public information is also a critical feature of controlling shortages during a gasoline supply emergency as changes in consumer habits can create tremendous pressures on an already-taxed supply and distribution system. On average, Americans travel with their gasoline tanks half full. A sudden switch in this practice to topping off tanks to "secure" fuel in case of service station outages actually creates an additional temporary surge in gasoline demand that can worsen the supply crisis.

Another feature weighing on retail gasoline price trends and the flexibility of the U.S. refining and distribution system to respond to sudden outages is the problem of "boutique fuels" and varied specifications for mandated gasoline additives. The term "boutique fuels" refers to the various gasoline formulations blended to meet differing air quality standards of different localities. Refiners and marketers in some states may have to meet requirements in different air quality attainment areas for one, two or even three different gasoline formulations. With each formulation, additional facilities are needed to segregate the material to be sent to a specific location. These varying formulations mean that extra infrastructure is required to meet the diverse needs of different localities and

that markets cannot clear effectively because extra product in one location cannot be moved to meet shortages in another that has a different formulation requirement. Thus, gasoline as a commodity is less fungible, creating localized shortfalls and price dislocations even when the overall U.S. market might be well supplied.

Nationwide, the U.S. market uses more than 55 different types of motor gasoline. Overall, about half of the gasoline used in the summer season is the conventional fuel that is not stringently regulated. About one fourth of all gasoline in the United States at summer time is reformulated gasoline (RFG) following federal requirements, including minimum oxygen content, a benzene cap, limits on nitrogen oxide and toxic emissions and a cap on volatility (Reid Vapor Pressure). The remainder of the gasoline pool consists of localized variations. California requires the use of cleaner-burning gasoline that has stricter requirements (for example, dictating lower sulfur and benzene) than federal RFG.

This balkanization has distorted markets, creating barriers to free trade in products to meet temporary fluctuations in demand. The result is that local, pocketed markets with their own individual quality or additive requirements have sporadically been susceptible to disruption and localized price spikes, raising costs to consumers in those areas. One such instance resulted from a refinery outage in the Midwest in 2000, creating a price spike premium of an extra 50 cents a gallon for reformulated gasoline supplies for several weeks. California has had similar problems during periods of unexpected refinery outages.

In October 2001, the EPA issued a report saying that despite the high number of state and local fuel programs, “the current gasoline production and distribution system is able to provide adequate quantities of boutique fuels, as long as there are no disruptions

in the supply chain." The issue resurfaced in 2007 with section 1541 of the energy bill, which allows the EPA to temporarily waive motor fuel additives or requirements in the case of circumstances that would cause a spike in the price of fuel, as to avoid serious disruptions. This waiver of environmental specifications was used successfully during the crisis last summer to ameliorate market impacts of the temporary loss of Gulf Coast refining capacity.

Some policy specialists are advocating to group states under one regional or national standard. This policy is referred to as "harmonization." While harmonization would definitely contribute to a greater fungibility in supply, probably easing localized disruptions, it could lead to higher pump prices for areas with less severe ozone problems and will create some stranded costs for refiners who do not currently have to tool facilities to meet clean air standards. The EPA is currently studying the potential effects of harmonization. In a preliminary report, the EPA found that under certain scenarios, quality standards could be harmonized without major cost increases, increases in emissions or reductions in gasoline supplies. The study specifically notes that even though some areas that would be harmonized had not yet faced supply disruptions, harmonization could reduce the possibility of future disruptions, thereby saving long-run costs. The study suggests that moving the entire country to one stringent environmental standard would create supply stability but might raise overall costs if it led to a reduction in overall refining capacity as new investments were required to meet the higher standard.

POLICY CONCLUSIONS

The fact of the matter is that there is no single approach to fixing the problem of high gasoline prices. Building more refineries could help to lower domestic gasoline

price volatility, but it will not lower the baseline level of gasoline prices. In order to achieve lower prices in the longer term, it is imperative that demand growth in the United States be curbed.

Many have pointed to growing demand in Asia as the culprit for higher prices, but the United States consumes 33 percent of the world's road transportation fuel and demand continues to grow. Thus, as American demand goes, so goes the world price of oil. Options such as opening the Alaskan National Wildlife Refuge and/or the Outer Continental Shelf for drilling and adopting alternative fuels such as ethanol and/or coal-to-liquids are potentially viable supply-side solutions to easing the upward pressure on future oil prices, but they do nothing to stem the tide of demand. Thus, future generations will have to solve the same problems that are being discussed today, because eventually demand will outgrow even those additional supply options. This is not to say the United States should not pursue supply-side solutions as part of a portfolio of options; rather, the intelligent approach would be to consider them as part of a broader approach that includes a wide portfolio of policies including demand reduction measures. The United States must recognize that supply-side answers alone will not solve the problems it is facing.

Steps to increase conservation could have a dramatic effect on the gasoline price, especially if taken in concert with other measures. A gasoline tax and higher mandates for fuel efficiency are two means of achieving this goal. Regarding a tax, the price inelasticity of gasoline demand means that the size of the tax necessary to induce a particular reduction in demand is uncertain. In addition, there is concern that a tax could be regressive in the short term, especially for low-income households that have no viable

public transportation option. Nevertheless, permanently altering price via a tax would certainly encourage people to increase fuel efficiency and seek alternative transportation options as has happened in Europe and Japan.

The analysis in this paper leads to a straightforward conclusion for policy makers; it is a familiar lesson from investment 101: the portfolio approach is best. In this case, a combination of conservation, higher fuel efficiency, alternative fuels, and greater domestic production capacity gives the greatest potential for future prices that are both manageable and acceptable.

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