AUTHENTICATED
U.S. GOVERNMENT
INFORMATION
GPO

S. HRG. 111–171

OIL AND THE ECONOMY: THE IMPACT OF RISING GLOBAL DEMAND ON THE U.S. RECOVERY

HEARING

BEFORE THE

JOINT ECONOMIC COMMITTEE
CONGRESS OF THE UNITED STATES

ONE HUNDRED ELEVENTH CONGRESS

FIRST SESSION

MAY 20, 2009

Printed for the use of the Joint Economic Committee

U.S. GOVERNMENT PRINTING OFFICE

52–393 WASHINGTON : 2009

For sale by the Superintendent of Documents, U.S. Government Printing Office
Internet: bookstore.gpo.gov Phone: toll free (866) 512–1800; DC area (202) 512–1800
Fax: (202) 512–2104 Mail: Stop IDCC, Washington, DC 20402–0001

JOINT ECONOMIC COMMITTEE

[Created pursuant to Sec. 5(a) of Public Law 304, 79th Congress]

HOUSE OF REPRESENTATIVES

CAROLYN B. MALONEY, New York, *Chair*
MAURICE D. HINCHEY, New York
BARON P. HILL, Indiana
LORETTA SANCHEZ, California
ELIJAH E. CUMMINGS, Maryland
VIC SNYDER, Arkansas
KEVIN BRADY, Texas
RON PAUL, Texas
MICHAEL BURGESS, M.D., Texas
JOHN CAMPBELL, California

SENATE

CHARLES E. SCHUMER, New York, *Vice Chairman*
EDWARD M. KENNEDY, Massachusetts
JEFF BINGAMAN, New Mexico
AMY KLOBUCHAR, Minnesota
ROBERT P. CASEY, JR., Pennsylvania
JIM WEBB, Virginia
SAM BROWNBACK, Kansas, *Ranking Minority*
JIM DEMINT, South Carolina
JAMES E. RISCH, Idaho
ROBERT F. BENNETT, Utah

NAN GIBSON, *Executive Director*
JEFF SCHLAGENHAUF, *Minority Staff Director*
CHRISTOPHER FRENZE, *House Republican Staff Director*

CONTENTS

Opening Statements of Members

Hon. Carolyn B. Maloney, Chair, a U.S. Representative from New York 1
Hon. Kevin Brady, a U.S. Representative from Texas 2
Hon. Michael Burgess, MD, a U.S. Representative from Texas 15

Witnesses

Statement of James D. Hamilton, PhD, Professor, Department of Economics, University of California, San Diego, California 5
Statement of Daniel Yergin, PhD, Co-Founder and Chairman of Cambridge Energy Research Associates, Washington, DC. 6

Submissions for the Record

Prepared statement of Representative Carolyn B. Maloney 26
Prepared statement of Representative Kevin Brady 26
Prepared statement of James D. Hamilton 27
Report titled "Causes and Consequences of the Oil Shock of 2007–08" 30
Prepared statement of Daniel Yergin 101
Prepared statement of Representative Michael Burgess 114

OIL AND THE ECONOMY: THE IMPACT OF RISING GLOBAL DEMAND ON THE U.S. RECOVERY

WEDNESDAY, MAY 20, 2009

CONGRESS OF THE UNITED STATES,
JOINT ECONOMIC COMMITTEE,
Washington, DC.

The committee met at 10 a.m., in Room 210, Cannon House Office Building, Hon. Carolyn B. Maloney (Chair), presiding.

Senators present: Brownback.

Representatives present: Maloney, Hinchey, Snyder, Brady, and Burgess.

Staff present: Gail Cohen, Nan Gibson, Colleen Healy, Marc Jarsulic, Andrew Wilson, Rachel Greszler, Lydia Mashburn, Jeff Schlagenhauf, Jeff Wrase, Ted Boll, and Chris Frenze.

Chair Maloney. The committee will come to order, and the Chair recognizes herself for 5 minutes for an opening statement.

OPENING STATEMENT OF HON. CAROLYN B. MALONEY, CHAIR, A REPRESENTATIVE FROM NEW YORK

Good morning, I would like to thank our distinguished experts for agreeing to testify this morning on the impact of last year's oil price shock on the U.S. economy and the potential effect of higher oil prices on our economic recovery.

This hearing is timely because the traditional start of the summer driving season gets underway this weekend. The most recent estimate from the Energy Information Administration is that regular gasoline prices will average $2.21 a gallon over the summer's driving season and that diesel fuel prices will be $2.23 a gallon, a far cry from the $4 or more a gallon for gasoline or diesel that drivers faced last summer. What a difference a year makes.

Although drivers will face much lower pump prices than they did last summer, crude oil and gasoline prices have ticked up recently. Indications of "green shoots" in the U.S. economy and fiscal stimulus measures adopted in China have already begun to nudge oil prices higher as expectations for greater demand rise.

Right now it looks like the surplus capacity of crude oil production is large enough to prevent an immediate repeat of last year's price spike. But today we want to explore with our witnesses the short-term policies that will help to avoid derailing our recovery and long-term policies for sustainable, economic growth.

While it would have been better for the last administration to have started on a sensible energy policy earlier in the decade, the

current decline in global demand for oil has given us some breathing room to change course.

Yesterday's announcement by President Obama ushering in tougher national fuel efficiency standards is truly an historic opportunity to reduce our dependence on oil. Higher standards mean we will get further on every tank of gas.

The American Recovery and Reinvestment Act also included policy changes that will help in the long run, such as investment in intercity light rail and funding and loan guarantees for research into advanced technology for vehicles and other innovative technology. These investments will help the United States develop a modernized transportation system with efficient alternatives to automotive travel.

Last year's oil shock showed us that right now it takes a very large increase in gasoline prices to reduce our consumption of oil. Part of the reason is because many consumers have no alternatives to their gasoline-powered cars.

In the long run, energy policies that increase alternatives to using a gas-fueled car, whether they are different modes of transportation or alternative fuels for cars, will help minimize the impact to the economy of a rise in the price of oil.

Energy efficiency, which allows us to use less energy for the same activity, is an important part of the solution. Smart grid technology will also allow us to use our electric transmission grid more efficiently.

In testimony before this committee last year, Dr. Yergin observed that the most recent oil shock underscores the need, and I quote, "to encourage timely investment across the energy spectrum." I am optimistic that we are moving in that direction and towards a long-term solution to reducing our dependence on oil.

I look forward to the testimony today and am pleased to recognize my colleague, Congressman Brady, for 5 minutes or as much time as he may need.

[The prepared statement of Representative Maloney appears in the Submissions for the Record on page 26.]

OPENING STATEMENT OF HON. KEVIN BRADY, A U.S. REPRESENTATIVE FROM TEXAS

Representative Brady. Thank you, Chairwoman, for hosting this hearing. I think it is an important topic, and I join with you in welcoming the witnesses testifying before us on oil prices and the economy, and the way forward.

Oil prices have plunged, as we know, during the recession but have started to increase more recently due to greater optimism about the economic outlook. And while some of this recent optimism may be questionable, given the latest data on retail sales and business investment, it is reasonable to believe the economy will be in recovery by next year, especially given the huge injections of money and credit by the Federal Reserve.

The key challenge to energy policy now, given the long lead time involved, is the need for investment in exploration and production to meet oil demand over the longer term as opposed to an oil price spike in the short term. Nonetheless, as the international economy recovers, it is likely that oil prices will increase.

In considering this issue, it is important to note that state-controlled oil companies in OPEC and Russia and others account for three-quarters of the world's oil reserves. These state-controlled companies, not private firms, are behind periodic attempts to manipulate the global oil market and exert monopoly power to hold up prices. Whatever the lasting success of these efforts, there is little doubt that state-controlled oil companies are a major and growing force in the world oil market.

There are also other state-to-state projects underway, such as the effort to arrange financing for the Brazilian national oil company with the Chinese government.

These efforts, whether they are undertaken with Iran or Venezuela, are not only an attempt to guarantee energy supply but also to guarantee energy work by suppliers and others with these foreign governments, and those jobs replace U.S. jobs.

OPEC's cuts in oil production hold up prices, only one of the many reasons we should want to encourage oil production in North America. The U.S. and Canada together hold 15 percent of the world's proven oil reserves, 200 billion barrels, and their resource potential is much greater. The U.S. can and must do much more to expand domestic production of oil as well as natural gas.

Technologies, such as hydraulic fracturing, seismic imaging enhanced by geopositioning satellite systems and steerable drilling with gyroscopic guidance systems, together can significantly expand economically recoverable oil and gas reserves. Steerable drilling allows precision drilling along variable trajectories without repositioning the drilling rig, which is particularly beneficial offshore. And furthermore, when horizontal drilling was combined with fracturing in the early years of this decade, large volumes of natural gas became recoverable from rock formations that previously had been regarded as depleted or could not be tapped at all with conventional methods.

Unfortunately, instead of encouraging U.S. oil and gas production, the Federal Government has placed excessive limits on exploration drilling, include effectively making offshore drilling impossible in many areas.

The administration would further penalize oil and gas production in the United States and would offshore U.S. energy jobs by the imposition of a variety of new energy taxes.

The Treasury Department justifies these tax increases by arguing that the lower taxation under current law "encourages overproduction of American oil and gas, and is detrimental to the long-term energy security," at least partly because it boosts "more investment in the oil and gas industry than would occur under a neutral system."

With all due respect, it is a policy designed to suppress traditional U.S. oil and gas production, and it is absurd. The Treasury notes that the lower taxation under current law is also inconsistent with the administration's policy of reducing carbon emissions, encouraging the use of renewable energy sources through a cap-and-trade program.

In other words, at a time when we are nearly 60 percent dependent on foreign oil and we need dramatic new investments in energy throughout the world, our government is proposing policy doing

just the opposite. Thus it appears that the counterproductive nature of the administration proposal is not an unintended consequence, but the result of deliberate design.

Congress should block these tax increases precisely because they would undermine oil and gas investment and production as the Treasury itself concedes. These traditional sources of energy are the bridge we need to the future of renewable energy.

We are all in favor of seeking more renewable energy sources, so long as they are economically viable. However, we should not be seeking to suppress traditional energy production that we know is economically viable.

According to the Energy Information Administration, the truth is that oil, gas and coal provide most of the energy in the U.S. economy and will continue to do so for many years. Tax increases targeting our U.S. energy production, including cap-and-trade tax, will weaken the economy, undermine U.S. competitiveness and lower American living standards for decades to come.

I yield back.

[The prepared statement of Representative Brady appears in the Submissions for the Record on page 26.]

Chair Maloney. Thank you very much.

Chair Maloney. Now I would like to introduce our distinguished witnesses. Dr. James Hamilton has been a professor at the University of California, San Diego, since 1992. He served as Chair of the Economics Department from 1999 to 2002.

He is the author of "Time Series Analysis," the leading text on forecasting and statistical analysis of dynamic economic relationships. He has done extensive research on business cycles, monetary policy and oil shocks and has been a research adviser and visiting scholar with the Federal Reserve system for 20 years.

Dr. Hamilton received his PhD in economics from the University of California at Berkeley.

Dr. Daniel Yergin is chairman of IHS Cambridge Energy Research Associates.

Dr. Yergin received the Pulitzer Prize—congratulations—for his work, "The Prize: The Epic Quest for Oil, Money and Power," which appears in a new updated edition in 2009.

He is a trustee of the Brookings Institution; a director of the New American Foundation and of the U.S.–Russia Business Council and on the advisory board of the Peterson Institute for International Economics and of the MIT Energy Initiative.

Dr. Yergin received his B.A. from Yale University and his PhD from Cambridge University, where he was a Marshall Scholar.

Thank you very, very much, and we are going to begin with Dr. Hamilton and end with Dr. Yergin. Thank you for being here, for your research, for your time, and for your testimony today. Thank you.

Dr. Hamilton.

STATEMENT OF JAMES D. HAMILTON, PhD, PROFESSOR, DEPARTMENT OF ECONOMICS, UNIVERSITY OF CALIFORNIA, SAN DIEGO, CALIFORNIA

Dr. Hamilton. Thank you very much, Chairman Maloney and Vice Chair Senator Schumer, Ranking Member Representative Brady, for holding this hearing.

In the OPEC oil embargo, the Iranian Revolution, the Iran-Iraq war and the first Persian Gulf War, we saw big increases in the price of oil, and each time it was followed by an economic recession.

In 2007–2008, the price of oil increased by more than it did in any of those historical oil shocks. And, in my opinion, there is no question that the oil shock of 2007–2008 made a material contribution to the current economic recession.

So why did it happen? Declines in production from mature oil fields in the North Sea and Mexico, disruptions in Nigeria, and production cuts from Saudi Arabia were all factors that prevented world oil production from increasing at all between 2005 and 2007. And although production stagnated, world demand for petroleum continued to boom.

World GDP was up more than 10 percent in 2006 and 2007, and if there had not been a big increase in the price of oil, with that kind of income growth, we would have anticipated very big increases in petroleum consumption.

Even with the price increases, oil consumption from China was up almost 1 million barrels a day, and yet no more oil was being produced. That meant something had to change to persuade the rest of us to reduce our consumption, despite the growing incomes.

The historical experience has been that even very large oil price increases cause relatively little immediate response on the part of consumers. And, the experience between 2004 and 2006 was that, if anything, consumers were responding even less than those small historical estimates to the price increases that had come so far. I think the main reason a lot of us were ignoring those initial price increases is because we could afford to.

The energy expenditures as a share of total consumption expenditures had been 8 percent in 1979 and had declined to 5 percent in 2004. But as the price of gasoline continued to go up and reached $4 a gallon, that expenditure share was boosted back up to 7 percent, a point at which nobody could have ignored the price of energy, then we started to see some dramatic changes.

Unfortunately, those quick changes in consumption spending can be very disruptive for key sectors of the rest of the economy. A prime example would be the U.S. auto sector. While sales of fuel-efficient imports were going up, the sales of the domestically manufactured models, particularly the SUVs, were plunging, and the lost production and sales in the U.S. auto sector made a significant negative contribution to GDP and employment.

More generally, the decline in consumer sentiment and overall consumer spending that we saw in 2007–2008 were very similar to the pattern that we saw in those earlier historical oil shocks.

Americans purchase about 140 billion gallons of gasoline each year, and that means that when the price went from $2 to $4 a gallon, that took away $280 billion at an annual rate from spending

power. The declines we saw in consumption are very much in line with that.

Now, granted, there were other problems for the economy besides just the oil shock, housing being at the foremost, but housing was actually making a bigger reduction to GDP in the year before the recession than it did in the first year of the recession.

Something else happened to turn that slowdown from housing into an outright decline in overall income and employment, and, in my opinion, these factors I have pointed to, in terms of effects of the oil shock, are a key aspect of that.

Now, furthermore, there is an interaction between what was going on with oil markets and what was happening in housing. Lost jobs, lost income, increased commuting cost to the exurbs were all factors further depressing house prices, further aggravating foreclosures. And eventually in the fall of 2008, we reached a point where those financial events were sufficiently severe that we entered a very serious new phase in the recession that we are still struggling with.

Now would we have had those problems eventually even without the recession, I don't know. But one thing I know for sure is that those problems were made significantly worse by having gone through a year of recession, and the fact that we were in a recession, rather than slow growth, was very much influenced by oil prices.

[The prepared statement of James D. Hamilton appears in the Submissions for the Record on page 27.]

[The report titled "Causes and Consequences of the Oil Shock of 2007–08" appears in the Submissions for the Record on page 30.]

Chair Maloney. Thank you very much.

Dr. Yergin.

STATEMENT OF DANIEL YERGIN, PhD, CO-FOUNDER AND CHAIRMAN OF CAMBRIDGE ENERGY RESEARCH ASSOCIATES, WASHINGTON, DC.

Dr. Yergin. Thank you. I want to thank you, Chair Maloney, Ranking Member Brady and the committee for the opportunity to join you this morning.

Amidst your very complex agenda, the committee is to be commended for taking up this issue of energy during a period of lower prices, when attention tends to shift. For these issues of energy are integral to our Nation's economy, to our well-being, our security and the safeguarding of our environment.

Chair Maloney, you said, what a difference a year makes, and that is certainly the case here.

And, Congressman Brady, you emphasized the importance of investment, and what I want to try and do in my testimony this morning is talk about the importance of not having an either/or approach to energy.

When I had the opportunity to testify before this committee a year ago, oil was on that very sharp, upward trajectory. I checked, it was 16 days after the hearing that oil hit $147.27 a barrel. And if you remember, at that time people were saying oil was going to be $200 or $250 or $500 a barrel. Although it seemed to us, when

we looked at it, that we really were near a break point, that the prices were going to come down.

It is noteworthy that it was on July 11th of 2008 that we hit that high point. That was 2 months, more than 2 months, before the collapse of Lehman Brothers when we went from moral hazard to that frightening world of systemic risk when many thought the financial system might actually collapse.

I think Professor Hamilton has made clear that it was not only the failure of the credit system that led to the deepest recession since the Great Depression, but that what happened with commodity prices, particularly oil, was extremely important. After all, the automobile industry was knocked flat on its back, not by the collapse of Lehman Brothers but by what happened at the gasoline pump.

So, in my testimony, I try and address three questions. One, how did we go from the demand shock of the stronger economy to the current recession shock?

The answer is that oil prices are, among other things, a barometer of the world economy, so that the number one reason is we went from what was called the best global economic growth within a generation to the deepest recession since the Great Depression. And we see it in many different indicators. Oil demand today on a global basis is back to a pre-2005 level. In April, U.S. oil demand was lower than it had been in any April since 1996, 13 years ago.

But the question on the mind of the committee is, what happens in the future? What are the prospects for another shock?

And we are now in what we call the Long Aftershock; we are seeing the effects of the price collapse and what happened to demand. And when we look at that, we look at it in terms of what is called spare capacity, which is a security cushion that we rely upon.

And today, in the global oil market, we have about 6.5 million barrels a day of spare capacity. This is a very large number. The last time we had this big a cushion was in 1988.

Compare that to 2005, when prices were headed up, when that spare capacity was only 1 million barrels a day—very tight market ready for a price shock. This cushion we have now, and it is noteworthy, is equivalent to the total exports combined of Iran, Venezuela and Nigeria. In other words, that takes some of the geopolitical risk out of the oil market.

But what's going to happen in the future?

By the way, we are looking at inventories, too. They are almost at their top levels.

But when we look at the future, it goes back to Congressman Brady's remarks, out of the 15 million barrels a day of new supply, roughly, that we would have expected to come on line on a global basis between now and 2014, about half of that, 7.6 million barrels a day, is at risk of delay, postponement, cancellation.

