IMO 2020: ECONOMIC PROSPECTS

With the IMO 2020 rule's imposition, diesel fuel prices could skyrocket, and the 2020 GDP loss might be as much as seven percent.

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SUMMARY

The restriction on shipping fuel sulfur content promulgated by the International Maritime Organization, which is scheduled to take effect in January 2020, has been the subject of hundreds if not thousands of articles. Many have addressed the rule's impact on refineries. Many have examined the prospects for compliance. Many have focused on the economics of ship operations. Some have presented calculations of the supply imbalances created in petroleum markets. A few have offered tentative suggestions regarding the effect on crude oil prices. No one, though, has tried to forecast the impact on economic growth.

This paper offers a first attempt to fill that gap. My initial conclusion is that the regulation will likely cost the global economy a full year's growth. Measured in current dollars, the cost exceeds $4 trillion, given the current rate of global growth and the World Bank's $80 trillion estimate of the current global GDP. The $4 trillion is a nontrivial sum based on any calculation.

Diesel fuel forms the foundation of my analysis. Many of the studies presented by organizations such as the International Energy Agency, Goldman Sachs, and Morgan Stanley address the supply-and-demand imbalance the IMO rule will create. A consensus of global diesel supply falling short of global demand by one million barrels per day seems to have formed.

The shortfall, though, is an ex ante gap, not an ex post gap. Markets clear in the absence of regulation. The global market for low-sulfur gasoil and diesel will clear in 2020 because it is not regulated. It will clear because prices will rise.

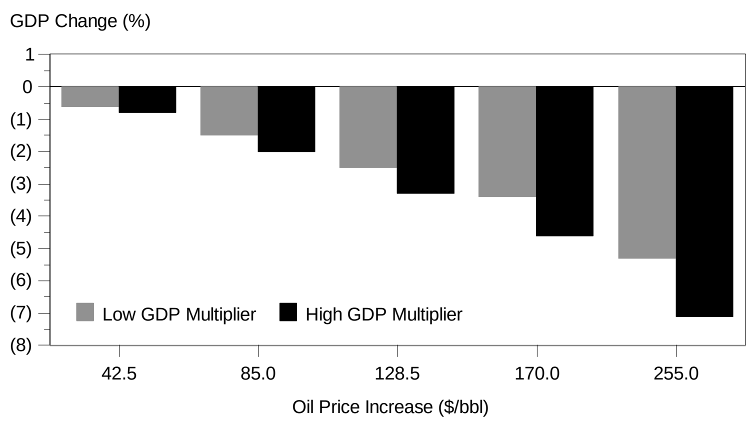
Increases in the politically sensitive retail price of diesel fuel will bring ex post consumption in line with ex post supply. The price increases must be large because the price elasticity of diesel fuel is very low. In the worst case, the retail price in the United States will need to rise one hundred forty percent.

The estimated increases are based on a simple model of demand for diesel in fifteen countries accounting for sixty-two percent of global distillate consumption.
Prices of other petroleum products will be pulled up by the rise in diesel prices. There is general agreement that gasoline prices must increase. Prices of other key products will rise except for heavy fuel oil. The product price increase will pull up crude prices.

There is a historical precedent for such increases. Early this century, new regulations were introduced requiring the removal of sulfur from diesel fuel. Prices rose when shortages developed. An economic recession followed. Professor James Hamilton of the University of California San Diego published a detailed analysis of how higher oil prices in 2007 contributed to the economic recession that, according to the National Bureau of Economic Research, began in December 2007. I use the approach employed by Professor Hamilton here to estimate the IMO 2020 rule's potential impact on the US economy.

I examined this impact under three different supply-and-demand gap scenarios: the consensus case of one million barrels per day, a smaller gap of five hundred thousand barrels per day, and a larger gap of 1.5 million barrels per day. I calculated changes in diesel prices for each gap using two different price elasticities: -0.1 and -0.05. The price increases associated with the gaps range from $30 per barrel to $180, with the lowest increase occurring with a price elasticity of -0.1 and a gap of five hundred thousand barrels per day and the largest increase with a gap is 1.5 million barrels per day and an elasticity of -0.05.

Figure 1
Estimates of Decline in US 2020 GDP Due to Oil Price Increases Induced by the IMO 2020 Rule



Source: PKVerleger LLC.

GDP losses range from 0.6 percent to 7.1 percent of 2020 GDP, clearly a very wide range. Figure 1 shows the GDP decline under two different multipliers that relate the change in consumer spending to changes in GDP. Note that the graph shows five rather six cases because two of the cases I examined produced identical results.

The wide range of the simulations was dictated by uncertainty concerning the IMO regulation's impact and the strength of global economic activity in 2020 when the rule takes effect. The economic effect will be more severe in 2020 if the global economy is growing rapidly, as it was in early 2018 or in late 2007. It will be less severe if an economic slowdown is under way.

While it is obviously too early to estimate the IMO 2020 impact with any precision, one can say that the regulation will likely have a very noticeable and memorable effect if the analyses of the diesel supply-and-demand gap completed by various organizations are close to being correct.

IMO 2020: ECONOMIC IMPACTS

Nobel-laureate and economist Paul Samuelson used to amuse audiences by telling them that equity markets had predicted nine out of the last five recessions. The joke always got a loud laugh.

Samuelson, a great investor, was unfair to markets, though, because they have a far better record than economists in projecting downturns. Economists, in fact, seem not to have forecast any of the last twelve recessions. New York Times writer Jeff Sommer emphasized this point seven years ago:

> Economists have an even worse record [than the stock market], particularly when it comes to predicting downturns. In 1929, for instance, the Harvard Economic Society declared that a depression was "outside the range of probability." Whoops.[1]

Economists also have a terrible reputation when it comes to predicting "Minsky moments" or other types of irrational exuberance that drive asset prices to excessive highs.2 Kindleberger and Aliber explain that such moments are the consequence of "manias" associated with general "irrationality" or "mob psychology."[3] Inevitably, the economic bubble bursts, and, inevitably, economists had failed to predict the financial collapse.

Statements by Ben Bernanke, a good economist and former chairman of the Federal Reserve, demonstrate the point:

> In July 2005 he [Bernanke] was asked by a CNBC reporter whether there was a housing bubble. He replied, "It's a pretty unlikely possibility. We've never had a decline in house prices on a nationwide basis. So, what I think is more likely is that house prices will slow, maybe stabilize, might slow consumption spending a bit. I don't think it's gonna drive the economy too far from its full employment path, though."
>
> In June 2008, six months after the recession began, he [Bernanke] stated, "The risk that the economy has entered a substantial downturn appears to have diminished over the past month or so."[4]

Bernanke missed the impending collapse in housing prices and the recession's start in December 2007. Indeed, Sommers criticizes the entire economic profession for not seeing the leadup to the Great Recession:

> With the benefit of hindsight, we now know that the downturn began in December 2007. Few people realized it at the time. A survey by Blue Chip Economic Indicators that month found that, as a group, economists believed that the economy would grow by 2.2 percent in 2008. Instead, it began to shrink.

In that instance, economists once again missed the signs. A few though, though, have on occasion made prescient forecasts. One famous one was penned in 1919 by John Maynard Keynes in *The Economic Consequences of the Peace*.[5] Keynes served as an adviser to the British delegation negotiating the Treaty of Versailles after World War I. He resigned in frustration because the harsh economic burdens being thrust on Germany and the

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[1] Jeff Sommers, "An Ugly Forecast That's Been Right Before," *The New York Times*, October 8, 2011 [https://tinyurl.com/y9umhfvn].

[2] A "Minsky moment," named after economist Hyman Minsky, is a "sudden collapse of asset prices after a long period of growth, sparked by debt or currency pressures." The definition can be found in many different sources. See L. Randall Wray, "Does the United States Face Another Minsky Moment?" Levy Economics Institute of Bard College [https://tinyurl.com/ydxmdg9a].

[3] Charles P. Kindleberger and Robert Aliber, *Manias, Panics, and Crashes* (New York: Wiley, 2005), p. 36.

[4] David Leonhardt, "Bernanke, Pro and Con," *The New York Times*, December 3, 2009 [https://tinyurl.com/y9tcevlv].

[5] J.M. Keynes, *The Economic Consequences of the Peace* (Cambridge, England: Macmillan and the St. Martin's Press for the Royal Economic Society, 1924 edition, reprinted 1971).

defeated countries were far too heavy to manage. Keynes warned that these would lead to revolution and further chaos. The ascendance of Hitler and the National Socialists proved him correct.

Keynes' foresight in this instance led many authors to adopt the "Economic Consequences" phrase from his book into their titles. One can find thousands of papers and books that incorporate these words. For this reason, I take a slightly different route with the title of this report: "IMO 2020: Economic Prospects."

