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The Triumph of Markets

US Oil Market Effects from Three Hurricane Events

Hurricane	Reduction in Refinery Inputs in PADD III (%)	US Retail Gasoline Price Rise (%)	Midwest Retail Gasoline Price Rise (%)
Katrina/Rita	54.1	65.1	43.8
Ike	52.8	34.8	36.0
Harvey	36.2	15.2	11.8

Note: Refinery input reduction computed from the average from January to end-July. Price change computed as price rise relative to January.

Source: PKVerleger LLC.

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Summary

The United States experienced two horrific hurricanes between late August and mid-September 2017. The storms were more severe than almost any that hit the United States previously, producing as much damage as Katrina, Rita, Ike, and Sandy.

First, Hurricane Harvey dumped more than forty inches of rain (one hundred two centimeters) on Houston and the surrounding areas, at one time putting almost twenty percent of US refining capacity out of business. The market impact, though, was minimal. Immediate price increases were smaller than in past crises and the duration shorter. Government policymakers acted to boost supply but did not attempt to manage product distribution. The most important step they took was relaxing environmental restrictions on gasoline. As demonstrated in previous episodes, especially a disruption in California in 2012, this helps tremendously regarding the market's functionality.

The table on the cover compares the physical and market impacts of Katrina/Rita, Ike, and Harvey. The three storms were similar in physical magnitude but differed dramatically in how they affected markets. Refinery inputs dropped more than fifty percent in the first two hurricanes and thirty-six percent in Harvey. Given the magnitude of these losses, one would expect large price increases in each case. However, retail prices rose only fifteen percent in the 2017 episode (from a January base). In contrast, retail prices rose sixty-five percent with Katrina/Rita from the 2005 base and thirty-five percent with Ike from the 2008 base. The modest price impact of Harvey in 2017 represents the triumph of the markets.

Harvey's market impacts were minimized despite the United States now being an important participant in the world petroleum products market and a major product supplier to Central and South America. Take Mexico, for example. Nearly fifty percent of its petroleum consumption is supplied by US refineries, most of it coming from the US Gulf Coast. The successful functioning of markets after Harvey is evident in the quick mobilization of product exports to Mexico from Singapore and other Asian nations as price increases attracted shipments. As a result, Mexico suffered no shortages.

Of course, product supplies were disrupted in areas around Harvey's path, even those not affected directly by the storm. Products were reportedly tight in Dallas, for instance. Such supply outages occurred because products normally move to other points in the country from Houston on pipelines. The supply problem in Dallas and other locales was quickly addressed by reversing pipelines that run from Texas to Oklahoma to send products south.

Shortages also took place in Florida as Hurricane Irma approached, especially as millions of residents heeded warnings and, later, evacuation orders to leave the exposed southern parts of the state. The unanticipated crush of vehicles combined with efforts by all residents to fill gasoline and diesel vehicles and generator tanks put pressure on distributors. Many stations ran out of fuel, and resupply efforts were hampered by road congestion and the lack of Jones Act vessels to bring gasoline to Florida terminals. Supply efforts were also hindered by a lack of ethanol. Ethanol is delivered by unit trains, and the movement of these has been slowed by storm damage to railroad roadbeds.

In the end, though, the petroleum supply and distribution system worked far better during the fall 2017 disruptions than ever before. Credit for this success belongs to those who have worked for years to expand and deepen petroleum markets, especially futures markets. Their efforts have broken down the traditional integrated supply model where control rested with executives of large multinational oil companies. Today, the leaders of Vitol, Glencore, Trafigura, and other major trading companies dominate the market, professing loyalty to only one thing: the dollar. They move supplies from one location to another without hesitation to increase profits and, in doing so, serve the consumers' best interest.

In contrast, twenty years ago, senior executives at firms like Chevron controlled the market. The junior execs could not address problems without first plowing through layers of bureaucracy. Fear over job security discouraged bold action. Hence, shortages did not get resolved rapidly, prices rose, company profits surged, and consumers suffered. Markets today have eliminated such roadblocks.

Ironically, the International Energy Agency has failed to notice the change. Perhaps this is not surprising, given the mindset there. For example, the IEA's supercilious executive director observed Harvey's impact from afar and then poohpoohed any call for the agency to respond:

> "Currently as far as Harvey is concerned, we do not see that there is a major physical shortage of oil which (would) make us consider to release stocks," the chief of the Paris-based agency, which coordinates energy policies of industrialized nations, said in Vienna.
>
> "There is a need to consider how we place our stocks, where we place our stocks and the combination of crude oil versus products is an issue that we need to pay attention to," he said when asked if the United States should reconsider moving its fuel stocks.[1]

Less than two weeks later, the IEA issued a press release that, while admitting the obvious fact that markets had worked to resolve supply issues, called for more market intervention. At the same time, the agency, which in its almost fifty years of operation has yet to have any impact on the market, had the gall to make this assertion:

> The oil market has coped relatively well with the challenges posed by the hurricane season thus far, but that said, now may be a good time to consider steps to mitigate the impact of future severe-weather events. This could encompass reviewing the robustness of the Gulf Coast energy infrastructure, including production facilities, refineries, crude and product storage capacity, pipelines and marine infrastructure, and what measures can be taken to minimize disruptions to port operations.[2]

The press release suggested as well that "more might be done by the industry and government working together," adding that the cooperation must include "the provision of government-held product stocks in the US."

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[1] *"No need to consider release of oil stocks after Harvey: IEA," Reuters, September 4, 2017 [https://goo.gl/xf5NQJ].*

[2] *IEA, "OMR: Ready for a rainy day," September 13, 2017 [https://goo.gl/gcucQb].*

In general, the views expressed by IEA officials and analysts, unencumbered by the difficulties associated with Harvey and Irma, are dead wrong. Our message is that physical and futures markets are functioning better and better, meaning they can manage external supply disruptions more easily. Furthermore, petroleum markets work best when governments stay out of the physical side and limit their activity to market oversight and setting (and adjusting in extreme conditions) market regulations.

The government-held stocks proposed by the IEA are an extremely bad idea. Economic research has shown that such inventories displace private holdings and that private stocks decline as public ones increase. Furthermore, experience has shown that government officials seem incapable of using stocks in a timely manner, which sticks consumers with higher prices. Bluntly put, consumers have paid an enormous price for IEA and government "activity" in the oil market, one that probably totals hundreds of billions.

The conclusion we offer in this issue of *The Petroleum Economics Monthly* is that oil markets are functioning increasingly well. Traders such as Vitol, which were a very small part of the market when the IEA was created, are now substantially involved and very skilled. Futures markets facilitate their activities. Consumers are the direct beneficiaries, and this benefit would increase if the IEA members came to their senses and terminated the agency.

The August 2017 *PEM* analyzes market behavior during two hurricanes: Katrina in 2005 and Harvey in 2017. We note that the economic impact was less from Harvey than in other disruptions despite Harvey's effect on refining capacity in the Gulf. We attribute the more moderate outcome to the broadening of global oil markets, the high global inventories, and the quick response of environmental officials.

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The Triumph of Markets

The United States experienced two major hurricanes in August and September 2017. The first was Harvey, which came ashore near Houston on August 26. The storm meandered over southern Texas and Louisiana for four days, depositing as much as fifty inches of rain in some areas. (Figure 1 details Harvey's path.) The floods were devastating. The storm forced more than eleven refineries to shut at its peak, while another nine operated at reduced levels. Harvey caused dislocations like those associated with Hurricane Katrina in 2005.

Harvey's direct effects were felt throughout the southeastern United States as the principal petroleum pipeline to the area, the Colonial, stopped product movements because US Gulf refiners were closed and could not input fuel to the line. The rest of the country felt indirect effects as suppliers adjusted product flows to take advantage of market conditions. Asia and Europe also experienced indirect impacts as suppliers there redirected exports to markets that had lost supplies.

Figure 1
Track of Hurricane Harvey

Source: NOAA.

Hurricane Irma came close on Harvey's heels, striking Cudjoe Key in the Florida Keys on September 10, 2017. Irma was a Category 4 storm when it made landfall in Florida. It was wider than the peninsula and, unlike other hurricanes, moved south to north, traversing the entire state. Parts of Miami on the east coast flooded as the storm's eye moved up the state's west coast. Figure 2 (page 6) shows Irma's track.

Irma created a second test for the petroleum supply system because Florida's governor ordered more than five million residents to evacuate. Roads, especially the interstate highways, were clogged. One driver reportedly took twelve hours to reach Orlando from Miami, a trip that normally takes four hours.[3]

As many as half the state's gasoline station reported outages. *The New York Times* noted that

[3] *Associated Press, "Irma Bears Down on Florida, More Than 5M Told to Flee Coast,"* The New York Times*, September 8, 2017 [https://goo.gl/WegX7Y].*

the big frustration was the lack of fuel. Most gas stations in South Florida were out. Some would receive a truckload only to see it vanish quickly. People used gas-finding apps to locate which stations had gas and then flock there like treasure hunters who had found the X on a map.[4]

Figure 2
Track of Hurricane Irma

Source: NOAA.

The state responded to this development by lifting weight restrictions on trucks so they could carry more fuel, allowing truck drivers to log extra hours, and providing police escorts for tankers.

The unrepaired refinery damage done by Harvey two weeks earlier in Texas and Louisiana delayed gasoline shipments from the region to Florida. These were also slowed by the Jones Act, a 1919 statue that requires all merchandise moving between US ports to be transported on US-flagged ships.

Despite these impediments, the storms' disruptive effect still was moderated by several factors. First, the petroleum market's maturation allowed supplies to be moved from one area to another almost seamlessly, spreading the price impact over many customers and thus minimizing it on those in the locations directly affected, assuming they could move in their vehicles. Second, the Environmental Protection Agency and Homeland Security acted quickly to remove constraints. Their response also boosted supply and reduced the price effect. Third, the United States had excess product supplies on hand because it is now a large gasoline and diesel fuel exporter. Products intended for export were redirected to US consumers. Hence, the net impact of Harvey and Irma on petroleum markets was broad but not deep. In view of what happened, one can assert that the globalization of oil and the removal of vertical barriers to entry allowed the oil market to function efficiently, indeed almost flawlessly.

Noticeable by its absence in all of this was the US Department of Energy. The DOE did sell some oil volumes to refiners in Louisiana from the Strategic Petroleum Reserve. Except for that, it was invisible. As noted below, the lack of a government presence in the energy sector facilitates market adjustments after hurricanes. The absence of such government activity also enables the dissemination of real-time information to consumers. For example, during

[4] *Lizette Alvarez, "In Florida Searching for Gas and Water, and Watching Irma,"* The New York Times*, September 7, 2017 [https://goo.gl/zW2Qeo].*

the storms, *Gas Buddy*, a smartphone app, provided such data regarding stations that still had fuel.[5]

In this report, we describe the market developments that made the market response to the two hurricanes so quick and widened the price impact area. These developments include

the growth and increased depth of petroleum markets;

the breakdown of the integrated supply chain and the presence of independent marketers that operate without loyalty or contractual restriction to any principal supplier, not only in the United States but in many other countries;

the emergence of the United States as a major exporter of petroleum products within the new international markets;

the development of deep, liquid futures markets;

ethanol's introduction as a petroleum substitute and the establishment of an adequate distribution system for the fuel;

the increased understanding of environmental regulators regarding rule adjustments they can make to moderate fuel supply disruptions; and

the expansion of social media, which has helped make the market more competitive.

