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Cost, Conflict and Climate: U.S. Challenges in the World Oil Market

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Cost, Conflict and Climate: U.S. Challenges in the World Oil Market

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Abstract: Dramatic increases in the price of crude oil since mid-2007 have ratcheted up attention on energy policy, but cost is only one of the three oil challenges that confront the U.S. In this short essay, I discuss the recent increases in oil prices and attempts to clarify how the challenge from high oil costs interacts with, but is distinct from, the geopolitical and climate change challenges that oil use also creates. Central to addressing these challenges successfully is recognizing that policy responses need to be evaluated in the context of the worldwide oil market.

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Interest in energy policy surged in the last 12 months as evidence of disruptive anthropogenic climate change accelerated and concern over conflict in oil-producing areas grew. For the average American, however, the most attention-grabbing factor was the high cost of gasoline. The climb to record prices — over $4 per gallon by June 2008 — were driven by oil prices that hit record levels in January 2008 and have risen an additional 30% since then. High gasoline prices will almost certainly keep oil in the policy debate for the remainder of 2008.

For that debate to be useful, however, it is critical to understand U.S. oil consumption and production in the context of the worldwide oil market, and to recognize the distinctions and relationships among three challenges that U.S. oil consumption presents: the economic impact of high oil prices, the geopolitical effects of large wealth transfers to some oil-producing countries, and the contribution to global climate change caused by burning oil and its refined products. These are often treated as a single issue in the policy debate and media coverage, but they are in fact quite distinct. Addressing any one of these challenges can help or hinder progress on the others.

I. THE CLIMB IN OIL PRICES

As figure 1 shows, the price of oil started 2007 around $60 per barrel. By late summer 2007, however, it was climbing steadily, rising to above $130 by June 2008.[2] June 2008 prices exceeded the previous historical peak in oil prices that occurred in 1981 by about 30% adjusted for inflation.[3]

The movements over the last year continue an important trend that began in 2003. For more than a decade — since the beginning of long-dated oil futures trading on the New York Mercantile Exchange (NYMEX)[4] — long-dated futures had traded very close to $20 per barrel (nominal), even as near-term contracts fluctuated above $40 and below $10 per

[2] The "front month" crude contract on the New York Mercantile Exchange shown in figure 1 is the price for delivery of oil about five weeks later on average. It is the price most commonly referred to as the "spot price" of oil.

[3] The prices are not exactly comparable, because no futures market for oil existed in 1981. The price that is generally used for the 1981 calculation is from a survey of bilateral spot oil transactions and is for more immediate delivery than the front month crude contract on the NYMEX.

[4] Futures contracts for a month or two in advance have been trading on the NYMEX since 1983, but "long-dated contracts" for years ahead evolved in the late 1980s and early 1990s.

barrel. Adjusted for inflation, the price of long-dated futures declined gradually. Figure 2 shows the futures curve for NYMEX light sweet crude contracts at annual intervals since 1990, all in May 2008 dollars.[5]

Figure 2 demonstrates that while the current high spot price is notable, even more remarkable is the change in the market's long-run pricing of oil. Short-term spot price fluctuations generally reflect transitory supply gluts or production constraints, but long-run pricing signals the overall market view of the longer-run resource scarcity. From 1983 to 2003, the market's long-run view of oil prices was fairly steady, actually declining slightly in real terms, but that view has changed completely since 2003.

Exchange Rate Effects

Recent oil price increases have frequently been discussed as a weak-dollar phenomenon. This is clearly part of the explanation, but it is frequently overstated. The weak dollar affects the world supply/demand balance of oil. A consuming country whose currency appreciates against the U.S. dollar will face a relatively lower price of oil and exhibit stronger oil demand than it would if its economy were based on the dollar. Figure 3 shows the appreciation of oil prices in four major currencies that float against one another.

Two extreme cases illustrate the magnitude of currency fluctuations on the dollar-denominated price of oil. If all the world economies were based on the U.S. dollar except for one tiny country, then a fall of the dollar against that tiny country's currency would — for any given dollar-denominated oil price — increase the oil demanded in the tiny country. But because it is a tiny country, it would have virtually no effect on the total world oil demand and thus would not change the dollar-denominated oil price. At the other extreme, if the dollar were used only in a tiny fraction of the world's economy, then a fall in the dollar against all other currencies would have no effect on the price of oil in those other currencies. In that case, the fall in the dollar would be nearly 100% reflected in an increase in the dollar-denominated oil price.

The reality lies between these two extremes. The U.S. dollar is the basis for a major share of the world economy, but so are the Japanese yen, the British pound, and the

[5] The futures curves shown in dashed lines in figure 2 present the price for delivery of oil at various dates in the future as of the date associated with the left endpoint of each curve.

Euro, among others. From January 2003 through May 2008, the dollar fell 12%, 18%, and 32% against these currencies, respectively. To take generous assumptions, say overall that the dollar has fallen 25% against "all other" currencies and that 75% of oil demand is denominated in those other currencies. That implies that world demand in terms of dollars has shifted up by about 19% (25% multiplied by 75%), so for a given quantity supplied, the price would have to be 19% higher in dollar terms in order to clear the market. Over this period, however, the actual increase in the dollar-denominated price of oil has been over 300%.

Of course, exchange rates also affect government fiscal policies, central bank decisions, macroeconomic growth, trade balances and other factors that in turn influence the price of oil. Those complex interactions with the oil market are probably significant, but the causal relationship is poorly understood. What we do understand, however, is that the direct effect of exchange rates is not the primary driver of recent oil price increases in the U.S.

The Role of Speculators

The media and many in Congress have seized upon the role that financial market participants — hedge funds, commodity index funds, and other "speculators" — have played in the run-up of oil prices. A great deal has been made of the fact that participants who do not operate directly in the oil industry have been taking larger financial positions in oil futures markets. This, the argument goes, has driven up prices well in excess of those justified by supply and demand fundamentals.

One view is that some financial players are manipulating the oil futures markets with the intent of driving up prices. A milder perspective is that many misguided investors are buying long-term oil futures as a part of complex hedging strategies and in aggregate are inadvertently driving up the prices of those contracts. The long-dated futures are then "pulling up" spot prices through an intertemporal arbitrage, high future oil prices encourage delaying production or hoarding supplies. The theories may have some initial appeal, but then they run headlong into some difficult realities. The first is that real physical supply appears to be matching real physical demand at the current high prices. If the price is being artificially inflated, then how is it that there are sufficient consumers in the marketplace willing to consume the available supply at those artificial prices? If the supply of oil is really being consumed at the current prices then it does not make sense to blame those prices on financial investors who are neither supplying physical oil nor consuming physical oil.