Many readers here will be familiar with Keynes' seminal volume, although few will have read it. As it has been in print for ninety-nine years, anyone attempting to peruse it will find much of the content obscure. For many, the International Maritime Organization (IMO) is equally obscure. Few know of the organization. Even fewer are aware of its activities. The point of this paper is to make readers cognizant of the organization in general but more importantly to focus attention on one regulation scheduled to take effect January 1, 2020. As shown below, the regulation, if implemented as decreed, could precipitate an economic downturn and "Minsky moment" process, one that might put the IMO-induced recession on par with the Great Recession of 2008 and 2009 in scope and magnitude.

Again, my primary goal here is to inform readers and promote debate on the IMO issue. I focus on estimating the possible economic impact of the marine fuel sulfur regulation. As noted below, my calculations will be sensitive to the economic developments of the next seventeen months. The rule's impact will be large if the US economy keeps expanding strongly, as Treasury Secretary Steven Mnuchin predicted it would at the end of July. The impact will be more moderate should economic activity slow, as could happen if the trade war started by the United States puts a drag on global economic growth.

Background: The IMO and the 2020 Marine Fuel Low-Sulfur Rule

Until recently few readers likely knew much about the IMO, and it is almost a sure bet that few in the general population still know of its existence. Today, to borrow from *Death of a Salesman*, attention must be paid. The marine fuel sulfur rule issued by the IMO may create an economic downturn in 2020 that equals the Great Recession.

How could this happen? The answer is simple. The IMO has set a tight restriction on the sulfur content in marine fuel that takes effect in 2020. The economic consequence of meeting the new standard could be catastrophic: gasoil prices may climb one hundred percent, crude prices might hit $200 per barrel, and global GDP could plummet five percent.

The IMO is a little-known United Nations agency that regulates global shipping. It sets the rules by which all goods move across oceans from port to port. Most shippers abide by these standards because they would likely lose their vessel and cargo insurance if they did otherwise.

Substantial debate has been occurring of late as to the degree of compliance with the IMO's sulfur regulation in its first year or two. The agency is aware of this and, in response, has threatened to declare ships that violate the rule as unseaworthy, which could invalidate their insurance. This risk for shipowners may assure compliance. Previous litigation has shown that the careless disregard of IMO regulations can saddle shipping firms with full liability for their hulls and cargos.[6]

The IMO sulfur rule, should it take effect as scheduled, will have a significant impact on the world petroleum market. Refiners will have to dispose of substantial volumes of the high-sulfur fuel now sold as bunker fuel. The latter will have to be displaced by approximately the same volumes of low-sulfur diesel, low-sulfur gasoil,

[6] See Waterman Steamship Corporation v. Gay Cottons, 444 F.2d 724 No 21767, August 5, 1969 [https://tinyurl.com/yahhkbeq].

and low-sulfur fuel oils, volumes that today are not being manufactured and that the world refining industry may not be able to produce by January 1, 2020.

The global economy will be affected if refiners fall short. Substantial amounts of low-sulfur diesel will have to be diverted from the land-based transportation and construction sectors. The diversion will cause increases in diesel fuel prices similar in magnitude to the 2005-2008 increases that set off the Great Recession.

This paper describes the IMO rule and discusses its possible economic impacts. I argue here that, in the worst case, the rule's implementation could cut US GDP as much as three percentage points in 2020 and begin a recession. Global growth rates would also be affected.

The IMO came into being in 1948 as the Inter-Governmental Maritime Consultative Organization (IMCO), although its first meeting as an agency did not occur until 1959. The IMCO designation was changed to the IMO one in 1982. The organization now has one hundred seventy-three Member States and three Associate Members.

The IMO acts as a specialized agency for the United Nations and is responsible for regulating oceangoing transport. More specifically, it is "the global standard-setting authority for the safety, security, and environmental performance of international shipping." Its purpose is "to create a regulatory framework for the shipping industry that is fair and effective, universally adopted and universally implemented."

Initially, the IMO focused on maritime safety. It then turned its attention to issues such as facilitating international maritime traffic and regulating the carriage of dangerous goods. The IMO became concerned about pollution in the 1960s, and pollution related to oil transportation overseas "caught its eye" following the Torry Canyon disaster in 1967.

In 1973, the IMO adopted the International Convention for the Prevention of Pollution from Ships (called MARPOL, which is short for maritime pollution). It then adopted an updated protocol in 1978 that focused on air pollution among other issues.

Then in 1997, the IMO added a new annex to MARPOL called the International Convention for the Prevention of Air Pollution from Ships. This annex dealt with reducing airborne emissions from ships of sulfur oxides, nitrogen oxides, volatile organic compounds, and emissions from shipboard incineration. It also provided for the creation of Sulfur Dioxide Emission Control Areas (SECAs) in maritime areas close to heavily inhabited areas such as the coasts of Europe, Japan, and the United States.

In concentrating on sulfur, the IMO was following the lead of the world's major environmental organizations. These organizations had battled the petroleum industry for years to get sulfur removed from all fuels but particularly from diesel fuel.

The harm to health caused by sulfur dioxide emitted from burning diesel and other fuels stems primarily from its contribution to particulate matter (PM) in the atmosphere. According to the Union of Concerned Scientists, "sulfur dioxide can react in the atmosphere to form fine particles and poses the largest health risk to young children and asthmatics."[7]

[7] Union of Concerned Scientists, "Cars, Trucks, and Air Pollution" [https://tinyurl.com/y93qamxt].

Sweden led the way in the fight against sulfur emissions. A January 2001 report from the US Energy Information Administration on the transition to low-sulfur fuel notes that Sweden mandated a reduction around 2000 that required the maximum sulfur content of diesel to be cut to ten parts per million (ppm).[8]

The effort to reduce sulfur in diesel began years before Sweden's action, however. A *BusinessWeek* article titled "Diesel Is Fueling a New Kind of Road Rage" chronicled previous attempts to limit sulfur by the United States:

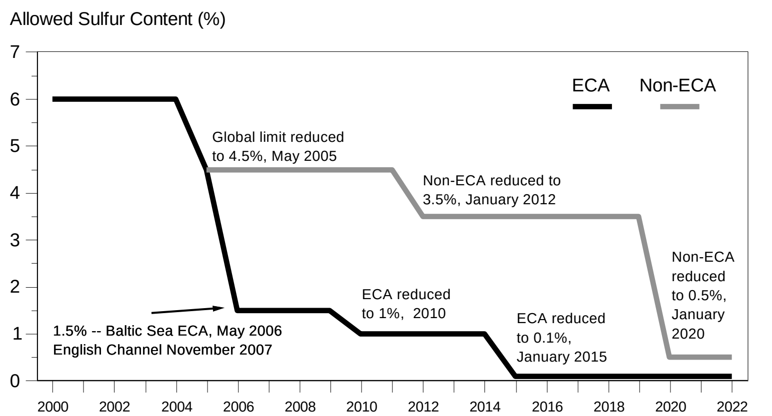
> In 1990 the EPA imposed strict limits on the sulfur content in diesel fuel limiting the maximum content to 3,000 ppm.
>
> Three years later EPA required the standard to be 300 ppm.
>
> Then in 2000 the EPA announced that the sulfur content must be cut to 10 ppm by 2006. This was one of the last environmental actions taken by the Clinton Administration.[9]

The IMO followed the actions of the US Environmental Protection Agency and other regulatory bodies by requiring gradual reductions in the sulfur content of marine fuels.

> Beginning in May 2005, the organization mandated that fuels sold for use on ocean-going ships contain no more than 4.5 percent sulfur.
>
> A year later, in May 2006, the organization ordered that the sulfur content of fuels used in the Baltic Sea Environmental Control Area (ECA) be limited to 1.5 percent. This requirement was extended to the English Channel in November 2007 and to waters off North American coasts in 2012.
>
> The sulfur content limit in ECAs was reduced to one percent in 2010 and to 0.1 percent in 2015.
>
> The sulfur content limit for non-ECA areas was reduced to 3.5 percent in January 2012.

Figure 2 tracks the changes in the IMO sulfur-content limits over time.

Figure 2
MARPOL Annex IV Marine Fuel Sulfur Content Limitations, 2000 to 2022



Source: IMO; PKVerleger LLC.

The regulations that took effect between 2005 and 2006 were adopted in 1997. The delay in their implementation gave the oil industry and shippers time to prepare. Then, in 2008, the IMO agreed to tighten emissions more, particularly on ships sailing the high seas outside of ECAs.