As mentioned, these changes allowed the storms' impacts to be spread from a few million consumers to perhaps a billion or more, lessening the individual economic pain. US consumers are the primary beneficiaries in this regard. Those in other countries have been left behind. In Europe, for example, the old entrenched integrated oil distribution systems seem to be far less flexible and thus less able to cope with disruptions. For this reason, European observers, particularly those at the IEA, have suggested the US DOE develop strategic product stocks like the ones owned by the companies that control product distribution in Europe, e.g., Total in France.

The success of the US market in mitigating the hurricanes' disruption demonstrates that the outdated petroleum distribution system in Europe is not needed in the United States. Markets and social infrastructure work in good times and bad.

A Crop Failure: An Example of Spreading Economic Pain

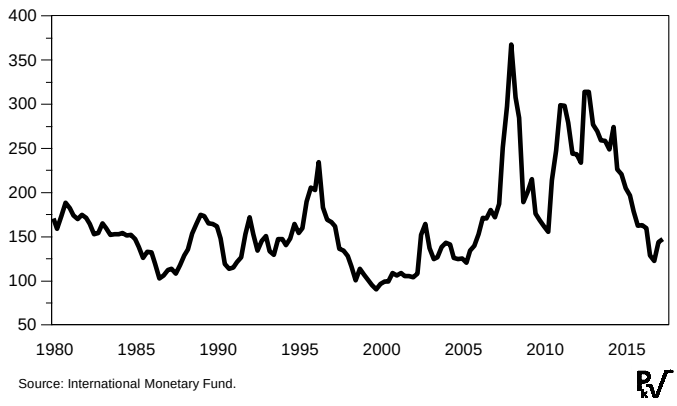
Our analysis starts by considering an agricultural example of how efficient markets work. The bulk of world wheat production comes from thirty-seven countries, with China, India, Russia, and the United States producing the largest amounts. Given the global nature of the wheat market, a crop failure in one country leads to price increases everywhere.

Take, for instance, the 2012 failure of the Russian wheat crop. *Financial Times*' Javier Blas reported that the Russian failure sent prices up because the remaining global supply of six hundred sixty-one million tonnes fell below world consumption of six hundred eighty-eight

[5] *Douglas MacMillan, "In Irma, Emergency Responders' New Tools: Twitter and Facebook,"* The Wall Street Journal, *September 11, 2017 [https://goo.gl/ynGtFD].*

million tonnes.[6] The price impact can be seen in Figure 3. Global wheat output declined four percent from the previous year as Russian output dropped thirty-three percent. Global wheat prices doubled, and consumers across the world paid more. At the same time, the global nature of the wheat trade lessened the price impact on Russian consumers, which would have been far greater—perhaps tenfold given the low price elasticities—had trade been blocked. It was not, though, and the trade in grain diminished the Russian increase by spreading the price effect across the world.

Figure 3
Global Wheat Price, Quarterly Data, 1980 to 2017



Studies of crop failures also acknowledge the impact of inventories. High global stocks of a foodstuff will moderate price fluctuations. Countless analyses of commodity markets have noted this. Newbery and Stiglitz provide a thorough study of price variations and the role of inventories as a stabilizing force.[7]

Oil Market Disruptions as Crop Failures

Oil prices today respond similarly to disruptions. This was not the case during the 1973 Arab Oil Embargo. At that time, certain Middle Eastern countries tried to cut exports to the United States and the Netherlands because the latter had assisted Israel during the October 1973 war. They were partially successful. Companies such as Exxon and Mobil, which had large concessions in the Middle East, stopped shipping crude to the US. In addition, some exporting countries did not respond immediately to US calls to divert oil to it.

Simultaneously, the oil-exporting nations participating in the embargo seized on the opportunity to sell small volumes of oil to eager buyers, raising prices almost tenfold. Nigeria, for example, auctioned fifty thousand barrels per day in supply. The international oil firms hoped prices might rise to, say, $2.75 per barrel. However, independent US refiners bid as high as $16.50 per barrel, and Japanese buyers offered around $14. Platts reported that the affiliate of a major oil company wanted to bid $7.50 but "was ordered home by the parent."[8] The price

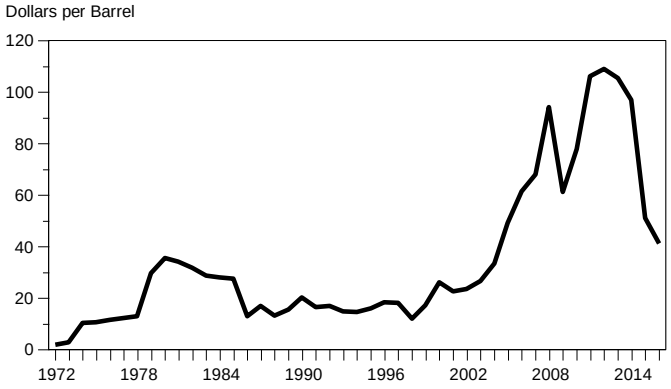
[6] *Javier Blas, "Wheat soars on Russian crop failure,"* Financial Times*, November 8, 2012 [https://goo.gl/upgdJL].*

[7] *David M. G. Newbery and Joseph E. Stiglitz,* The Theory of Commodity Price Stabilization: A Study in the Economics of Risk *(New York: Oxford University Press, 1981) [https://goo.gl/D7wxqF].*

[8] *"Nigeria and the rest of the world: A market or a gun at the head,"* Platts Oilgram Price Report*, November 29, 1973.*

increases continued and eventually spread to official prices. Hence, the 1973 episode demonstrates a market failure. Oil-exporting nations used this to jack up crude prices for all consumers, as Figure 4 illustrates.

Figure 4
Nominal Spot Prices for Dubai Crude, 1972 to 2016



Source: BP Statistical Review of World Energy.

Another market failure occurred in 2000 when reformulated gasoline was introduced into US Midwest markets. Prices shot up when this happened, and the Federal Trade Commission responded to the resulting protests with an investigation. A 2001 press release summarizes the results. (The report is no longer available on the FTC website.)

> While gasoline prices increased nationwide in the spring and early summer of 2000, increases in some local markets, particularly in the Midwest, eclipsed those experienced in past years and were far greater than those experienced in other U.S. markets. Consumers in Chicago and Milwaukee saw significant price spikes at the retail level for reformulated gasoline ("RFG") required under the Clean Air Act, and consumers throughout the Midwest saw significant price increases for conventional gasoline. The price runup was intense, and peaked during the week of June 18-24. In response to requests for an investigation by a bipartisan group of Senators and Representatives, the Commission began the investigation on June 20, 2000.[9]

The FTC report described the retail price rise in the spring:

> Beginning in May and peaking in mid-June, the national average retail price for reformulated baseline ("RFG"), required by Environmental Protection Agency regulation in certain areas, reached a high of $1.67 per gallon. The price increase in the Midwest, however, was significantly higher. The price of RFG reached $2.13 a gallon in Chicago and $2.02 a gallon in Milwaukee.

The report authors noted that the runup was intense but by mid-July prices had returned to previous levels.[10]

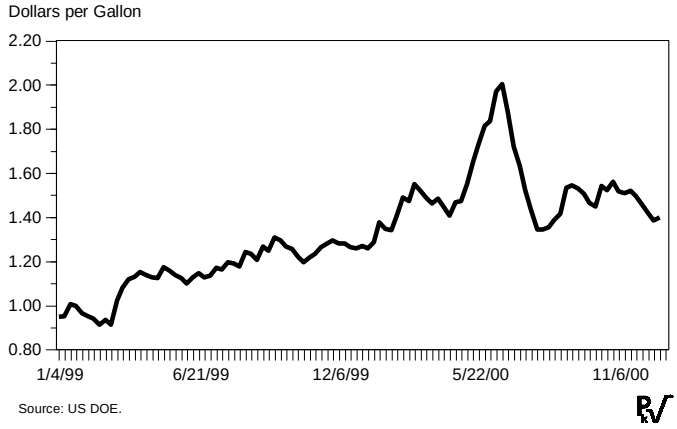
Figure 5 (page 10) traces the increase and decrease in Midwest gasoline prices for reformulated gasoline as reported by the DOE from 1999 to 2001. The price increase from the start

[9] *FTC press release, "FTC Issues Report on Midwest Gasoline Price Investigation," March 30, 2001 [https://goo.gl/H2TTDn].*

[10] *FTC, "Final Report of the Federal Trade Commission Midwest Gasoline Price Investigation," March 29, 2001, p. 2.*

of the year to the peak was sixty-six percent, roughly the same as the rise that occurred following the 2017 hurricanes.

Figure 5
RFG Prices in the US Midwest in 1999 and 2000



The FTC investigators found no collusion among refiners. However, the market in 2000 was far more constrained than it is today. Large independent marketers had not yet emerged, the major trading firms had not penetrated the market, and reformulated gasoline was just being introduced. The Commission also noted that refinery disruptions and pipeline outages contributed to the problem, as did the industry's adoption of "just in time distribution techniques."[11] These led to low inventories prior to the disruptions.

Large firms, in short, still enjoyed significant market power, which they exercised at the time. Two paragraphs in the FTC report explain the effect:

> A significant part of the reduction in the supply of RFG was caused by the investment decisions of three firms. When determining how they would comply with the stricter EPA regulations for summer-grade RFG that took effect in the spring of 2000, three Midwest refiners independently concluded it was most profitable to limit capital expenditures to upgrade their refineries only to the extent necessary to supply their branded stations and contractual obligations. As a result of these decisions, these three firms produced, in the aggregate, 23 percent less summer-grade RFG during the second quarter of 2000 than in 1999. Consequently, these three firms were able to only satisfy the needs of their branded stations and their contractual obligations, and could not produce summer-grade RFG to sell on the spot markets as they had done in prior years. On the other hand, these three firms produced more conventional gasoline in the second quarter of 2000 than in 1999.
>
> In addition, at least one firm increased its summer-grade RFG production substantially and, as a result, had excess supplies of RFG available and had additional capacity to produce even more RFG at the time of the price spike. It thus found itself with considerable market power in the short term. This firm did sell off some inventoried RFG, but acknowledged that it limited the magnitude of its response because

[11] *FTC Midwest gasoline report, p. 3.*

> it recognized that increasing the supply to the market would push down prices and thereby reduce the profitability of its overall RFG sales.[12]

The FTC concluded that no violation of antitrust law occurred. Instead, structural and operating decisions, bad forecasts, and accidents lay behind the price increase. Profit maximization by the parties contributed as well.