The speculator theory might be salvaged if it were augmented with an inventories hoarding hypothesis: some oil traders are taking physical oil off the market and storing it, creating a current shortage and driving up prices.[6] While the inventory hoarding hypothesis makes logical sense, it isn't supported by the facts. First, there is no evidence of a significant increase in world inventories over either the 5+ years in which oil has risen from the $20 range, or over the last year in which it has about doubled from $60 per barrel. According to the International Energy Administration, oil inventories in the developed economies have fluctuated relatively little over the last decade and, adjusting for daily usage, have so far this year been quite close to their decade-long average levels.

Second, the numbers just aren't going to add up. Over a one or two-year timeframe a reasonable estimate of the price elasticity of demand for oil is unlikely to be smaller than -0.1, which implies that for prices to be even 30% above market equilibrium levels due to inventory hoarding would require someone to be storing at least 3% of world supply on an ongoing basis. That would mean a supply shortfall of over 2.5 million barrels of oil per day is being created by hoarding. At that rate, in less than a year the hoarders would have built an inventory larger than the entire U.S. Strategic Petroleum Reserve. Where? That much oil would be very difficult to hide.

Talk of speculators often leads into talk of a bubble in the oil market. Despite the frequent analogies to the dot-com boom, oil actually is not like some tech startup company. The stock price of the tech startup was driven by forecasts of profits years or decades in the future. Oil, and other commodities, face a physical market every day in which actual product is supplied and consumed. Unless someone is squirreling away massive quantities of oil, actual demand is being revealed every day. The logistical and financial cost of storage makes it extremely difficult for price manipulation or a bubble in the spot price of oil to persist for very long.

That doesn't mean that the price of long-dated oil futures will turn out to be accurate

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[6] Implicitly, OPEC subscribes to some variant of this theory when the organization argues that the oil market is being "adequately supplied," and that the high prices are due to market speculators.

predictors of oil prices 2, 5, or 8 years in the future. Aggregate market expectations are frequently incorrect, though they are generally a better guide than the predictions of any one pundit. It is possible that the very wisest market observers know that the price will be much lower in 2013 than the futures market predicts, but there is no agreement on the forecast among leading oil pundits.[7] Some are forecasting a rapid climb to over $200 and others see a reversion to well under $100 very soon. But even if such a "bubble" exists in long-dated futures, anyone claiming that the *current* price is being distorted by financial traders must explain how physical supply and demand are still matching at those distorted price.

So Why is Oil So Expensive?: The Disheartening Conventional View

The most likely reason for high oil prices is the simplest and, unfortunately, also the most intractable: too much demand chasing too little supply. While the price has been rising, the demand for oil *at any given price* has still continued to grow. Worldwide oil consumption was about 1% higher in the fourth quarter of 2007 than a year earlier despite the fact that the price was about 50% higher.[8] The economies of China, India, and other developing countries are growing rapidly, as are their demands for oil. A number of these countries seem to be reaching an inflection point where a much larger share of their populations can afford automobiles. The U.S. economy has seen a decrease in the quantity of oil it soaks up everyday, but that's only because the price has skyrocketed. At any given price, even the U.S. demand is almost certainly continuing to increase.

Still, world demand has grown for decades and, until very recently, we have not seen this sort of prolonged price climb. What changed? Until this decade, the capacity to supply oil had been growing just as fast as demand, leaving plenty of available production capacity in the market. In the last decade, and particularly in the last few years, there is substantial evidence that the capacity to supply conventional oil has stopped keeping pace. Due to government mismanagement and internal conflicts, Mexico, Venezuela, Nigeria, Iran and Iraq, for instance, have seen production drop. The United States, Norway, Indonesia and some other producers have seen some of their largest fields enter decline. For most of this

[7] And no agreement generally about who are the very wisest oil market forecasters.

[8] If one again assumes a short run price elasticity of demand equal to -0.1, this implies that the worldwide demand for oil shifted out by about 6% between fourth quarter 2006 and fourth quarter 2007.

decade, worldwide production capacities have not kept pace with the growth in demand to the point that the ability to expand output in the short run is now widely viewed as limited to a single country, Saudi Arabia.

There is a some uncertainty in these worldwide production and demand data, but the picture is clear that demand growth has outstripped supply growth over the last five years and that there is very little ability to expand output in the current market. While it is difficult to see how a supply shortfall of 2.5 million barrels per day or more could be created by secret oil hoarding, it is easy to see how that shortfall could result from demand in developing economies accelerating somewhat faster than expected and supply growth not meeting expectations.

Talk of a supply shortfall and of extremely limited spare capacity also raises the possibility that some producers might be ratcheting down output in order to create higher prices. The one place that massive quantities of oil could be stored easily is right where the dinosaurs left them. That's not financial speculation; that's simple market power on the part of some producers. Saudi Arabia almost certainly has that kind of power, but for political reasons has been hesitant to exercise it on its own. In the early 1980s, OPEC attempted to coordinate all its members in a joint exercise of market power. They had mixed success until late 1985 when the effort crumbled entirely and prices plunged. OPEC was largely ineffective for the following 20 years, but Saudi Arabia's position has changed drastically over the last few years as demand has continued to expand and other producers have begun to run up against their own capacity constraints. Saudi Arabia produces only about 12% of the world's oil, but we learned during the California electricity crisis that in a capacity-constrained market with inelastic demand, a producer with even a fairly small market share may be able to reduce supply and artificially raise prices.

Robust demand growth combined with mismanaged oil fields, domestic conflicts, and simple well depletions that have undermined supply expansion could easily explain a market shortfall of a few million barrels per day or more. Add in Saudi Arabia's decision to take the "cautious" approach of holding 1 or 2 million barrels per day of its capacity in reserve and the prices we have seen since 2003 are well within a conventional supply and demand view of the market. This doesn't prove the case conclusively, but the supply/demand explanation — augmented somewhat by a weak dollar — is far more plausible than the view that financial market participants are having any significant effect on current oil prices.