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[8] See Chapter 3, "Desulfurization Technology" in "The Transition to Ultra-Low Sulfur Diesel Fuel: Effects on Prices and Supply," US Energy Information Administration, May 2001 [https://tinyurl.com/ybgokbhg].

[9] Patrick McGuire, "Diesel is Fueling A New King of Road Rage," *BusinessWeek*, September 18, 2000, p. 154.

The rules adopted in 2008 required marine fuel sulfur content to be reduced to 3.5 percent in 2012 and then to 0.5 percent at some point between 2020 and 2025. In 2016, delegates to the MARPOOL meeting agreed that the 0.5-percent rule could take effect in 2020.

Potential Oil Market Impacts of IMO 2020 Rule

It is the 0.5-percent rule that is generating concern. Among other things, it will create large challenges for European refiners that, as Cowell, Bennett, and Lakani note, "have large surpluses of HSFO [high-sulfur fuel oil] that need to be placed elsewhere in the market."[10]

Cowell, Bennett, and Lakani also point out a synergy between refiners and the shipping industry: "Shippers rely on supply of heavy fuel oil (HFO) and marine diesel-gasoil from refiners while refiners rely on shippers as an outlet for a large portion of their HSFO." They add that worldwide HFO production has exceeded four hundred million tons per year (7.6 million barrels per day), with forty-seven percent of the supply going to marine bunkers.

They explain that refiners must find a way to dispose of half the HFO they now produce. Russian refiners, for example, face significant difficulties because they process Urals crude from inland Russia and export much of their heavy fuel oil as bunker fuel. After the IMO regulation takes effect, the Russians will need to find a new market for this fuel.

In a presentation to customers, Rick Joswick of S&P Global Platts displayed a table that more precisely illustrates the heavy fuel disposal issue.[11] A key portion of his presentation focused on the supply-and-demand balance for specific products. I reproduce his table here as Table 1.

Table 1. Shift in Technical Balance of Global Refining Industry between 2017 and 2020 (Thousand Barrels per Day)

New Refining Capacity Will Not Balance Market – Changes from 2017 to 2020	Net Supply	Demand	Long/Short
Gasoline/Naphtha	800	900	-100
Middle Distillate	3,000	4,000	-1,000
HS VGO	-750		
HS VR	-850		
HS Resid/HFO 3% Sulfur	-1,600	-3,000	1,400
Others	500	550	-50
LS Resid	1,100	1,350	-250
Total	3,800	3,800	0

Source: Joswick presentation (see text).

[10] Ken Cowell, Tim Bennett, and Ramin Lakani, "IMO 2020 rules challenge European, Russian refiners–1," *Oil & Gas Journal*, July 2, 2018 [https://tinyurl.com/ydd73jsx].

[11] Rick Joswick, "Making waves: the final countdown to IMO 2020," S&P Global Platts, May 22, 2018 [https://tinyurl.com/ybxv55vx].

Table 1 shows the cumulative changes from 2017 to 2020 in supply and demand for key petroleum products linked to new refinery additions. Column 1 of the table shows the net supply offered, column 2 the change in demand, and finally, in column 3, the change in balance (long or short).

Starting from the top, one notes that the global gasoline supply is projected to increase by eight hundred thousand barrels per day, while demand is projected to rise by nine hundred thousand barrels per day. The difference, a "shortage" of one hundred thousand barrels per day is trivial given the market's size, put by BP in its *Statistical Yearbook of World Energy* at more than 25.6 million barrels per day.

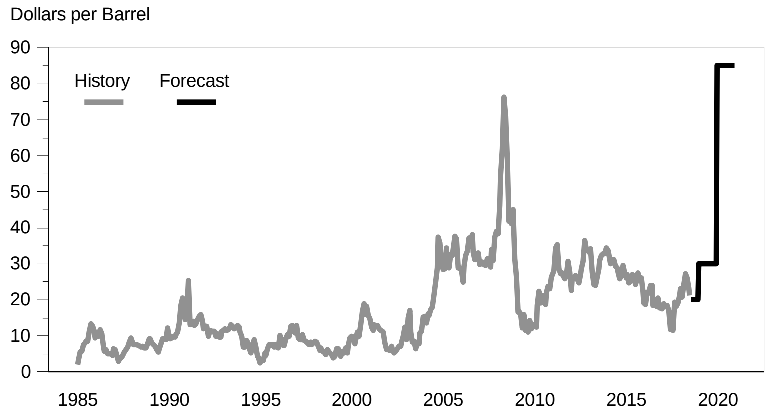
The situation for middle distillate is different. Supply is projected to increase three million barrels per day as new facilities are brought onstream at world refineries. Demand, though, will rise four million barrels per day, leaving an imbalance of one million barrels per day, or 3.6 percent of the world's 2017 consumption.

Demand for low-sulfur residual fuel oil (LS Resid in the table) is also projected to increase 1.35 million barrels per day, with all the fuel going to the maritime industry if supply is available. Joswick sees a shortage of two hundred fifty thousand barrels per day because supply will increase only 1.1 million barrels per day.

Heavy, high-sulfur fuel oil will be in surplus. Joswick sees supply dropping 1.6 million barrels per day as demand drops three million barrels per day.

Market imbalances, of course, are an ex ante, not an ex post possibility, if prices can adjust. Prices will adjust. Thus, analysts at the International Energy Agency, Morgan Stanley, Goldman Sachs, and EnSys/Navigistics, as well as Joswick, have projected price changes. Most of the forecasts concentrate on the change in price spreads rather than the absolute price level. Joswick's initial focus, for example, is on the spread between gasoil and HSFO. This spread traditionally has fallen between $10 and $30 per barrel, except in 2008 when it spiked to $50.

Figure 3
The Rotterdam Gasoil-to-Fuel Oil Price Spread, History and Forecast through 2020



Source: Argus Media; Joswick (see text).

Figure 3 shows my version of a graph presented by Joswick, which was titled "The gasoil-fuel oil spread will widen as distillate demand supports gasoil while HSF declines to compete into the power generation." I note that my graph differs in two ways. First, I use data from Argus Media, not Platts. Second, I present monthly data from 1985 to mid-2018 and then show my view of his projection. The historical data, though, are similar. For example, the average spread in 2008 computed from my monthly data is identical to Joswick's. In both cases, the spread moves within a narrow range until 2005 and then jumps, first by a factor of 3.5 and then doubling. After 2008, it drops back to the $20 to $30-per-barrel range. I note that the 2005 jump coincided with the introduction of low-sulfur diesel in Europe and the US.

Joswick sees the spread widening to a level fifty percent above the 2008 peak of $50 per barrel in 2020 (based on the Argus data). If he is correct, the spread will exceed $100 per barrel in that year.

Analysts at Morgan Stanley see a similar impact. They write that the spread between low-sulfur diesel and HSFO will need to increase from the current $25 per barrel to $87 when the IMO rule takes effect.[12]

Goldman Sachs analysts see the market the same way. They project the spread between diesel and fuel oil to rise to $50 per barrel. Their analysis shows that the previous peak in 2008 was $40 per barrel, not the $50 figure cited by Joswick. Adjusting the data to be comparable, Goldman Sachs sees a $62-per-barrel spread.

The consulting firms EnSys and Navigistics have presented a report to clients that examines the issue in detail. They see an even larger differential of $110 per barrel at the peak.[13]

Table 2 provides a quick recapitulation of the results along with the estimated peak differential in 2008 where provided in the source material. Some analyses also offer projections of gasoline and diesel cracks (refining margins), as shown in Table 2.

Table 2. Various Projections of IMO 2020 Rule Impact on Gasoil/HSFO Spread and Middle Distillate and Gasoline Cracks (Dollars per Barrel)

Study	2020 Gasoil/ HSFO Spread	2008 Gasoil/ HSFO Spread	2020 Middle Distillate Crack	2008 Middle Distillate Crack	2020 Gasoline Cracks	2008 Gasoline Cracks
S&P Global Platts	75	50	40	30	13	25
Morgan Stanley	62		26	40	10	
Goldman Sachs	62	52	20	27	17	15

Source: See text.

While most forecasters project similar large increases in refining margins for diesel and gasoline, as well as substantial declines (losses) in refining margins for residual fuel oil, few take the next step and forecast much higher crude oil prices. Instead, most see crude oil prices rising over the next two years, but none project prices of $100 per barrel. In fact, in Consensus Economics' survey, the highest forecast for Brent was $90. Figure 4 (page 10) displays the mean, high, and low projections of the twenty-eight organizations polled.

These forecasts may prove correct. However, the price refiners pay for crude is tied to product prices. Every refiner computes the value or worth of a crude using the current and projected prices of the products that will be produced from it. This is called the gross product worth. Refiners use this value when they bid for crudes in the spot market.