So as the economy recovers, we will see that spare capacity shrink. And, therefore, we will start to become vulnerable to future shocks, and I can assure you that, 3 to 5 years from now, we will be looking at a very different oil market again, and this committee will be looking, as it does, with much concern about, what are the risks to our economy?

The third part of my testimony is looking at one important element of energy security. We just this week have done a new study called "Canadian Oil Sands: Finding the Right Balance."

We don't think about it this way very often in this country, but Canada has the second largest oil reserves in the world. Canada is the largest source of oil imports in the United States, almost 20 percent. And the oil sands have seen very substantial growth because of technological innovation.

There are two types of questions that hang over it, though. One is the investment risk, a large risk. Many new projects are being postponed because of cost. And secondly, there is a lot of debate about the CO2 impacts and oil sands coming into the United States. We looked at that very carefully. And if you look at it from the production of oil sands right through our automobile tail pipes, it is about 5 to 15 percent more CO2, a manageable number, a number that needs to be brought down, but it is within the range.

And so I think, when we think about our future energy security, energy independence, all of those kinds of questions, we really have to pay very close attention to Canada.

The point I would like to leave the committee with is the reality of cycles. This recession will end. Maybe it is already ending.

We have to think about the energy future. Major initiatives have now been launched by the U.S. Government to help further diversify and strengthen our energy system. We see it in smart grids in transmission, electric batteries, renewables and alternatives. There is also the opportunity to make real advances in energy efficiency. That is wholly welcome.

And I am so struck that there is an embrace of energy efficiency all across the energy spectrum in a way that we have never seen before. We are going to see, I think, major impacts that will come from sustained spending on energy research and development.

We talk so often in energy about diversification, I think we can say that the concept of diversification is, itself, being diversified, and that is a major contribution to our security.

But—and here is the, "but" lead time and scale are very important. We use in this country the equivalent total energy of 46 million barrels a day of oil.

So even if we start to electrify our automobile fleet, that will take time. Even as we have more efficient automobiles, and we have heard the announcement yesterday from the President that will accelerate that, it will take time.

Meanwhile, we will see the growth in oil demand, particularly coming from emerging markets. We are already there. It is very striking that over the last 3 months, each of the last 3 months, more new cars have been sold in China—in China—than the United States, something that we would not have really imagined 5 years ago.

So when economic growth resumes, so will growth in energy demand. And that will put energy security back on the agenda, and given the lead times, our policy decisions need to look longer term to protect the American economy and the American consumer.

And that gets me to my very final point. As part of that longer-term view, we need to get beyond the either/or energy debate. It is not one or the other.

We need to take a more ecumenical approach, ensuring that there is a combination of conventional energy, renewable and energy efficiency, alternatives—all developed with appropriate environmental and climate change consideration.

Consider that today conventional energy, oil, natural gas and coal supply over 80 percent of our total energy. There is no single answer to the energy needs of our $14 trillion economy. Oil itself is about 40 percent of our total energy. That makes clear the importance of oil and the evolution of oil to our economy and security in the years ahead and to the global economy of which we are so much part.

That is precisely why the focus of this committee today is so significant. Thank you.

[The prepared statement of Daniel Yergin appears in the Submissions for the Record on page 101.]

Chair Maloney. Thank you so much.

Dr. Hamilton, in your opinion, can an increase in domestic production have a significant long-term effect on the price that the U.S. pays for oil? Can we drill our way out of this problem?

Dr. Hamilton. Well, there is no question, if we had had additional oil brought to the market last summer, it would have been helpful. Those were unusual market conditions, as Dr. Yergin was pointing out in terms of the very, very, low excess capacity.

But I would further emphasize that it is a global market for oil. And had there been no increase in the price of oil from 2005 to 2008, I could easily see a need for another 5 million barrels a day on the world market.

And even the most optimistic assessments of what we might be able to do with domestic production wouldn't make a dent in that. And even if they did, in a few more years down the road, with these levels of sales of cars from China, we would be back in the same boat.

So I would very much endorse what Dan was saying about the need for a combination of approaches. Yes, domestic production would be helpful, but it is by no means a silver bullet that solves the problems by itself.

Chair Maloney. Well, what should we do, or what steps should we take? Both of you have touched on it in your testimony. But if you could elaborate more on how to reduce the impact of oil price increases in the long run, and during this time when we seem to have a little bit of a breathing space, what is the most efficient way that we can use our resources to move us in the right direction for energy independence?

Dr. Yergin and Dr. Hamilton, if both of you would comment.

Dr. Yergin. When you look at it, we import about 56, 57 percent of our oil today. If you take that in terms of our total energy, of course, it is a smaller share of that.

I so often think when people use the phrase energy independence, they really mean energy security, so that our economy and consumers are not vulnerable to future shocks. And I think it is a diversified approach.

Obviously, we are seeing a step up in a focus on the longer term, which particularly means energy research and development, so

that young scientists can really make long-term careers there. And so that, I think, is part of the picture.

Certainly, what we are seeing on the renewables and alternatives is very significant. But, if you say what has been the biggest innovation in energy in the United States in the last 2 years, you pause and you say, well, it is actually what is happening in natural gas.

The revolution in unconventional gas is really a big deal. It has been kind of piecemeal so it hasn't gotten a lot attention. It is a domestic resource. That means that actually we have the capacity to meet more of our needs for natural gas, domestic natural gas. I think that is part of the picture.

And, clearly, if we import 56 percent of our oil, we produce 44 percent, and so continuing to maintain domestic production, there is no single number there, but it all adds up.

Chair Maloney. A number of people suggested that speculation contributed to the size of the oil price spike that we suffered.

Can you estimate how much of the oil price increase was the result of speculation, if any, and would you advocate policy action to curb speculation, such as increased margins for purchase of oil future contracts?

Dr. Hamilton and Dr. Yergin, could you comment on speculation and its contribution?

Dr. Hamilton. I know a number of people have proposed numbers for what was the contribution speculation; though in my opinion, there isn't a sound bases for making that kind of calculation.

I would emphasize that whatever you want to think about in terms of financial markets, there is ultimately a physical commodity that is involved here. There is a physical commodity produced and consumed.

And if the quantity that is produced is bigger than the quantity that is consumed, that ought to go into inventories. What we saw happening to inventories in the early part of 2008 was that they were well below normal rather than above normal. So I think it is hard to argue that the price at the beginning of 2008 was one at which there was an excess supply.

Now, I think that it did come to be the case, that, obviously, the movement of the price in the summer of 2008 was overshooting. People were underestimating the degree of these adjustments that people did start to make when that expenditure share got higher.

I think there are some changes we could make to financial markets to make sure we limit the exposure to risk of institutions that shouldn't be taking risk, and making sure that there are adequate margin requirements for trading on organized exchanges. I am in favor of all of those measures.

But I think we shouldn't be blaming financial speculators for giving us a message we didn't like. And the basic message is, the world wanted more oil, and there wasn't more oil available for it.

Chair Maloney. Thank you.

Mr. Brady.

Representative Brady. Thank you, Madam Chairman.

I think Dr. Yergin's point is a great one, which is it is not an either/or proposition. I think we find ourselves in the sound byte

role too often, whether it is "we can't drill our way out of it" or "drill, baby, drill," probably two extremes in this.

It really is an all-of-the-above solution, energy efficiency, investments in renewable energy and then traditional energy that can be that bridge until we get to that renewable point.

A couple of thoughts, one, the ecumenical approach you suggest, Dr. Yergin and Dr. Hamilton, I think, are excellent. One of the myths is that demand for oil and gas is slowing, but in fact it is growing. The International Energy Agency World Energy Outlook estimates that the demand for traditional oil will grow from 85 million barrels a day, as it is currently, to 106 million barrels a day by 2030. And much of this, of course, will be in the developing countries.

So the thirst for oil, even with all of our progress from renewables will continue to grow. There is also a myth that we are running out of energy. The truth of the matter is that our reserves are not shrinking; they are growing. We are seeing this in areas like Brazil. But we also often hear people say America consumes 25 percent of the world's energy; only has 3 percent of the proven reserves. This is misleading for a couple of reasons. Your testimony shows that Canada and the U.S. together have 15 percent of the reserves. And, secondly, reserves are growing by the day. Technology has done that. In the U.S. alone, our reserves have doubled since the 1970s.

The problem is we have blocked away so much of our opportunities to explore. You don't know till you get in there what is there. That is also, I think, causing real supply problems globally that could have provided, perhaps, that leeway to keep prices from spiking, which is why the administration's proposal that we are overproducing here in the United States is just crazy. It is, to be kind, I think, naive and maybe bordering on the ignorance of our world's global supply.

So my question has to deal with what types of investments should we be making now to ensure that there is adequate supply?

It seems to me this administration is making a keen investment in renewable energies.

Private companies, though, are outpacing the U.S. Government's investment by about 5–1. Private business is making key investments in energy efficiency. Our commercial buildings are 30 percent more efficient than they were just a few years ago.

So my question is, what types of investments, in addition to renewable energy, what types of investments in traditional energy should U.S. be making, and what types of policy changes should we be making to be able to access the oil sands of Canada, for example, which have been sort of given a cold shoulder recently by this government.

What types of investments in policy should we be taking and furthering today to ensure we don't have that price spike in the future?

Dr. Yergin.

Dr. Yergin. There are a range of answers to that. I think that one thing, if we go back to diversification as the starting point, it is in our interest to see a lot of different forms of energy being developed around the world and to be encouraged.

When Winston Churchill made the historic decision to convert the British Navy from coal to oil just before World War I, his critics said, well, you are going to be dependent upon oil from Iran, Persia. And his answer was, safety in oil lies in variety, and variety alone.

So I think some of it is to encourage; some of it is to not put obstacles in the way of things. We should give clear signals to Canadian oil sands or to Brazil in terms of developing its offshore, that we would like to see that happen. I think those are kinds of the signals.

There is a big research agenda. We know that the questions of clean coal have to be addressed on a global basis, particularly when you look at China and India. It is also a reasonable development of resources in the United States.

As I mentioned before, the development of unconventional natural gas is really a big deal for our country, but you need to develop those resources, and I think that includes the question of offshore exploration in a reasoned, environmentally careful manner as part of the agenda.

Representative Brady. Thank you very much.

Dr. Hamilton, do you want to weigh in?

Dr. Hamilton. To that, I would just add I think nuclear technology is a known technology with some known problems, but it has to be part of the solution. Investments are needed there.

And I would also emphasize that to make use of some of these alternative sources, such as wind, some significant investment is required in the electrical transmission infrastructure to get the power from where the wind is to where the people are.

Representative Brady. I agree, Texas leads the Nation in wind power. The trick is making it reliable, creating a transmission grid, and having natural gas, for example, to be that safety net.

I would note, too, we have a member of the Energy and Commerce Committee here today, but I think the new cap-and-trade bill devotes 58 pages to light bulbs and 2 sentences to nuclear energy. It probably ought to be the other way around.

I yield back.

Chair Maloney. Thank you.

Mr. Hinchey.

Representative Hinchey. Thank you very much, Madam Chairman.

Thank you both. I very much appreciate everything that you have said and what you have written in your statements and your involvement in those issues.

Dr. Yergin, I very much appreciate that wonderful book that you wrote quite a while ago and is now out in a new version. I am very interested in looking at the new version and seeing what additional information you may be providing there. I am sure there may be some that is very interesting.

The issue that we, are dealing with here is very complex, very difficult and I think, in some ways, very dangerous. The amount of oil on this planet is limited.

We may not know precisely how much it is, but we do have a very good idea about how much it is.

There is very little of it that we are not aware of and that we may be able to obtain. And some of that, that we may be able to obtain, is very complicated.

For example, the oil in Canada. Canada has a huge amount of oil, but obtaining that oil, getting it, is not as easy as it is in drilling in the Middle East, where it is much more accessible and much more easy to get out. It is much more expensive to pull it out in Canada, and the consequences of pulling it out can be complicated, can be dangerous, can have some issues dealing with the environment that may be consequential in some ways.

Same thing with natural gas here in the United States, a lot of activities going on to produce natural gas here in the United States, but in some ways in which it is being done as a result of the change in those regulations, as a result of the 2005 energy policy bill that passed this Congress, which stopped the examination of this kind of activity in order to prevent the natural resources, particularly water. All of that is very complicated, could be very, very dangerous.

So this situation that we are dealing with is something that we need to spend an awful lot of time on and come up with some very good responses.

The amount of oil that is being consumed on this planet keeps growing, even though the amount of oil that we have on this planet remains what it is, remains the same.

As you were pointing out, the increase in automobiles in China, which has a population of about 1 billion people, is growing up very, very dramatically. That is likely to also grow in other places like India, where there is another 1 billion population.

So the impact on the availability of oil is going to continue to increase dramatically. And so, therefore, the price will continue to go up. We are seeing that price go up now in spite of the fact that the economy globally is still in a very difficult set of circumstances; the price of a barrel of oil has gone up. The price of a gallon of gasoline has gone up here in the United States and elsewhere. So this is something that is very, very complicated.

We are importing now, something in the neighborhood of like 70 percent of the oil that we use, that we use in this country, about 70 percent is coming out from someplace else.

We produce about 6 percent of total oil, but in terms of what is known, we hold about 2 percent of the known oil reserves around the world. So we are impacting on our known oil reserves in a very dramatic way, which is going to run it out rather quickly, unless we are wise enough to get ahold of this energy situation in a more intelligent and reasonable way.

Now, some of the things that you talked about were alternative energy. You just mentioned wind energy, and I just drove through Pennsylvania early this week, saw a lot of those windmills up there, 12 of them in one particular place.

It reminds me of what I saw in places like Amsterdam, a lot of windmills over there, and, as you said, Texas, and other places.

But we need to focus on alternative energy, don't we? What do you think? Do you think that we should be focusing our attention on alternative energy? Should we be developing solar energy? Solar energy is probably the most solid availability of energy anywhere

on this planet; that is the strongest source of energy. And as a number of people have talked about it for a long time, it gives us the opportunity to produce the energy we need if we could just do it in an effective way.

So what can you tell us about the circumstances that we are dealing with and what we should be doing to reduce our dependence on fossil fuels and particularly our dependence on oil and changing that to a dependence on something else, maybe solar energy?

Dr. Yergin. That is a big question. You have put a lot of different pieces together.

As we think about it, we need to divide the picture in two parts; one is electricity, and then there is transportation. And at this point, the transportation depends upon the internal combustion engine, and I think that part of that picture is indeed a more efficient automobile—the direction that we are going in. That is welcome, and it is sort of the obvious thing to do, and it is something that just kind of fell off the agenda for many years.

Wind is already becoming a substantial business. Solar is still quite small. They will grow as substantial businesses, but they are still parts of our overall mix. And, again, I go back to, we have a $14 trillion economy. So I say, yes, those should be encouraged, stimulated.

They will become bigger, but we have to still look at where does most of our energy come from, and how do we deal with where we are going to be in the next 5 or 10 years?

Imports, you mentioned the 70 percent number, those are the gross import numbers. It depends whether you look on imports in terms of the gross number of barrels we import, because we actually export some as we refine it and so forth, so it varies that sometimes the numbers used are 70 percent. But if you look at a net basis, it is 56 percent. That is still a very, very, very large number. We import more oil than any other country consumes. So we are very much integrated into that energy market.

So the answer is that it is really all of the above when you have a $14 trillion economy, and we can't afford to make mistakes.

What we have seen, as Professor Hamilton said, is that we are paying a heavy price now for what happened over the last few years. And it was not only the credit system; it was also inadequate supply.

Dr. Hamilton. I would like to underscore what Representative Hinchey said about the oil sands. They are a very energy-intensive resource. It takes a lot of energy to get oil out. It is a very capital-intensive resource. It is a very water-intensive resource, and it is very hard to scale up.

So we can look at the total reserves, but to get anything other than a tiny fraction of that on an annual basis near term is very challenging, even if we ignored the environmental issues.

So those challenges are significant, and I am very much in agreement with Dr. Yergin that we need all of the above. And it is specifically a transportation question, and we should be looking at the transportation infrastructure in addition as we evaluate these questions.

Dr. Yergin. I have great respect for Professor Hamilton, but let me slightly clarify it. At one point, 3 million barrels a day, it starts to become a significant number. When we do the numbers for where is the major growth in oil supply going to be in the top 15 over the next 10 days years—what we call the "O–15," Canada is like number 3 because of the oil sands, so it is not inconsiderable.

There are a series of environmental, important environmental questions that need to be addressed, but the water issue, for instance, is mostly a winter question, not a summer question, and I think there is a high priority on addressing them.

The development of the oil sands, it is a very highly regulated business in Canada. And, clearly, there is going to be more and more focus on what do you do to continue to bring down the CO2 compared to other sources?

So it is not to say that it is more important than some others; just to say that it is actually pretty important, and it happens to be next door to us, and it is one of the things we have to look at when we think of, what is the equation for our energy security, and where do our supplies come from.

Chair Maloney. Thank you very much.

Congressman Burgess for 5 minutes.

OPENING STATEMENT OF HON. MICHAEL BURGESS, A U.S. REPRESENTATIVE FROM TEXAS

Representative Burgess. Thank you.

We are doing this hearing, the Joint Economic Committee, and I am also in a hearing two buildings over on the cap-and-trade bill that is working its way through our Energy and Commerce Committee, so it is very instructive to have this hearing this morning.

I think, Dr. Yergin, we spent some time a year ago in our Oversight Investigations Subcommittee in Energy and Commerce about the speculation of the futures market and the very high prices that we were facing.

Oddly enough, now we are putting ourselves in a position, the recession fixed the problem of the high prices in the oil market, and we may be reinstituting those high prices with our cap-and-trade legislation that we are working on in Energy and Commerce.

The issue of diversification, and Representative Brady mentioned that there was really only scant mention of nuclear in the cap-and-trade bill that we are doing right now, the energy tax bill that we are doing right now.

Nuclear does have a place, in my opinion, in whatever we do, as far as the Nation's future energy armamentarium. It also seems like, during the run-up to this hearing that we are having in Energy and Commerce, we heard testimony from the standpoint of oil sands in Canada, the colocation of nuclear facilities close to the oil sands could, the excess energy produced with production of nuclear energy could in fact be used to satisfy some of these higher energy demands that are required for getting the tar sands.

Is that a correct observation?

Dr. Yergin. Representative Hinchey mentioned my book The Prize, and one of the lessons that I take away from it is about constant innovation in energy. The reason the oil sands are more significant now than they were 10 years ago is because of major inno-

vation, and I think we see that in renewables, alternatives, all across the way.

And one of the issues on the agenda is, could there be small nuclear power plants used to provide the heat for the in situ recovery of oil sands, and I think that is a very reasonable research question.