The FTC authors also noted that the problems could occur again: "Unless gasoline demand abates or refining capacity grows, price spikes are likely to occur in the future in the Midwest and other areas of the country."[13] Their observation was correct. Prices rose following Hurricane Katrina and Hurricane Ike, prompting additional government investigations.

The FTC's report on Katrina's economic impact is two hundred twenty-two pages long. It required almost a year to complete. In the storm's aftermath, Congress demanded that the agency scrutinize the oil industry's actions and funded the review. As the Commission noted, gasoline prices doubled from $1 to $2 per gallon between January 2002 and May 2004. Prices then increased to $2.50 in August 2005 before Katrina and a second hurricane, Rita, occurred. Following the hurricanes, prices rose another fifty cents per gallon.[14]

In its investigation, the FTC subpoenaed information from oil market participants in all parts of the country and conducted thousands of under-oath interviews. Following the inquiry, the Commission reached conclusions identical to those of its earlier studies. Refiners, marketers, and other participants behaved competitively.

The 2006 investigation delved carefully into firms' inventory practices and examined the role of futures markets. The Commission concluded that companies were keeping stocks low and that futures markets had no impact.[15] Critically, however, **the FTC economists failed to acknowledge—and likely did not understand—the role futures markets might have played in mitigating price fluctuations.**

Hurricane Harvey: Another Crop Failure

Hurricane Harvey was an uninvited guest for southern Texas and Louisiana. The storm brought the "normal" destruction associated with a hurricane and then, by overstaying its welcome, dumped as much as fifty inches of rain on parts of Houston. An estimated fifteen thousand homes were destroyed, fifty thousand suffered major damages, and seventy-five thousand had minor damage.[16] While the harm was severe, Harvey was far less destructive than Katrina, which demolished an estimated three hundred thousand homes.[17]

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[12] FTC Midwest gasoline report, p. 4.

[13] FTC Midwest gasoline report, p. 4.

[14] FTC, "Investigation of Gasoline Price Manipulation and Post-Katrina Gasoline Price Increases," Spring 2006 [https://goo.gl/K5vcZ4], p. i.

[15] FTC Katrina report, p. viii.

[16] Dan Frosch and Laura Kusisto. "Texas Grapples with Housing Crunch," The Wall Street Journal*, September 18, 2017 [https://goo.gl/XboNnm].*

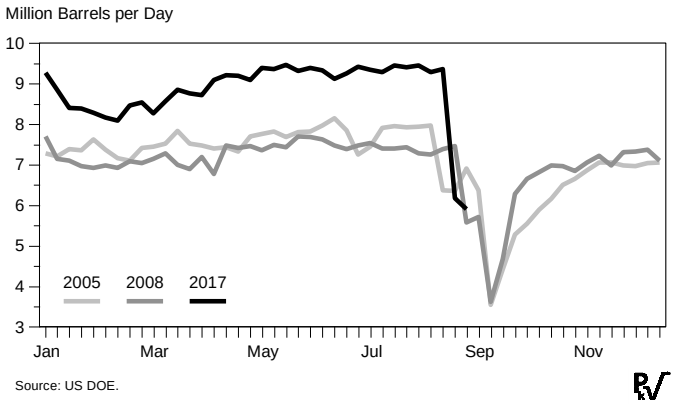
[17] Dan Frosch and Laura Kusisto, "Housing Effort Poses Test for FEMA After Harvey," The Wall Street Journal*, September 17, 2017 [https://goo.gl/YS5YVs].*

Harvey's impact on the oil sector operations, though, was nearly as severe as Katrina. Figure 6 compares refinery gross inputs in 2005 (Hurricanes Katrina and Rita) with 2008 (Hurricane Ike) and 2017 (Hurricane Harvey). The data measure the crude volume input into refineries by week for all weeks in each year.[18]

Comparing the three episodes reveals a similarity between the Katrina/Rita and Ike events. In the first case, inputs were cut four million barrels per day when the disruption reached its worst point. In the second, they declined 3.6 million barrels per day. Harvey's effect was not as bad. Inputs "only" declined three million barrels per day. On a percentage basis, the decline was thirty-six percent versus fifty-four percent with Katrina/Rita and fifty-two percent with Ike.

The impact on spot and retail prices was a different matter. Retail prices as reported by the DOE increased only fifteen percent nationally after Harvey compared to sixty-five percent after Katrina and thirty-four percent after Ike. Figure 7 (page 13) tracks the retail price rise in each occasion. For display purposes, we have converted prices to indices and used the January average price for each year as a base.

Figure 6
Gross Refinery Inputs in PADD III in Three Years That Experienced Major Hurricanes



Source: US DOE.

Consumers in the Midwest suffered from Hurricanes Katrina, Rita, and Ike. Prices rose due to distribution problems. Retail prices went up forty-four percent after Katrina and Rita and thirty-six percent after Ike. In contrast, Midwest gasoline prices rose just twelve percent after the most recent disruption.

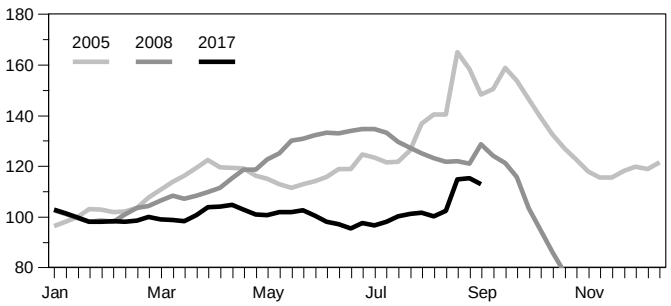
The rise in gasoline spot prices was more extreme. Figure 8 (page 13) presents the jump in spot prices in New York Harbor. As with the consumer price graph, prices are shown as indices with data for the month of January as the base. In New York, one saw spot prices spike more than two hundred percent after Katrina/Rita but much smaller increases after Ike and Harvey (fifty percent).

[18] We use total refinery inputs as our measure because information on refinery utilization by region was not published.

The data on Ike are a little confusing because prices rose during the spring. Figure 9 (page 14) shows data on RFG spot prices in Houston. Here the spike from Ike is much clearer. Again, one notes that Harvey was almost a nonevent in markets compared to the earlier episodes.

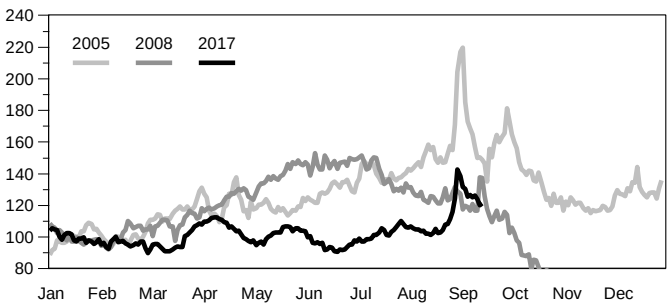
Table 1 (page 14) presents the oil industry impacts of the three hurricane events. The columns show the name of the hurricane, the year, the percentage loss in refinery inputs in PADD III, the percentage increase in prices across the US, the percentage increase in prices in the Midwest, the percentage increase in New York spot prices, and the percentage increase in Houston gasoline spot prices. The percentage increases are measured as the average peak during the hurricane period relative to the average price in January.

Figure 7
US Retail Gasoline Prices in Three Years That Experienced Major Hurricanes



Note: The graph shows the index beginning from 80. The index for 2008 (Ike) fell below 80 in fall 2008 when Lehman Brothers collapsed and the Great Recession began.
Source: US DOE; PKVerleger LLC.

Figure 8
US Spot Gasoline Prices in New York Harbor in Three Years that Experienced Major Hurricanes



Note: The graph shows the index beginning from 80. The index for 2008 (Ike) fell below 80 in fall 2008 when Lehman Brothers collapsed and the Great Recession began.
Source: US DOE; PKVerleger LLC.

A review of the table suggests the three incidents were similar physically in terms of the refinery inputs lost. The market impacts were very different, however. The remainder of this report explains the very moderate price movement that occurred after Harvey. Two key findings emerge. First, markets worked. Specifically, the growth of the oil futures market and its wider acceptance in the industry—forced on the older integrated companies by trading companies such as Vitol—were major factors contributing to the muted price reaction. Quick action by environmental authorities also helped moderate price increases after the storms.

Table 1. US Oil Market Effects from Three Hurricane Events

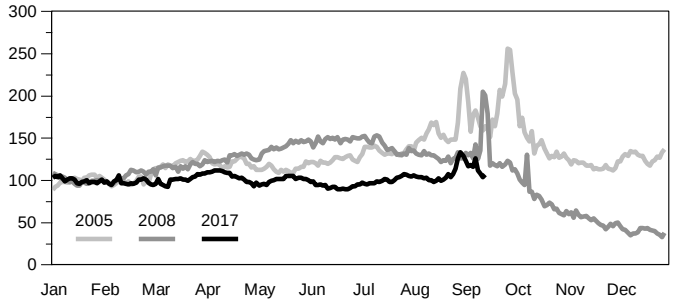
Hurricane	Year	Reduction in Refinery Inputs in PADD III (%)	US Retail Gasoline Price Rise (%)	Midwest Retail Gasoline Price Rise (%)	NY Gasoline Spot Price Rise (%)	Gulf Coast Gasoline Spot Price Rise (%)
Katrina/Rita	2005	54.1	65.1	43.8	113.5	118.4
Ike	2008	52.8	34.8	36.0	37.4	102.5
Harvey	2017	36.2	15.2	11.8	29.4	20.6

Note: Refinery input reduction computed from the average from January to end-July. Price change computed as price rise relative to January.

Source: PKVerleger LLC.

The Success of Markets

Figure 9
US Spot Gasoline Prices on the Gulf Coast in Three Years That Experienced Major Hurricanes



Note: The graph shows the index beginning from 80. The index for 2008 (Ike) fell below 80 in fall 2008 when Lehman Brothers collapsed and the Great Recession began.
Source: US DOE; PKVerleger LLC.

Fuel supplies were disrupted in each of the three hurricane episodes. The shutdowns began with refineries. The table and charts above reveal that significant refining capacity was closed during each and product movements were disrupted. Power losses stopped activity on key pipelines after Katrina and Rita. The key Colonial Pipeline was inoperative because pump stations were flooded and without electricity. The Colonial was shut again after Harvey because the products needed to fill it were unavailable from Texas refineries.

The market impact of the disruption caused by Harvey was offset in varying proportions by six important factors:

- Environmental authorities eased regulations on the fuel types that could be provided as well as constraints on shipping.
- An alternative fuel, ethanol, was available for blending into gasoline.
- Crude and product inventories could be tapped to ease the crisis.
- Larger, more liquid futures markets promoted inventory accumulation.