Refiner bids for a crude will rise if the prices offered by product buyers rise and decline if product prices fall. The crude price will be bid higher and higher if the price of one or more products rises dramatically.

Here there is a real risk that diesel and gasoil prices will shoot up in 2020 if shortages develop. Joswick anticipates a shortfall of one million barrels per day (see Table 1 above). The IEA projects incremental diesel demand to increase one million barrels per day due to the IMO rule but does not forecast a deficiency.[14] Rats et al. of Morgan Stanley project a boost in low-sulfur product demand of 2.8 million barrels per day and suggest

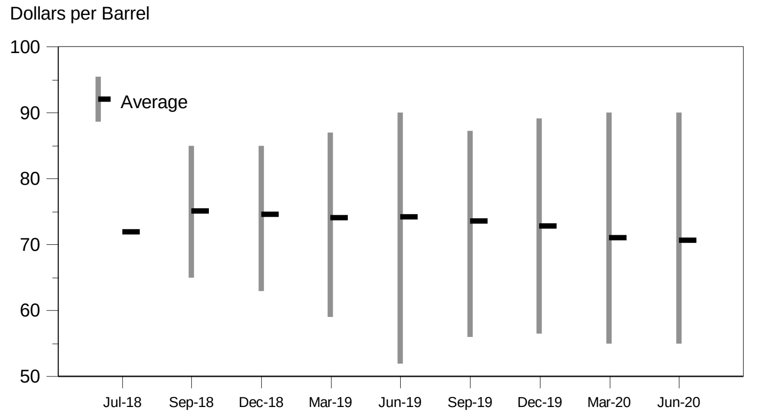
[12] Martijn Rats et al., "Countdown to IMO 2020: Not Plain Sailing," Morgan Stanley Research, May 15, 2018, p. 12.

[13] "Marine Fuels 2020," first-quarter 2018 report, EnSys Energy [https://tinyurl.com/y8kqwzkn], May 31, 2018.

[14] "Oil 2018: Analysis and Forecasts to 2023," IEA, March 5, 2018 [https://tinyurl.com/y7vn39ao], p. 19.

middle distillate demand will rise 1.5 million barrels per day.[15] While they do not predict a shortage, they see global refining runs climbing sharply along with distillate cracks. (Refer back to Table 2. The Morgan Stanley team projects a $26-per-barrel distillate crack.)

Figure 4
Brent Price Projections by Quarter through 2020: High, Low, and Average



Source: Consensus Economics.

Similar forecasts were issued more than ten years ago as preparations began to remove sulfur from diesel fuel used in the United States. A 2001 projection by the US Energy Information Administration expected only a modest price increase when the US began the transition to low-sulfur diesel in 2007.[16] The EIA analysis also foresaw a minimal increase in production costs. In the worst-case scenarios, these rose just ten cents per gallon ($4.20 per barrel). They did note, though, that shortages and greater price increases might occur. Their words may serve as a warning for today:

> The scenarios indicate the possibility of a tight diesel market when the ULSD Rule is implemented. Supply scenarios that assume more cautious investment indicate inadequate supply compared with the demand levels projected in the Annual Energy Outlook 2001. Only more aggressive investment scenarios or lower demand scenarios show adequate supply to meet estimated demand. Furthermore, this analysis compares supply and demand at a very aggregate level. Maintaining a balance of supply and demand across regions and throughout the distribution system could be even more difficult.
>
> If supplies fell short of demand, sharp price increases would likely occur to balance supply and demand. Sharply higher prices would curtail demand for diesel fuel. Truckers would reduce consumption to the extent possible and try to pass higher fuel costs on to customers, who would then look for alternative means to transport goods. In this situation refiners would attempt to maximize ULSD production.[17]

The EIA did not project a price spike, but prices shot up. The IEA attributed the increases to greater use in China as it prepared for the 2008 Summer Olympics and the EU's coincidental shift to low-sulfur diesel. Markets were very tight. Prices rose to clear them.

The same situation will likely occur in 2020. Prices will rise to close the gap between projected supply and demand, as noted by Joswick and others. The increase required to do this will depend on several factors, including

[15] Rats et al., p. 9.

[16] "The Transition to Ultra-Low Sulfur Diesel Fuel: Effects on Price and Supply," US EIA, May 2001 [https://tinyurl.com/ybgokbhg].

[17] EIA, p. xii.

- the size of the "gap" between supply and demand,
- the global economy's growth rate as the IMO 2020 rule takes effect,
- the price elasticity of demand for diesel,
- the government response to the diesel price rise, and
- the refining industry's ability to boost supply quickly.

The gap between global supply and demand is the key determinant of the required diesel price rise. Most analyses, as noted earlier, put the shortfall at one million barrels per day. However, that magnitude is clearly uncertain.

Here I assume the global economy continues to expand at projected rates. The most recent estimates published by Consensus Economics foresee growth of 3.3 percent in 2018 and 3.2 percent in 2019. These rates should result in a continued rise in global distillate use. An increase of six hundred to eight hundred thousand barrels per is expected in 2018 over 2017 and in 2019 and 2020. The increases more than exceed the anticipated boost in world refining capacity.

The price elasticity of demand is thought to be low, between -0.05 and -0.1 for final demand in the short run. Hamilton cites higher estimates for gasoline at around -0.25.[18] Diesel elasticities will be lower because many retailers can pass the higher cost on to customers.

The government response to price increases is also important. Rising diesel prices can roil countries. In May 2018, Brazil's government had to cut diesel prices for truckers through price subsidies to end a nationwide strike that crippled the nation.[19] Such intervention lessens the impact of price increases and cuts the price elasticity of demand.

Finally, refiners' ability to boost supplies as diesel margins climb will affect outright retail prices. That effect, though, is hard to gauge. Rats and his Morgan Stanley colleagues concluded that refiners can do little to boost their per-barrel distillate yield. Instead, they suggest that refiners could meet the incremental demand by processing 1.8 million barrels per day of incremental crude between 2019 and 2021.[20] This seems an unlikely outcome.

Closing the Gap: High Retail Prices

One primary goal for this paper was to estimate the diesel price increase required to close the gap between supply and demand. To do this, I calculated the retail price increase necessary to cut consumption by the gap amount after gathering data on consumption and retail prices (the critical element) in fifteen countries. These nations account for sixty-two percent of global gasoil consumption. Table 3 (page 12) here shows consumption by country. Figure 5 (page 12) presents the retail diesel price in each. The consumption data are for 2017 and the price data for early 2018.

After collecting these data, I calculated the retail price increase needed to close supply-and-demand gaps of five hundred thousand barrels per day, one million barrels per day, and 1.5 million barrels per day using price elasticities of -0.05 and -0.1.

[18] Hamilton (2009), p. 218.

[19] Alexandra Alper and Maria Carolina Marcello, "Petrobras slashes diesel prices to ease Brazil trucker protest," Reuters, May 23, 2018 [https://tinyurl.com/y998r27d].

[20] Rats et al., p. 11.

Table 4 (page 13) presents the resulting price increases in dollars per barrel. Note that these are not cost-based increases such as those calculated from refinery models used by Platts and many investment banks. Rather, these are calculations of the price required to balance the market.

I converted the estimated diesel prices shown in Table 4 into estimated values for Brent crude oil at a European hydroskimming refinery. The results are shown in Table 5 (page 13).

The results presented in Table 5 represent the core of this analysis. For this reason, a detailed explanation follows.

Table 5 presents the estimated product yields (percentage of the crude processed) and gross product worth (weighted average of product prices) for a hydroskimming refinery processing Brent. A hydroskimming refinery is the simplest of the types of refineries operating today. These facilities cannot upgrade the residual fuel oil produced in the refining process, as can the more advanced coking and cracking refineries. For this reason, the refinery example used here converts thirty-eight percent of the crude processed to residual fuel oil.

I examine the economics of Brent crude because Brent is the international benchmark. Note that the current GPW is $79.25 per barrel while the Brent price is $74.

I chose a hydroskimming refinery for this calculation because these units are the least profitable and most vulnerable to being shut down. They are the economist's marginal units. Thus, their decision to stay in operation or close will be a strong factor affecting crude prices.