I think generally what you say about nuclear power, and Professor Hamilton has mentioned it already, it is 20 percent of our electricity today. It is not like should we have nuclear? It is a significant part of our electricity supply. The question there, too, is, what kind of technological advances will make it a third or fourth or fifth generation part of the mix? We certainly see it happening in other parts of the world, and it is a carbon-free form of electricity.

Representative Burgess. Correct, and if I have time, we will come back to that.

Let me just ask a question about the, Dr. Yergin, you mentioned the issue of electricity, the issue of transportation.

Now, in my part of north Texas, we actually happen to be blessed with one of those alternative shale formations 8,000 feet under the ground, the Barnett shale. And out of that type of shale, we are now producing a significant amount of natural gas. Our good friend back in Texas, T. Boone Pickens, always talks about putting our heavy transportation fleet on natural gas fuel as opposed to the diesel fuel.

Is that a realistic outlook to be able to replace our transportation fuel with a compressed natural gas that we have here that is made entirely in America?

Dr. Yergin. Between 1895 and 1905, we had a horse race in this country between the horseless carriage, what was going to power it? Was it going to be alcohol fuels? Was it going to be gasoline? Was it going to be electricity? And the internal combustion engine and gasoline and diesel won. Today that race is wide open again, and we are looking at all these difference choices.

I think the reality is that we will probably need the natural gas for electric generation. I think that is—and particularly as we develop more wind, as has been pointed out, we need natural gas generation to back up that wind production.

We know that our automobile industry is in a deeply wounded state. And, yesterday the President announced the acceleration of the fuel efficiency standards. I think there are only so many things that the automobile industry can be asked to do at the same time.

And it seems to me, what we are saying is, become more efficient; that over here are hybrids; here, let's see what can be done with electric batteries. And that is a pretty big agenda for an industry that is very short on resources.

Representative Burgess. And, yet, if 20 percent nuclear is significant, no question about it, there is a big nuclear facility not far from my district down in Comanche Peak, Texas, but I rather suspect the size of that could be significantly increased, and the barriers to doing that have always been the regulatory aspects and the environmental impacts, so that it seems as if we could streamline some of that process and allow colocation of next-generation nu-

clear facilities on the sites where we are already generating nuclear power, so there is not the siting issue.

More of our base load for electricity could be generated by nuclear, thus freeing it up for transportation. I agree that wind is not a stable enough source. Certainly in Texas where there are high energy demands on a hot day, the wind isn't blowing, and you need natural gas right now for those plants to supply the energy required for air conditioning.

But if you were able to take care of more of the base load with nuclear; 20 percent is significant, but what if we could bring it to 30, 35 or 40 percent? That would certainly free up more of the natural gas to be used for our transportation sector.

Dr. Yergin. Right. I think the challenge for nuclear right now is our, as our electricity demand grows, will nuclear stay at 20 percent? Will it drift down? We have seen these nuclear power plants that used to operate at 55 or 60 percent capacity now at 85, 90 percent.

There are a number of, as you know, applications for new nuclear power plants, and it does seem that the process has been streamlined. There is still risk, but a number of people want to do it.

But I think what you say is most likely that those plants will be colocated next to existing nuclear power plants. And, again, it is part of the mix.

Of course, what has also happened over the years is we have lost a lot of our capacity to have a nuclear industry, and that business now has become globalized, too.

Representative Burgess. Thank you.

[The prepared statement of Representative Burgess appears in the Submissions for the Record on page 114.]

Chair Maloney. Mr. Snyder.

Representative Snyder. Thank you, Madam Chairman, for having another good hearing.

Dr. Yergin, I appreciate what you said a while ago. I think too many of us—probably more on this side of the table—in our zeal back home, our populace sphere, talk about energy independence and produce all our energy right here. The reality is our country has always been a trading Nation; it will always be a trading Nation.

What we should be looking for is predictability of supply and price. And we are always going to be selling energy, we are always going to be buying energy, and we shouldn't be alarmed by that, but we should be alarmed by threats to predictability of supply and price. And I hope that we will be, as the years go by, a major seller of technology for developing. I mean, it will be a huge plus for us in our job situation.

The interrelationship between all these things going on in the American economy right now, I think it is a fair statement, isn't it, that because of what is going on in the credit markets right now, some of our investments in venture capital and things like wind production has been held back. Is that a fair statement?

Dr. Yergin. Yes. There was a lot of buoyancy in the renewables and alternatives a year ago. The collapse in the credit markets has really hit these projects very hard, and you see it both in the devel-

opment projects; you also see it in terms of the venture capital. The discovery is that everything is harder, and it takes longer.

Representative Snyder. There are still very good projects sitting out there. Arkansas has a lot of dynamic things going on in energy. One of them is we have developing blade manufacturers that have moved in, and some other things. And there are some projects on the table that are good business opportunities, but whether it is a gas station or a restaurant, you can't get the money to get it going.

Dr. Yergin. Yes. Part of the green stimulus program has been aimed at trying to put a floor under the renewables and alternatives so that while policy wants to move in that direction, the economic realities doesn't move in the other direction. But I think for a lot of entrepreneurs, the last 8 months in this sector, as in many others, has been very, very difficult.

Representative Snyder. Right. Mr. Brady mentioned Texas and natural gas. Arkansas has been a major new producer of natural gas for this country, and I think, as you mentioned, not a lot of people know about it. I think my district has probably been the center of new production of natural gas for the country for the last several years. And it is still going on, despite the downturn in price; we still have companies that are drilling today and producing new wells.

You all talked about—one of you phrased it "the flight to commodities" in terms of price, and whether it is speculation or not speculation. Would you talk about the issue of how this might impact on our producers? If we have folks who are producing new natural gas wells out there, they need to have a predictable price to make it worthwhile for them. And so they get contracts, they get some hedge contracts so they have some predictability of price.

There is some apprehension that in our zeal and necessity of regulating the speculative market that we will do it in such a way that may hurt what we all see as the traditional healthy use of commodity hedge contracts to have that predictability of price. Would you all comment on that issue with regard to natural gas?

Dr. Hamilton. Well, I would like to point out that the futures markets play a role not just for hedging, but also for information provision. And I think it is vital for the economic future that we get an accurate reading on what are these challenges in terms of global demand, and what are the available supplies. And that is a very important function that futures markets have to provide.

If you define hedging as taking a position on a futures contract to reduce your risk, you could argue that a pension fund that is in commodities is hedging because the commodities may go up at the time your other assets go down, and they diversify your portfolio.

Representative Snyder. It just seems like there is a dramatic difference between a producer that cuts a contract with somebody down the line that this is what our price will be 2 years from now. That is so dramatically different from somebody speculating in the commodities market.

Dr. Hamilton. Well, on the other hand, if you define speculation as taking a position because of what you think is going to happen to the price, it is hard to think that even somebody who has phys-

ical delivery involved is not also taking into consideration what they think is going to happen to the price.

So I am a little uncomfortable with this very sharp distinction between hedging on the one hand and speculation on the other. I think it is vital that these markets function correctly and send an accurate signal. And I am all in favor of any institutional changes that help to promote that. But again, we do need to face the future, and if the future means tighter energy, we need to know about that now, and we need to respond to it now, rather than blame the futures markets for pricing that, I think.

Dr. Yergin. Can I add reinforcement to what Professor Hamilton is saying? I certainly remember last year testifying before this committee, and, of course, last summer speculation was a very hot subject. But if you take two real-world examples, one is you are an airline, and you see key people keep saying the world is running out of oil, oil is going to be 200 or 250, and you go out and you hedge your position. Are you hedging or are you speculating?

Another example, a specific pension fund, an $80 billion pension fund, concerned about instability in the Middle East, wanting to protect its retirees, takes a position in oil as a way to protect itself against conflict in the Middle East. Is that a hedger or a speculator?

On the other hand, you have people who are just kind of playing the game and looking at technical analysis back and forth. When you look at the market today and you say the oil market is really not reflecting the fundamentals of supply and demand, there are a lot of green shoots in the oil price right now. There is a pent-up demand for demand, and people are saying China looks pretty good now, and it is all going to come back again. And by the way, the other thing that happens here is that—and we saw that in the run-up last time the weakness of the dollar tends to lead to that flight to commodities as an offset, And we see that, too.

We all struggle to identify that sharp dividing line between hedging and speculating, and it is awfully hard to find it. But certainly, what you are talking about, a producer who is making a commitment to invest for the next several years with the risk and trying to take some of that market risk out of it, that is a very important tool to be able to do that in a sound and legitimate way, to be able to go ahead and finance the development that they want to do. And you are seeing it exactly in your district.

Representative Snyder. The tool is so important; it is the difference between whether they produce or not. And I think we have to be careful we don't stifle that somewhere. And it will be this side of the table; if a mistake is made, it will be this side of the table.

Dr. Yergin. Yes. Because you are going into that business, you have the risk of do you have the resource? Do you have the market? Then you have the price. What you are really trying to do when you are in that business is manage the whole series of different risks at the same time.

Chair Maloney. Professors Yergin and Hamilton, oil prices started rising over 5 years ago, and real crude oil prices doubled from 2003 to 2006, and then doubled again in mid-2007 and 2008, and oil companies experienced record profits. Did these profits translate into increased domestic exploration and development?

Dr. Yergin. We certainly saw budgets with E&P, which is the upstream which you are talking about, went up very dramatically. At the same time, what was also going up—less attention was being paid to it, and I have a chart about it in my testimony—is that the cost went up. There was a shortage of engineers, drilling rigs, drill ships, everything else. So when you were investing in 2008, if you were starting a new project, you would literally have to budget twice what you had budgeted in 2004 to be able to do that same project. So all of those factors were working together.

Chair Maloney. Dr. Hamilton.

Dr. Hamilton. There were big increases in investment. I was surprised we didn't see a little bit more. But I would also emphasize the difference between the private oil companies and the national oil companies. The private oil companies were reinvesting 25 percent of their gross revenues, and the oil-producing countries were reinvesting 6 percent of their net export revenues. So there is a real difference there. That is part of why we are not developing resources in the places in the world that would be helpful.

Chair Maloney. What does this suggest about domestic oil supply in the future?

Dr. Hamilton. Well, American production has been in a long-term decline since 1970. And we can talk, as we were earlier, about getting to some of these other sources. But to think we are going to significantly increase production for a significant period of time just within this country, I think, is very ambitious. Yes, we need that investment where there are promising alternatives, but I want to come back to this theme that we need all of these solutions. It is a huge problem, and it is too big a challenge for any one of these ideas, however good that one idea might be, to get anywhere near solving the problem by itself.

Dr. Yergin. I guess I would add to it is that investment will be made somewhere. If it is made in the United States, it creates jobs in the United States and activity here rather than revenues going into the treasury of other countries.

Professor Hamilton is quite right, we are not going to, from everything we know, increase our oil production. The question is do we stabilize it and keep it at a reasonable level?

What we also see is the impact of technology. In the late 1970s, the so-called "deep water frontier," if you were going out and drilling, was 600 feet of water. Today people are drilling in 6,000, 7,000, 8,000 feet of water. All across the energy spectrum—renewables, alternative, conventional—you see this march of technology. That is really a source of actually confidence when you look at the totality of our $14 trillion economy.

Chair Maloney. Thank you.

Mr. Brady.

Representative Brady. Thank you, Madam Chairman. This hearing is very instructive.

We always have conspiracy theories in Congress abound whenever oil prices go up that they are being manipulated by fuel oil companies; and, of course, every investigation shows that that is not the case. Once people realize that national oil companies owned by other governments hold 80 percent of the reserves—nearly 80 percent of the reserves in the world and produce equivalently to

that, they understand that there is a new geopolitics of oil, where national oil companies owned by their governments are now cutting political deals with other governments that guarantee access, guarantee jobs, and shrink the role of private international energy companies in trying to develop oil reserves. In fact, I think there are 60 national oil companies, half of which have reserves outside their own countries, so they are moving very aggressively.

Here in the U.S., we seem to be doing just the opposite, discouraging investment in the U.S. and discouraging production in those key investments. An example, in 2004, Congress passed a change in the Tax Code. Worried about jobs being offshored, they changed the Tax Code so that companies that manufactured here in the U.S., produced in the U.S., invested in the U.S. had a lower tax rate than companies that do the same activities offshore, in an incentive to produce here.

But this Congress, in the last 2 years, has repeatedly chosen one sector, American energy, to single out and say, we are not going to treat you like that, we are going to—raise your taxes and treat you, when you manufacture, invest and produce jobs in the United States, as if you are doing it overseas; in other words, creating incentives to produce less here in America, and offshore those jobs and investments overseas. This at a time, again, where technology is allowing us to access more and more of our own resources in an environmentally friendly way, and also identify more reserves so that we can, again, continue to hit that balance of more renewables, more efficiency, more traditional oil.

So I guess my question to both you of is as we look forward on pricing, the new geopolitics of oil where countries cut deals with other countries, and the role of private companies become smaller, what is that impact potentially on future prices here in the United States?

Dr. Hamilton. Well, I think it is unfavorable, as I was saying, insofar as many of these governments are not running the industry as efficiently as they could. And when you go through the list of these countries—Venezuela, Nigeria, Iran, Russia—there are plenty of worries about the political stability in any of these. And, for me, it is one question of is the oil there? It is a second question of are we going to get it and get it in time?

Representative Brady. In the past, private companies have had the competitive advantage on financing and technology and expertise, but that seems to be disappearing as well; there is a gap.

Dr. Yergin.

Dr. Yergin. Yes. I think up through last summer, many of the private companies were saying, well, what is going to be their role in the international scene in the future because of the role of the national oil companies. With prices down, you see that the balance changing. Indeed, I should say that one of the major themes in the new part of The Prize is this change in balance between national oil companies and private oil companies. It had looked like we were moving into this era of just national oil companies really dominating things. Price is down, suddenly the picture looks different; their countries need investment again, they don't have the revenues, and there is more openness.

Private companies bring project management. These projects now are $5- or $10 billion projects. They can execute them. Capital becomes important again. So I think we can say that there is kind of a new balance emerging again in this part of the cycle.

But I think the point—and the point for this hearing is that we really do move in cycles. In 3 to 5 years from now, the kind of concerns that we had last year will be back on the agenda again. And the question is having as solid a foundation that reflects the entire energy spectrum to deal with it.

Representative Brady. I actually think there is more common ground on this issue than some of the sound bites allow us to pursue. But thank you both for being here. You are very informative.

Representative Hinchey. I want to express my appreciation for you, too. Thank you both very much for being here, and thank you for what you have said in response to the questions.

This is a very complicated and very critically important issue that has to be dealt with very effectively. And I can see how people here in the United States as well as a lot of other people around the world are trying to control this issue.

I think that, as you were saying, as our production began to decline back around 1970, that was one of the initiators of the Middle East to organize themselves together and to begin to control oil prices and drive up the price for their benefit. And God knows, they have been enormously successful. The huge amount of money that flows into those countries—Saudi Arabia, particularly, but others as well—has been incredible since then, and it is just continuing.

In some ways, that reminds me of a little story that dates back to the early part of the 20th century, which you included in the prize, the Teapot Dome scandal, where you had an interest in one particular company at that time controlling as much as they could of the known oil reserves on publicly owned land around the country. We have seen something similar to that over the course of the last year here, where we had people on one side of the aisle in this Congress saying that the best way to control oil prices would be to open up oil drilling offshore and extend the leases to companies. That would drive down the price. Well, we argued about that, and we saw that that was not really the case at all.

We are dealing with a very fascinating issue here, very fascinating and very critical. It has got to be dealt with effectively, not just for now, which is very complicated, but even more so as time goes on. This is going to get more and more complex, more and more difficult to deal with. And this is something that this Congress has got to take into consideration, because one of the responsibilities we have is not just for today, but for future generations.

So I am just wondering what you think we should be doing most effectively—not just now, but maybe now—but also, what we should be doing, thinking about what would be most effective three or four decades from now.

Dr. Hamilton. Well, three or four decades is farther than I can think. I think it is a big enough challenge to get through the next 10 years.

But one point that I wanted to make that I think our discussions brought out is how interrelated all these questions are. We were

talking about natural gas; well, do we use it for electricity? Do we use it as an energy source for the oil sands? Do we use it as a supplement for wind power? Or we can drive our vehicles with it directly. Even though we are looking at the moment at a crunch in terms of transportation, we need a transportation technology, that analysis brings up how interrelated these are. And if you make progress on one front—for example, I have been mentioning nuclear power as a known option that we can pursue further, it gives you a little more breathing room on some of the other. But again, we need to be moving with all of these options at the same time.

Dr. Yergin. As you say, this is very complicated. There is no single mastermind grand plan, I think, that will answer it because there are a lot of things we don't know. No one thought 2 years ago or 3 years ago we would have this revolution of natural gas. No one thought a few years ago that we would see wind grow as much as it has grown recently. So I think that in the nearer term, it is a focus on security, so that 3 to 5 years from now this committee is not meeting asking, how did we get into this situation again, how did the great economic recovery that started in 2009 or 2010 end up flat on its back.

Longer term, three or four decades from now, I really do think if we have a sustained level of investment in research and technology, not with that uncertainty that you don't know whether the dollars are there or not, that we may see some very happy surprises, very beneficent.

You talked about solar. You know, the logic of solar and photovoltaics is so compelling, it is so powerful. The question is to get scale, to get the cost down. I am on the advisory board at the MIT Energy Initiative, and when you are on that campus, and you see all of these people working these questions, you say, that is where the future is three or four decades from now, and that is where we really need to make our investment. And you look at the last three or four decades, and that investment has gone up and down. So I think that kind of consistency will help us answer the question with greater clarity.

Chair Maloney. Thank you so much. This has been a very informative hearing on a crucial subject. You are both leading experts. We will circulate your testimony to other Members of Congress.

The meeting stands adjourned.

[Whereupon, at 11:19 a.m., the joint committee was adjourned.]

SUBMISSIONS FOR THE RECORD

PREPARED STATEMENT OF REPRESENTATIVE CAROLYN B. MALONEY, CHAIR

Good morning. I would like to thank our distinguished experts for agreeing to testify this morning on the impact of last year's oil price shock on the U.S. economy and the potential effect of higher oil prices on our nascent economic recovery.

This hearing is timely because the traditional start of the summer driving season gets underway this weekend. The most recent estimate from the Energy Information Administration is that regular gasoline prices will average $2.21 a gallon over this summer's driving season and that diesel fuel prices will be $2.23 a gallon—a far cry from the $4 or more a gallon for gasoline or diesel that drivers faced last summer.

What a difference a year makes.

Although drivers will face much lower pump prices than they did last summer, crude oil and gasoline prices have ticked up recently. Indications of "green shoots" in the U.S. economy and fiscal stimulus measures adopted in China have already begun to nudge oil prices higher as expectations for greater demand rise.