- US Gulf refiners are now a significant participant in world markets, which meant the supply loss impact was shouldered not just by US consumers but also by those in Latin America and other parts of the world.
- Suppliers outside the United States could step in and meet the fuel needs of consumers affected by disruptions, wherever those consumers were located.
- The flexibility of the US distribution system spread the impact of Harvey across much of the nation.

Relaxation of environmental and logistical rules and increased ethanol use. Government officials at the EPA and Homeland Security have played an important role in mitigating hurricane market impacts. In the US, environmental law requires petroleum product distributors to lower gasoline Reid Vapor Pressure during summer months, which reduces supply. After Katrina and Rita in 2005 and Harvey and Irma in 2017, the EPA granted widespread waivers of these regulations. In 2005, EPA waived the gasoline rules for the entire country, as a CRS report to Congress explained:

> The Agency waived the volatility requirements that apply to gasoline sold during the summer driving season. Lower volatility gasoline is less prone to evaporation, thereby lowering emissions of the volatile organic compounds that contribute to the formation of ground-level ozone. The volatility requirements vary depending on region of the country, making the supply of gasoline available in Northern states unusable in the South during summer months. The summer volatility requirements expire on September 15 of the year in most states. In order to prevent supply disruptions that might otherwise have occurred, EPA waived these requirements beginning August 30 in Alabama, Florida, Louisiana, and Mississippi, and, on August 31 extended the waiver to all 50 states and the District of Columbia. This waiver has now expired in most states, but on September 13, the agency extended the waiver until late September or October in California, Texas, and Phoenix, Arizona, all of which require low volatility gasoline after September 15.[19]

The EPA also allowed some areas to sell conventional gasoline rather than RFG and lifted regulations relating to gasoline and diesel sulfur content.

The agency was less flexible after Hurricane Ike. Again, shortages occurred, especially in the southeastern United States areas served by the Colonial Pipeline, but this time regulations on fuel quality were apparently not generally relaxed.[20]

The EPA made an about-face in 2017. Summer gasoline requirements were waived for all states east of the Rockies on August 31, days after Hurricane Harvey made landfall. In addition, the EPA allowed blenders to increase the ethanol amount mixed into gasoline to fifteen percent. The blending rule change presumably stretched gasoline supply in areas where ethanol was available. Whether this adjustment had any effect will not be known for

[19] *James E. McCarthy and Claudia Copeland, "Emergency Waiver of EPA Regulations: Authorities and Legislative Proposal in the Aftermath of Hurricane Katrina," CRS Report to Congress, September 29, 2005 [https://goo.gl/FNFchh], p. 7.*

[20] *Patrik Jonsson, "Post-Ike gas shortages may take weeks to end,"* The Christian Science Monitor*, September 25, 2008 [https://goo.gl/4kbWF5].*

some time, however, because the EPA required any marketer raising the ethanol percentage to fifteen to comply with the federal rules requiring them to post notices on pumps informing consumers that the gasoline contains fifteen percent ethanol. This may have prevented a rapid switch to the higher-ethanol blend.

After Harvey, the more progressive implementation of fuel rules and the more proactive response of the EPA helped dampen the price increase. The ability to substitute large volumes of ethanol during market disruptions could be very important, again if the ethanol is available. In the current circumstances, a two-percent loss in gasoline supply could send prices up forty percent, as occurred in prior crises. The price increase could be much smaller, though, if greater amounts of ethanol could be blended into fuel. The modest price rise after Harvey suggests that this had the desired effect.

Higher inventories and the futures markets also played a key role. One key development in global oil markets since 2000 has been the expansion of oil futures markets. Open interest in the three primary crude oil futures has increased from seven hundred thousand contracts in 2000 to 5.4 million contracts in 2017. Open interest in gasoline futures has climbed from eighty-seven thousand contracts in 2000 to more than four hundred thousand contracts in mid-2017.

The runup in open interest has significantly affected oil industry operations because it has promoted inventory accumulation. These stocks are available to the market during disruptions and this seems to have moderated any price increases associated with supply interruptions.

Most economic studies of disruptions ignore the impact of futures markets on inventory accumulation. For example, the FTC's 2006 investigation of price increases after Hurricane Katrina focused on other concerns:

> Petroleum companies believe that they have achieved a consistent service level over time, particularly for contractual customers. Because refiners have many repeated interactions with their customers, they have a strong incentive to provide customers with product reliably, both to maintain existing business and to win future business. Refiners' frequent ownership of the brand names used by retail stations furnishes them with a further incentive to maintain a reliable supply.
>
> At the same time, keeping product in inventory represents a substantial cost of doing business for petroleum companies. Two types of costs are particularly important: storage costs and carrying costs. Storage costs—fees paid to terminal owners—include both a monthly fee based on the number of barrels stored and a throughput fee based on the number of barrels moved into and out of the terminal. Carrying costs represent the opportunity costs of holding product in storage, *i.e.*, the interest that a company forgoes (or pays to creditors) by holding a product in storage rather than selling it in the market immediately. Because holding inventory is not costless, firms have an incentive to reduce the amount of product in inventory.[21]

[21] *FTC Katrina report, pp. 47-48.*

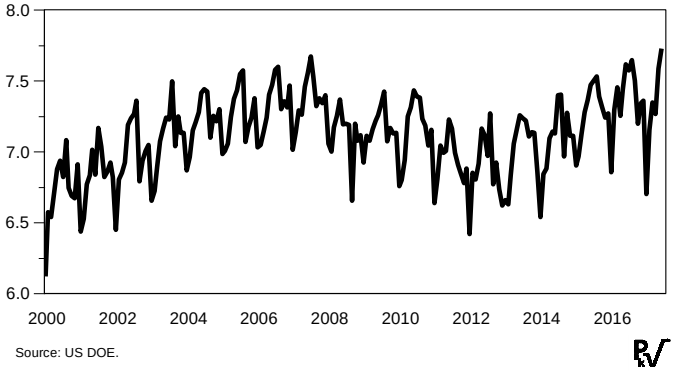
In its 2006 investigation, the Commission sought to determine whether a coordinated effort to withhold gasoline from the market had occurred. It found no evidence of this. The agency also examined the role of the gasoline futures market for signs of exploitation:

> In response to stories in the media and some industry complaints, staff explored whether gasoline futures prices are susceptible to manipulation through control over certain storage and physical assets. Because the prices of many physical bulk gasoline sales are tied to gasoline futures prices, manipulation of futures prices could affect both physical and futures markets.

The FTC discovered no evidence of market manipulation, noting that the New York market was one of the most liquid in the country. They also found that the storage market had a very low Herfindahl-Hirschman Index (HHI) score, meaning it was very competitive.[22]

The FTC economists did not attempt, however, to determine whether the industry used gasoline futures to hedge. If they had, they might have concluded that the futures market promoted inventory building that helped moderate the price increase. The data regarding Katrina are inconclusive. However, the data today reveal that futures markets did promote stock building prior to the hurricanes and the higher stocks likely helped constrain the price rise.

Figure 10
Monthly Gasoline Use in PADDs I, II, and III, January 2000 to June 2017



We illustrate the impact of futures here using a series of charts and a table. Our analysis starts with Figure 10, which shows monthly gasoline use in PADDs I, II, and III from January 2000 to June 2017. The data, which are not seasonally adjusted, represent the Energy Information Administration's calculation of "product disappearance"—consumption, in other words.

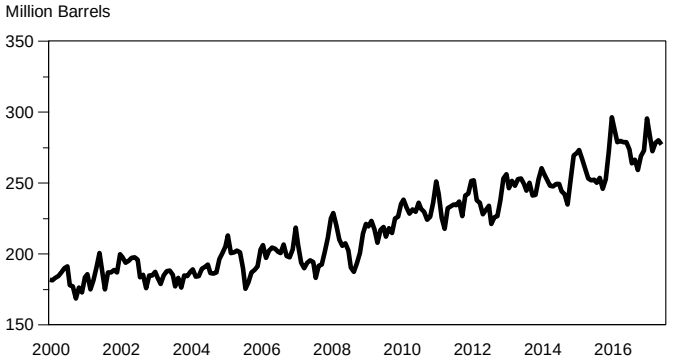
The three PADDs encompass an area that runs from the US East Coast to the eastern slopes of the Rocky Mountains. This span covers, roughly, the states between Virginia in the east and Nebraska in the west and from Maine in the north to Texas in the south. We aggregated the consumption data for the three districts because they seem to act as a single physical market. Gasoline will flow south from Minnesota to Iowa, for example, if Texas experiences

[22] *FTC Katrina report, p. 55.*

a shortage, while supplies that might normally move from Missouri or Oklahoma to Iowa are directed south.

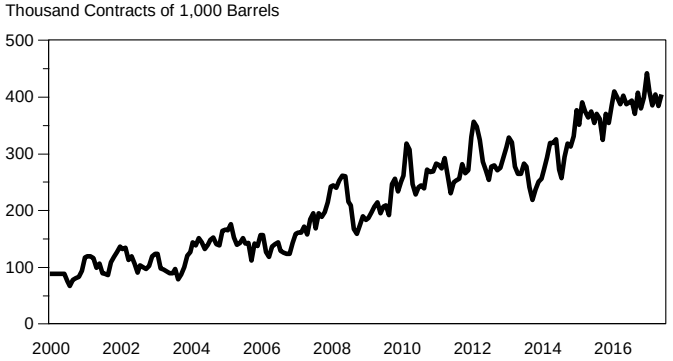
Figure 11 shows the inventories in these three areas of finished gasoline and gasoline blend stocks. Note that stocks have increased from one hundred eighty million barrels in 2000 to two hundred eighty million barrels in 2017, while gasoline consumption in three PADDs has been relatively constant, fluctuating between seven and 7.5 million barrels per day. This increase seems to contradict the FTC's conclusions that the industry is practicing "just in time stock management" and that "because holding inventory is not costless, firms have an incentive to reduce the amount of product in inventory."

Figure 11
Monthly Finished Gasoline and Gasoline Blend Stocks Held in PADDs I, II, and III, January 2000 to June 2017



Source: US DOE.

Figure 12
Monthly Open Interest in Gasoline Futures Contracts, January 2000 to June 2017



Source: CME.

One explanation for the stock rise lies in the greater open interest in gasoline futures. As Figure 12 shows, open interest in gasoline futures is four times higher in 2017 than in 2000, rising to four hundred four thousand contracts at the end of June. The increase of more than three hundred thousand contracts equates to a rise of three hundred million barrels of gasoline.

The increase in open interest is tied closely to the increase in gasoline days of supply in PADDs I, II, and III. Days of supply are measured as the ratio of inventories, shown above in Figure 11, to consumption, shown in Figure 10. As Figure 13 (page 19) illustrates, days of supply coverage in the PADDs rose from 27.4 in 2000 to 35.8 in June 2017.