The Price at the Pump

Energy wonks talk about oil prices, but most people don't even know how much oil is in a "barrel." U.S. consumers take notice when retail prices shoot up, most immediately at the gas pump. That price has been rising in real terms since 1999, which was when the inflation-adjusted price of gasoline hit its lowest level ever. Figure 4 shows real retail gasoline prices since 1990. The rising price of gasoline is attributable primarily to oil prices, with every $1 per barrel increase in crude prices translating approximately to an additional 2.5¢ per gallon at the pump.[9]

Beyond oil prices, the prices of gasoline, diesel and other petroleum products are also driven by refinery margins. The oil shocks of the 1970s drastically reduced the growth in gasoline demand relative to expectations at the time and left the oil industry with a great deal of excess refining capacity. As a result, refinery capacity expansion was sluggish in the late 1980s and 1990s even as demand grew, so that by the beginning of this decade the capacity overhang had mostly disappeared. Mergers in the industry also created at least some pockets of market power, though it is difficult to say how much impact this has had on refining margins.[10] Around 2000, demand started straining domestic refining capacity at some times of the year. The result has been higher and more volatile refinery margins. Figure 5 shows the inflation-adjusted "crack spread", the difference between the (front month contract) price per gallon of crude oil and gasoline on the NYMEX — the most common measure of refining margins — since a gasoline contract began trading in 1985.[11] Refinery capacity limits, which are particularly constraining in the spring and

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[9] This relationship (which includes the average state-level sales tax) is widely understood in the industry, but is frequently confused in the media when reports compare *percentage* changes in the price of oil to *percentage* changes in the price of gasoline. As a share of the total gasoline cost, the cost of the oil that goes into making a gallon of gasoline varies widely with fluctuations in the price of oil and in refining margins, so there is not a consistent relationship between percentage changes in the price of oil and gasoline. Thus, a statement like "oil prices have risen 50% and gas prices are up only 30%" is not really informative.

[10] See Borenstein, Bushnell and Lewis (2004).

[11] In 2006, the NYMEX switched over from trading a contract for gasoline futures to a contract for "RBOB," the gasoline component that is blended with ethanol (on average about 95% RBOB, 5% ethanol) to make the gasoline product that is now most commonly sold in the U.S. Figure 5 reflects the changeover in contract type.

summer, are reflected in larger refinery margins.

This year has seen a change in the usual pattern of refinery margins. Typically, while margins on gasoline have been highest in the spring and summer, margins on heating oil and diesel—the two products are virtually identical—have been higher in the winter. So far this summer, refinery margins on heating oil/diesel are more than double those on gasoline. Refinery margins on gasoline are well below average summer levels of the last few years because the very high price of oil has pushed down total gasoline demand and greatly lessened gasoline production constraints at the refinery. Less constrained gasoline refining capacity has meant lower margins.

At the same time, heating oil/diesel margins at the refinery are unusually high for this time of year.[12] The strain on heating oil/diesel demand seems to be coming primarily from growth in demand for these products from Europe, Japan, and developing countries. The U.S. exports large quantities of heating oil/diesel and imports large quantities of gasoline. In the last 10 years, the share of new cars running on diesel in Europe has gone from less than 25% to more than half. In many parts of the developing world, diesel still plays a major role in electricity generation, where demand continues to rise. Refineries have a limited range in which they can shift production among products. Most are now producing as much heating oil/diesel as they can, but the diesel market is still quite constrained so the margins are very high. Eventually, high heating oil/diesel margins will induce more refineries to retrofit for greater production of those products, which will bring down those margins while probably pushing up gasoline margins.

II. HIGH OIL PRICES AND THE U.S. ECONOMY

The full effect of an oil price shock extends well beyond the pump, of course. Only 45% of refined oil product used in the U.S. is motor gasoline. Figure 6 shows the variety of oil uses in the U.S. and their shares. In all, the U.S. uses 21 million barrels of oil (and imported refined oil products) per day or about 7.6 billion barrels per year, slightly less than one-quarter of worldwide total consumption. Over the medium to long run, virtually all of the cost of that oil must be paid directly or indirectly by consumers.[13] That means

[12] Jet fuel is a "middle distillate" like diesel and heating oil, so the refining capacity squeeze is also affecting airlines.

[13] That is, intermediate buyers of oil and refined oil products operate in industries that for the most part

that oil at $130 per barrel costs U.S. consumers about $760 billion per year more than oil at $30 per barrel, roughly an extra $2500 per person annually.

Oil is also produced in the U.S., however. In 2007, the quantity produced was about one-quarter of the U.S. quantity consumed. This shortfall of production in the U.S. is frequently presented as the primary energy challenge the country faces, particularly by advocates of expanded exploration and drilling in the U.S. In reality, expanded production in the U.S. would have only a very modest effect on the price of petroleum products. Oil prices are set based on the balance of worldwide supply and worldwide demand. This means that additional production of oil in the United States has effectively no more benefit to U.S. consumers than production in any other part of the world that has sufficient geopolitical stability to deliver reliable supply. It also means that any increment to supply must be seen in comparison to the world oil market in order to evaluate its effect on prices. Drilling in the Arctic National Wildlife Refuge in Alaska, for instance, would most likely deliver about 1 million barrels per day to what would likely be nearly a 100 million barrel per day oil market by the time that oil came online in 10 years. While a 1% increase in supply would likely have a noticeable effect if it occurred over the course of a few weeks or months, the elasticity of demand (and of alternative supply) is much larger over a decade, so the additional oil supply would have a very modest effect on world oil prices. The fact that it would expand oil production in the U.S. by more than 15% is entirely irrelevant for evaluating its impact on prices to consumers.

Nonetheless, while expanded U.S. oil production would not substantially change oil prices, the wealth created by oil production in the U.S. offsets to some extent the impact on the economy from high oil prices. This occurs through two different mechanisms: oil company profits and royalty or tax payments to federal and state government and private land owners. Nearly all of the incremental income from oil production in the U.S. falls into one of these categories. Payments to government are recirculated to consumers through either lower taxes or increased government services. The distributional impact will depend on the exact disposition of the revenues.

U.S. oil company profits are more complicated. The revenue returned to U.S. consumers/shareholders could be greater or less than the incremental income from oil produc-

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will earn normal rates of return in the medium to long run. Thus, increases or decreases in the price of oil are unlikely to be absorbed by those firms.

tion inside the U.S. "U.S. oil companies" also operate outside of the United States; their incremental profits when oil prices rise come from both U.S. and non-U.S. production. On the other hand, non-U.S. oil companies are also engaged in production on U.S. land. BP is the largest oil producer in the U.S. This discussion, of course, raises the question of what a "U.S." oil company actually is. Put differently, who owns each oil company? For the purpose of this analysis, one would like to know the share of marginal oil company profits that are distributed to U.S. citizens. Without that information, which is not publicly available, it is difficult to estimate the amount of oil company incremental profits that are distributed to U.S. consumers. Nonetheless, with more nearly three-quarters of oil for U.S. consumption coming from outside the country — and worldwide production by U.S.-headquartered companies less than 40% of U.S. consumption — the net negative wealth effect in the U.S. of an oil price increase is quite substantial. Perhaps equally important, the redistribution of oil company profits almost certainly has a substantial regressive effect on income distribution.[14]

Beyond these direct effects of oil price increases, there are also macroeconomic concerns about the process of economic adjustment. Oil price shocks are associated with nearly all of the economic downturns that have occurred in the United States since 1970.[15] Although there has been extensive study of this relationship, the impact of the most recent run-up may not be predictable from the experience of last half of the 20th century. The major oil shocks of the 1970s occurred at a time when gasoline prices were regulated and oil made up a larger share of the economy. Probably more important, the federal government responded to international oil market disruptions by imposing price and allocation regulations that significantly worsened the macroeconomic impact. Finally, prior to the last few years, the experience with oil price shocks has been primarily from sudden supply-side disruptions, while the current increase is probably driven as much or more by strong worldwide demand. A less-regulated gasoline market, a more flexible economy in which petroleum products play a smaller role, and an oil price shock occuring primarily due to strong demand seems likely to result in less pressure towards macroeconomic decline. Still, with oil at $130 per barrel as compared to the $30 price that the 2003 futures market forecast for 2008, the U.S.