Right now, it looks like the surplus capacity of crude oil production is large enough to prevent an immediate repeat of last year's price spike.

But today we want to explore with our witnesses the short-term policies that will help to avoid derailing our recovery and long-term policies for sustainable economic growth.

While it would have been better for the last administration to have started on a sensible energy policy earlier in the decade, the current decline in global demand for oil has given us some breathing room to change course.

Yesterday's announcement by President Obama ushering in tougher national fuel efficiency standards is truly an historic opportunity to reduce our dependence on oil.

Higher standards mean we'll all get further on every tank of gasoline.

The American Recovery and Reinvestment Act also included policy changes that will help in the long run, such as investment in intercity light rail and funding and loan guarantees for research into advanced technology for vehicles and other innovative technology.

These investments will help the United States develop a modernized transportation system with efficient alternatives to automotive travel.

Last year's oil shock showed us that right now it takes a very large increase in gasoline prices to reduce our consumption of oil. Part of the reason is because many consumers have no alternatives to their gasoline powered cars. In the long run, energy policies that increase alternatives to using a gas-fueled car—whether they are different modes of transportation or alternative fuels for cars—will help minimize the impact to the economy of a rise in the price of oil.

Energy efficiency, which allows us to use less energy for the same activity, is an important part of the solution. Smart grid technology will also allow us to use our electric transmission grid more efficiently.

In testimony before this committee last year, Dr. Yergin observed that the most recent oil shock underscores the need "to encourage timely investment across the energy spectrum." I am optimistic that we are moving in that direction and towards a long term solution to reducing our dependence on oil.

I look forward to the testimony of our witnesses.

PREPARED STATEMENT OF KEVIN BRADY, SENIOR HOUSE REPUBLICAN

I am pleased to join in welcoming the witnesses testifying before us today on oil prices and the economy.

Oil prices have plunged during the recession but have started to increase more recently due to greater optimism about the economic outlook. While some of this recent optimism may be questionable given the latest data on retail sales and business investment, it is reasonable to think that the economy will be in recovery by next year, especially given the huge injections of money and credit by the Federal Reserve.

The key challenge to energy policy now, given the long lead time involved, is the need for investment in exploration and production to meet oil demand over the longer term, as opposed to an oil price spike in the short term. Nonetheless, as the international economy recovers, it is likely that oil prices will increase.

In considering this issue, it is important to note that state-controlled oil companies in OPEC and Russia account for three quarters of world oil reserves. These state-controlled companies, not private firms, are behind periodic attempts to manipulate the global oil market and exert monopoly power to hold up prices. Whatever the lasting success of these efforts, there is little doubt that state-controlled oil companies are a major force in the world oil market. There are also other state-

to-state projects underway such as the attempts to arrange financing for the Brazilian national oil company by the Chinese government.

OPEC's cuts in oil production to hold up prices are only one of many reasons we should want to encourage oil production in North America. The U.S. and Canada together hold 15 percent of the world's proven oil reserves, 200 billion barrels, and their resource potential is much greater. The U.S. can and must do much more to expand domestic production of oil as well as natural gas.

Technologies such as hydraulic fracturing, seismic imaging enhanced by geopositioning satellite systems, and steerable drilling with gyroscopic guidance systems together can significantly expand economically recoverable oil and gas reserves. Steerable drilling allows precision drilling along variable trajectories without repositioning the drilling rig, which is particularly beneficial offshore. Furthermore, when horizontal drilling was combined with fracturing in the early years of this decade, large volumes of natural gas became recoverable from rock formations that previously had been regarded as depleted or could not be tapped with conventional methods.

Instead of encouraging U.S. oil and gas production, the federal government has placed excessive limits on exploration and drilling, including effectively making offshore drilling impossible in many areas. The Administration would further penalize oil and gas production by the imposition of a variety of new energy taxes.

The Treasury justifies these tax increases by arguing that the lower taxation under current law, "encourages overproduction of oil and gas, and is detrimental to long term energy security," at least partly because it boosts "more investment in the oil and gas industry than would occur under a neutral system." With all due respect, a policy designed to suppress U.S. oil and gas production is absurd. The Treasury notes that the lower taxation under current law is, "also inconsistent with the Administration's policy of reducing carbon emissions and encouraging the use of renewable energy sources through a cap and trade program."

Thus it appears that the counterproductive nature of the Administration proposal is not an unintended consequence, but a result of deliberate design. Congress should block these tax increases precisely because they would undermine oil and gas investment and production, as the Treasury itself concedes. These traditional sources of energy are the bridge we need to the future of renewable energy.

We are all in favor of seeking renewable energy sources, so long as they are economically viable. However, we should not be seeking to suppress traditional energy production that we know is economically viable. According to the Energy Information Administration (EIA), the truth is that oil, gas, and coal provide most of the energy in the U.S. economy, and will continue to do so for many years. Tax increases targeting U.S. energy production, including the cap and trade tax, would weaken our economy, undermine U.S. competitiveness, and lower American living standards for decades to come.

PREPARED STATEMENT OF JAMES D. HAMILTON

Big increases in the price of oil that were associated with events such as the 1973–74 embargo by the Organization of Arab Petroleum Exporting Countries, the Iranian Revolution in 1978, the Iran-Iraq War in 1980, and the First Persian Gulf War in 1990 were each followed by global economic recessions.

The price of oil doubled between June 2007 and June 2008, a bigger price increase than in any of those four earlier episodes. In my mind, there is no question that this latest surge in oil prices was an important factor that contributed to the economic recession that began in the U.S. in 2007:Q4.

Unlike those earlier episodes, in which there had been a single dramatic development behind the oil price spike, the price rise over 2007–08 resulted from a number of separate factors. World oil production decreased slightly between 2005 and 2007. Declining production from mature oil fields in the North Sea and Mexico played a role, as did political instability in Nigeria. Saudi Arabian production, which many analysts had expected would have increased to meet rising demand, fell by 850,000 barrels/day between 2005 and 2007. These declines were enough to offset production gains in places such as Angola and central Asia, with the result that total global oil production dropped slightly over this two-year period.

Although production stagnated, the demand for petroleum continued to boom. World petroleum consumption had increased by 5 million barrels per day during 2004 and 2005, driven largely by a 9.4% increase in global GDP over the two years. Over the next two years—2006 and 2007—world GDP grew an additional 10.1%, which in the absence of an increase in the price of oil would have produced further big increases in the quantity of oil consumed. Even with the price increases, Chinese

oil consumption increased by 870,000 barrels per day between 2005 and 2007. With no more oil being produced, that meant that residents of the U.S., Europe, and Japan had to reduce our consumption a comparable amount. The price of oil needed to rise by whatever it took to persuade us to do so.

How much the price needed to rise in order to balance global demand with supply depends on how quickly consumers change their habits in response to a change in the price of oil. The historical experience has been that even very large oil price increases cause relatively little immediate change in the quantity of oil consumed. The response of consumers to energy price increases over 2004–2006 was if anything even smaller than those historical estimates. One reason for that smaller response may be that energy expenditures as a fraction of total spending by U.S. consumers had fallen from 8% in 1979 to 5% in 2004. The reason that we were purchasing about the same quantity of gasoline despite the increase in the price was that many of us could afford to do just that.

By June of 2008, the price of gasoline had reached $4/gallon, driving the energy budget share back up to 7%. While some people had been ignoring $3 gasoline, $4 definitely got their attention. The resulting abrupt changes in spending patterns can be quite disruptive for certain key economic sectors and seem to be part of the mechanism by which the earlier oil price shocks had contributed to previous economic recessions. The kinds of economic responses we saw between 2007:Q4 and 2008:Q3 were in fact quite similar to those observed to have followed previous dramatic oil price increases.

One notable example was the plunge in auto sales. The number of light trucks sold (which includes the once-dominant SUV category) fell by 23% between 2007:Q2 and 2008:Q2. One indication that this sales decline was caused by oil prices and not other economic developments is the observation that sales of imported cars were up by 9% over this same period. Since the domestic manufacturers were more heavily reliant on sales of the less fuel-efficient vehicles, these changes represented a significant hit to the domestic auto sector. Declining production of motor vehicles and parts alone subtracted half a percent from total U.S. real GDP between 2007:Q3 and 2008:Q3. In the absence of those declines, real GDP would have clearly grown over this period and it is unlikely that we would have characterized 2007:Q4–2008:Q3 as a true economic recession. One hundred and twenty-five thousand jobs were lost in U.S. auto manufacturing between July 2007 and August 2008. If not for those losses, year-over-year total job gains for the U.S. economy would have been positive through the first year of what we now characterize as an economic recession.

More broadly, another pattern we observed in earlier oil price shocks was a deterioration in consumer sentiment and slowdown in overall consumer spending. Americans buy about 140 billion gallons of gasoline each year, meaning that a dollar per gallon increase in the price takes away $140 billion from their annual purchasing power. The declines in consumer sentiment and slowdown in consumer spending that we observed between 2007:Q4 and 2008:Q3 are very much in line with what we saw happen in response to historical energy price shocks of similar magnitude.

In 2003, I published a description of the response of U.S. real GDP to a change in oil prices that implies that the biggest economic effects of an oil price increase are not seen until 3 or 4 quarters after the oil prices go up, as the downturn multiplies and propagates across sectors. When you feed in the values of GDP through 2007:Q3 and oil prices through 2008:Q2, that model would have predicted the value of 2008:Q3 real GDP—one year in advance—with an error of less than 0.2%.

I was quite surprised by that last result, because of course there were other serious problems for the U.S. economy over this period besides the price of oil. Foremost among these would be the depression in new home construction. But residential fixed investment had subtracted 0.94% from GDP between 2006:Q4 and 2007:Q3, despite which the economy overall continued to grow and we were not at that point in an economic recession. On the other hand, residential fixed investment subtracted only 0.89% from GDP over 2007:Q4 to 2008:Q3, during which period the U.S. economy did enter recession. Something else, in addition to the pre-existing problems in the housing sector, contributed to tipping the scales from an economic slowdown into a self-feeding dynamic of falling output and employment. I see little basis for doubting that a key aspect of that new drag on the economy resulted from the effects of the oil price shock.

There is also an interactive effect between the oil price shock and the problems in housing. Lost jobs and income were an important factor contributing to declines in home sales and prices, and we saw the biggest initial declines in house prices and increase in delinquencies in areas farthest from the urban core, suggesting an interaction between housing demand and commuting costs. Once house price declines and concomitant delinquencies reached a sufficient level, the solvency of key financial institutions came to be doubted. The resulting financial problems turned

the mild recession we had been experiencing up until 2007:Q3 into a much more severe downturn in 2008:Q4 and 2009:Q1. Whether those financial problems were sufficiently insurmountable that we would have eventually arrived at the same crisis point even without the extra burden of the recession of 2007:Q4–2008:Q3 is a matter of conjecture. But that oil prices made an important contribution both to the initial downturn as well to the magnitude of the problems we're currently facing seems to me to be indisputable.

Could anything have been done to prevent this? The decision by the Federal Reserve to drop interest rates so quickly in the first few months of 2008 likely contributed to some of the commodity price speculation. In the spring of 2008 I had further recommended some temporary sales of oil out of the Strategic Petroleum Reserve as another measure that might have proven beneficial. There is also a tradeoff between our goals of environmental protection and reducing U.S. energy use, and certainly there are policy options we could have explored for reducing our demand for low-sulfur oil in particular. I would recommend that the U.S. have an emergency plan in place for various regulatory adjustments that could be made on very short notice to help reduce petroleum demand in response to any future crisis in global oil supplies. For example, in my opinion the decision to accelerate the shift to winter fuel requirements was helpful in containing the economic damage from Hurricane Katrina in the fall of 2005.

But although there are some concrete steps that might have helped, it would be a mistake to focus exclusively on short-term gimmicks. The fundamental problem that I have highlighted above—booming world petroleum demand in the face of stagnant world oil production—is very much a long-run challenge. The reality is that no policy could have prevented a substantial increase in the price of oil between 2005 and the first part of 2008. The main lesson that I hope we draw from this experience is that this long-run challenge is something with very real and present short-run consequences.

Will the recent uptick in oil prices undermine prospects for recovery from the recession? Retail gasoline prices have risen about 50 cents a gallon from their low in December. That takes away about $70 billion from consumers' annual spending power, which is hardly helpful for the broader challenge of restoring household balance sheets to a level where spending could be expected to pick back up. But let me emphasize that although I believe that the initial spike in oil prices was an important element of the process that produced our current difficulties, we are currently at a point at which the multipliers and spillovers associated with the recession dynamic itself have become far more important factors than the price of oil. The problems faced by U.S. automakers at the moment—and those problems are very, very daunting—are not caused by the price of gasoline. What is needed to restore U.S. vehicle sales now is not lower gas prices but instead more income, jobs, and confidence on the part of consumers.

Notwithstanding, the recent rise in oil prices again underscores the present reality of the long-run challenges. Even if we see significant short-run gains in global oil production capabilities, if demand from China and elsewhere returns to its previous rate of growth, it will not be too long before the same calculus that produced the oil price spike of 2007–08 will be back to haunt us again.

Supplementary material for testimony by Professor James D. Hamilton, University of California, San Diego, U.S. Congress Joint Economic Committee, May 20, 2009

Paper presented at Brookings Institution, April 2, 2009
to be published in *Brookings Papers on Economic Activity*

Causes and Consequences of the Oil Shock of 2007-08*

James D. Hamilton

jhamilton@ucsd.edu

Department of Economics, UC San Diego

February 3, 2009 Revised: April 27, 2009

ABSTRACT

This paper explores similarities and differences between the run-up of oil prices in 2007-08 and earlier oil price shocks, looking at what caused the price increase and what effects it had on the economy. Whereas historical oil price shocks were primarily caused by physical disruptions of supply, the price run-up of 2007-08 was caused by strong demand confronting stagnating world production. Although the causes were different, the consequences for the economy appear to have been very similar to those observed in earlier episodes, with significant effects on overall consumption spending and purchases of domestic automobiles in particular. In the absence of those declines, it is unlikely that we would have characterized the period 2007:Q4 to 2008:Q3 as one of economic recession for the U.S. The experience of 2007-08 should thus be added to the list of recessions to which oil prices appear to have made a material contribution.

*I am grateful to Alan Blinder, David Romer, Lutz Kilian, conference participants, and an anonymous referee for helpful comments on an earlier draft of this paper, and to Davide Bertoli for supplying the Blanchard-Galí data and code.

1 Introduction.

Figure 1 plots the real price of oil over the last half century. A series of dramatic events in the 1970s sent the price of oil over $40/barrel by the end of the decade, which would be over $100/barrel in current prices. The price remained very volatile after the collapse in the 1980s, but was still as low as $20/barrel in 2001. The next 6 years saw a steady increase that tripled the real price by the middle of 2007. Later that year, the path of oil prices steepened sharply, sending the price to a high of $145/barrel on July 3, 2008, only to be followed by an even more spectacular price collapse. What caused this remarkable behavior of oil prices, and what were the effects on the economy?

To answer these questions, I begin in Section 2 by exploring the causes of several of the big oil shocks of the late 20th century, and then turn in Section 3 to an analysis of what happened to produce the dramatic price moves in 2007 and 2008. Section 4 reviews some of the evidence of how the economy seemed to respond to earlier oil price shocks, with Section 5 investigating the effects on the U.S. economy of the oil shock of 2007-2008. Some implications for policy are briefly noted in Section 6.

2 Causes of historical oil shocks.

2.1 Some observations on petroleum demand.

The most important principle for understanding short-run changes in the price of oil is the fact that income rather than price is the key determinant of the quantity demanded. One

quick way to become convinced of this fact is to examine Figure 2, which plots petroleum consumption against GDP for the U.S. over the last 60 years.[1] Despite the huge fluctuations in the relative price of oil over this period, petroleum consumption followed income growth remarkably steadily. There was some downward adjustment in oil use at the end of the 1970s, though achieving that 20% drop in petroleum consumption required an 80% increase in the relative price and two recessions in a 3-year period over 1980-82.

There is a flattening in the slope of this path over time, which some might attribute to delayed conservation consequences of the 1970s oil shocks. However, this flatter slope persists long after the price had fallen quite dramatically, and seems more likely to be due to the fact that income elasticity declines as a country becomes more developed. One sees a similar pattern of slowing growth of petroleum use as other developed countries became richer, while post-1990 data for the newly industrialized countries is still quite supportive of an income elasticity near unity (Hamilton, 2009; Gately and Huntington, 2002).

Table 1 summarizes the estimated price elasticities for gasoline and crude oil demand from a half-dozen meta-analyses or literature reviews. Since crude oil represents about half the retail cost of gasoline, one would expect that a 10% increase in the price of crude would be associated with a 5% increase in the price of gasoline,[2] in which case the price elasticity of the demand for crude oil should be about half as big as that for retail gasoline. Most of

[1] This is essentially a scatterplot with adjacent years connected by a smoothed curve. Tracing this curve from the lower left to the upper right identifies the combinations of real GDP and petroleum consumption that were observed at increasingly later dates as one moves along the curve.

[2] The regression coefficient relating the log of the nominal U.S. gasoline retail price to the log of the nominal WTI in a monthly cointegrating regression estimated over 1993:M4-2008:M8 is 0.62. Data from EIA, "Spot Prices for Crude Oil and Petroleum Products," http://tonto.eia.doe.gov/dnav/pet/pet_pri_spt_s1_m.htm.

the studies behind these summaries reported low estimates of the price-elasticity of gasoline demand and significantly smaller elasticities for crude.

The price elasticity of petroleum demand has always been small, and it is hard to avoid any conclusion other than that it had become an even smaller number for the U.S. in the 2000s. One can barely detect any downward deviation from the trend in petroleum consumption in Figure 2 despite the enormous price increase through 2007. Hughes, Knittel, and Sperling (2008) estimated that short-run gasoline demand elasticity was in the range of 0.21 to 0.34 over 1975-1980 but between only 0.034 and 0.077 for the 2001-06 period.

Another key parameter for determining the consequences of an energy price increase for the economy is the value share of energy purchases relative to total expenditures. The fact that the U.S. income elasticity of demand has been substantially below unity over the last quarter century induces a downward trend in that share– for a given relative price, if the percentage growth in energy use is less than the percentage growth in income, total dollar expenditures on energy would decline as a percentage of income. On the other hand, the very low short-run price elasticity of demand causes the value share to move in the same direction as the relative price– if the percentage increase in price is greater than the percentage decrease in quantity demanded, dollar spending as a share of income will rise when the price of energy goes up.

Figure 3 displays the net effect of these two factors on spending by consumers on energy goods and purchases as a percentage of total consumption spending. The income-elasticity effect imparts a chronic downward trend, and by 2002 this share had fallen to a little over 4%

of a typical consumer's total budget. However, subsequent energy price increases produced a dramatic reversal of this trend, with the share in 2008 almost twice the 2002 value.