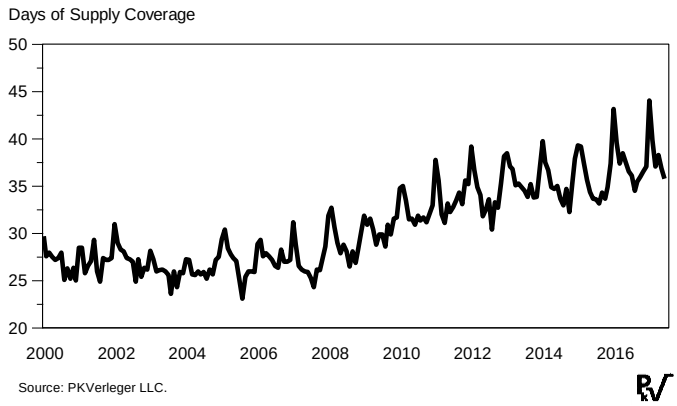
Table 2. Days of Gasoline Supply by Month for PADDs I, II, and III, January 2000 to June 2017

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	29.7	27.6	28.0	27.5	27.2	27.4	28.0	25.1	26.3	25.2	26.4	25.0
2001	28.5	28.5	25.8	26.6	27.1	29.3	26.0	24.9	27.4	27.2	27.2	27.4
2002	31.0	29.0	28.3	28.1	27.4	27.3	27.0	24.9	27.3	25.4	26.4	26.2
2003	28.2	27.3	26.0	26.1	26.2	26.0	25.6	23.6	26.0	24.3	25.9	25.8
2004	27.3	27.2	25.7	25.6	26.0	25.7	25.9	25.2	26.2	25.7	27.2	27.5
2005	29.4	30.4	28.4	27.8	27.4	27.1	25.1	23.1	25.4	26.0	26.0	25.9
2006	28.9	29.3	27.6	27.9	27.6	27.2	26.6	26.4	28.3	27.0	27.0	27.2
2007	31.2	28.9	26.6	26.2	26.0	25.9	25.3	24.3	26.2	26.1	27.5	28.6
2008	31.9	32.7	30.7	29.0	27.9	28.8	28.1	26.5	28.1	26.9	28.3	30.1
2009	31.9	30.9	31.6	30.4	28.8	29.9	29.9	28.6	30.9	29.9	31.6	31.7
2010	34.8	35.0	33.5	31.5	31.6	30.9	31.9	31.4	31.7	31.2	32.1	33.0
2011	37.8	35.6	32.0	31.1	33.2	32.3	32.8	33.5	34.3	33.1	35.6	35.2
2012	39.2	36.7	34.9	34.1	31.8	32.5	33.6	30.4	33.3	32.7	35.3	38.2
2013	38.5	37.1	36.8	35.1	35.3	34.9	34.5	33.9	35.2	33.8	33.9	36.9
2014	39.8	37.5	36.7	34.9	34.7	35.0	33.7	33.0	34.7	32.3	35.5	37.9
2015	39.3	39.2	37.4	35.7	34.4	33.7	33.6	33.2	34.3	33.7	34.9	37.4
2016	43.2	39.6	37.4	38.5	37.5	36.6	36.1	34.5	35.5	36.0	36.6	37.1
2017	44.1	39.9	37.1	38.3	36.9	35.8						

Source: PKVerleger LLC.

Naturally, days of supply fluctuate from month to month because consumption fluctuates from month to month. This is shown in Table 2 above, which presents the days-of-supply calculation for the three PADDs month by month.

Figure 13
Monthly Days of Supply for Gasoline in PADDs I, II, and III, January 2000 to June 2017



Figures 14 and 15 capture the link between days of supply and open interest. Both graphs show days of supply in PADDs I-III and open interest. Figure 14 (page 20) presents monthly data with open interest graphed against the left vertical axis and days of supply against the right vertical axis. Figure 15 (page 20) presents a scatter diagram of these data, with open interest graphed on the horizontal axis and days of supply on the vertical axis.

Figure 14 makes it clear that open interest in gasoline began a sharp increase after 2007, as did days of supply. A rough calculation suggests that a rise in open interest of one hundred thousand contracts will boost inventories thirty to forty million barrels. A three hundred thousand contract increase would prompt a stock rise between one hundred and one hundred twenty million barrels.

Interestingly, the short position of merchants from 2007 to 2016 has increased by almost exactly one hundred thousand contracts. Figure 16 (page 21) shows the weekly data published by the Commodity Futures Trading Commission in merchant short positions in gasoline futures and options equivalent positions. These data were first reported in mid-2006. The graph covers 2007 to 2017. The statistics strengthen the case that the relationship between the increase in gasoline futures contracts and the increase in days of supply is tied to the rise in gasoline open interest.

Figure 14
Open Interest in Gasoline Futures Contracts vs. Days of Supply in PADDs I, II, and III, January 2000 to June 2017

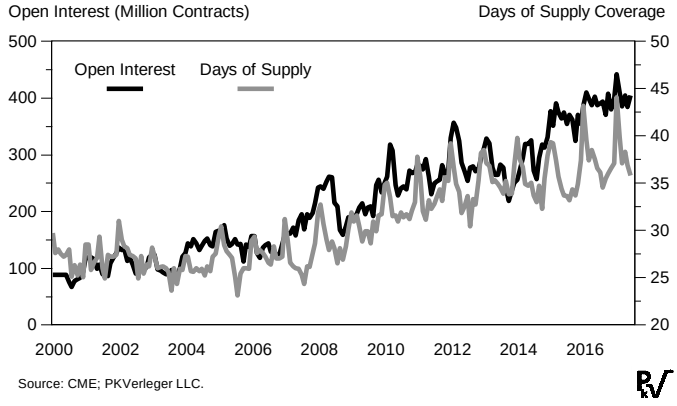
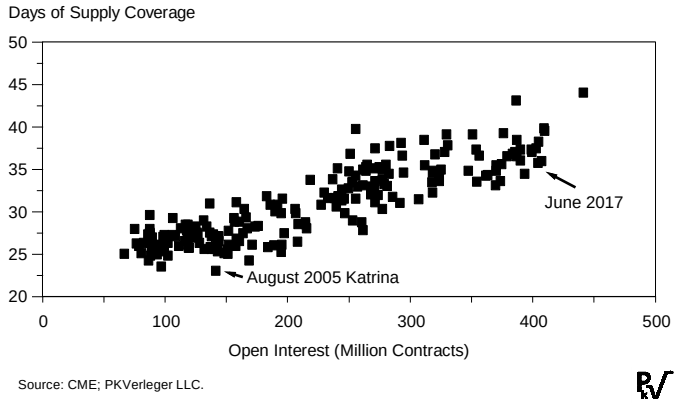


Figure 15
Open Interest in Gasoline Futures Contracts vs. Days of Supply in PADDs I, II, and III, January 2000 to June 2017



One can conclude from the data that oil merchants (refiners, traders, etc.) are adding to stocks because the futures market offers them an opportunity to do so. This finding seems contradictory to the FTC view that *firms have an incentive to reduce the amount of product in inventory*. The correct economic statement is that *firms have an incentive to reduce the amount of product in inventory <u>if they cannot hedge the incremental stocks.</u>*

Futures markets, then, by offering investors and speculators a chance to bet on the future level of gasoline prices, promote inventory accumulation by commercial players. The wagers and forward buying by users or other merchants facilitate this stock building.

The United States has also become a significant participant in the international product market, with most exports coming from US Gulf Coast refiners. Hurricane Harvey, by damaging US ports, interrupted much of the export activity, which spread the supply loss over a much wider market.

The rise in US exports is tracked in Figure 17. This graph shows total exports by month from 2000 for all US refiners and traders aa well as the export volume from the Gulf Coast.

The boost in exports shown in Figure 17 is remarkable. In 2000, US refiners exported fewer than one million barrels per day. One could say the United States was not a player then in the international products market. Seventeen years later, US exports have surpassed four million barrels per day. Hence, the US is now a participant in global market for products. Figure 17 makes it clear that most US exports come from the Gulf Coast. In 2000, PADD III refineries accounted for seventy percent of US exports. Today the percentage is eighty-three.

Figure 16
Merchant Short Position in Gasoline Futures, January 2007 to August 2017

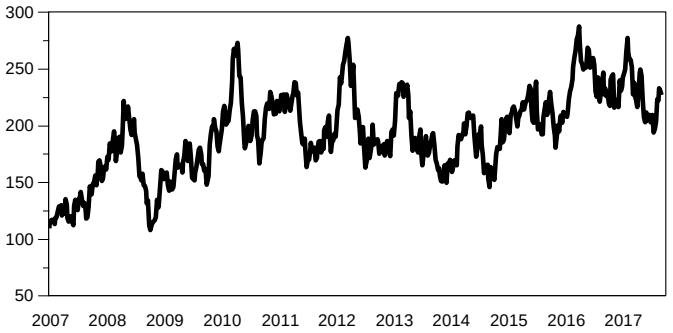
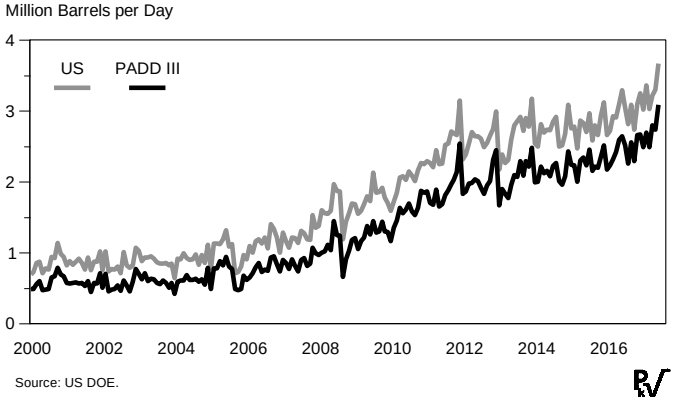


Figure 17
US and PADD III Exports of Petroleum Products, Monthly Data, January 2000 to June 2017

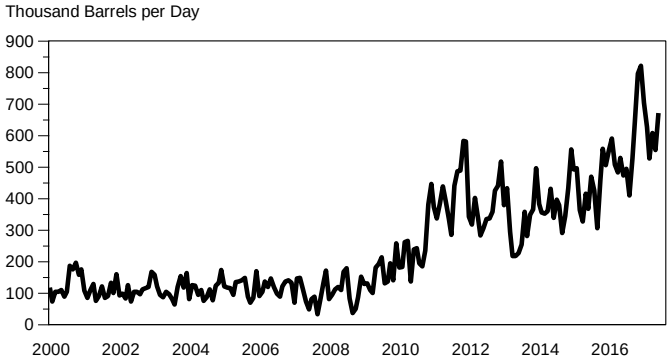


US exports have increased primarily because independent refiners on the Gulf (Valero, Marathon, Phillips 66, and others) have invested in capacity to produce clean fuels, particularly gasolline and diesel. It is the exports of these fuels that have gone up by such large amounts. Figure 18 (page 22) tracks the rise in gasoline exports, which have gone from one hundred thousand barrels per day in 2000 to seven hundred thousand barrels per day in 2017.