[14] Within the U.S., it is almost certainly the case that the income elasticity of oil consumption is well below the income elasticity of oil company equity ownership.

[15] See Hamilton (2003).

is today spending about $500 billion more per year for oil imports than was anticipated five years ago. In the $13 trillion U.S. economy, that is a substantial drag.

III. GEOPOLITICS OF OIL

The international wealth transfers from oil price changes also have geopolitical impact. While some confused observers cite figures about the geographic source of the oil that is consumed in the U.S., the worldwide integration of the oil industry means that all oil demand pushes up the price of all the world's oil and benefits all sellers of oil. It doesn't matter how much oil the U.S. buys from the Middle East or Venezuela, only how much oil it buys in total (including from domestic production).

The increase in world oil prices strengthens the economic hands of oil exporters, including some that are vocally antagonistic to U.S. interests. Oil at $130 per barrel means that Iran is earning at least $65 billion more per year from its oil exports than it would be earning if the price were $30 per barrel. Financing Hamas and Hezbollah to the tune of hundreds of millions of dollars per year — or investing in the technology to build nuclear weapons — would be barely noticeable in the Iranian government accounts compared to the effect of these oil price movements. Venezuela is enjoying a similar size windfall and using some of it to influence the politics of other South American countries in ways that are almost surely contrary to U.S. interests.

One might think that such a significant transfer away from U.S. consumers and towards unfriendly and repressive governments (and only occasionally their populations) — combined with the high cost of the oil-related war in Iraq — would inspire policies aimed at reducing use of oil in the U.S., but there has been little movement in that direction. The view of many American consumers seems to be more aptly captured by the bumper sticker that asks "*What's our oil doing underneath their country?*".

High oil prices and large import quantities also contribute to international trade deficits. The trade deficit weakens the U.S. currency and means the U.S. must either borrow back those funds or sell assets. Both have been occuring, leading to the somewhat inconsistent U.S. position that exporters of oil (as well as other goods and services) should continue to sell to the U.S., but should not use the revenues from those sales to purchase U.S. banks, ports, oil companies, or other valuable assets. The U.S. cannot continue to run huge trade deficits and simply expect that it can settle those accounts with an ever-growing pile of dollar-denominated debt instruments. With a weakening dollar, holders of those debts will be more inclined to convert them to real assets. This is sound financial behavior on the part of countries that run a trade surplus, not in itself evidence of a scheme to achieve greater economic dominance.

One of the most recent ideas from Congress for lowering oil prices is to prosecute OPEC for collusion under U.S. antitrust laws, an approach promoted with the media-savvy name "NOPEC." The idea is that while Saudi Arabia could unilaterally restrict its supply in order to raise price without violating our antitrust laws, collusion among independent entities — state-owned oil companies in this case — to reduce output and raise price violates section 1 of the U.S. Sherman Act. The legal basis for such a prosecution of companies that are wholly owned and controlled by foreign sovereign nations is murky at best. Moreover, it is not hard to find instances of the U.S. government coordinating with other governments and foreign companies to reduce competition and raise prices. Remember the "voluntary export restrictions" on Japanese auto shipments to the U.S. in the early 1980s? Ironically, many of the same politicians supporting NOPEC are also arguing that the U.S. should coordinate with other oil-consuming countries to reduce our imports in order to lower prices. If such inter-governmental coordination were actually subject to the Sherman Act, agreements to reduce consumption in order to lower prices would constitute the same violation of the Act as agreements to reduce production and raise prices.

IV. OIL CONSUMPTION AND CLIMATE CHANGE

Until the 2008 run-up in oil prices, concerns about climate change seemed poised to become the primary focus of oil and energy policy debate. Unfortunately, energy discussions often fail to distinguish between cost, geopolitical and climate change concerns. The coal industry sometimes compounds such confusion by touting its product as a solution to the U.S. energy problem. Much greater use of coal could indeed reduce U.S. use of oil through a coal-to-liquids technology that produces a gasoline-equivalent product. That technology is economic at current oil prices. It is, however, no solution at all to the climate change challenge; gasoline production from coal-to-liquids emits two to three times more greenhouse gases than production from conventional oil. "Clean coal" technologies may someday allow a transportation fuels to be produced from coal without the process emitting greenhouse gases, but that carbon sequestration technology is not close to commercial at this point. Even if it were, the liquid fuel would still be burned in an internal combustion engine and would emit CO_2 from the tailpipe in the same quantities as occurs today from the use of gasoline. Coal-to-liquids and other non-conventional sources, such as oil shale and tar sands, are probably the most important examples of conflict among policies that address the three different energy challenges.

Ultimately, addressing the effect of oil consumption on climate change will require much greater use of non-fossil fuels for transportation. Two broad technologies are most relevant for the medium run of 10-20 years: biofuels and electric vehicles.

The dominant biofuel in the U.S. is corn-based ethanol. Over 95% of transportation energy is supplied by oil in the United States, with nearly all of the remainder coming from corn-based ethanol. Unfortunately, due to the energy intensive production process, corn-based ethanol likely reduces greenhouse gases by no more than 20% compared to gasoline, and may actually increase GhGs when the full life-cycle impact is considered.[16] Corn ethanol does significantly reduce oil consumption — by about 80% overall — but it does little or nothing to reduce emissions of greenhouse gasses. The energy from coal and natural gas that goes into ethanol production, along with conversion of forest and grassland to new cropland, offset most or all of the GhG reduction from burning less oil. Ethanol can be produced from other plant feedstocks, some of which don't require arable land as corn and other food-based feedstocks do, but these all remain very expensive as of today. Ethanol also has the problem of being more corrosive and more prone to absorb water than refined oil products, so is more costly to transport and use. Currently, domestically produced ethanol receives a tax credit of 52 cents per gallon in the U.S. and is protected from import competition by a large tariff on ethanol coming from most other countries. Hydrocarbons that are much more similar to conventional oil can also be produced through biologic processes. One of the most exciting is as a by-product of algae growth that consumes CO_2 in a process that can be slightly carbon negative. Unfortunately, cost again remains a significant barrier.