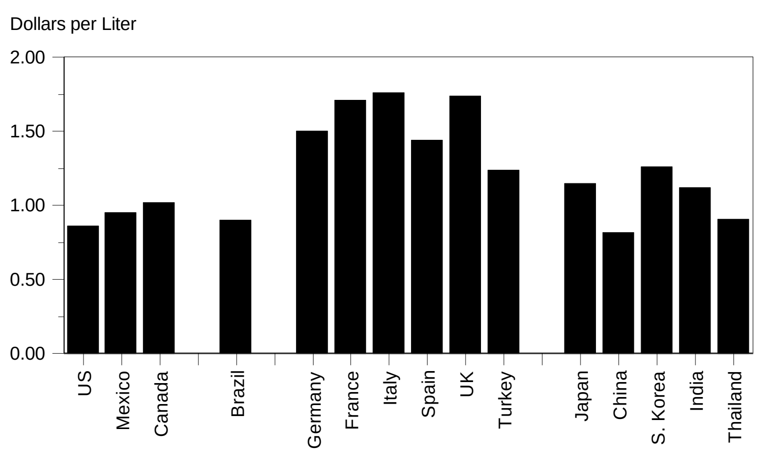
Cowell, Bennett, and Lakani note in their analysis that many European coastal refineries fall into the hydroskimming category and that these "have a high yield of residual fuel oil

Table 3. Diesel Fuel Consumption in Fifteen Countries and Global Total (Thousand Barrels per Day)

Country	Consumption
North America	
United States	3,938
Mexico	394
Canada	582
South America	
Brazil	944
Europe	
Germany	1,132
France	976
Italy	553
Spain	630
United Kingdom	655
Turkey	480
Asia	
Japan	771
China	3,485
South Korea	507
India	1,633
Thailand	414
Total	17,094
BP Global Total	27,775
Fifteen Countries as % of World Total	62

Source: Energy Intelligence Group; BP *Statistical Review of World Energy*.

Figure 5
2018 Average Retail Diesel Prices in 15 Countries



Source: PKVerleger LLC.

reflecting the relatively small coking and residual hydroprocessing capacity in place in European refineries compared to North America" (page 54). They also note that the operators of these refineries will likely bid aggressively for very low-sulfur crude oils that allow them to produce fuel oil with less than 0.5-percent sulfur. This bidding will drive up sweet crude prices.

Table 4. Diesel Price Increase Required to Achieve Needed Global Diesel Consumption Reduction under Two Price Elasticities (Dollars per Barrel)

Consumption Cut	Price under Elasticity -0.05	Price under Elasticity -0.1
500 mbd	$60	$30
1 million MBD	$120	$60
1.5 million MBD	$180	$90

Source: PKVerleger LLC.

Table 5 presents my calculation of GPW and the implied Brent price under six distillate supply-and-demand gap cases. Note that I increased the diesel and gasoil prices shown in the scenario columns by the increments shown in Table 4. For example, the diesel price rises to $267 per barrel in the most extreme case.

Table 5. GPW of Brent Crude for a European Hydroskimming Refinery under Six Distillate Supply-and-Demand Gap Scenarios and Brent Price Implied by the GPW (Dollars per Barrel)

			Price Elasticity -0.05			Price Elasticity -0.1		
Product	Yield (%)	Current Price	500 mbd Gap	1 million MBD Gap	1.5 million MBD Gap	500 mbd Gap	1 million MBD Gap	1.5 million MBD Gap
Propane	0.69	49.45	94	154	214	64	94	124
Butane	1.95	49.27	94	154	214	64	94	124
Naphtha	8.00	67.23	115	175	235	85	115	145
Premium Gasoline	12.86	89.01	134	194	254	104	134	164
Jet Kerosene	10.00	87.72	148	208	268	118	148	178
Diesel 10 ppm	19.77	87.30	147	207	267	117	147	177
Gasoil 0.2% Sulfur	8.47	85.12	145	205	265	115	145	175
Fuel Oil 0.77% Sulfur	38.19	73.00	37	37	37	37	37	37
GPW		79.25	99	136	173	81	99	118
Implied Brent		74.00	94	131	168	76	94	113

Source: Refinery yields – EIG; International Crude Oil Handbook 2010; PKVerleger LLC.

The prices for other products were calculated as differentials to diesel based on projections of the changed relationship between diesel and the specific product. For example, most observers believe the refining margin for gasoline that currently exceeds diesel by $2 per barrel will drop to a discount of $15. Thus, the gasoline price shown in the Table 5 forecasts is set $15 per barrel less than the distillate price. In similar fashion, the discount of fuel oil to gasoline increases from $15 per barrel to $50.

The key results appear in the table's bottom two rows. I see the GPW rising to $173 per barrel from $79 in the most extreme case, which assumes a supply-and-demand gap of 1.5 million barrels per day and a price elasticity of -0.05. Brent would rise to $168 per barrel in this case. The price increase would be less if the supply-and-demand gap were only one million barrels per day. In that instance, Brent might rise to $131 in the low elasticity case or $94 in the higher elasticity case.

These calculations provide a basis for assessing the impact of the IMO regulation on the US and global economies. As noted at the outset, oil price increases have contributed to all economic slowdowns since 1973. Examining the last substantial price increase, which occurred from 2006 to 2008, will also help us assess the IMO 2020 rule's possible economic impacts. I do this in the next section.

2020 versus the Events of 2007/2008

The economic profession, including Ben Bernanke, failed to anticipate the recession of 2008 for one simple reason: it and he discounted the impact of oil prices on the US and global economies. They treated the steep rise in oil prices—and retail gasoline prices—as statistical noise, that is, an unimportant economic event. This was a mistake.

For example, *The Wall Street Journal* polled fifty-four economists in December 2007. Table 6 presents their projections for quarterly and yearly growth in 2008. On average, these economists expected growth of 2.2 percent in 2008. Instead, GDP declined 2.7 percent, an error of five percentage points.

Figure 6 tracks Brent's rise and fall from January 2005 to December 2009. Prices had already increased to $90 per barrel when the WSJ forecasts were prepared in late 2007. However, much of the rise occurred during the three or four previous months and had not registered yet in the macro data or the minds of the forecasters.

Table 6. Real GDP Increase Projections vs. Realizations in 2008

	Actual	WSJ Survey
Q1	-2.3	1.5
Q2	2.1	2.1
Q3	-2.1	2.5
Q4	-8.4	2.7
Q4:08 over Q4:07	-2.7	2.2

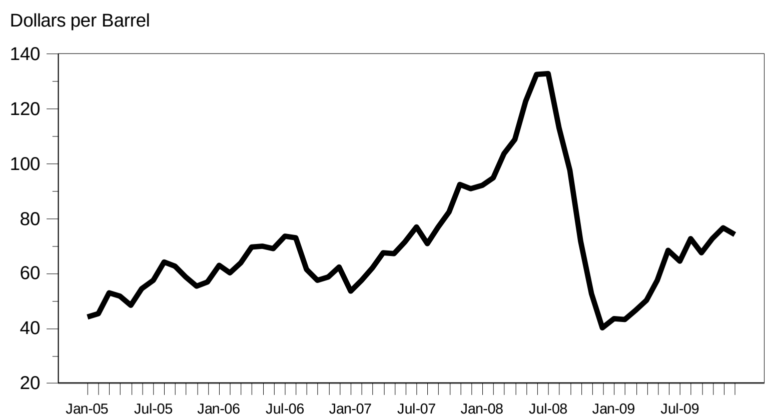
Source: US Bureau of Economic Analysis; *The Wall Street Journal* (see text).

Of course, the surveyed economists could claim rightly that they did not see the Bear Sterns or Lehman Brothers collapses coming. They could also assert that the nearly nine-percent decline in GDP in the fourth quarter of 2008—the economy's Minsky moment—could not have been projected.

The forecasting error for the first quarter of 2008, though, stands out. Oil prices had been rising steadily for a year. Retail gasoline prices had already increased twenty percent. Furthermore, there were widespread warnings that prices could rise more. GDP forecasters, though, were uninterested in energy. Thus, they foresaw growth of 1.5 percent in the first quarter of 2008. GDP declined 2.3 percent, a 3.8-percent error.

While mainstream economists ignored the oil price rise, at least one economist warned of the coming recession, although the timing of the prediction was off. The economist was the author of this report. He warned at the end of 2005 in a paper titled "Hundred Dollar Oil, Five Percent Inflation, and the Coming Recession" that economic growth could pull crude prices above $100 per barrel in 2006. The price increase, in his view, would force the Federal Reserve to raise interest rates, which would slow output growth and lead to a

Figure 6
Dated Brent Prices, Monthly Data, January 2005 to December 2009



Source: PKVerleger LLC.

recession. He added, "This recession, like the previous three instances, will be caused by constraints in the energy sector."[21]

Today, in mid-2018, the world confronts yet another oil shock. Once again, the economic profession is ignoring the issue. Yet again, an oil price rise threatens global economic stability. Once again, senior economic policymakers could be surprised. Furthermore, as in 2007 and 2008, the recession could lead to another "Minsky moment" in which the downturn begun by rising oil prices ignites another financial crisis for which no one is prepared.