Figure 3 also serves to remind us that a price elasticity cannot be globally below unity. If you don't reduce the quantity purchased by as much in percentage terms as the price goes up, the item comes to consume a larger fraction of your budget. If the price elasticity were globally less than unity, an arbitrarily large price increase would ultimately bring the consumer to a point where 100% of the budget was going to energy, in which case ignoring the price would no longer be physically possible. The low expenditure share in the early part of this decade may be part of the explanation for why Americans were largely ignoring the early price increases– we didn't change our behavior much because most of us could afford not to. By 2007-08, however, the situation had changed, as energy had once again returned to an importance for a typical budget that we had not seen since the 1970s.

2.2 Historical supply disruptions.

Figure 4 plots monthly oil production levels for three Middle East countries that have recurrently appeared in the news over the last 35 years. Three events over this period– the Iranian revolution in the fall of 1978, Iraq's invasion of Iran in September 1980, and Iraq's invasion of Kuwait in August 1990– resulted in dramatic and immediate disruption of the flow of oil from key global producers. Another episode, not evident in Figure 4 but that I will nevertheless include in the set of historical oil shocks discussed, is the cut in oil production that followed the Yom Kippur War that began October 6, 1973. Although the military conflict did not directly prevent any significant shipments of oil, the Organization

of Arab Petroleum Exporting Countries (OAPEC) announced[3] on October 16 that it would cut production by 5%

> until the Israeli forces are completely evacuated from all the Arab territories occupied in the June 1967 war and the legitimate rights of the Palestinian people are restored.

Hamilton (2003) included the Suez Crisis of 1956 as a fifth significant oil shock, though the price increase from that episode was much more modest, and data for the kinds of comparisons performed below are not readily available for that period, so this paper will use just these four episodes.

The bold line in the first column of Figure 5 records the drop in oil production from the affected countries in the months following the events just mentioned. The first panel in that column uses the combined output of the members of OAPEC. The panel in the second row, first column shows the production from Iran. The third row of column 1 gives the combined production of Iran and Iraq, and the fourth row the combined production of Iraq and Kuwait. In each case, the production shortfall is expressed as a percentage of total global production prior to the shock.[4] Each of these events knocked out between 7 and 9 percent of world supply.

[3] Quotation is taken from an OAPEC ministers' press release reported by Al-Sowayegh (1984, p. 129).

[4] These numbers differ slightly from the values reported in Table 4 of Hamilton (2003) due to small differences in the estimates of total global oil production used, and the fact that here the Iranian shortfall is dated as beginning in October rather than September of 1978.

In each episode, there was some increase in production coming from other countries that partially mitigated the consequences. The net consequences of the disruptions are captured by the dashed lines in the first column of Figure 5, which portray the percentage decline in actual total world production following each of the events. Production increases from other countries were rather minor in 1973-74, but quite substantial in 1990-91.

The subsequent path of oil prices is indicated in the second column of Figure 5. Each of these episodes was associated with significant increases in the price of oil, with the price jumping 25% in 1980 and 70% in 1990. Note that there were some price controls in effect for the first three episodes, which spread the consequences over time.

Kilian (forthcoming) downplays the contribution of these supply disruptions to the price movements portrayed in Figure 5, instead attributing much of the historical fluctuations in the price of oil to what he describes as "precautionary demand associated with market concerns about the availability of future oil supplies." He identifies the latter as any movements in the real price of oil that cannot be explained statistically by his measures of shocks to supply and aggregate demand. Another way one might try to measure the contribution of precautionary demand is by looking at changes in inventories. The third column of Figure 5 records the monthly change in U.S. inventories of crude oil and petroleum products beginning with the first month of each of the four episodes, again measured as a percentage of total global production. In each of these episodes, inventories were going down, not up, at the time of the sharpest price movements, suggesting that inventory changes were serving to mitigate rather than aggravate the magnitude of the price shocks. Positive inventory

investment typically came much later, as firms sought to restock the storage that had been earlier drawn down.

One can also explore whether the supply disruptions alone offer a sufficient explanation for the observed price movements on the basis of plausible elasticities. Table 2 compares the average decline in global oil production during these four episodes with the observed price change to calculate implied price-elasticities of demand under the assumption that there was zero shift in demand from growing income over these episodes and that the supply shift was the sole explanation for the price increase. These elasticities are a bit smaller than might have been expected from the consensus estimates in Table 1, but in no case does it seem implausible on the basis of the implied elasticity to attribute most of the price change to the supply shortfall itself.

Kilian (2008) also argues that the bold lines in the first column of Figure 5 overstate the magnitude of the supply disruptions caused by these 4 episodes. He observes, for example, that Iraq increased production significantly in anticipation of both the 1980 and 1990 wars, so that using the Iraqi production levels just prior to the conflict overstates the size of the shock (see the middle panel of Figure 4). Note, however, that this is not a factor in the dashed lines of Figure 5 or the calculations in Table 2, which are based on the observed global decline subsequent to the indicated date. Moreover, despite the high levels of pre-war Iraqi production, global production in September 1980 was 2.9% below its level 3 months earlier and 5.4% below its level of 6 month earlier. Likewise, global production in July 1990 was down 2.1% or 0.7% from its values 3 months or 6 months earlier. Hence, if we'd compared

global production in these episodes with a value earlier than the September 1980 or July 1990 reference dates used, the imputed quantity reductions in Table 2 would have been even more significant.

Kilian (forthcoming) and Barsky and Kilian (2002) argue, quite correctly in my view, that demand pressures also made a contribution to the magnitudes of the oil price increase observed in several of these episodes. In particular, it would be irresponsible to claim that the nominal oil price increase in 1973-74 had nothing to do with the general inflation and boom in the prices of other commodities also observed at that time. Nevertheless, I share Blinder and Rudd's (2008) doubts about whether inflationary pressures can be construed as the primary explanation for why OAPEC chose to reduce the quantity of oil they produced by 5% within weeks of the onset of the Yom Kippur War.

My overall conclusion thus supports the conventional interpretation: historical oil price shocks were primarily caused by significant disruptions in crude oil production that were brought about by largely exogenous geopolitical events.

3 Causes of the oil shock of 2007-08.

Figure 6 plots five different measures of energy prices during the last quarter of 2007 and first half of 2008. By any measure, this episode qualifies as one of biggest shocks to oil prices on record. However, the causes were quite different from events associated with the 4 episodes examined above.

3.1 Supply.

Despite occasional dramatic news such as hurricanes in the Gulf of Mexico in September 2005, turmoil in Nigeria in 2006-2008, and ongoing strife in Iraq, global production has been remarkably stable; (see Figure 7). The big story has been not a dramatic reduction in supply of the kinds summarized in Figure 5, but a failure of production to increase between 2005 and 2007.

Why did global production stagnate? In any given producing field, eventually pressure falls and daily production levels begin to decline. Increasing global production requires moving on to new producing areas. The U.S. has been extensively explored and developed, and total U.S. production is now about half the level we achieved in 1971; (see the top panel of Figure 8) World production nevertheless has increased substantially since then as new fields became developed, though Figure 8 shows that several of these are now in significant decline, including the North Sea (which had accounted for 8% of world production in 2001) and Mexico's Cantarell Field (formerly the world's second largest producing field). Production declines caused former OPEC member Indonesia to become an oil importer, and the nation dropped out of OPEC in 2008.

The most important world oil exporter has for many years been Saudi Arabia, whose monthly production levels are plotted in the bottom panel of Figure 8. These have historically been quite volatile and exhibited substantial swings up and down not because of depletion but because the Saudis followed a deliberate strategy of adjusting production in an effort to stabilize prices. For example, the kingdom's decision to substantially increase

production in late 1990 was a reason why the oil price shock of 1990 was so short-lived (see the bottom row of Figure 5).

Because the Saudis had historically used their excess capacity to mitigate the effects of short-run supply shortfalls, many analysts had assumed that they would continue to do the same in response to the longer run pressure of growing world demand, and most forecasts called for continuing increases in Saudi production levels over time. For example, even as recently as in their 2007 *World Energy Outlook,* the International Energy Agency was projecting that the Saudis would be pumping 12 million barrels per day by 2010. In the event, however, Saudi production went down rather than up in 2007. It is a matter of conjecture whether the decline in Saudi production in 2007 should be attributed to depletion of its Ghawar oil field, to a deliberate policy decision in response to a perceived decline in the price-elasticity of demand, or to long-run considerations discussed below. Whatever its cause, the decline in Saudi production was certainly one important factor contributing to the stagnation in world oil production over 2005-2007. It also unambiguously denotes the latter episode as a new era as far as oil pricing dynamics are concerned– without the Saudis' willingness or ability to adjust production to smooth out price changes, any disturbance to supply or demand would have a significantly bigger effect on price after 2005 compared with earlier periods.

3.2 Demand.

Although supply stagnated, demand was growing strongly. Particularly noteworthy is oil consumption in China, which has been growing at a 7% compound annual rate over the

last two decades; (see Figure 9). Chinese consumption in 2007 was 870,000 barrels per day higher in 2007 than it had been in 2005.

How can it be that China was consuming more oil, yet no more oil was being produced? Mathematically, consumption in other regions had to decline, and indeed it did. Consumption in the U.S. in 2007 was 122,000 b/d below its level in 2005; Europe dropped 346,000 and Japan 318,000. And what persuaded residents of these countries to reduce oil consumption in the face of rising incomes? The answer is, the price had to increase sufficiently to reduce consumption in the OECD countries commensurate with the increase from China, given the stagnation in total global production.

Let us consider some quick ballpark estimates of how big a price increase that should have required. According to IMF estimates,[5] World real GDP experienced 2-year total growth of 9.4% in 2004 and 2005. As noted above, the income elasticity of petroleum demand in countries like the U.S. is currently about 0.5, whereas in the newly industrialized countries it may be above unity (Hamilton, 2009; Gately and Huntington, 2002). World petroleum production was 5 million barrels per day higher in 2005 than in 2003, a 6% increase. Thus it is entirely plausible to attribute the 6% increase in oil consumption between 2003 and 2005 to a shift in the demand curve caused by the increase in world GDP.

World real GDP grew an additional 10.1% in 2006 and 2007. Hence it seems reasonable to suppose that, if oil had remained at the 2005 price of $55/barrel, quantity demanded would have increased by at least another 5 million barrels per day by the end of 2007. Eco-

[5] IMF, *World Economic Outook: October 2008,* Table A.1.

nomic growth slowed significantly in 2008:H1, but remained positive, and I've conservatively assumed that economic growth would have added at least another half million barrels per day to the quantity demanded in the first half of 2008, more than enough to absorb the slight increase in global production that finally appeared in the first half of 2008. Under these assumptions, the price had to rise between 2005 and 2008:H1 by an amount sufficient to reduce the quantity demanded by 5 mb/d; (see the top panel of Figure 10).

It's worth commenting on what was new about the contribution of Chinese and world economic growth over this period. While China had been growing at the remarkable rate noted for a quarter century, it has only recently become big enough relative to the global economy to make a material difference. For example, the 4.9% world GDP average annual growth rate over 2003-2007 compares with a 2.9% average over the robust 1990s. And judging from the gap between EIA figures for China's total petroleum production and consumption,[6] China was a net exporter of petroleum up until 1992, and its imports were only up to 800,000 barrels/day in 1998. But by 2007, China's net imports were estimated to be 3.6 million barrels per day, making it the world's third biggest importer and a dominant factor in current world markets. The magnitude of the global growth in petroleum demand in recent years is thus quite remarkable, and although there have been other episodes when global production stagnated over a two-year period, these were inevitably either responses to falling demand during recessions or physical supply disruptions detailed above.

[6] Data from EIA, "World Petroleum Consumption, Most Recent Annual Estimates,1980-2007," (http://www.eia.doe.gov/emeu/international/RecentPetroleumConsumptionBarrelsperDay.xls) and "World Production of Crude Oil, NGPL, and Other Liquids, and Refinery Processing Gain, Most Recent Annual Estimates, 1980-2007,„ (http://www.eia.doe.gov/emeu/international/RecentTotalOilSupplyBarrelsperDay.xls).

Although Figure 10 is drawn with vertical short-run supply curves, the analysis here does not require any particular assumptions about the short-run supply elasticity. I simply take it as an observed fact that, as a result of whatever combination of shifts of or movements along the short-run supply curve, the quantity supplied in 2008:H1 was essentially the same as that supplied in 2005 and that the price and output pairs for the two dates both represent an intersection of supply and demand. The exercise explores the necessary adjustments if the strong growth of world GDP between the two periods is presumed to have shifted the demand curve to the right by 5.5 mb/d. The question is then, what price increase would have been necessary to have moved along that second demand curve to a point where quantity demanded would have been as low as 85.5 mb/d?

The answer to that question depends of course on the slope of the 2008:H1 demand curve. If, for illustration, the price-elasticity of demand were $\varepsilon = 0.06$, then the price would have been predicted to have risen to \$142/barrel under the above scenario:

$$\varepsilon = \frac{|\Delta \ln Q|}{\Delta \ln P} = \frac{\ln 90.5 - \ln 85.5}{\ln 142 - \ln 55} = 0.06.$$

On the other hand, such numerical calculations are extremely sensitive to the assumptions about the short-run price elasticity of demand. If instead the elasticity were $\varepsilon = 0.10$, the price would only need to rise to \$97 to prevent global quantity demanded from increasing.

Which is the correct short-run elasticity, 0.06 or 0.10? Recalling Tables 1 and 2, one could easily defend either value or numbers significantly smaller or bigger. Moreover, as noted by Hughes, Knittel and Sperling (2008), the elasticity relevant for 2007-08 could have been much smaller than those that governed other episodes. One key variable to look at

for this question is the value of inventories. If the price increase between 2005 and 2008:H1 was bigger than needed to equate supply with demand, inventories should have been piling up, whereas if the price increase was too small, inventories would be drawn down.

We don't have reliable data on all stored oil, but have pretty good measures on the inventories of crude oil held by U.S. refiners. Figure 11 plots the average seasonal pattern of these inventories, along with the actual values in 2007 and 2008. In the first half of 2007, inventories were a bit above trend. But in late 2007 and the first half of 2008, when the price increases were most dramatic, inventories were significantly below normal, suggesting that indeed an assumed elasticity of 0.10 was too big, and that price increases through the end of 2007 were not sufficient to bring quantity demanded down to equal quantity supplied.

Just as academics may debate what is the correct value for the price elasticity of crude oil demand, market participants can't be certain, either. Many observers have wondered what could have been the nature of the news that sent the price of oil from $92/barrel in December 2007 to its all-time high of $145 in July 2008. Clearly it's impossible to attribute much of this move to a major surprise that economic growth in 2008:H1 was faster than expected or that the oil production gains were more modest than anticipated. The big uncertainty, I would argue, was the value of ε. The big news of 2008:H1 was the surprising observation that even $100 oil was not going to be sufficient to prevent global quantity demanded from increasing above 85.5 mb/d and that no more than 85.5 mb/d was going to be available.

This explanation of the price shock also requires that market participants could have had little inkling in 2008:H1 of the massive economic deterioration that was just ahead. In this,

they certainly would have had some good company. Here was the analysis offered publicly by European Central Bank President Jean-Claude Trichet on July 3, 2008:[7]

> On the basis of our regular economic and monetary analyses, we decided at today's meeting to increase the key ECB interest rates by 25 basis points....[Inflation is] expected to remain well above the level consistent with price stability for a more protracted period than previously thought.... [W]hile the latest data confirm the expected weakening of real GDP growth in mid-2008 after exceptionally strong growth in the first quarter, the economic fundamentals of the euro area are sound.

And although a growth slowdown in the United States was certainly acknowledged at that point, many were unpersuaded that it would become serious enough to qualify as a true recession. Professor Edward Leamer wrote in August 2008 that U.S. economic indicators would "have to get much worse to pass the recession threshold."

One may be able to rationalize the dramatic oil price spike of 2007-08 as a potentially appropriate response to fundamentals. But what about the even more dramatic subsequent price collapse? Certainly Trichet, Leamer, and everyone else changed their minds about those assessments of real economic activity as the disastrous economic news of 2008:H2 came in. But economic collapse alone is not a sufficient explanation for the magnitude of the oil price decline, if the analysis in the top panel of Figure 10 is correct. Even a 10% drop of global GDP would only undo the effects of the rightward shift of the demand curve since

[7] Introductory Statement from the ECB, http://www.ecb.int/press/pressconf/2008/html/is080703.en.html.

2005. Bad as the news in 2008:H2 had been, it does not come close to that magnitude as of yet, yet the price by the end of December was down to $40, well below the 2005 price of $55. Nor can the modest production increases of another half-million barrels/day in 2008:H2 over 2008:H1 go too far as an explanation. Instead, one would need again to attribute a significant part of the 2008:H2 price collapse to yet another shift in the elasticity. Whereas a short-run price elasticity of 0.06 might be needed to interpret developments of 2008:H1, a higher intermediate-run elasticity, as petroleum users made delayed adjustments to the earlier price increases, is needed to be postulated as another factor contributing to the price decline in the second half of the year; (see the bottom panel of Figure 10).

It is hardly controversial to suggest that the long-run demand responses to price increases are more significant than the short-run responses. The more fuel-efficient vehicles sold in the spring and summer of 2008 are going to mean lower consumption, at least from those vehicles, for many years to come. The EIA reported that U.S. petroleum and petroleum products supplied in 2008:Q3 were 8.8% lower (logarithmically) than in 2007:Q3, a far bigger drop in percentage terms than the presumed 6.3% rightward shift between the 2005 and 2008:H1 world demand curves assumed in the top panel of Figure 10, and again far in excess of anything attributable to the drop in income alone.

3.3 The role of speculation.

One can thus tell a story of the oil price shock and subsequent collapse that is driven solely by fundamentals. But the speed and magnitude of the price collapse leads one to give serious consideration to the alternative hypothesis that this episode represents a speculative

price bubble that subsequently popped. One proponent of the latter view has been Michael Masters, manager of a private financial fund who has been invited a number of times to testify before the United States Senate. Masters blames the oil price spike of 2007-08 on the actions of investors who bought oil not as a commodity to use but instead as a financial asset, claiming that by March 2008, commodity index trading funds held a quarter trillion dollars worth of futures contracts. A typical strategy is to take a long position in a near-term futures contract, sell it a few weeks before expiry, and use the proceeds to take the long position in a subsequent near-term futures contract. When commodity prices are rising, the sell price should be higher than the buy, and the investor can profit, viewing this as a synthetic way to take a long position in the commodity without ever physically taking delivery. As more investment funds sought to take positions in commodity futures contracts for this purpose, so that the number of buys of next contracts always exceeded the number of sells of expiring, Masters argues that the effect was to drive up the futures price, and with it, the price of the associated spot commodity itself. He argues that this "financialization" of commodities introduced a speculative bubble in the price of oil.