Electric vehicles are considered by most observers to be a somewhat less likely alternative transportation paradigm over the next two decades, but are certainly not out of the running. If electricity for these vehicles were produced from conventional fossil fuels,

[16] See Farrell et. al. (2006) and Searchinger et. al. (2008).

some GhG reduction would still occur, but it would be limited. With power from wind, solar, geothermal, nuclear or other zero-GhG generation, the gains would be much larger. With all costs considered, these sources are more expensive than coal and natural gas and would remain so for at least many years even with a moderately high GhG tax or tradeable permit cost of, for instance, \$50/ton.[17] The only non-fossil fuels with significant market share in electricity are nuclear (19%) and hydroelectric (7%) power. The other alternatives amount to a tiny share of U.S. electricity generation. And federal support for research to improve these technologies has been stagnant since 2001, just as the need for technological improvements in these areas has become more apparent and pressing.

Regardless of the generation source, electricity will not contribute to reducing greenhouse gases from transportation until an efficient, low cost, electric storage technology for mobile usage is available. Researchers are working on this battery problem, but progress has been dishearteningly slow. Storage remains less space-efficient, more-expensive, and shorter-lived than it needs to be for electric vehicles to be cost competitive. With the most recent technology, lithium ion, safety concerns have emerged as a result of batteries that have caught fire. Despite these challenges, hybrid electric vehicles, such as the Toyota Prius, are already on the market and plug-in hybrids — which run mostly on electric power, but also carry an engine that can burn gasoline — are likely to be available in the U.S. in 2010.

Electric vehicles face one additional challenge compared to biofuels that may be significant in the short run. Depending on the biofuel that is produced, it could potentially be used in some or all of the existing fleet of cars with internal combustion engines. About 3% of the current U.S. car and truck fleet are "flex fuel" vehicles that can use E-85, a blend of 85% ethanol and 15% gasoline. All cars can run on a blend with up to 10% ethanol. One could argue, however, that the current production of ethanol from corn is not addressing either cost or environmental issues of oil use, so the fact that corn-based ethanol could be rapidly adopted does not really strengthen the argument for biofuels.

Finally, productive policy debate on transportation energy is frequently undermined by

[17] The statement is disputed by many nuclear power advocates. Nuclear power, however, continues to face significant safety, security, and waste disposal issues. Without government protection from insurance liability, few people argue that it would be economically viable. The rosy scenarios for nuclear power costs that are frequently cited by nuclear power advocates ignore both this liability protection and the real cost of nuclear waste disposal, including the cost of compensating neighboring communities around such a disposal site. Even the direct construction costs of nuclear power have been climbing as plans for new plants have become more concrete.

arguments about hydrogen as a new source. Hydrogen is an energy storage technology, not a new source of energy. It has to be produced through some other energy consuming process; right now the most cost effective process involves burning fossil fuels, hardly a solution to the greenhouse gas challenge. Scientists generally view hydrogen transportation fuel as 20+ years from viability, and even then the energy source for producing hydrogen will remain a question.

V. OIL CHALLENGES WITHIN A WORLD OIL MARKET

Americans can and should respond to the oil challenges, but it is important to understand the potential impact of these responses in the context of the world oil market. The policies generally proposed to address oil issues—*e.g.,* increasing fuel economy of automobiles, opening more domestic land for oil exploration, or replacing 10% of gasoline in the U.S. with biofuels—if carried out only in the U.S. would have fairly modest effects on the world market and, in particular, on the world price of oil.

Increasing U.S. fuel economy by 40%, from 25 to 35 miles per gallon, if it caused no increase in total miles driven, would lower oil consumption by about 3.6 million barrels per day, about 17% of current U.S. oil consumption. While that would create substantial direct savings, such a gradual reduction over more than two decades — the speed of this change that is implied by the 2007 energy bill once one accounts for the fact that U.S. automobile fleet turnover is under 8% per year — would have a small effect on the world oil price.[18] The entire reduction would be less than the growth in world demand between 2003 and 2005. By 2020, this would likely be less than 3.5% of daily demand. Replacing 10% of U.S. gasoline with biofuels would have a still smaller impact on price, and would not offer the direct financial savings that would result from improved fuel economy. There are many pros and cons in the debate over these policies, but claims that they will substantially alter the world oil market are not well founded.

The same is true of domestic exploration for oil. Even the most optimistic forecasts of expanded U.S. oil drilling suggest production increases of about the same magnitude as the oil savings from the proposed auto mileage improvements over a similar decade-plus

[18] Over two decades, oil demand is much more price elastic then the short run elasticity of -0.1 discussed earlier. Long run demand elasticity estimates are generally at least -0.5, and supply also is surely somewhat elastic over that time frame. In a 100 million barrel per day market, a 3.6 million barrel demand drop would yield a price drop of 7% or less.

time frame. Increased domestic production raises issues of the tradeoff of environmental damage at the production site versus the wealth gains to Americans through increased corporate profits and government revenues. One can have a reasoned debate about those costs and benefits, but there isn't a sound basis for arguing that increased domestic oil production would have a substantial effect on the prices of refined petroleum products in the U.S.[19]

This is not to suggest that the demand side of the world oil market, or supply from non-OPEC countries, has no effect on price. Rather, it emphasizes the need to analyze such changes in the context of the entire world market. The global recession in the early 1980s drove down oil demand by 7% worldwide between 1980 and 1983 and probably helped lead to the collapse of oil prices in late 1985. None of the policies currently under consideration in the U.S. today, however, would have even one-tenth as great an impact on world supply-demand balance over a similar three-year period. Such a comparison suggests that without multinational coordination in demand reduction (preferably not coordination through widespread macroeconomic decline) or much more significant unilateral changes by the United States, any reductions in the price of oil or the wealth transfers to producing nations will be quite modest.

In the context of the world oil market, it is also clear just how vacuous calls for "energy independence" really are. The U.S. consumes far more oil than it produces, and that will remain the case so long as petroleum products are the basic transportation fuel in the country. But even if demand were reduced dramatically or abundant new supplies were found so that domestic supply and demand were more closely balanced, the U.S. oil market would never be "independent" of the rest of the world. Short of drastic government intervention that no policymaker is likely to, or should, support, oil in the U.S. will sell at the world price of oil and prices of gasoline and other refined products will reflect that oil

[19] Some economists have argued that policies that would raise oil supply or lower oil demand many years in the future would reduce current oil prices. Essentially, the argument is that the prospect of a lower future price would induce suppliers to put more oil on the market today, in order to take advantage of the current higher price, and in the process would drive down today's price. The problem with this argument is that there is very little evidence that oil producers could increase current output even if they believed that oil would sell for much less in the future. Almost no excess production capacity is believed to exist outside of Saudi Arabia, which itself is seen as having only 1-2 million barrel's per day of unused capacity. Saudi Arabia has a much more complex set of incentives, because it is aware that it can push prices up by restricting its output. More generally, the fact that nominal futures prices are about the same or somewhat lower than the spot oil price already gives producers strong incentives to accelerate production.

cost.