The origins of the coming troubles are precisely the same as the origins of the 2008 experience: an obscure regulation governing the nature of large quantities of fuels sold for commercial purposes. The 2006 article explained that the recession would occur because the global energy industry lacked the capacity to "*transform* raw energy supplies into the product volumes needed and demanded by consumers" and that the constraint could limit economic growth for several years.

A key sentence in "Hundred Dollar Oil" stated, "The adoption of new regulations requiring sulfur reduction in diesel fuel imposed by China, the European Union, India, and in 2006, the United States, will cut into the diesel fuel supply next year."

The forecast presented, like all forecasts, was imperfect. Crude oil prices did not touch $100 until February 2008, more than twenty-five months late according to the view expressed in "Hundred Dollar Oil." The expected recession, though, did begin in December 2007, and, as explained by James Hamilton in "Causes and Consequences of the Oil Shock of 2007-2008," it was caused initially by high oil prices.[22]

Hamilton notes that the oil market disruption of 2007 and 2008 was different from previous shocks, which had been caused by interruptions in supply. The 2007/2008 disruption was cause by "strong demand confronting stagnating world production." Hamilton found that the impact on the economy was like that of earlier episodes, including significant effects on consumption spending and purchases of domestic automobiles. He adds that, absent these effects, there would have likely been no recession from the fourth quarter of 2007 through the third quarter of 2008.[23]

The Hamilton paper presents a highly aggregated analysis of global oil demand that highlights the increase in consumption and crude oil prices. Missing from the analysis, though, is a focus on the constraint caused by regulations relating to fuel sulfur content, the point made by Verleger. Thus, Hamilton notes that Chinese use of oil had surged but fails to note that China had also imposed strict regulations on diesel fuel sulfur content to reduce pollution during the 2008 Summer Olympics.[24]

The value of the Hamilton study, though, is not its incorrect analysis of the disruption's source, which is not important, but rather in the diagnosis of the impact of higher oil prices on the consumer and the global economy. In his view (and ours), the "key parameter for determining the consequences of an energy price increase is the *value share* of energy purchases in total expenditures" [emphasis added].[25]

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[21] Philip K. Verleger, Jr., "Hundred Dollar Oil, Five Percent Inflation and the Coming Recession," *The International Economy* (Winter 2006), pp. 16-19 [https://tinyurl.com/ybz37q5d].

[22] See James D. Hamilton, "Causes and Consequences of the Oil Shock of 2007-2008," Brookings Papers on Economic Activity (Spring 20009) [http://goo.gl/6DXh6b], pp. 215-261.

[23] Hamilton, p. 215.

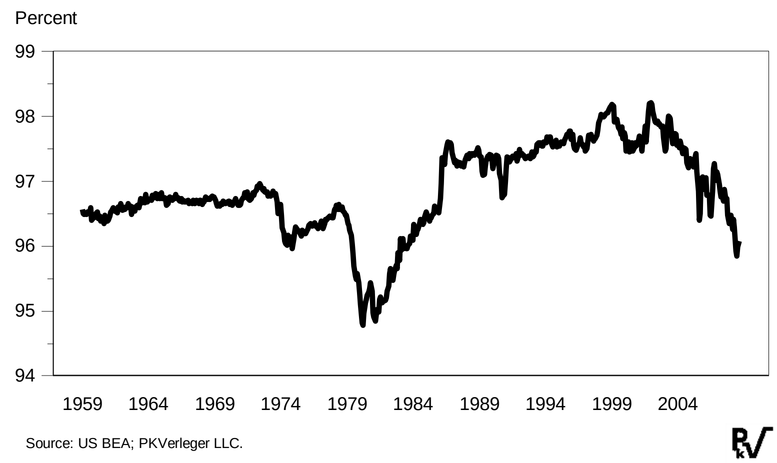
[24] See Philip K. Verleger, Jr., "Understanding Price Behavior During Oil Market Disruptions," *The Petroleum Economics Monthly*, March 2018.

[25] Hamilton, p. 218.

The value share of energy expenditures is measured as the percentage of total consumer expenditures accounted for by energy. In "Causes and Consequences," Hamilton shows that energy consumption expenditures declined steadily from 1959 to 2000 from 7.5 percent to five percent of total spending. However, as he explains, "subsequent energy price increases produced a dramatic reversal of this trend, with the share in 2008 rising to almost twice the 2002 value."[26] Hamilton presents data on consumer energy expenditures as a share of total personal consumption expenditures from January 1959 to September 2008.

Figure 7 replicates Hamilton's graph with one minor change. There, I show consumer energy expenditures on items other than motor fuel, the only volatile component of consumer energy expenditures, as a percentage of total personal consumption expenditures (PCE).

Figure 7
US Consumer Share of Income Not Spent on Motor Fuels, January 1959 to September 2008



Hamilton then extends his analysis to the impact of higher oil prices on consumption, offering this explanation for consumer behavior:

> One short-run option for the consumer (and indeed, given the empirical evidence reviewed above, not a bad approximation to what actually happens) is to continue to purchase the same quantity of energy as before. If income cannot be increased, this would require that the consumer either reduce saving or cut spending on other items.[27]

Hamilton then dissects the consumer response to a twenty-five percent gasoline price increase (recall that gasoline prices rose twenty percent in 2007). He reports his findings:

> The first is the magnitude of the real PCE response: following a decline that eventually would have reduced consumers' ability to purchase nonenergy items by 1.7 percent, consumers on average eventually cut their spending by 2.2 percent. Why should consumption spending fall by even more than the predicted upper bound? The second surprising aspect concerns timing: although the change in price immediately reduces purchasing power, the biggest declines in total spending do not appear until six months or more after the initial shock.[28]

After digging through the data in detail, Hamilton finds the answer in the ways consumers spend. Expenditures on services and nondurables are not affected significantly. The impact of a higher energy price is five times greater on expenditures on durables such as autos. Hamilton notes that a twenty-percent increase in energy prices would result in a ten-percent cut in expenditures on motor vehicles within two months.

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[26] Hamilton, p. 219.

[27] Hamilton, pp. 240-241.

[28] Hamilton, p. 242.

In a provocative table, Hamilton calculates the impact on GDP growth in several oil price cycles under the assumption that sales of autos were not affected by the oil price rise. The table (Table 7 here) suggests that the price increase causes roughly a 0.7 percentage point decline in spending on autos. As he speculates, the price rise could be linked to consumer concern over the cost of vehicle operation and job security.

Table 7. Growth of Real GDP in Oil Shock Episodes under Alternative Scenarios (Percent)

Period	Actual	Without Automobiles	Without Oil Shock (Blanchard/ Gali)	Without Oil Shock (Hamilton)
Pre -2000 Recessions				
1974Q1-1975Q1	-2.5	-2.0	-0.1	2.3
1979Q2-1980Q2	-0.4	0.4	0.4	2.5
1981Q2-1982Q2	-1.5	-1.3	-2.0	2.0
1990Q3-1991Q3	-0.3	0.2	0.5	3.6
2007-08 Recession				
2007Q4-2008Q3	0.7	1.2	1.4	4.2
2007Q4-2008Q4	-0.7	-0.0	-0.2	3.2

Source: Hamilton (see text); Oliver Blanchard and Jordi Gali, "The Macroeconomic Effects of Oil Price Shocks" in *International Monetary Policy* (Chicago: University of Chicago Press, 2008).

Hamilton concludes by focusing on the large vehicle sales, particularly those of trucks and sport utility vehicles (SUVs). He finds that rising gasoline prices combined with falling incomes contributed to a large decline in these sales. Ultimately, though, the impact spread to all vehicles. He concludes that "the first half of 2008 saw not just a big decline in auto purchases but also a slowdown in overall consumer spending and a big drop in consumer sentiment, again very much consistent with what was observed after earlier oil shocks."[29]

Hamilton presented his paper at a conference sponsored by the Brookings Institute. Included with the published paper are the comments of some notable economists, many of whom were surprised to learn in 2009 that the oil price rise had contributed to the Great Recession—or at least to the slowdown from the fourth quarter of 2007 to the second quarter of 2008. However, a careful reading of the comments leads one to conclude that the oil price rise had contributed to a slowdown, although as one commentator noted, oil prices were not the sole cause of the recession.

Whatever its import for the Great Recession, Hamilton's approach provides a way to assess the impact of the IMO 2020 rule on the US economy. Furthermore, based on historical relationships, one can infer its impact on the global economy. In the sections that follow, I lay out my calculations of the rule's potential effect.