The change in distillate exports was even larger. US refiners invested in the hydrotreaters required to boost diesel production and cut sulfur, allowing them to capture market share from European refiners and refiners in South America. Exports have climbed from less than one hundred thousand barrels per day in 2000 to more than 1.5 million barrels per day in 2017.

The destination of US exports varies. Table 3 lists countries importing more than one hundred thousand barrels per day of petroleum products from the United States. These twelve nations received two-thirds of US exports. Mexico and Canada alone purchased thirty percent of US refinery exports.

Figure 18
Finished Gasoline Exports from PADD III, Monthly Data, January 2000 to June 2017



Source: US DOE.

Product exports were cut by Hurricane Harvey. The DOE's weekly data show a decline from 4.4 million barrels per day to 3.4 million barrels per day. Figure 19 (page 23) tracks exports by week from January through September. Gasoline and distillate exports dropped noticeably.

Table 3. Major Destinations for US Petroleum Product Exports in 2016 (Thousand Barrels per Day)

	Volume	% of US Exports
Total	4,670	67.4
Mexico	880	18.8
Canada	576	12.3
Brazil	260	5.6
Japan	242	5.2
Netherlands	222	4.8
China	181	3.9
Chile	155	3.3
India	140	3.0
Colombia	139	3.0
Singapore	136	2.9
Ecuador	108	2.3
Panama	107	2.3

Source: PKVerleger LLC.

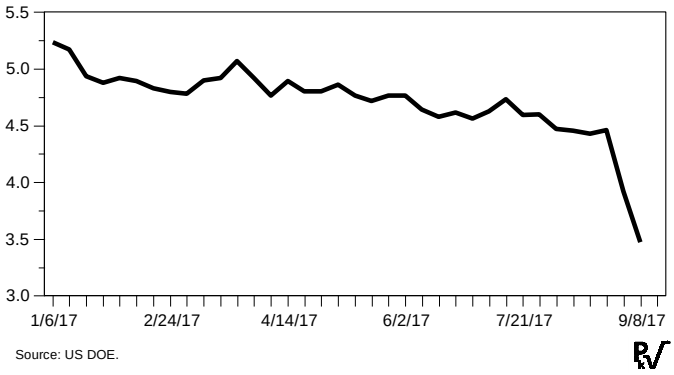
Mexican buyers were especially affected. The Deer Park refinery in Texas, jointly owned by Shell and Pemex, was shut for more than a week. It processes heavy crude imported from Mexico and sends product back. Platts noted that Mexico could be particularly affected because the hurricane closed major rail and maritime export outlets. Furthermore, a major refinery on the country's west coast had been closed. To make matters worse, as Platts reported, Mexico's product stocks were low, down to roughly three days of consumption. In June, the last month for which data are available, the US provided eighty-eight percent of Mexico's five hundred sixty thousand barrels per day of gasoline imports.[23]

Mexico has not experienced shortages yet because traders across the world seized the opportunity to ship products there. Argus Media reports that five hundred thirty-six thousand barrels of gasoline were shipped from Asia for delivery

[23] *Daniel Rodriguez, "Harvey could raise challenges for Mexican fuel supply,"* Platts on the Net*, August 28, 2017.*

in Mexico during the week ending September 6. Additional volumes were on the way.[24] European refiners were also reportedly diverting gasoline cargos originally destined for the US East Coast to Mexico.

Figure 19
US Petroleum Product Exports, Weekly Data, January to September 2017



Source: US DOE.

The full magnitude of the adjustments in international markets will not be known for some time. What is clear, though, is the system adapted and is now moving products around the globe, spreading the impact of Harvey's disruption to all consumers, just as all consumers bear the brunt of a major crop failure.

The flexibility of the domestic and global petroleum distribution system was another factor that helped spread Harvey's supply impact out across much of the United States. Consequently, there should be an inverse impact of a fixed supply cut on prices as the number of consumers affected increases. This is the case with petroleum products. The US market has become so interconnected that consumers that seemingly should be unaffected by a disruption on the US Gulf can feel the impact. This effect can be seen from Table 4 (page 24), which shows the change in retail gasoline prices in selected states from highest to lowest from August 25 to September 1.

The price boost after Harvey in the hardest-hit states—Georgia, Maryland, Tennessee, Alabama, and Virginia—is not surprising. These states rely on the Colonial Pipeline as a primary supply source, and its shutdown would affect fuel availability there. Why, though, did New Jersey end up third on the list and Massachusetts and Connecticut seventh and eighth, all ahead of Texas, the state that suffered most physically from Harvey?

The answer may be the nature of the distribution system. For example, New Jersey refineries provide a substantial portion of that state's gasoline supply. After Harvey, firms operating there chartered tankers and moved product to the states affected by the supply cutoff, especially Florida. The shift left New Jersey with less gasoline.

Massachusetts and Connecticut receive a significant portion of their fuel supplies from a Nova Scotia refinery owned by Irving. Gasoline and diesel production cuts by refiners on the Gulf Coast after Harvey created a marketing opportunity for the firm in Mexico and other

[24] *"Asia Pacific gasoline: More cargos head to Mexico," Argus Media, September 13, 2017.*

Table 4. Initial Impact of Hurricane Harvey on US Retail Gasoline Prices in Selected States (Dollars per Gallon)

	Price on September 4	Price on August 25	Change	% Change
Georgia	2.693	2.231	0.462	20.7
Maryland	2.707	2.289	0.418	18.3
New Jersey	2.771	2.366	0.405	17.1
Tennessee	2.552	2.157	0.395	18.3
Alabama	2.480	2.087	0.393	18.8
Kentucky	2.648	2.257	0.391	17.3
Virginia	2.510	2.134	0.376	17.6
Massachusetts	2.707	2.336	0.371	15.9
Connecticut	2.839	2.469	0.370	15.0
Texas	2.506	2.148	0.358	16.7
Minnesota	2.491	2.136	0.355	16.6
Florida	2.644	2.307	0.337	14.6
Pennsylvania	2.853	2.540	0.313	12.3
Missouri	2.443	2.138	0.305	14.3
Oklahoma	2.370	2.119	0.251	11.8
Colorado	2.580	2.334	0.246	10.5
Louisiana	2.367	2.142	0.225	10.5
Illinois	2.591	2.408	0.183	7.6
Michigan	2.624	2.483	0.141	5.7
California	3.114	2.980	0.134	4.5
Ohio	2.390	2.296	0.094	4.1
Arizona	2.353	2.261	0.092	4.1
Utah	2.614	2.608	0.006	0.2

Source: AAA.

South American countries, which means some of the product intended for New England states got diverted to those markets and to Florida.

Prices also rose in Minnesota. The increase during the first week of Harvey's disruption put the state in eleventh place in terms of the higher prices, just behind Texas. Why, one asks, did Harvey have such a large impact on Minnesota? The answer seems straightforward. Minnesota has local refineries. These supply Minnesota consumers but also those in neighboring states. With a disruption such as Harvey, though, gasoline and diesel that normally stay within the state can be shipped south to Iowa, which enables supplies in Missouri that ordinarily go to Iowa to be moved further south to Arkansas, west to Oklahoma and Kansas, or east to southern Illinois, Ohio, and Kentucky. The gasoline and diesel being sent south from Missouri to Oklahoma would allow refiners to move gasoline from Oklahoma to northern Texas, an area normally supplied from Houston. This happened after Harvey. In one case involving the Magellan Pipeline from Dallas to Oklahoma, "Oklahoma refineries Tuesday were serving Dallas through the reversed line, the company [Magellan] said."[25]

Even California was affected by Harvey despite the Rocky Mountain barrier that prevents products from moving easily from the rest of the United States to the West and vice versa.

[25] *Jeffery Gair, "Magellan reverses gasoline diesel pipeline flow to serve Dallas,"* Platts Global Alert*, August 31, 2017.*

As Table 3 shows, California prices rose thirteen cents per gallon. While this is a smaller amount than other areas experienced, California still felt the price effects of Harvey. In the future, we will likely learn that supplies destined for California from Asia were diverted to Mexico. We may also learn that California refiners sent products to Mexico to help cover the shortage created by the Gulf Coast closures.

The arbitrage process has melded the US gasoline market east of the Rockies into a single unit rather than a group of heterogenous areas. Indeed, the entire nation may be a single market. This conclusion is supported by econometric tests conducted by PKVerleger LLC. These tests, which will be discussed in a future report, reveal that gasoline prices are set by price movements in the CME gasoline futures contract. Fluctuations in cities such as Boston, Cleveland, Chicago, Houston, and Miami, as well as in West coast cities, are based almost entirely on price changes on the futures exchange. The only exception occurs when physical disruptions make it impossible to supply a market, as was the case for Miami in early September following Hurricane Irma. The market's interconnected nature facilitates arbitrage. Meanwhile, the ability to store profitably using futures markets to hedge under certain conditions allows companies to avoid dumping product on the market when local conditions would otherwise cause prices to fall.

This homogenization of the US market has happened because the integrated mechanism by which gasoline and diesel were supplied between large companies has collapsed. At one point, the large firms would supply other firms through exchanges. Citgo, for example, would deliver products to Exxon buyers in markets where Exxon had no supplies and take back volumes from Exxon in another market. One firm might pay the other a penny or two per gallon as an exchange premium.

The system was widely criticized by economists for years because outside firms were unable to enter a specific geographic market unless they found their own supply. This cozy arrangement is mostly defunct. Today large independent retailers such as Costco and Wal-Mart, with market capitalizations multiple times higher than those of large refining companies, have acquired terminals or established links to companies having terminals to provide their fuel supplies. This has enabled them to enter markets previously dominated by a few firms, has brought prices down, and has made exchange arrangements a thing of the past.

The breakdown to barriers to entry has essentially made most of the country part of one market. Looking at Table 4, one can see an exception, however: Utah. Refineries there sell gasoline and diesel to Nevada, but few products seem to flow into the state, leaving the refiners there with a protected market.

Conclusion: Markets Worked

Hurricane Harvey dealt a serious blow to the nation's petroleum industry, forcing refineries in Houston and the US Gulf to close and cutting product supply. Some facilities remain inoperative as of this writing. However, markets did not respond as in the past. High inventories linked to the success of the futures market, the wider global market served by US refiners, quick action by environmental regulators, and the greater flexibility of the US petroleum distribution system combined to minimize the regional impacts of the Gulf Coast disruption. This modest impact was a triumph for markets.