VI. WHAT CAN OR SHOULD THE U.S. DO?

The three distinct challenges from oil consumption — cost, geopolitics, and greenhouse gases — are likely to remain at the forefront of politics and the policy debate. Each threatens the U.S. economy and quality of life in a different way, but all three threats are significant. Understanding the distinctions between these challenges, and the need to analyze them in the context of the integrated world oil market, will be critical in moving towards a more effective energy policy.

The world market for oil means there is little that the U.S. can do in the near term to drive down the price of oil. But there is much we can do in the longer run to change the world energy markets and address the challenges from decades of oil addiction. Progress can begin with U.S. leaders dropping the rhetoric of "energy independence" and focusing instead on the more appropriate and achievable goal of energy security. Domestically, this means developing a diverse set of energy sources and technologies from which supplies can be procured reliably without subjecting the U.S. economy to extreme volatility in total energy costs. Improving vehicle fuel economy and reducing reliance on petroleum-based transportation fuels will be critical to this effort. It will be important, however, to understand that the primary impact in the short run will be to lower our oil consumption, and therefore our total oil cost, not to drive down the price.

Addressing the geopolitical dangers of high oil prices will be a longer term goal requiring international coordination among oil consuming countries. The scale of plausible U.S. reductions will not be sufficient on their own to stanch the flow of wealth to leaders of some oil-producing nations who reject democracy and seek wider military and political influence.

The desire for domestic and international energy security is likely to increase pressure for development of non-conventional hydrocarbons, such as tar sands, oil shale, and coal-to-liquids. Such policies, however, would undermine attempts to address the challenge of controlling greenhouse gases and climate change. Reducing reliance on conventional oil without increasing greenhouse gas emissions necessitates technology advances that can eventually be adopted in both the developed and the developing world.

The basic scientific knowledge for those advances is a public good that should be supported by the governments that have the wealth and expertise to back the research, with the U.S. at the forefront.[20] Commercial development and consumer adoption of these technologies will then require strong economic incentives on an international scale. Such incentives could be enacted through a tax on greenhouse gases, but are probably more politically viable as a cap-and-trade program.

The economic consequences of reducing oil use and mitigating climate change will fall disproportionately on the poor, both domestically and internationally. Within the U.S., the financial impact of increased energy taxes — either through direct taxation or a tradable permit system that has the same effect of raising energy prices — should be offset for lower income families by using some of the tax revenue (or income from auctioning permits) to reduce payroll and other taxes that disproportionately hit the poor.

The challenge internationally is even greater. One could argue that if there is a fair market price for greenhouse gas emissions today, it would be equitable to also apply that price to past emissions that remain in the atmosphere. The U.S. and other developed countries are extremely unlikely to accept the enormous wealth transfers such a policy would engender. More realistically, and perhaps more helpfully in combating climate change, the developed economies could and should invest significant resources in developing the technologies for energy and transportation that produces little or no greenhouse gases. Creation and very low cost licensing of those technologies in less developed countries would be a productive way to shift the burden of greenhouse gas reduction to where it most fairly and efficiently belongs.

[20] Not surprisingly, such wealth and expertise is highly correlated with past production of greenhouse gases.

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Data Sources for Figures

Figure 1: NYMEX crude futures

Figure 2: NYMEX crude futures; BLS all urban consumers & all goods price index

Figure 3: NYMEX crude futures; International Monetary Market currency futures

Figure 4: U.S. EIA conventional gasoline prices; BLS all urban consumers & all goods price index

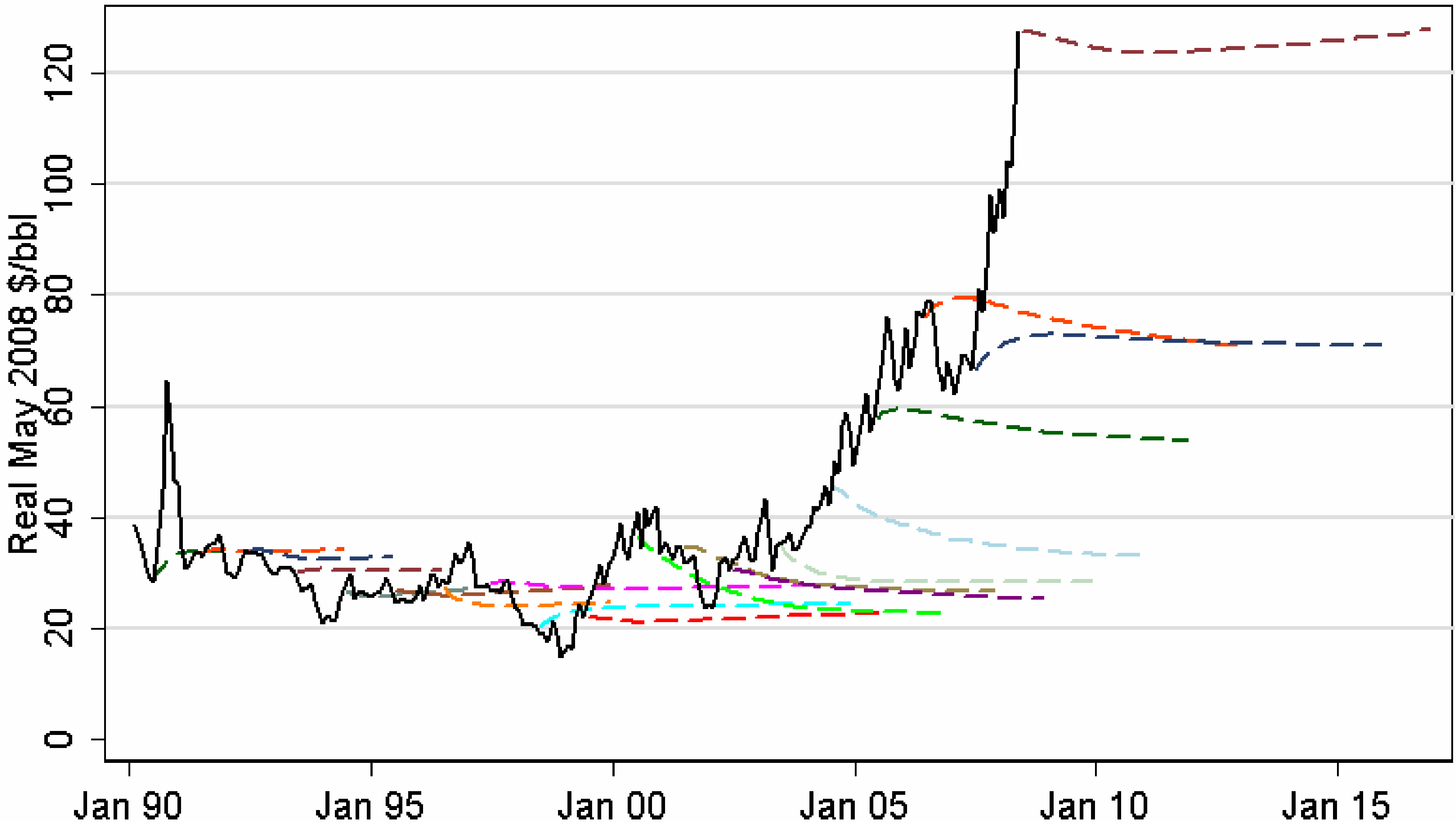
Figure 5: NYMEX crude, unleaded gasoline, and reformulated blendstock (RBOB) futures; BLS all urban consumers & all goods price index