Potential Impacts of the IMO 2020 Rule on the US Economy with Implications for Global Economic Activity

Professor Hamilton's assessment of the impact of higher oil prices on the US economy in 2008 provides a basic framework for gauging the impact of the increases expected to result from the IMO rule's imposition. The central piece of the analysis is the share of consumer expenditures spent on motor fuels compared to the share of expenditures on all other items.

[29] Hamilton, p. 251.

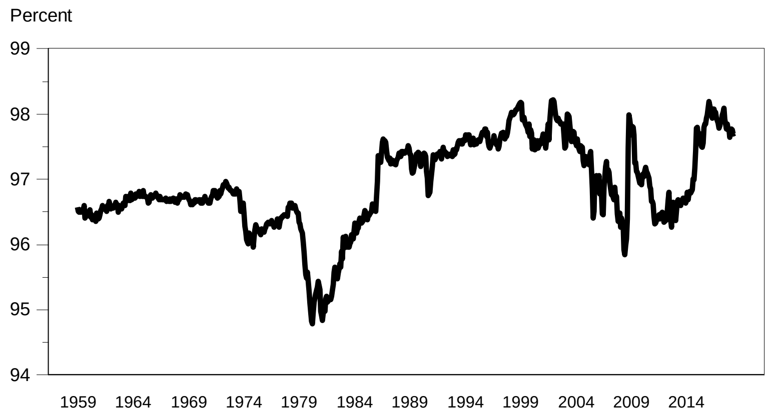
Many writers have noted that an oil price increase acts like a tax on the economy. The higher prices force consumers to spend a much larger share of their budgets on fuel because the price elasticities of demand for fuel are so low. Consequently, consumers cut spending on other items, dig into capital (savings), or increase debt. As Hamilton and I have both explained, the evidence shows that spending on nonenergy items is always reduced.

Hamilton also notes that it is expenditures on consumer durables that suffer the largest reductions. Auto sales, reported as consumption of durable goods, are particularly affected.[30]

The decline in consumption of goods and services other than gasoline acts as an economic depressant. Restaurant patronage will decline, for example, causing those employed in the sector to be made redundant or earn less. Car sales will decrease, leading to reduced output at auto plants and less activity at auto dealerships. Fewer pleasure trips will be taken, leading to lower income and employment in the airline industry and the hospitality sector. The list goes on. Those losing hours, income, or jobs will spend less, and the reduction in economic spending will multiply. The "multiplier" effect will lead to lower GDP.

I base my calculation of the economic impact of the IMO 2020 rule's implementation on a projection of the share of consumer dollars not spent on motor fuels. The analysis began with the data cited by Hamilton. Figure 8 here presents data on the percentage of consumer expenditures not spent on motor fuels by month from 1959 to June 2018. The percentage is calculated by dividing nominal dollar expenditures on everything but motor fuels by the nominal dollar expenditures on everything.

Figure 8
US Consumer Share of Income Not Spent on Motor Fuels, January 1959 to June 2018



Source: US BEA; PKVerleger LLC.

In the calculation, I used the most recent release of PCE data. These data were issued at the end of July 2018 and represent a reassessment of expenditures back to 2014 based on new survey material.

I then conducted a test to determine whether the relative gasoline price (the deflator for expenditures on motor fuels divided by the deflator for total personal consumption expenditures) could explain the shift in the percentage. To do this, I regressed the change in the percentage of expenditures spent on everything else on the change in the relative gasoline price. (I used first differences in the regression to remove any correlation with a time trend.)

The result is shown on Figure 9 (page 19). This graph compares the actual percentage of PCE not spent on motor fuels to the predicted level from January 2015 to June 2018. Note that I based the predicted values shown in the graph on the actual share in December 2014 and the changes in the relative gasoline price in the forty-two following months with no error correction.

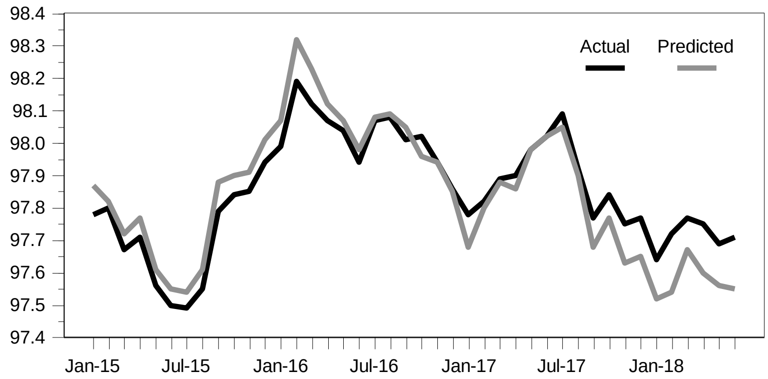
[30] Hamilton, p. 248.

I then used this formula to project the share of consumption not spent on motor fuels in 2020 based on my estimates of the relative gasoline prices that would prevail in 2020 in the six cases discussed above. Figure 10 shows a history of the relative gasoline price from 2000 to 2018 and the price in 2020 for the six scenarios.

Note that the projected prices were based on the gasoline price increases shown in Table 5, which presented product prices under the six supply-and-demand gap cases. Here I assumed a dollar-for-dollar passthrough of the spot gasoline price to the retail price in each case. This permitted the calculation of a percentage change in retail gasoline price and the percentage change in the deflator for personal consumption expenditures on gasoline (which closely tracks the retail price).

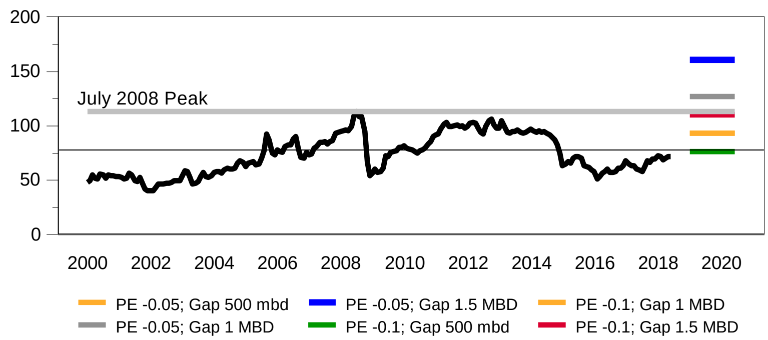
I also projected the deflator for personal consumption expenditures. I assumed the overall rate of inflation would hold at two percent.

Figure 9
US Consumer Share of Income Not Spent on Motor Fuels vs. Predicted Share, January 2015 to June 2018



Source: US BEA; PKVerleger LLC.

Figure 10
Relative Price of Gasoline: History and Gap Scenario Projections, January 2000 to June 2020



PE = Price Elasticity
Note: The PE -0.05 Gap 500 mbd and PE -0.1 Gap 1 MBD cases have the same value.
Source: PKVerleger LLC.

Figure 10 shows the relative gasoline price that would prevail under the six cases. Note that the projected relative price under the shortage case of one million barrels per day with an elasticity of -0.05 takes relative prices slightly higher than the previous peak in 2008 (marked with a horizontal line). This suggests the IMO 2020 regulation could have a significant impact on GDP, especially since the price increase would last longer.

I used the relative gasoline price levels to project forward the share of personal consumption expenditures on everything except motor fuels. The results appear in Figure 11 (page 20). The horizontal line shows the previous low for this percentage set in July 2008. Again, the one-million-barrel-per-day shortfall with an elasticity of -0.05 takes the economy back to the 2008 situation.

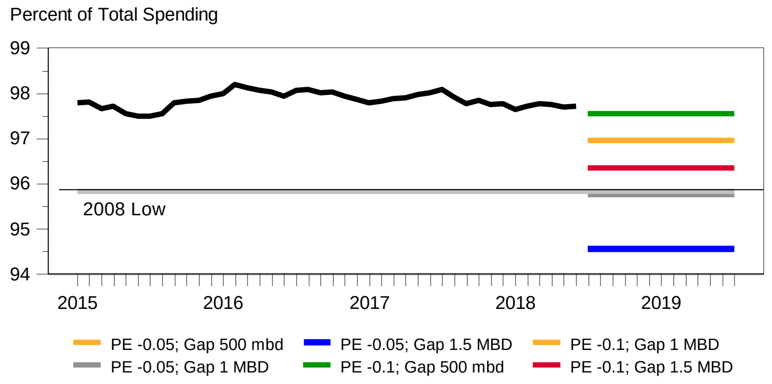


Figure 11
Actual vs. Projected Consumer Expenditures on Everything But Motor Fuels, January 2015 to June 2018 and Projected to 2020

PE = Price Elasticity
Note: The PE -0.05 Gap 500 mbd and PE -0.1 Gap 1 MBD cases have the same value.
Source: PKVerleger LLC.