The International Energy Agency has reached a similar conclusion grudgingly because the successful operation of markets makes it superfluous. Even so, the agency offered, as noted earlier, the following suggestions in an *Oil Market Report* issued just days after Harvey:

> The oil market has coped relatively well with the challenges posed by the hurricane season thus far, but that said, now may be a good time to consider steps to mitigate the impact of future severe-weather events. This could encompass reviewing the robustness of the Gulf Coast energy infrastructure, including production facilities, refineries, crude and product storage capacity, pipelines and marine infrastructure, and what measures can be taken to minimize disruptions to port operations. There is also an opportunity to examine whether more can be done by industry and government working together to strengthen energy security, perhaps including the provision of government-held product stocks in the US.[26]

We have an entirely different perspective. The market functioned as well as it could given the impacts of the storms on production facilities. Furthermore, government officials in environmental agencies acted promptly to ease regulations, which helped increase product supplies. These officials moved quickly, we believe, because they controlled nothing of value. In contrast, government officials who do control something valuable—inventories, in particular—have been slow to react in every crisis, causing significant harm to consumers. Indeed, consumers have always been hurt when industry and governments "work together," to quote the IEA, because only part of the industry is invited to cooperate. History shows that the industry representatives invited have been from the legacy oil companies, not from trading companies or futures exchanges. Such "cooperation" does not benefit consumers.

The success of markets in addressing the chaos following Harvey and Irma demonstrates that the IEA and the idea of coordinated industry/government action is passé. Going forward, we hope the Trump administration recognizes this fact and steps aside from energy markets.

[26] *IEA, "OMR: Ready for a rainy day" (see footnote 2).*

Glossary

Cash-and-Carry Transactions — Cash-and-carry transactions involve the simultaneous purchase of a physical commodity and sale of a future at a higher price to establish a trading profit. Cash-and-carry transactions can only be entered into in contango markets.

CFTC Commitments of Traders Data — CFTC data on Commitments of Traders defines three types of traders: commercials, noncommercials, and nonreporters. *Commercials* are traders who customarily use a futures position to hedge their position in a commodity market. *Noncommercials* are traders who do not use the futures market for hedging. *Nonreporting* traders are those who hold positions that fall below the reporting requirements established by the CFTC. By custom, speculators are defined as noncommercial and nonreporting traders.

Contango — The condition said to exist when forward prices exceed spot prices.

Cost of Carry — The costs associated with holding (or carrying) a commodity or an asset. These include financing costs, storage costs, and insurance costs.

Endogenized Forecast — An endogenized forecast or simulation uses the predicted values of all explanatory variables for the current and prior periods to forecast the next period.

NDTFI—Non-Deposit-Taking Financial Institution.

OPEC Basket — The OPEC basket comprises Algeria's Saharan Blend, Indonesia's Minas, Nigeria's Bonny Light, Saudi Arabia's Arab Light, Dubai of the United Arab Emirates, Venezuela's Tia Juana Light, and Mexico's Isthmus crude (definition from *Platts Global Alert*).

Open Interest — Open interest represents the number of open contracts at the end of trading. By convention, it is the number of long or short positions, not the sum of the positions. An open contract is an obligation to take or make delivery at the expiration of the contract.

Put — An option that gives the buyer, or holder, the right, but not the obligation, to sell a futures contract at a specific price within a specific period of time in exchange for a one-time premium payment. It obligates the seller, or writer, of the option to buy the underlying futures contract at the designated price, should an option be exercised at that price.

Refinery Crack — The spread between the price of products (customarily gasoline or heating oil) and crude (customarily WTI).

Spread Position — As defined by the CFTC, a spread position involves the purchase and sale of futures contracts for delivery of the same commodity, with the contracts having different maturities. For example, a spread trade in gasoline might involve the purchase of a September contract and the sale of an October contract.

Sterilization — Sterilization of a commodity occurs when the commodity is transferred to a storage facility to be held for purposes other than meeting current or near-term demand. For example, the oil held in the strategic petroleum reserves of IEA countries is sterilized.

Sovereign Wealth Funds (SWFs) — "Vehicles that are long of capital at a time when developed Western marketers seem suddenly short of it." (Source" Michael Gordon, *Financial Times*, November 6, 2007); *Technical Definition*: SWFs are pools of capital controlled by

government entities from developing or non-industrialized countries such as Singapore, China, United Arab Emirates, or Kuwait.

Technicals — Indicators of future price trends computed by mathematical formulas from historical price data.

Statistical Appendix

Table S-1. Gasoline Cracks, Returns to Storage, and Open Interest as of 9/15/2017 Compared to Prior Years

	Current	Last Week	Last Month	2016	2015	2014	2013	2012	25-Year Average
Gasoline Cracks* (Dollars per Barrel)									
Spot	18.77	24.46	13.79	13.35	8.57	12.61	0.34	22.91	7.97
November	8.72	8.76	7.70	8.66	7.43	5.90	0.53	6.46	5.46
December	7.58	7.12	6.62	6.28	5.67	3.42	0.57	4.61	4.64
January	7.11	6.64	5.78	5.37	4.88	2.33	1.16	4.01	4.43
February	7.27	6.84	5.63	5.23	4.80	2.19	2.10	4.37	4.61
March	7.79	7.38	5.91	5.54	5.22	2.57	3.24	5.35	5.04
April	14.72	14.55	6.59	12.56	13.21	9.88	10.42	11.88	7.30
Average	10.28	10.82	7.43	8.14	7.11	5.56	2.62	8.51	5.64
Returns to Storage** (Percent at Annual Rates)									2011
October	-87.7	-89.9	-38.2	-17.4	2.8	-16.7	0.1	-76.0	-4.5
November	-65.7	-75.1	-33.5	-31.4	-4.9	-25.6	-4.4	-51.3	-7.8
December	-53.9	-64.8	-29.8	-32.2	-9.4	-23.5	-6.0	-43.4	-8.2
January	-44.9	-55.3	-24.9	-27.1	-7.5	-17.9	-5.3	-39.0	-6.7
February	-37.3	-47.1	-20.3	-21.9	-3.8	-14.2	-3.9	-32.8	-5.0
March	-30.9	-40.1	-14.6	-17.1	0.0	-11.1	-2.5	-27.5	-3.6
April	-13.0	-22.6	2.1	3.1	25.3	1.5	8.1	-17.4	3.4
May	-11.4	-20.0	2.0	3.7	23.6	1.5	6.4	-16.0	2.8
June	-10.9	-18.7	1.0	3.3	20.7	0.7	4.1	-15.3	1.9
Open Interest (Number of Contracts)									
Total	430,225	399,173	417,567	401,775	384,173	291,753	263,646	288,434	275,052
October	77,443	109,744	123,937	68,558	57,830	41,981	48,685	73,427	66,381
November	137,100	96,827	67,429	130,958	115,058	92,518	98,232	76,506	63,293
December	79,536	61,751	56,191	70,830	62,792	41,536	48,312	56,666	45,586
January	44,119	43,082	35,303	27,452	35,509	25,710	21,706	26,344	31,075
February	16,229	13,286	10,974	12,055	17,098	13,830	12,298	10,307	10,886
March	26,914	25,492	17,841	23,820	17,386	17,588	13,225	11,908	12,254
April	14,618	15,203	11,113	19,537	12,926	17,432	7,444	8,350	8,407
May	6,862	6,207	5,113	7,030	12,678	11,018	3,884	4,143	4,179
June	9,289	9,905	9,598	12,511	14,478	9,951	3,636	7,162	12,997

* All gasoline cracks measured against Brent from September 2010 forward with RIN cost removed.

** All returns to storage have been adjusted for the cost of funds using the three-month LIBOR.

Sources: Petroleum Argus, NYMEX, and PKVerleger LLC.

Table S-2. Heating Oil Cracks, Returns to Storage, and Open Interest as of 9/15/2017 Compared to Prior Years

	Current	Last Week	Last Month	2016	2015	2014	2013	2012	25-Year Average
Heating Oil Cracks* (Dollars per Barrel)									
Spot	19.04	19.91	16.39	12.35	14.45	16.91	16.08	19.34	8.32
October	19.59	19.77	15.56	13.70	16.08	15.97	17.00	19.36	8.92
November	19.41	19.40	16.04	13.79	16.19	15.65	17.71	19.68	9.77
December	19.20	19.06	16.31	13.88	16.29	15.47	18.43	19.87	10.32
January	18.69	18.45	16.49	13.86	16.09	15.16	19.03	19.78	10.69
February	17.92	17.72	16.49	13.60	15.52	14.64	19.24	19.34	10.62
March	16.99	16.91	16.28	13.11	14.62	14.10	19.35	18.76	9.93
Average	18.69	18.75	16.22	13.47	15.61	15.41	18.12	19.45	9.80
Returns to Storage** (Percent at Annual Rates)									2011
October	-2.9	-3.9	9.1	11.2	21.0	0.2	-0.3	-4.5	6.2
November	-4.9	-7.3	6.4	9.8	20.1	0.4	-0.2	-2.5	4.6
December	-6.4	-9.1	5.5	10.1	19.3	0.6	-0.3	-2.2	3.6
January	-6.4	-8.9	4.6	10.4	18.7	3.6	-0.4	-0.7	-0.0
February	-7.2	-9.4	3.6	10.2	15.9	3.1	-0.5	-0.8	-0.1
March	-8.2	-9.9	3.7	9.3	13.6	2.2	-0.8	-1.6	0.5
April	-9.4	-10.5	0.9	7.7	11.0	1.4	-1.0	-2.1	-1.2
May	-9.4	-10.2	0.1	6.9	10.2	1.1	-1.3	-2.9	-2.4
June	-9.1	-9.8	-0.3	6.4	10.0	1.2	-1.6	-3.3	-2.8
Open Interest (Number of Contracts)									
Total	449,994	428,727	402,729	395,938	399,871	374,841	288,935	339,579	334,061
October	75,451	99,490	84,485	59,127	47,844	45,268	52,903	85,068	72,632
November	106,962	81,063	52,285	90,606	79,783	81,868	65,710	64,483	70,724
December	76,299	67,423	56,094	62,260	63,603	55,606	46,135	57,141	54,234
January	51,449	46,563	32,779	41,973	38,905	34,392	29,768	34,790	36,890
February	20,946	20,156	18,512	19,866	34,752	30,787	24,912	13,377	13,604
March	29,330	27,565	16,184	27,800	32,007	33,130	12,650	23,389	12,966
April	15,364	13,356	8,755	12,751	24,706	23,563	13,016	24,188	6,917
May	9,340	10,092	7,700	8,858	10,099	8,153	4,258	11,703	5,808
June	24,104	23,517	22,230	24,848	24,305	22,741	17,450	12,547	32,433

* All heating oil cracks measured against Brent from 2011 forward.

** All returns to storage have been adjusted for the cost of funds using the three-month LIBOR.

Sources: Petroleum Argus, NYMEX, and PKVerleger LLC.