Figure 6: U.S. EIA, 2006 data

Figure 1: NYMEX Front Month Crude Contract

Figure 2: NYMEX Crude Front Month and Forward Curves

Solid line is front month contract; forward curves taken every May



Forward curves inflation-adjusted according to their trade date, not their contract date.

Figure 3: NYMEX Front Month Crude, Various Currencies

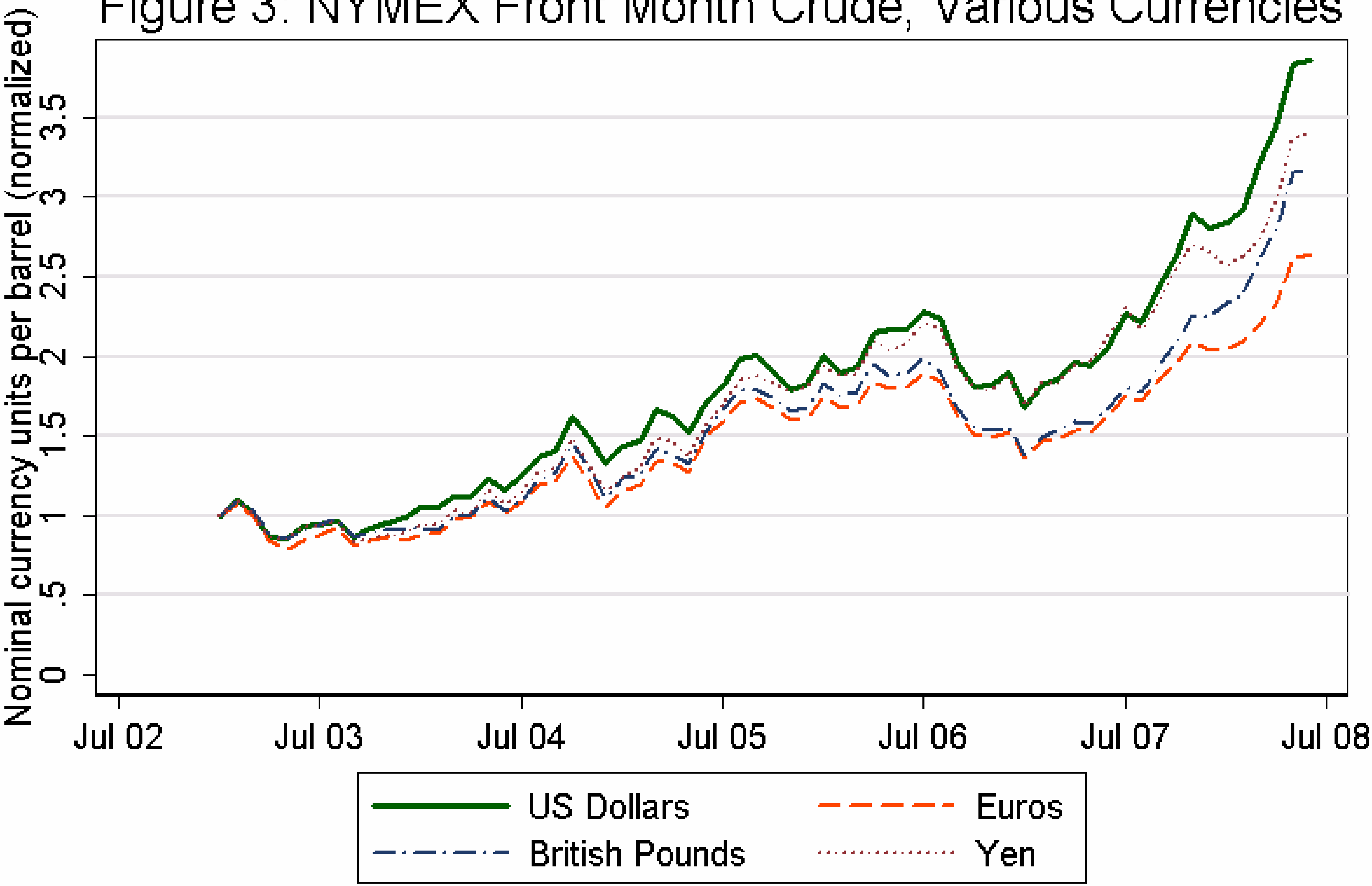


Figure 4: Retail Conventional Gasoline Price

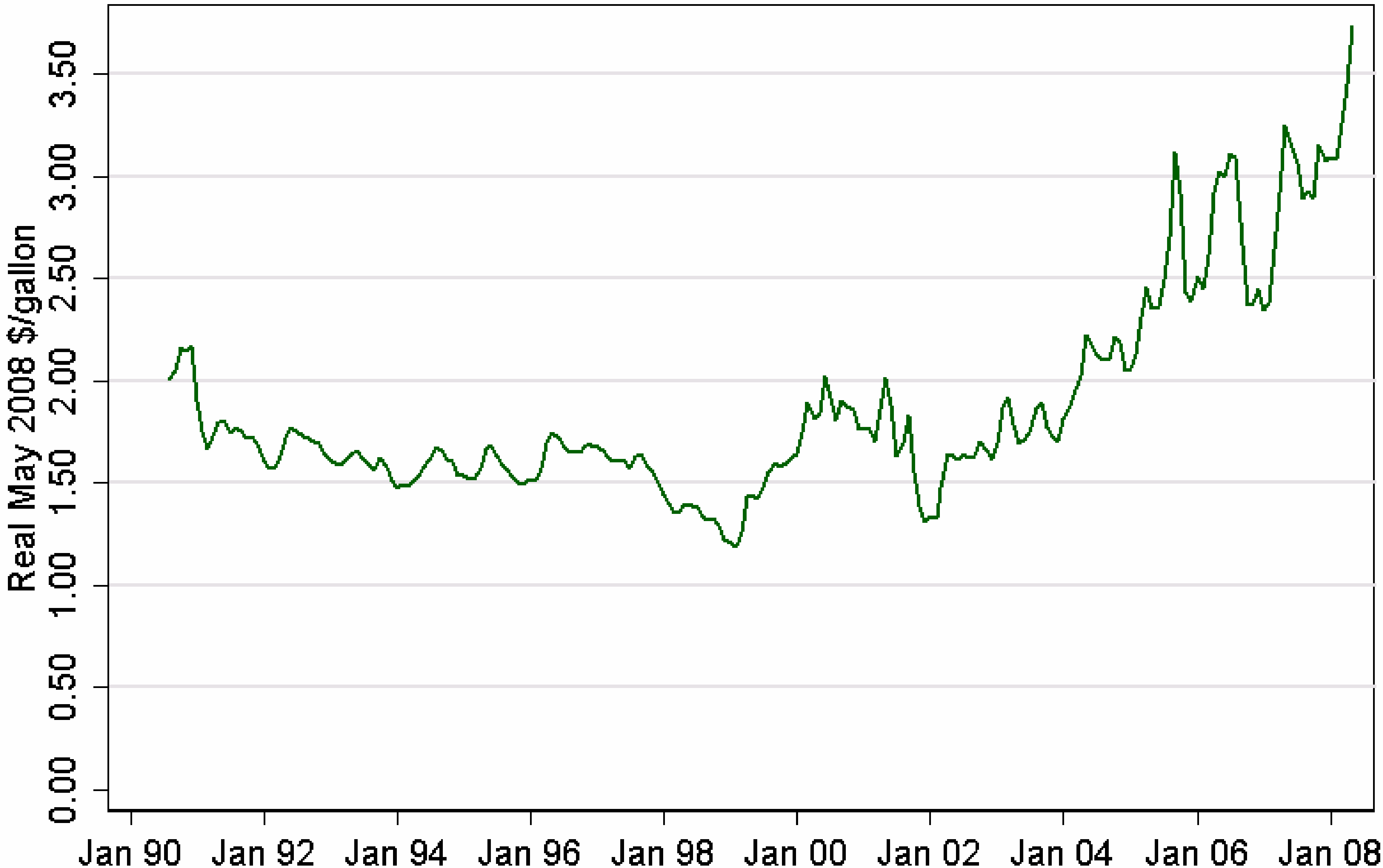


Figure 5: NYMEX Front Month Crack Spreads

Spread is the difference between gasoline and crude oil contracts

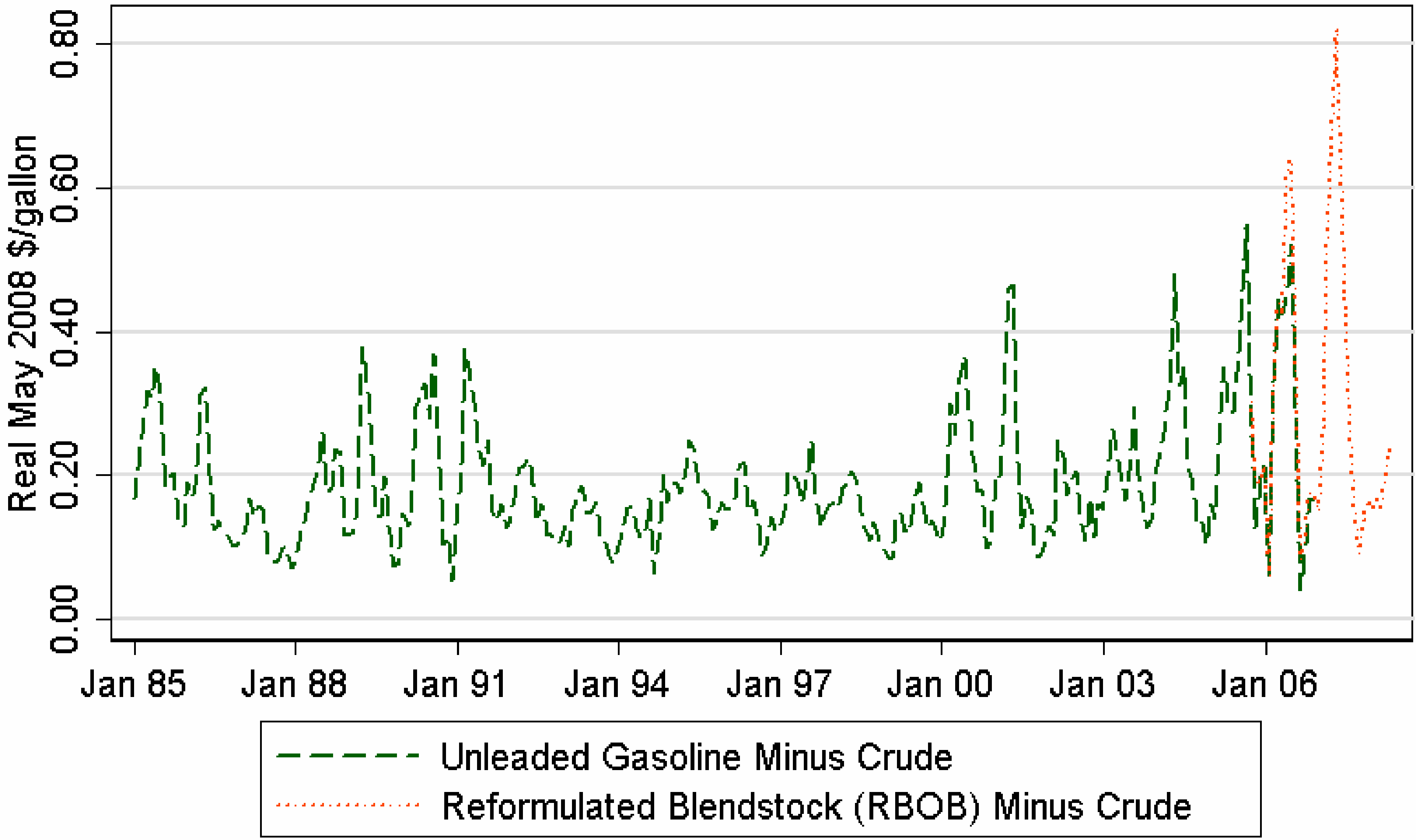


Figure 6: Uses of Crude Oil in the United States