The key intellectual challenge for such an explanation is to reconcile the proposed speculative price path with what is happening to the physical quantities of petroleum demanded and supplied. To be concrete about the nature of this challenge, consider a representative refiner who purchases a quantity Z_t of crude oil at price P_t per barrel, of which X_t is used up in current production of gasoline and the remainder goes to increase inventories I_t:

$$I_{t+1} = I_t + Z_t - X_t. \tag{1}$$

This is simply an accounting identity– if the quantity of oil that is consumed by users of the product (in this case, X_t) is smaller than the quantity that is physically produced (Z_t), inventories must accumulate. If we hypothesize that, as a result of whatever process, financial speculation produces some particular value for the price P_t, that price necessarily has implications for those who use the product (X_t) and those who produce it (Z_t). It seems impossible to discuss a theory of price P_t that makes no reference to the physical quantities produced, consumed, or held in inventory.

To explore this issue more fully, consider the following simple model. Suppose that the refiner produces a quantity of gasoline y_t sold at price G_t (where both P_t and G_t are measured in real terms), according to the production function

$$y_t = F(X_t, I_t).$$

The second term reflects the idea that it would be impossible for the refiner to operate efficiently if it maintained zero stock of inventories. A positive value for the derivative $F_I(X_t, I_t)$ introduces a "convenience yield" from inventories, or motive for the firm to hold a positive level of inventory even if it anticipates falling crude oil prices ($P_{t+1} < P_t$). The refiner faces a real interest rate of r_t and cost of physically holding inventories $C(I_{t+1})$. The refiner's objective is thus to choose $\{Z_t, X_t, I_{t+1}\}_{t=0}^N$ so as to maximize

$$\sum_{t=0}^{N} \frac{1}{\prod_{\tau=1}^{t}(1+r_\tau)} [G_t F(X_t, I_t) - C(I_{t+1}) - P_t Z_t]$$

taking I_0 and $\{P_t, G_t\}_{t=0}^N$ as given. Note I pose this as a perfect-foresight problem, since the complications introduced by uncertainty are not relevant for the points I want to make here, and liquid futures markets exist for P_t and G_t.

The first-order conditions for this optimization problem are[8]

$$G_t F_X(X_t, I_t) = P_t \tag{2}$$

$$P_t + C'(I_{t+1}) = \frac{1}{(1+r_t)}\left[G_{t+1}F_I(X_{t+1}, I_{t+1}) + P_{t+1}\right]. \tag{3}$$

Equation (2) is the optimality condition associated with the firm purchasing one more barrel of crude oil, whose marginal cost is P_t, and using the crude immediately to refine and sell more gasoline, whose marginal benefit to the firm is $G_t F_X(X_t, I_t)$. Equation (3) is the condition required for optimal inventory management. If the firm buys one more barrel of crude today to store as inventory, the marginal cost is $P_t + C'(I_{t+1})$. If the inventory is then used to reduce next period's crude purchases, the discounted marginal benefit is $(1+r_t)^{-1}\left[G_{t+1}F_I(X_{t+1}, I_{t+1}) + P_{t+1}\right]$.

If the firm were to face an increase in P_{t+1} with all other prices fixed, it would respond by increasing I_{t+1} until (3) was restored. This plan would be implemented by increasing current crude purchases Z_t and decreasing Z_{t+1}. In the market equilibrium that we will finish spelling out shortly, that would put upward pressure on P_t and downward pressure on P_{t+1}. But it's interesting to comment now on the limiting case of a constant physical storage cost ($C'(I_{t+1}) = s$) and constant convenience yield ($F_I(X_{t+1}, I_{t+1}) = c$), the latter including as a special case zero convenience yield or a situation that inventories are already so high that there would be no sales gains from building inventories even higher ($F_I(X_{t+1}, I_{t+1}) = 0$).

[8] Specifically, the values of $\{X_t, Z_t, I_{t+1}\}_{t=0}^{N}$ are determined as functions of $\{Q_t, P_t\}_{t=0}^{N}$ from (2) for $t = 0, ..., N$, (1) for $t = 0, ..., N$, (3) for $t = 0, ..., N-1$, and the terminal condition $I_{N+1} = 0$.

In this case (3) becomes

$$P_t + s = \frac{1}{(1+r_t)}\left[G_{t+1}c + P_{t+1}\right]. \tag{4}$$

In this limiting case, (4) becomes an equilibrium condition that would have to characterize the relation between P_t and P_{t+1} in any equilibrium with nonzero inventories. If, for example, the right-hand side of (4) exceeded the left, there would be an infinite increase in the demand for crude Z_t and infinite decrease in Z_{t+1}, to which the equilibrium prices P_t and P_{t+1} would have to respond until the equality (4) was restored.

More generally, if $C'(I_t)$ and $F_I(X_t, I_t)$ are relatively flat functions of I_t, then the effect of (3) is to force P_t and P_{t+1} to move closely together. In crude oil markets, the futures price P_{t+1} serves an information discovery role, with any changes in the futures price translating instantaneously into a corresponding movement in spot prices. For example, Figure 12 plots f_{1d}, the price of crude oil for the nearest-term futures contract on day d, and f_{3d}, the price of oil for the futures contract expiring two months after the expiration of the contract associated with f_{1d}. The two series move very closely together. For 93% of the 6,421 business days between April 5, 1983 and November 12, 2008, f_{1d} and f_{3d} changed in the same direction from the previous day. A regression of $\Delta \ln f_{3d}$ on $\Delta \ln f_{1d}$ has an R^2 of 0.86. Thus this part of Masters' claim– that if speculation affected the futures price, the spot price would be forced to move with it– is very much consistent with both theory and evidence.

We can close the model by specifying that crude oil is exogenously supplied,

$$Z_t = \overline{Z}_t, \tag{5}$$

and gasoline demand has a price elasticity of β:

$$\ln F(X_t, I_t) = \alpha - \beta \ln G_t. \tag{6}$$

The system of equations (1)-(3), (5), and (6) then determine $\{Z_t, X_t, I_{t+1}, P_t, G_t\}_{t=0}^N$ as functions of $\{\overline{Z}_t\}_{t=0}^N$.

Notice that if the marginal storage cost $C'(I_{t+1})$ is negligible, then equations (1)-(3) and (5) are homogenous of degree 0 in $\{P_t, G_t\}_{t=0}^N$. Without (6)– if there were no response of gasoline demand to the price of gasoline– the price of crude oil would be indeterminate. Suppose we were initially in a situation where all 5 equations were satisfied, and consider the limiting case when the demand for gasoline is perfectly price inelastic ($\beta = 0$). Suppose that for some reason speculators bid up the futures price of crude (P_{t+1} increases). By inventory arbitrage (3), P_t would have to go up with it. In this sense, we might claim to have a theory of how financial speculation in the oil futures price P_{t+1} could be the determining factor in the price of oil.

On the other hand, when the price elasticity $\beta > 0$, the above analysis no longer goes through. In response to the hypothesized increase in P_{t+1} and P_t, the price of gasoline G_t would go up from (2), the quantity of gasoline demanded would decline, and the crude X_t needed to produce this would be lower. An increase in P_{t+1} and P_t induced by speculation would thus cause crude inventories I_{t+1} to accumulate relative to the firm's desired path.

If the price elasticity is small but not zero, this feedback would be subtle, and it is conceivable that it would take some time before mispricing from the futures markets would be recognized and corrected. It is interesting to note, however, that the same condition

needed to rationalize a speculation-based interpretation of the oil shock of 2007-08– a very low price elasticity of oil demand– is exactly the same condition that would enable us to attribute the event to fundamentals alone.

The other possible way in which advocates of the price bubble interpretation might attempt to reconcile their story with the physical side of the petroleum market is to hypothesize a mechanism whereby the quantity of oil supplied $\overline{Z}_t$ is itself influenced by the futures price. Given the pressures for growth in petroleum demand from countries like China to continue, if it remains difficult to increase global production, the price pressures of 2008 are only the beginning of the story. Recalling the Hotelling (1931) principle, it would in this situation pay the owners of the resource to forego current production, in order to be able to sell the oil at the higher future price. One might then argue that oil producing countries were misled by the speculative purchases of oil futures contracts into reducing current production $\overline{Z}_t$ in response, by this mechanism reconciling the postulated speculation with the physical dynamics of oil supply and demand (1); for more discussion see Jovanovic (2007).

If so, such miscalculation by oil producers could not have been based on comparing the longer-term futures price with the spot price available in 2008. Figure 13 plots the term structure of prices implied by New York Mercantile Exchange futures contracts at the height achieved by oil prices in July 2008. Although there was a modest upward slope in the very near-term contracts (for example, the December 2008 contract sold for a higher price than August 2008), that slope turned distinctly downward after the February 2009 contract, meaning that any producers who used the futures contracts to sell their oil forward could plan

on selling future production at a lower price than current production. This downward slope from 2009 onward is inconsistent with a natural Hotelling interpretation of why producers might keep oil in the ground. Notwithstanding, one might argue that producers distrusted the futures markets, and could not use them as a significant hedge given the volumes. Ex post, the high spot price in 2008 meant that a country that had held off production from 2001 to 2008 would have been richly rewarded, which experience might persuade some of the benefits of not producing all out in 2008, either. Of interest is this report from Reuters news service on April 13, 2008:

> Saudi Arabia's King Abdullah said he had ordered some new oil discoveries left untapped to preserve oil wealth in the world's top exporter for future generations, the official Saudi Press Agency (SPA) reported.
>
> "I keep no secret from you that when there were some new finds, I told them, 'no, leave it in the ground, with grace from God, our children need it'," King Abdullah said in remarks made late on Saturday, SPA said.

With hindsight, it is hard to deny that the price rose too high in July 2008, and that this miscalculation was influenced in part by the flow of investment dollars into commodity futures contracts. It is worth emphasizing, however, that the two key ingredients needed to make such a story coherent– a low price elasticity of demand, and the failure of physical production to increase– are the same key elements of a fundamentals-based explanation of the same phenomenon. I therefore conclude that these two factors, rather than speculation per se, should be construed as the primary cause of the oil shock of 2007-08. Certainly the

casual conclusion one might have drawn from glancing at Figure 1 and hearing some of the accounts of speculation[9] – that it was all just a mistake, and the price should have stayed at \$50/barrel throughout the period 2005-08– would be profoundly in error.

4 Consequences of historical oil shocks.

In essentially any theoretical model of the economic effects of a change in oil prices, a key parameter is the value share such as the series plotted in Figure 3. To see why this is a key parameter, consider for example a firm producing output Y_t with inputs of capital K_t, labor N_t, and energy E_t. Suppose that the firm is operating at a point where the marginal product of energy is equal to its relative price:

$$\frac{\partial F(K_t, N_t, E_t)}{\partial E_t} = P_t. \tag{7}$$

Multiplying both sides of (7) by $E_t/F(K_t, N_t, E_t)$ establishes that the elasticity of output with respect to energy is given by the value share,

$$\frac{\partial \ln F(K_t, N_t, E_t)}{\partial \ln E_t} = \alpha_t$$

for $\alpha_t = P_t E_t / F(K_t, N_t, E_t)$. Alternatively, consider a consumer facing a π% increase in the relative price of energy. One short-run option available to 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. This would require the

[9] For example, the Obama campaign site in June of 2008 included a number of quotes from analysts such as Shell President John Hofmeister that the proper range of crude oil is "somewhere between \$35 and \$65 a barrel." See http://www.econbrowser.com/archives/2008/06/how_big_a_contr.html for details.

consumer either to reduce saving or to cut spending on other items. If α_t denotes the consumer's energy expenditure share, the requisite percentage cut in spending on other items would be given by $\alpha_t \pi$.

A large number of papers have investigated the economic consequences of previous oil price shocks. Recent refinements include investigations of the following: (1) nonlinearity in the relation, with oil price increases having a bigger effect on the economy than oil price decreases (e.g., Hamilton, 2003); (2) the causes of the oil shock, with price increases brought about by surging global demand having less of a disruptive effect than those caused by losses in supply (e.g., Kilian, forthcoming); and (3) a changing relation over time, with the modern economy more resilient to an oil price shock than it had been historically (e.g., Blanchard and Galí, 2008).

Although these issues are unquestionably quite important, it is useful to look first at some simple linear representations of the basic correlations in the historical data, with a minor automatic adjustment for one source of a possible changing impact over time due to the changes in α_t. This is the approach taken by Edelstein and Kilian (2007). They estimated monthly bivariate autoregressions of the form

$$\begin{aligned} x_t &= k_1 + \sum_{s=1}^{6} \phi_{11} x_{t-s} + \sum_{s=1}^{6} \phi_{12} y_{t-s} + \varepsilon_{1t} \\ y_t &= k_2 + \sum_{s=1}^{6} \phi_{21} x_{t-s} + \sum_{s=1}^{6} \phi_{22} y_{t-s} + \varepsilon_{2t} \end{aligned}$$

where y_t is a macro variable of interest and x_t is the change in relative energy prices weighted

by the expenditure share,

$$x_t = \alpha_t(\ln P_t - \ln P_{t-1})$$

for α_t the series plotted in Figure 3 and P_t the ratio of the personal consumption expenditure deflator for energy goods and services to the overall PCE deflator. Thus for example a unit shock to x_t would result if there were a monthly 20% increase in relative energy prices ($\ln P_t - \ln P_{t-1} = 0.20$) at a time when energy consumed 5% of household budgets ($\alpha_t = 5.0$). A unit shock to x_t means that households would suffer a 1% loss in ability to purchase non-energy items if they attempted to hold real energy consumption fixed following a shock of size $x_t = 1$.

I re-estimated a number of the Edelstein-Kilian regressions for the sample period they used (with the dependent variable running from 1970:M7 through 2006:M7), and first report the results for $y_t = 100(\ln Y_t - \ln Y_{t-1})$ with Y_t real personal consumption expenditures. Figure 14 reproduces their orthogonalized impulse-response functions (with energy prices x_t ordered first) for the cumulative consequences for the levels $X_t = \sum_{j=1}^{t} x_t$ and $100 \ln Y_t$ of a unit shock to x_{t-s}. The first panel shows that there is relatively little serial correlation in the energy price change series x_t. Almost all of the price consequences appear within the first two months– if x_t increases by one unit at time t, one would typically expect another 0.5 move up at $t+1$, with very minor subsequent adjustments resulting in an eventual 1.7% cumulative loss in purchasing power as a result of a unit shock to x_t.

The second panel shows the decline in real consumption expenditures following historical energy price increases. There are two aspects of this graph that are not what one would have

expected from the simple expenditure-impact effect sketched above. The first is the magnitude of the response– following a decline that eventually would have reduced consumers' ability to purchase non-energy items by 1.7%, we observe that on average consumers in fact eventually cut their spending by 2.2%. Why should consumption spending fall by even more than the predicted upper bound? The second surprising aspect concerns the timing– although the price moves immediately reduce purchasing power, the biggest declines in total spending don't come until 6 months or more after the initial shock.

One way that Edelstein and Kilian sought to explain these anomalies is by breaking down the responses in terms of the various components of consumption. Figure 15 reproduces their findings for Y_t corresponding respectively to the services, nondurables, and durables components of real personal consumption expenditures. The magnitude of the first two responses is in line with the simple expenditure-share effects, while the response of expenditures on durable goods is five times as big.

The first panel of Figure 16 looks in particular at the motor vehicles component of durables. In contrast to the gradual response one sees in broader consumption categories, here the response is immediate and quite huge, with for example a 20% increase in energy prices in an environment with an energy expenditure share of 5% resulting in a 10% decrease in spending on motor vehicles. That there would be a direct link between such spending and energy prices is quite plausible, and its mechanism comes not from the simple budget-constraint effect. Indeed, for this category of spending there are a number of other factors that are much more important, such as postponing the purchase of a new vehicle until better

information about where gas prices are going to end up is available and shifting the purchase from bigger to more fuel efficient (and perhaps less expensive) vehicles.

If we take it as given that there are big and immediate effects on purchases of items such as motor vehicles, both the delayed response and the multiplier effect on other categories of spending can also be better understood. The shift in spending means a reduction in income for those employed in manufacturing and selling cars. Given the significant technological frictions in relocating the now underutilized labor and capital to other sectors, the result is a decline in aggregate income and a loss in purchasing power over and above that caused by the initial price increase itself (Hamilton, 1988).

The second panel of Figure 16 presents a second effect identified by Edelstein and Kilian that is huge and immediate– a drop in consumer sentiment.[10] For whatever reason, consumers found the historical oil shocks to be very troubling events, with a 20% increase in relative energy prices (assuming again a base case value share of $\alpha_t = 5$) producing a 15-point drop in the index of consumer sentiment. One can argue whether a response of this magnitude is rational given the size of the shock. The budget consequences of spiking gasoline prices are something consumers experience immediately, and represent an aggregate event that forces everybody to make changes at the same time. Certainly if your job is related to the auto industry (or if you perceive that what happens to them will have eventual implications for your own job security), it's quite rational to view these events as

[10] Note that unlike the previous figures in which the second variable in the VAR, $y_t = 100(\ln Y_t - \ln Y_{t-1})$ represented a rate of change (with impulse-response graphs subsequently translated back into implications for the levels $100 \ln Y_t$), in the second panel of Figure 16, the variable y_t is the level of the index of consumer sentiment itself and the graph shows the consequences for y_{t+s} following a unit shock to x_t.

carrying pessimistic implications beyond the immediate loss in spending power. In any case, the changes in sentiment that we find in the data could easily have made a significant contribution to the subsequent path of both consumption and investment spending.

Suppose we stick just to the narrowest effect of the energy price shock, namely changes in spending on motor vehicles and parts. How big a contribution would this alone have made to the subsequent economic downturns, ignoring any possible multiplier effects? The first column of Table 3 reports the actual average growth rate of real GDP over the 5 quarters following each of the 4 historical oil shocks discussed here. All of these episodes– in which GDP fell on average over a period of 5 quarters– are included in the list of U.S. economic recessions. The second column does a very simple calculation, asking what the average GDP growth would have been if there had been zero change in the motor vehicles and parts component of GDP over these 5 quarters, with all other components of GDP staying the same as reported.[11] Although this is a modest contribution (less than 0.8% in any episode), it is enough to move the average from negative to positive territory in the case of the 1980 and 1990-91 recessions, offering some basis for thinking that, had it not been for the significant downturn in autos in each of these episodes, they might have been regarded as episodes of sluggish growth rather than clear recessions. By contrast, in the more serious 1973-75 and 1981-82 recessions, there was clearly something more significant than just autos bringing down the economy.