Table S-3. WTI Returns to Storage and Open Interest as of 9/15/2017 Compared to Prior Years

	Current	Last Week	Last Month	2016	2015	2014	2013	2012	2011
Returns to Storage (Percentage at Annual Rates)									
October	-1.1	44.6	0.4	-0.6	-4.1	-1.1	-2.1	-0.3	-0.0
November	4.6	23.0	1.1	6.6	1.6	-5.0	-0.6	1.7	1.5
December	5.5	12.9	1.2	11.0	5.5	-5.6	-4.7	2.2	2.1
January	5.5	7.1	1.2	12.9	8.1	-5.0	-7.1	2.5	2.5
February	5.2	3.3	1.1	13.8	9.6	-4.4	-8.3	2.7	2.6
March	4.7	0.4	2.3	14.3	10.4	-4.1	-9.1	2.6	2.8
April	4.1	-2.0	0.8	14.2	10.8	-3.9	-9.6	2.3	2.8
May	3.5	-3.9	0.7	13.8	10.7	-3.6	-9.4	1.9	2.9
June	3.0	-5.5	0.6	13.4	10.4	-3.4	-9.5	1.4	2.9
July	2.6	-6.9	0.4	12.8	10.0	-3.3	-9.5	0.8	2.9
August	2.2	-8.0	0.3	12.2	9.7	-3.2	-9.5	0.2	2.9
September	1.9	-8.9	-1.1	11.7	9.5	-3.1	-9.4	-0.3	2.8
Open Interest (Number of Contracts)									
Total	2,402,765	2,314,727	2,262,844	1,837,689	1,646,515	1,498,764	1,926,391	1,614,522	1,419,069
October	160,272	421,000	499,651	108,655	71,524	48,176	29,351	137,527	79,239
November	530,077	298,449	202,628	499,814	443,979	285,808	357,471	288,554	300,180
December	348,359	333,109	326,935	299,197	270,404	221,675	276,745	208,258	191,737
January	204,745	195,348	153,397	120,588	106,346	89,788	87,866	107,690	98,193
February	83,229	72,380	64,706	73,919	72,066	43,656	57,422	58,085	36,199
March	165,057	140,609	132,784	123,310	87,020	82,175	85,356	63,512	43,185
April	46,946	45,040	37,130	40,039	31,519	34,829	43,298	30,191	25,286
May	46,147	44,396	40,828	30,957	23,387	28,090	41,688	23,548	23,489
June	173,914	166,910	154,285	115,508	111,678	118,362	125,056	95,412	77,794
July	36,605	36,090	31,521	22,110	24,907	30,623	42,130	29,654	37,363
August	26,846	27,439	22,869	18,007	20,521	23,936	37,388	20,830	17,603
September	62,816	55,917	96,943	39,309	43,026	38,611	50,089	30,363	18,492

Note: All returns to storage have been adjusted for the cost of funds using the three-month LIBOR.

Sources: Petroleum Argus, NYMEX, and PKVerleger LLC.

Table S-4. Natural Gas Returns to Storage and Open Interest as of 9/15/2017 Compared to Prior Years

	Current	Last Week	Last Month	2016	2015	2014	2013	2012	2011
Returns to Storage (Percentage at Annual Rates)									
November	8.6	10.5	13.2	11.3	14.0	14.3	18.2	39.1	23.4
December	31.6	33.8	30.1	32.6	33.9	20.7	37.1	72.5	45.6
January	50.4	52.7	43.1	37.2	38.8	17.6	35.7	68.4	45.5
February	35.1	37.6	31.7	30.1	30.5	13.3	26.5	52.7	35.6
March	22.4	25.0	23.5	22.2	22.3	7.7	18.8	41.1	26.9
April	-5.6	-0.6	-2.3	5.5	10.5	-2.2	11.8	33.5	21.3
May	-7.8	-2.5	-4.3	3.3	9.2	-2.6	10.8	31.2	19.7
June	-5.5	-0.7	-2.6	4.0	9.6	-1.5	10.4	29.0	18.8
July	-3.8	0.5	-1.3	4.6	10.1	-0.4	10.2	27.5	18.1
August	-3.7	0.7	-1.1	4.3	9.7	-0.1	9.6	25.2	17.0
September	-4.3	-0.5	-1.3	3.3	8.7	-0.5	8.6	23.0	15.5
Open Interest (Number of Contracts)									
Total	1,332,943	1,312,069	1,329,934	1,042,467	922,579	971,243	1,311,117	1,150,514	970,855
October	157,350	263,510	286,735	114,615	101,886	66,149	59,794	137,498	115,780
November	240,485	165,443	128,061	235,754	261,909	219,865	286,326	250,905	213,620
December	112,643	102,805	92,573	88,278	95,821	88,070	100,803	118,493	83,396
January	144,528	143,845	140,831	146,269	119,930	125,913	184,604	181,653	165,316
February	86,402	76,816	60,993	37,390	30,040	51,851	44,245	34,695	37,099
March	106,098	105,121	86,080	89,435	69,782	67,733	111,668	65,706	51,251
April	122,804	123,979	113,071	78,860	60,648	78,348	132,494	71,851	79,086
May	63,336	53,443	45,467	28,966	22,469	44,110	36,958	27,283	18,170
June	33,467	28,459	26,734	26,698	19,714	25,889	26,116	15,689	13,763
July	29,338	26,693	27,039	16,353	16,441	19,227	23,598	18,202	11,636
August	27,205	27,402	25,909	14,986	19,187	20,683	19,337	11,664	10,287
September	26,207	22,803	126,271	15,533	12,168	14,799	22,668	10,718	8,728

Note: All returns to storage have been adjusted for the cost of funds using the three-month LIBOR.

Sources: NYMEX and PKVerleger LLC.

Table S-5. Brent Returns to Storage and Open Interest as of 9/15/2017 Compared to Prior Years

	Current	Last Week	Last Month	2016	2015	2014	2013	2012	2011
Returns to Storage (Percentage at Annual Rates)									
November	-8.8	-6.1	8.9	-1.2	5.7	10.9	-4.6	-0.7	-16.4
December	-8.0	-6.0	5.8	2.5	9.9	7.1	-6.2	-3.3	-15.3
January	-7.1	-5.5	4.4	4.8	12.2	9.0	-7.0	-3.6	-13.4
February	-6.2	-4.9	3.6	6.2	13.5	8.2	-7.3	-4.0	-11.9
March	-5.5	-4.4	4.5	7.2	14.0	7.6	-7.4	-4.4	-10.9
April	-4.9	-3.9	2.7	7.6	14.3	6.8	-7.4	-4.7	-9.9
May	-4.5	-3.5	2.4	7.8	14.3	6.1	-7.4	-4.9	-9.1
June	-4.2	-3.2	2.2	7.9	14.2	5.5	-7.4	-5.2	-8.5
July	-3.9	-2.9	2.0	7.9	13.9	5.0	-7.2	-5.3	-7.9
August	-3.6	-2.7	1.8	7.8	13.6	4.4	-7.1	-5.4	-7.4
September	-3.4	-2.5	1.6	7.4	13.2	4.0	-7.1	-5.6	-7.1
October	-3.3	-2.4	16.4	7.3	12.9	3.7	-7.0	-5.7	-6.8
Open Interest (Number of Contracts)									
Total	2,363,594	2,312,437	2,381,840	2,121,707	1,971,888	1,369,198	1,500,356	1,170,480	856,384
November	363,067	495,289	465,703	270,684	282,299	273,772	271,246	262,653	207,386
December	547,143	466,495	391,966	506,048	360,929	286,739	274,569	203,866	188,399
January	244,917	191,927	122,651	228,910	194,004	114,578	117,745	88,468	52,390
February	114,653	116,352	91,037	110,794	118,499	56,066	59,064	43,514	26,447
March	153,640	130,093	96,645	167,418	175,134	75,801	66,206	47,302	47,630
April	41,493	40,158	35,459	53,877	95,801	43,056	54,674	23,461	18,427
May	41,170	41,306	34,942	43,974	51,690	32,448	27,905	22,983	14,717
June	143,250	138,548	132,596	121,194	135,729	93,446	118,080	70,808	53,962
July	31,806	29,279	24,128	32,604	36,918	26,432	23,407	23,279	11,767
August	24,927	21,981	21,614	21,632	30,069	25,396	30,505	28,482	8,659
September	42,145	42,394	36,127	50,191	43,722	29,972	31,909	30,876	13,263
October	20,846	20,948	343,949	21,004	20,589	20,964	24,929	27,639	7,154

Note: All returns to storage have been adjusted for the cost of funds using the three-month LIBOR.

Sources: IPE and PKVerleger LLC.

Table S-6. Gasoil Returns to Storage and Open Interest as of 9/15/2017 Compared to Prior Years

	Current	Last Week	Last Month	2016	2015	2014	2013	2012	2011
Returns to Storage (Percentage at Annual Rates)									
October	-2.9	-8.3	3.4	5.1	10.5	12.6	3.6	4.4	4.8
November	-10.3	-13.9	-1.1	5.1	9.9	6.0	0.1	0.4	-0.8
December	-14.0	-16.2	-3.4	5.1	8.7	5.5	-1.6	-2.0	-2.8
January	-13.2	-14.7	-2.8	6.2	9.2	5.1	-2.1	-2.9	-3.3
February	-12.3	-13.3	-2.2	6.9	9.5		-2.8	-3.5	-3.5
March	-11.7	-12.4	-0.7	7.3	9.5		-3.5	-4.4	-3.8
April	-11.0	-11.7	-1.8	7.2	9.2		-3.9	-5.1	-3.9
May	-10.1	-11.1	-1.8	7.2	9.2		-4.2	-5.6	-4.0
June	-9.4	-10.4	-1.7	7.1	9.1		-4.3	-5.7	-3.9
Open Interest (Number of Contracts)									
Total	968,386	940,526	922,461	819,858	787,619	389,883	626,348	603,868	598,974
October	222,120	239,942	216,640	137,516	156,086	158,710	154,307	145,649	148,231
November	164,281	99,506	60,687	102,155	153,594	104,062	115,814	107,655	104,500
December	138,245	134,562	132,165	163,024	121,724	84,785	99,475	85,092	76,676
January	62,616	51,766	46,332	67,452	46,066	42,326	42,757	47,716	61,991
February	42,873	37,873	30,792	37,128	34,532		29,389	25,478	30,890
March	42,315	37,402	27,234	35,454	27,583		32,174	22,253	20,508
April	22,488	18,418	14,657	19,876	24,316		18,798	19,152	15,409
May	15,520	14,275	11,571	14,244	16,771		11,952	12,267	12,521
June	43,158	41,783	49,141	50,407	51,175		44,341	40,328	42,200

Note: All returns to storage have been adjusted for the cost of funds using the three-month LIBOR.

Sources: IPE and PKVerleger LLC.