I next used these results to estimate the impact of the IMO 2020 rule on US GDP, which I present in Table 8 (page 21). The calculation is complicated. I have inserted row numbers in the table's left-hand column to make it easier to follow my explanation.

Row 1 shows the gasoline price increase associated with each scenario in dollars per barrel. Row 2 shows the increase in dollars per gallon.

Row 3 shows the current or base gasoline price as reported by the US Department of Energy. It is the same in all six cases. Row 4 shows the price adjusted for the scenarios, which is calculated as the base price plus the increase shown in Row 2.

Row 5 shows the current price index for gasoline in the national accounts. It is the same for all six cases. Row 6 shows the adjusted index, which represents the current price index adjusted by the percentage increase calculated as the adjusted gasoline price divided by the current price.

This index is used to predict the share that will be spent on everything but gasoline. The estimates are presented in Row 8. These values are same as those shown in Figure 11.

Finally, I converted the shares into dollars. The estimates (in millions of current dollars) are shown in Row 9. I based these estimates on a projection of 2020 total personal consumption expenditures of $14.8 trillion. This amount represents a 3.6-percent-per-year increase from current levels.

Row 9 shows the percentage decline in personal consumption expenditures from levels that would have prevailed had there been no fuel price increases. These range from negative 0.4 percent to negative 3.6 percent.

I show the GDP impacts in Rows 10 and 11. In Row 10 (Low Case), I used a multiplier of 1.5, meaning an additional fifty cents was cut from GDP for every dollar lost due to a drop in expenditures on everything but motor fuels due to higher prices. In Row 11 (High Case), I use a multiplier of 2.0.

The impacts range from negative 0.6 percent in the high elasticity case with a gap of only five hundred thousand barrels per day to negative 7.1 percent where the gap is 1.5 million barrels per day and the elasticity is -0.05. The range is obviously wide. In my view, the most likely case is where the gap is one million barrels per day and the price elasticity is -0.05. This suggests that the loss in US GDP may be on the order of three to four percent.

Mitigating Factors

I predicated the forecasts presented here on predictions that the imposition of the IMO rule will create ex-post shortages of diesel fuel. Higher prices, of course, would resolve the issue, meaning at the end of the day there would be no shortages. I note, however, that the projections of shortfalls rest on supply-and-demand forecasts that apparently assume the global economy keeps expanding at the current torrid pace. There are reasons to doubt these projections.

Table 8. Potential Impact of IMO 2020 Rule on US Consumer Expenditures on Everything But Motor Fuels and US GDP under Six Distillate Supply-and-Demand Gap Scenarios

Row Number		PE -0.05 500 mbd Gap	PE -0.05 1 Million MBD Gap	PE -0.05 1.5 Million MBD Gap	PE -0.1 500 mbd Gap	PE -0.1 1 Million MBD Gap	PE -0.1 1.5 Million MBD Gap
1	Gasoline Price Increase ($/bbl)	45	105	165	15	45	75
2	Gasoline Price Increase ($/gal)	1.07	2.50	3.39	0.36	1.07	1.79
3	Base Gasoline Price ($/gal)	2.865	2.865	2.865	2.865	2.865	2.865
4	Adjusted Price ($/gal)	3.94	5.37	6.79	3.22	3.94	4.65
5	PCE Index Price	71.8	71.8	71.8	71.8	71.8	71.8
6	Adjusted PCE Index Price	93.07	126.84	160.62	76.18	93.07	109.95
7	% of PCE Spent on Items Other than Motor Fuels	96.77	95.53	94.30	97.39	96.77	96.15
8	Dollars Spent on Items Other than Motor Fuels (Millions)	14,355	14,172	13,988	14,447	14,355	14,264
9	Reduction in PCE in 2020 as % of Base PCE	-1.0	-2.3	-3.6	-0.4	-1.0	-1.7
10	Possible Reduction in US GDP – Low Case (%)	-1.5	-3.4	-5.3	-0.6	-1.5	-2.5
11	Possible Reduction in US GDP – High Case (%)	-2.0	-4.6	-7.1	-0.8	-2.0	-3.3

Source: PKVerleger LLC.

First, the economic situation in China is uncertain. Hundreds of articles have been written on the apparently shaky finances that underlie much of China's economic activity. Some have cautioned that the country faces a Lehman-type Minsky moment. These warnings have been largely discounted.

Economic activity in China does seem to be slowing, though. The country's imports of key materials are off substantially. The most significant impact of this can be observed in copper prices, where the decline (shown in the Yahoo Finance graph included below) reflects a drop in Chinese demand. Chinese demand for oil seems to have fallen as well.

The trade war with the United States could further dampen activities in the country. US officials have boasted that they expect China to "sue for peace" as its economy slows. They could be correct. It is equally possible that China will match the United States on tariffs while accepting lower growth. Actions taken recently point in this direction.

Second, some believe the US economy is headed for a slowdown. The economists surveyed by *The Wall Street Journal* in July see US economic activity slowing from an annualized rate of 2.9 percent in 2018 to 2.3 percent

in 2019 and 1.8 percent in 2020. Polls of economists done by other organizations point the same way. An escalation of the trade war will likely make the slowdown worse.

Third, economic activity in other parts of the world also appears to be decelerating. Growth in Europe will be below two percent in 2019 according to Consensus Economics. Growth in Latin America could brake as well, especially given the difficulties in Brazil.

Slower global growth—or even slow global growth—would cut on-land diesel demand. Slow global growth combined with a trade war would reduce the amount of goods moving in international trade, which would lower the maritime industry's demand for fuel. Slow steaming—the operation of vessels at, say, fourteen knots rather than eighteen knots—would further cut maritime demand.

Slow growth, then, could solve the problem. The adjustment related to the IMO 2020 rule could be made without difficulty if global economic activity expanded by, say, two percent rather than the four percent used in the IEA's March 2018 medium-term outlook.

Perhaps the conclusion, then, is that growth must slow. Otherwise, the imposition of the IMO rule will cause economic collapse, if other factors do not do so first.

Will This Time Be Different?

The IMO's marine fuel sulfur-content regulation threatens to disrupt the global oil market, especially regarding gasoil and distillate fuel. Supply-and-demand imbalances of as much as one million barrels per day have been predicted for the gasoil/diesel market. A doubling or worse of retail diesel prices could be required under the worst circumstances. The doubling could push the prices of light sweet crude oil like Brent to levels last seen in 2008 or even higher.

The price increases in 2020, should they occur, will be unlike the increases of twelve years earlier. The price spike in 2008 was a blip. The increase in 2020 threatens to persist because the forces that removed pressure in 2008 are absent.

The 2008 increase occurred simultaneously with an economic collapse caused by the dramatic decline in real estate prices in the United States, the failure of financial institutions, and a "freeze" of the financial system. Lending for real estate transactions—a primary driver of US economic growth until 2008—stopped dead. Housing prices were falling. Motor vehicles sales, which had reached seventeen million units in February 2007, had already declined to thirteen million units in July 2008 when crude peaked. A year later, they would fall to 9.4 million units at annual rates. The recession was well underway as oil prices reached their high point.

The economic collapse in 2020 will follow but not coincide with the peaking of prices should economic growth not slow in 2019. The price rise will start the process of a slowdown. Speculation may exacerbate it.

The price increase will also persist, in part because key market participants will aggressively resist any last-minute attempts to weaken the IMO regulation. Oil refiners capable of supplying the new fuel will fight such efforts strongly, arguing as they have often in the past that they have invested to make the clean fuels and should be able to profit from their investments. Indeed, refiners like Valero that are well-prepared to supply low-sulfur fuel could become the angels of death for the global economy by resisting any regulatory adjustment.

Environmental advocates, especially the vociferous lobby for the IMO standard in Europe, will also insist that the regulation be enforced, pointing to the lives this will theoretically save.

These proponents of the new sulfur-content standard will be joined by the large shipping companies that have prepared for the transition. These firms will see high fuel prices as an opportunity to put smaller, financially vulnerable competitors out of business.

The consequence of the rule's imposition in 2020 will be a fairly long period of high prices that is likely followed by a severe global economic collapse if—and it is important to emphasize the *if*—prices rise to very high levels. Should high prices and an economic slowdown occur, they will likely have damaging effects. These could include the bankruptcy of firms that borrowed heavily during the time of low interest rates. Higher interest rates and slower economic activity might even push US debt high enough to create the financial crisis Professor Feldstein and others have been predicting. I hope this statement turns out to be hyperbole and that prices do not rise to a point that starts such a cycle.

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