[11] This was calculated by subtracting from the growth rate of real GDP the contribution of motor vehicles and parts as reported in Table 1.5.2 from the Bureau of Economic Analysis. Note that this contribution is a negative number in each episode, so that subtracting it would make the GDP growth rate bigger.

I next examine the implications of two earlier studies of the effects of oil prices on the overall economy. The first comes from Blanchard and Galí (2008), whose overall conclusion was that oil shocks made a relatively modest contribution to the downturns of the 1970s and are even less important today. Their analysis is based on a vector autoregression that has 3 nominal shocks in addition to oil prices (as captured by the CPI, GDP deflator, and wages), two output indicators (real GDP and total hours worked), and with the oil price summarized by the average price of West Texas Intermediate crude oil over the quarter. All variables were measured in quarterly percentage changes, and a quadratic time trend was included. The authors estimated two separate versions of the VAR, the first using data only from 1960:Q1 to 1983:Q1, and the second from 1984:Q1 to 2007:Q3.

I used the VAR coefficients as estimated from the separate subsamples to perform the following calculation.[12] One can form a dynamic forecast implied by the coefficients for what each of the 6 variables should have been for, say, 1974:Q1 through 1975:Q1 based on information available (that is, the observed values of the 6 variables) as of 1973:Q4. Associated with this forecast and the ex-post realized values of these variables is an implied set of errors for forecasting each of the 6 variables for 1 to 5 quarters ahead, obtained by comparing these forecasts with the actual values. One can decompose these observed errors into contemporaneously orthogonal components, based on the variance-covariance matrix used by Blanchard and Galí, and then find the answer to the following question: what would be the error predicting each of the variables up to 5 quarters ahead if we could condition on

[12] I am most grateful to Davide Debortoli for supplying the data and code that were used for the original estimation of the Blanchard-Galí paper.

the ex post realizations of the innovations in oil prices, but did not know anything else?[13] On the basis of this number, I calculated what the average GDP growth over 1974:Q1-75:Q1 would have been had there been no oil price shock but the other 5 shocks to the CPI, deflator, wages, GDP, and hours had been identical to the realized historical residuals. The answer to that "what if" question is reported in the third column of Table 3. The Blanchard-Galí estimates imply that, had there been no oil shock, the severe downturn of 1973-75 would have been only a very mild recession. Interestingly, although their estimated post-1984 effects of oil prices are much smaller than those for their earlier sample, and although the authors did not single out the aftermath of the First Gulf War as a separate oil shock, their estimates also imply that, had the price of oil not spiked following Iraq's invasion of Kuwait, the U.S. might have avoided the 1990-91 recession.

Surprisingly, the Blanchard-Galí estimates imply that the 1981-82 downturn would actually have been *more* severe in the absence of disturbances to oil prices. This is because the measure they used for the price of oil, the price of WTI, actually *fell* between July 1980 and March 1981. Other indicators, however, suggest a very different story. For example, the

[13] Mathematically, the estimated VAR coefficients imply a set of moving average matrices $\hat{\mathbf{\Psi}}_s$ (as in equation [10.1.19] in Hamilton, 1994), and the Cholesky factor of the residual variance matrix can be obtained as $\hat{\mathbf{\Omega}} = \hat{\mathbf{P}}\hat{\mathbf{P}}'$. The s-step-ahead forecast error can then be written

$$\mathbf{y}_{t+s} - \hat{\mathbf{y}}_{t+s|t-1} = \hat{\boldsymbol{\epsilon}}_{t+s} + \hat{\mathbf{\Psi}}_1\hat{\boldsymbol{\epsilon}}_{t+s-1} + \ldots + \hat{\mathbf{\Psi}}_s\hat{\boldsymbol{\epsilon}}_t$$

for $\hat{\boldsymbol{\epsilon}}_t$ the implied one-step-ahead forecast errors. Define the orthogonalized residuals by $\hat{\mathbf{v}}_t = \hat{\mathbf{P}}^{-1}\hat{\boldsymbol{\epsilon}}_t$ and let $\hat{\mathbf{p}}_1$ denote the first column of $\hat{\mathbf{P}}$. Then the contribution of $\{\hat{v}_{1t}, \hat{v}_{1,t+1}, \ldots, \hat{v}_{1,t+s}\}$ to this forecast error is calculated as $\sum_{k=0}^{s} \hat{\mathbf{\Psi}}_k\hat{\mathbf{p}}_1\hat{v}_{1,t+s-k}$, and the calculation of what the value of $\mathbf{y}_{t+s}$ would have been in the absence of the oil shocks is calculated as $\mathbf{y}_{t+s} - \sum_{k=0}^{s} \hat{\mathbf{\Psi}}_k\hat{\mathbf{p}}_1\hat{v}_{1,t+s-k}$. Note that although the VAR shocks to oil prices and the CPI are correlated in the data ($\hat{\epsilon}_{1t}$ is correlated with $\hat{\epsilon}_{2t}$), the shocks $\hat{v}_{1t}$ and $\hat{v}_{2t}$ are orthogonal in the sample by construction. Thus when we ask what would have happened if $\hat{v}_{1t}$ had been zero but $\hat{v}_{2t}$ had been as observed historically, we are implicitly subtracting out that movement in the CPI that is correlated statistically with the oil price, and leaving in other, uncorrelated factors.

EIA's series for the refiner acquisition cost (the series plotted in the row 3, column 2 panel of Figure 5) shows a 27% (logarithmic) increase over this same period, the BLS's producer price index for crude petroleum (the series used by Hamilton, 1983 and 2003) shows a 42% increase, the BEA's implicit price deflator for consumption expenditures on energy goods and services (the series used by Edelstein and Kilian, 2007) shows a 12% increase, and the BLS's consumer price index for gasoline shows an 11% increase. It therefore seems likely that, despite the results implied by Blanchard and Galí's estimation, energy prices were a factor reducing GDP growth over this episode along with the others.

As another comparison, I turned to the nonlinear specification investigated in Hamilton (2003), whose key result (equation 3.8) was a regression of quarterly real GDP growth on a constant, 4 of its own lags, and 4 lags of the "net oil price increase", defined as the percentage change in the crude oil PPI during the quarter if oil prices made a new 3-year high at the time, and zero if oil prices ended the quarter lower than a point they had reached over the previous 3 years. The coefficients for that relation, estimated over t = 1949:Q2 through 2001:Q3 were as follows

$$\begin{aligned} y_t &= \underset{(0.13)}{0.98} + \underset{(0.07)}{0.22} y_{t-1} + \underset{(0.07)}{0.10} y_{t-2} - \underset{(0.07)}{0.08} y_{t-3} - \underset{(0.07)}{0.15} y_{t-4} \\ &\quad - \underset{(0.014)}{0.024} o^{\#}_{t-1} - \underset{(0.014)}{0.021} o^{\#}_{t-2} - \underset{(0.014)}{0.018} o^{\#}_{t-3} - \underset{(0.014)}{0.042} o^{\#}_{t-4}. \end{aligned} \tag{8}$$

To get a sense of the magnitudes implied by these coefficients,[14] I calculated for each quarter in the episode the difference between the 1-quarter-ahead forecast implied by equation (8),

[14] One could in principle find the answer to an s-period-ahead forecasting equation as in footnote 13, though this would require a specification of the dynamic path followed by the net oil price increase variable. No such specification was proposed in Hamilton (2003), and it seems unlikely that spelling one out would change the results significantly from the simpler calculation provided here.

and what that 1-quarter-ahead forecast would have been if the oil price measure $o^{\#}_{t-1}, ..., o^{\#}_{t-4}$ had instead been equal to zero, and took this difference as a measure of the contribution of the oil shock to that quarter's real GDP growth. From the fourth column of Table 3, it appears that this specification would attribute almost all of the deviation from trend in each of the four recessions to the oil shock alone.

To summarize, there is a range of estimates available as to the size of the contribution that oil shocks have made to historical U.S. recessions. But even the most modest estimates support the claim that the oil shocks made a significant contribution in at least some of these episodes. My conclusion is that, had the oil shocks not occurred, GDP would have grown rather than fallen in at least some of these episodes.

5 Consequences of the oil shock of 2007-08.

Let us begin by examining what happened to motor vehicle sales in response to the price changes noted in Figure 6. Figure 17 reports sales in the U.S. of domestically manufactured light vehicles broken down in terms of cars versus light trucks. The latter include the sport utility vehicle (SUV) category, which up until 2007 had been outselling cars in the U.S. market. Beginning in 2008, sales of SUVs began to plunge, and were down more than 25% relative to the preceding year in May, June and July. SUV sales rebounded somewhat when gas prices began to fall in August, only to suffer a second hit in September through December.

To what extent was the decline in SUV sales in the first half of 2008 caused by rising

gasoline prices as opposed to falling income? One measure relevant for addressing this question is the contrast between the sales of light trucks (top panel of Figure 17) and those of cars (bottom panel). A general drop in income would affect both categories, whereas the effects of rising gasoline prices would hit light trucks much harder than cars. In the event, domestic car sales were only down on average by 7% in May, June, and July 2008 compared with the same months in 2007. Even more dramatic are the comparisons for imports. Imported cars were up 10% over these same three months (bottom panel of Figure 18). Sales of imported light trucks (top panel of Figure 18), by contrast, were down 22%. Thus the dominant story in the first half of 2008 was one in which American consumers were switching from SUVs to smaller cars and more fuel-efficient imports.

Although gasoline prices were likely a key factor behind plunging sales for U.S. automakers in the first half of 2008, falling income appears to be the biggest factor driving sales back down in the fourth quarter of 2008. Here we see, in contrast to the first half of 2008, the sales decline was across the board, hitting cars if anything more than SUVs, and imports along with domestics.

The result was a significant shock to the U.S. auto industry in 2008:H1, quite comparable in magnitude to what was observed in the wake of the oil shock of 1990. The contribution of motor vehicles and parts to U.S. real GDP (measured in 2000 dollars at an annual rate) was $30 billion smaller in 1991:Q1 than it had been in 1990:Q3, similar to the $34 billion decline in this sector between 2007:Q4 and 2008:Q2 (BEA Table 1.5.6). Granted, that $34 billion in 2007-08 represents a smaller share of total GDP than did the lost auto production

in 1990-91, but the most recent slump still represents a sizable number, and it would be hard to defend the claim that a recession began in 2007:Q4 had it not been for the contribution from the auto sector. The first two columns of Table 3 include details on this breakdown, looking ahead either 4 or 5 quarters beginning with 2007:Q4. Focusing first on just the four quarters 2007:Q4-2008:Q3, average real GDP growth over this period was actually +0.75% at an annual rate. Had there been no decline in autos, that number would have been nearly half a percentage point higher. It would be very hard to characterize 2007:Q4-2007:Q3 as a full year of recession, had the average growth indeed been +1.2%. The Business Cycle Dating Committee of the National Bureau of Economic Research reported that it was looking not just at GDP (which even with the decline in autos showed clearly positive overall growth), but also at gross domestic income, which differs from GDP only by a statistical discrepancy; (see Nalewaik, 2007). GDI growth averaged -0.4% over this period, offering more justification for the NBER's recession call. But again, without the hit to autos, this number instead would also have registered positive, albeit very anemic, growth.

The 2007-08 shock was also comparable to 1990-91 in terms of the effect on employment in the automobile industry. Seasonally adjusted manufacturing employment in motor vehicles and parts fell by 94 thousand workers between 1990:M7 and 1991M3, whereas it fell by 125 thousand between 2007:M7 and 2008:M8 (BLS series CES3133600101). Again the latter is relative to a larger economy, but again it is not an inconsequential number. A year-over-year drop in total employment is viewed by some as a defining characteristic of a U.S. recession. This threshold was crossed in June 2008, when 8,000 fewer workers were employed compared

with June 2007. Again without the contribution of autos, it would not be at all clear that the U.S. economy should have been characterized as being in recession during 2007:Q4-2008:Q2.

Of course, the first half of 2008 saw not just a big decline in automobile 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 other historical oil shocks. Like SUV sales, consumer sentiment spiked back up dramatically in an initial response to falling gasoline prices at the end of the summer, but, like SUV sales, then plunged back down as broader economic malaise developed in the fall of 2008.

For some more formal statistical evidence and quantification, I turn to several of the studies described in the previous section. I first examine in Table 4 how well the models proposed in previous studies have performed in terms of describing data that have arrived in the time since those papers were written. To evaluate the Edelstein-Kilian bivariate VARs, I used the parameter values for the relations as estimated over 1970:M7-2006:M7 to form forecasts over the post-sample interval 2006:M8-2008:M9. I compared those post-sample one-month-ahead mean squared errors with the MSEs that would have been obtained by a univariate autoregression (excluding energy prices) estimated over the same original sample (1970:M7-2006:M7). As reported in the last column of Table 4, for each of the 6 Edelstein-Kilian relations used here, energy prices made a useful contribution to the post-sample forecasts, giving us some confidence in using those estimates to measure the contribution that energy prices may have made to what happened to the economy in response to the oil shock of 2007-08.

I used the Edelstein-Kilian relations as estimated over 1970:M7-2006:M7 to form a 1- to 12-month-ahead forecast of how these variables might have behaved over 2007:M9 through 2008:M9 had there been no oil shock. The top panel of Figure 19 presents the results for real personal consumption expenditures. The dotted line represents the forecast of the model for PCE over these 12 months. In the absence of any new shocks, the Edelstein-Kilian bivariate VAR would have predicted consumption to continue growing at the rate it had over the previous half year. In the event, actual consumption (the solid line) grew much more slowly than predicted through May and then started to decline. The dashed line represents the portion of the forecast error at any date that could be accounted for by the cumulative surprises in energy prices between 2007:M9 and the indicated date, calculated as described in footnote 13. Energy prices can account for about half of the gap between predicted and actual consumption spending over this period. The second and third panels repeat the exercise for the big drops in spending on motor vehicles and consumer sentiment. Most of the declines in these two series through the beginning of 2008 and about half the decline through the summer of 2008 would be attributed to energy prices according to the Edelstein-Kilian regressions.

I also examined the post-sample performance of the Blanchard-Galí VAR as estimated over their second subsample, 1984:Q1-2007:Q3. In this case I compared their 6-variable VAR with a 5-variable VAR that leaves out oil prices. Their model with oil prices in fact does somewhat worse at predicting GDP growth rates for data that appeared subsequent to their study than would a similar VAR without oil prices; (see the third row from the

bottom of Table 4). I nevertheless examined how much of the downturn of 2007-08 their coefficients would attribute to oil prices, looking at the errors made forecasting GDP growth over 2007:Q4 to 2008:Q3 or Q4 on the basis of information available as of 2007:Q3, and at the contribution of oil price surprises to these forecast errors. The result of this calculation (reported in the third column of Table 3) suggests that real GDP growth would have been 0.7% higher on average in the absence of the oil shock. Thus, the Blanchard-Galí calculations also support the conclusion that the period 2007:Q4-2008:Q3 would not reasonably be considered to have been the beginning of a recession had there been no contribution from the oil shock.

Finally, I looked at the post-sample performance of the GDP-forecasting regression (8) estimated by Hamilton (2003). As seen in the next-to-last row of Table 4, this relation has about the same mean squared error over the period 2001:Q4-2008:Q4 as does a univariate AR(4) fit to the 1949:Q2-2001:Q3 data. In part this lack of improvement is due to the fact that the oil-based relation predicts slower GDP growth than was observed for 2005 and 2006, when the price of oil rose but the U.S. economy seemed to be little affected.

It is interesting to note that the historical relation (8) significantly outperforms a univariate specification when evaluated on the same post-sample intervals used to evaluate the Edelstein-Kilian and Blancard-Galí relations in Table 4. Equation (8) has a 45% improvement in terms of the post-sample MSE over the period 2007:Q1-2008:Q4 compared with a univariate autoregression. Indeed, the relation could account for the entire downturn of 2007-08; (see the last column of Table 3). If one could have known in advance what hap-

pened to oil prices during 2007-08, and if one had used the historically estimated relation (8) to form in a 1- to 5-quarter-ahead forecast of real GDP looking ahead to 2007:Q4 through 2008:Q4 from 2007:Q3, one would have been able to predict the level of real GDP for both of 2008:Q3 and 2008:Q4 quite accurately; (see Figure 20).

That last claim seems hard to believe, since Blanchard and Galí are doubtless correct that there has been some decrease in the effects of oil prices as the economy has become less manufacturing-based and more flexible, and since the housing downturn surely made a critical contribution to the recession of 2007-08. Nevertheless, a few points about the respective contributions of housing and the oil shock deserve mentioning. I would note first that housing had been exerting a significant drag on the economy before the oil shock, despite which economic growth continued. Residential fixed investment subtracted an average of 0.94% from the average annual GDP growth rate over 2006:Q4-07:Q3, when the economy was not in a recession, but subtracted only 0.89% over 2007:Q4-2008:Q3, when the recession began. At a minimum it is clear that something other than housing deteriorated to turn slow growth into a recession. That something, in my mind, includes the collapse in automobile purchases, slowdown in overall consumption spending, and deteriorating consumer sentiment, in which the oil shock was indisputably a contributing factor.

Second, there is an interaction effect between the oil shock and the problems in housing. Cortright (2008) noted that in the Los Angeles, Tampa, Pittsburgh, Chicago, and Portland-Vancouver Metropolitan Statistical Areas, house prices in 2007 were likely to rise slightly in the zip codes closest to the central urban areas but fall significantly in zip codes with

longer average commuting distances. Foreclosure rates also rose with distance from the center. And certainly to the extent that the oil shock made a direct contribution to lower income and higher unemployment, that would also depress housing demand. For example, the estimates in Hamilton (2008) imply that a 1% reduction in real GDP growth translates into a 2.6% reduction in the demand for new houses.

Eventually, the declines in income and house prices set mortgage delinquency rates beyond a threshold at which the overall solvency of the financial system itself came to be questioned, and the modest recession of 2007:Q4-2008:Q3 turned into a ferocious downturn in 2008:Q4. Whether we would have avoided those events if the economy had not gone into recession, or instead would have merely postponed them, is a matter of conjecture. Regardless of how we answer that question, the evidence to me is persuasive that, if there had there been no oil shock, we would have described the U.S. economy in 2007:Q4-2008:Q3 as growing slowly, but not in a recession.

Lastly I take up the question of why the oil price increases prior to 2007:Q4 failed to have a bigger effect on the economy. Why did consumers respond so little when the price of oil went from $41/barrel in July 2004 to $65 in August 2005 (a 59% increase), and yet were observed to have such a big response to the increase from $72 in August 2007 to $134 (an 86% increase) in June 2008?[15] Equations posed in terms of percentage changes, such as (8), would predict that the 2004-2005 price increases should also have had significant effects on output. However, in terms of the dollar impact on household budgets, the $62/barrel

[15] Oil prices quoted here are monthly averages of daily West Texas Intermediate prices.

price increase in 2007-08 is considerably more than twice as significant as the \$24/barrel increase in 2004-2005.

To explore this possibility more concretely, I looked at the consequences of modifying equation (8) to take into account the changes in the energy budget share over time, replacing $o_t^{\#}$ with the product $o_t^{\#}\alpha_{t-1}$ for α_t the energy share plotted in Figure 3.[16] This results in a slight improvement in fit for the original sample period (t = 1949:Q2 to 2001:Q3), raising the log likelihood from -281.78 for the original specification to -281.47 for the new. The share-weighted regression has a significantly better post-sample performance, producing a 10.8% improvement in the MSE over the period 2001:Q4-2008:Q4 relative to an autoregression with no role for oil prices. For the specific years 2005:Q1-2006:Q4, the modified specification as estimated over 1949:Q2 to 2001:Q3 would have predicted an average annual real GDP growth rate of 1.9%, a bit below the sluggish 2.5% that was actually observed.

Oil prices thus appear to have exerted a moderate drag on real GDP in 2005-2006 and made a more significant negative contribution in 2007-2008. The principle reason that Americans ignored the earlier price increases would seem to be because they could afford to do so. By 2007:Q4, they no longer could, and the sharp spike in oil prices led to an observed economic response similar to what we had seen in earlier episodes.

[16] The monthly series was converted to quarterly by using the third month of the quarter. Values for α_t for t prior to 1959:Q1 were simply set equal to the January 1959 value (7.354).

6 Policy implications.

I have raised the possibility that miscalculation of the long-run price elasticity of oil demand by market participants was one factor behind the oil shock of 2007-08, and that speculative investing in oil futures contracts may have contributed to that miscalculation. Were any policies available to mitigate this? One option to consider would have been for the U.S. government to sell some oil directly out of the Strategic Petroleum Reserve in the spring of 2008, perhaps timing the sales to coincide with the NYMEX crude contract expiry dates. If there was speculative momentum buying, such steps might have succeeded in reversing it. If not, the worst would be that the government made a profit on its SPR investment by buying low and selling high.

A more conventional policy tool would be monetary policy. A number of observers suggested that the very rapid declines of short-term interest rates in 2008:Q1 fanned the flames of commodity speculation, with negative real interest rates encouraging investments in physical commodities (e.g., Frankel, 2008). In January 2009, Federal Reserve Chair Ben Bernanke offered the following retrospective on that debate:

> The [Federal Open Market] Committee's aggressive monetary easing was not without risks. During the early phase of rate reductions, some observers expressed concern that these policy actions would stoke inflation. These concerns intensified as inflation reached high levels in mid-2008, mostly reflecting a surge in the prices of oil and other commodities. The Committee takes its responsibility to ensure price stability extremely seriously, and throughout this period

> it remained closely attuned to developments in inflation and inflation expectations. However, the Committee also maintained the view that the rapid rise in commodity prices in 2008 primarily reflected sharply increased demand for raw materials in emerging market economies, in combination with constraints on the supply of these materials, rather than general inflationary pressures. Committee members expected that, at some point, global economic growth would moderate, resulting in slower increases in the demand for commodities and a leveling out in their prices–as reflected, for example, in the pattern of futures market prices. As you know, commodity prices peaked during the summer and, rather than leveling out, have actually fallen dramatically with the weakening in global economic activity. As a consequence, overall inflation has already declined significantly and appears likely to moderate further.

Bernanke seemed here to be taking the position that since the Fed got the long run correct (ultimately there would be a significant downturn in both the economy and commodity prices, with strong disinflationary pressure), the short-run consequences (booming commodity prices in 2008:H1) were less relevant. On the other hand, if it is indeed the case that the spike in oil prices was one causal factor contributing to the downturn itself, the Fed can hardly afford to ignore those short-run implications. The evidence examined here suggests that the Fed needs to give careful consideration to the possible consequences of its actions for relative commodity prices.

But while the question of the possible contribution of speculators and the Fed is a very

interesting one, it should not distract us from the broader fact: some degree of significant oil price appreciation during 2007-08 was an inevitable consequence of booming demand and stagnant production. It is worth emphasizing that this is fundamentally a long-run problem, which has been resolved rather spectacularly for the time being by a collapse in the world economy. However, the economic collapse will hopefully prove to be a short-run cure for the problem of excess energy demand. If growth in the newly industrialized countries resumes at its former pace, it would not be too many more years before we find ourself back in the kind of calculus that was the driving factor behind the problem in the first place. Policy-makers would be wise to focus on real options for addressing those long-run challenges, rather than blame what happened last year entirely on a market aberration.

References

Al-Sowayegh, Abdulaziz H. 1984. *Arab Petropolitics.* London : Croom Helm.

Barsky, Robert B., and Lutz Kilian. 2002. "Do We Really Know that Oil Caused the Great Stagflation? A Monetary Alternative." In Ben Bernanke and Kenneth Rogoff (eds.), *NBER Macroeconomics Annual 2001*, pp. 137-183.

Blanchard, Olivier J., and Jordi Galí. 2008. "The Macroeconomic Effects of Oil Price Shocks: Why are the 2000s so Different from the 1970s?" In Jordi Galí and Mark Gertler (eds.), *International Dimensions of Monetary Policy*, University of Chicago Press (Chicago, IL).

Bernanke, Ben S. 2009. "The Crisis and the Policy Response," Stamp Lecture, January 13, London School of Economics, http://www.federalreserve.gov/newsevents/speech/bernanke20090113a.htm.

Blinder, Alan S., and Jeremy B. Rudd. 2008. "The Supply-Shock Explanation of the Great Stagflation Revisited," NBER Working Paper No. 14563.

Brons, Martijn Brons, Peter Nijkamp, Eric Pels, and Piet Rietveld. 2008. "A Meta-Analysis of the Price Elasticity of Gasoline Demand: A SUR Approach," *Energy Economics* 30, pp. 2105–2122.

Cooper, John C.B. 2003. "Price Elasticity of Demand for Crude Oil: Estimates for 23 Countries," *OPEC Review* 27(1), pp. 1-8.

Cortright, Joe. 2008. "Driven to the Brink: How the Gas Price Spike Popped the Housing Bubble and Devalued the Suburbs," Discussion paper, CEOs for Cities, http://www.ceosforcities.org

/newsroom/pr/iles/Driven%20to%20the%20Brink%20FINAL.pdf.

Dahl, Carol A. 1993. "A Survey of Oil Demand Elasticities for Developing Countries," *OPEC Review* 17(Winter), pp. 399-419.

Dahl, Carol and Thomas Sterner. 1991. "Analysing Gasoline Demand Elasticities: A Survey," *Energy Economics* 13, pp. 203-210.

Edelstein, Paul, and Lutz Kilian. 2007. "Retail Energy Prices and Consumer Expenditures." Working paper, University of Michigan.

Espey, Molly. 1998. "Gasoline Demand Revisited: An International Meta-Analysis of Elasticities," *Energy Economics* 20, pp. 273-295.

Frankel, Jeffrey A. 2008. "The Effect of Monetary Policy on Real Commodity Prices" in John Campbell (ed.), *Asset Prices and Monetary Policy*, University of Chicago Press, pp. 291-327.

Gately, Dermot, and Hillard G. Huntington. 2002. "The Asymmetric Effects of Changes in Price and Income on Energy and Oil Demand," *Energy Journal* 23(1), pp. 19-55.

Graham, Daniel J., and Stephen Glaister. 2004. "Road Traffic Demand Elasticity Estimates: A Review," *Transport Reviews* 24(3), pp. 261–274.

Hamilton, James D. 1983."Oil and the Macroeconomy Since World War II," *Journal of Political Economy* 91, pp. 228-248.

_____. 1988. "A Neoclassical Model of Unemployment and the Business Cycle," *Journal of Political Economy* 96, pp. 593-617.

_____. 1994. *Time Series Analysis.* Princeton, NJ: Princeton University Press.

_____. 2003. "What Is an Oil Shock?", *Journal of Econometrics* 113(2), pp. 363-398.

_____. 2008. "Daily Monetary Policy Shocks and New Home Sales," *Journal of Monetary Economics* 55, pp. 1171-1190.

_____. 2009. "Understanding Crude Oil Prices." *Energy Journal,* forthcoming.

Hotelling, Harold. 1931. "The Economics of Exhaustible Resources," *Journal of Political Economy* 39(2), pp. 137-75.

Hughes, Jonathan E., Christopher R. Knittel and Daniel Sperling. 2008. "Evidence of a Shift in the Short-Run Price Elasticity of Gasoline Demand." *Energy Journal* 29(1), pp. 93-114.

Jovanovic, Boyan. 2007. "Bubbles in Prices of Exhaustible Resources,", working paper, New York University.

Kilian, Lutz. 2008. "Exogenous Oil Supply Shocks: How Big Are They and How Much Do They Matter for the U.S. Economy?" *Review of Economics and Statistics* 90(2), pp. 216-240.

_____. "Not All Oil Price Shocks Are Alike: Disentangling Demand and Supply Shocks in the Crude Oil Market," forthcoming, *American Economic Review.*

Leamer, Edward E. 2008. "What's a Recession, Anyway?" NBER Working Paper No. 14221.

Nalewaik, Jeremy J. 2007. "Estimating Probabilities of Recession in Real Time Using GDP and GDI." Working paper, Board of Governors of the Federal Reserve System.

Table 1. Estimates of absolute value of short-run demand price elasticity.

Study	Product	Method	Elasticity
Dahl and Sterner (1991)	gasoline	literature survey	0.26
Espey (1998)	gasoline	literature survey	0.26
Graham and Glaister (2004)	gasoline	literature survey	0.25
Brons, et. al. (2008)	gasoline	literature survey	0.34
Dahl (1993)	oil (developing countries)	literature survey	0.07
Cooper (2003)	oil (average of 23 countries)	annual time-series regression	0.05

Source: Hamilton (2009).

Table 2. Sizes of quantity and prices changes in historical oil shocks.

Episode	Supply reduction	Price change	Implied elasticity
Oct 73 - Mar 74	4.0%	41.3%	0.10
Nov 78 - Jul 79	1.3%	38.7%	0.03
Oct 80 - Mar 81	1.2%	25.8%	0.05
Aug 90 - Oct 90	2.9%	71.6%	0.04

Notes. *Second column.* Average shortfall of global production of crude petroleum over indicated period as a percent of global production the month before the indicated episode. *Third column.* Cumulative change in 100 times the natural log of crude oil price over the indicated episode. Data sources same as those for Figure 5. *Fourth column.* Ratio of second to third columns.

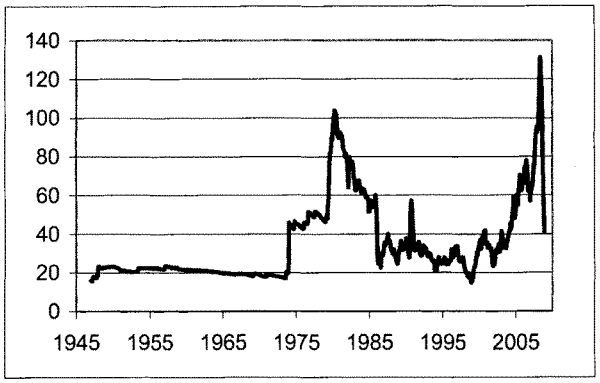
Table 3. Average annual real GDP growth rates under alternative scenarios.

Period	Actual	Without autos	Without oil shock (Blanchard-Gali)	Without oil shock (Hamilton)
1974:Q1-75:Q1	-2.5%	-2.0%	-0.1%	+2.3%
1979:Q2-80:Q2	-0.4%	+0.4%	+0.4%	+2.5%
1981:Q2-82:Q2	-1.5%	-1.3%	-2.0%	+2.0%
1990:Q3-91:Q3	-0.1%	+0.2%	+0.5%	+3.6%
2007:Q4-08:Q3	+0.7%	+1.2%	+1.4%	+4.2%
2007:Q4-08:Q4	-0.7%	-0.0%	-0.2%	+3.2%

Table 4. Improvements in post-sample mean squared errors provided by alternative models.

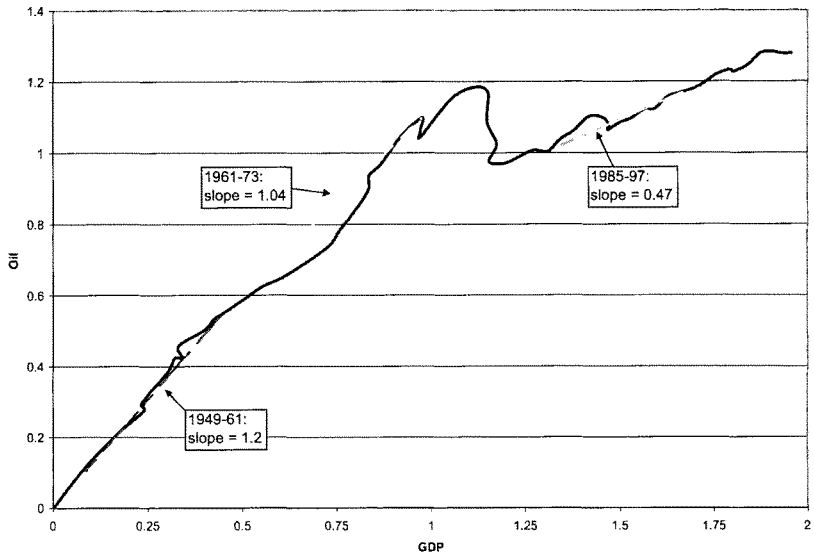
Dependent variable	**Study**	**Sample period**	**Evaluation period**	**Comparison model**	**Percent improvement**
real PCE	Edelstein and Kilian (2007)	1970:M7-2006:M7	2006:M8-2008:M9	AR(6)	33%
PCE services	"	"	"	"	8%
PCE nondurables	"	"	"	"	23%
PCE durables	"	"	"	"	30%
PCE autos	"	"	"	"	26%
consumer sentiment	"	"	"	"	9%
real GDP	Blanchard and Galí (2008)	1984:Q1-2007:Q3	2007:Q4-2008:Q4	VAR(5)	-11%
"	Hamilton (2003)	1949:Q2-2001:Q3	2001:Q4-2008:Q4	AR(4)	0%
"	"	"	2007:Q1-2008:Q4	AR(4)	45%

Figure 1. Real price of crude petroleum in November 2008 dollars per barrel.



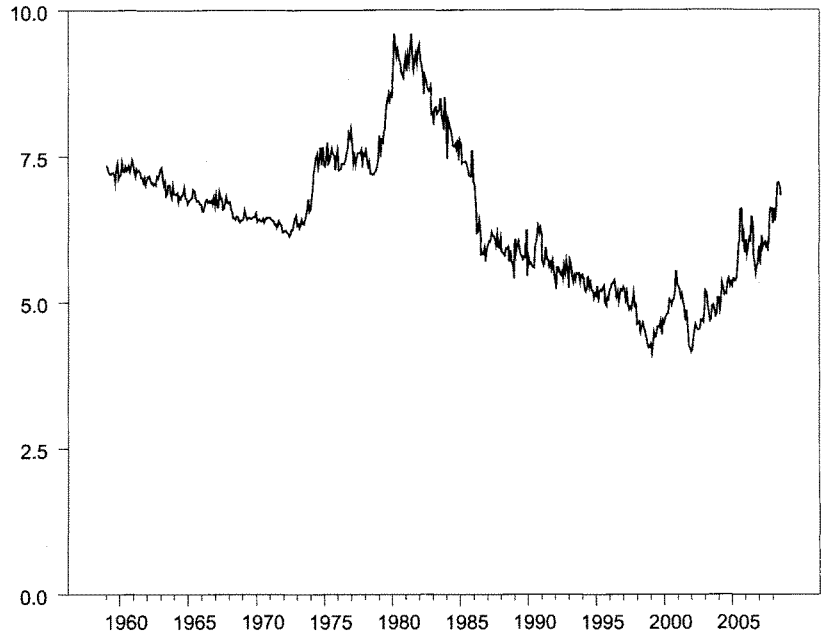
Notes. Monthly average price of West Texas Intermediate divided by ratio of consumer price index for indicated month to consumer price index for November 2008, for 1947:M1 through 2008:M12.

Figure 2. Logs of U.S. real GDP and oil consumption, 1949-2007.



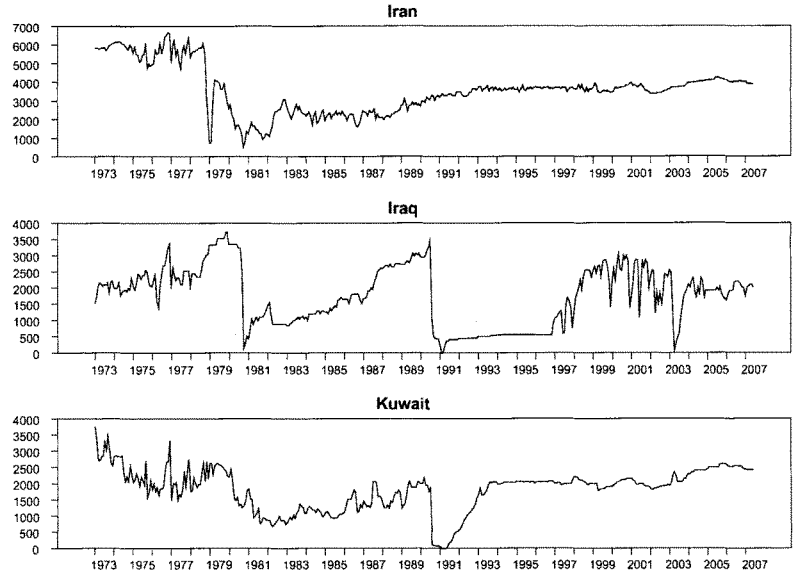
Notes. Horizontal axis: cumulative change in natural logarithm of U.S. real GDP between 1949 and the year for which a given data point is plotted, from Bureau of Economic Analysis Table 1.1.6. Vertical axis: cumulative change in natural logarithm of total petroleum products supplied to U.S. market between 1949 and the year for which a given data point is plotted, from Energy Information Administration, "Petroleum Overview, 1949-2007", Table 5.1 (http://www.eia.doe.gov/emeu/aer/txt/ptb0501.html). Source: Hamilton (2009).

Figure 3. Dollar value of energy expenditures as a percentage of total consumer expenditures, 1959:M1-2008:M9.



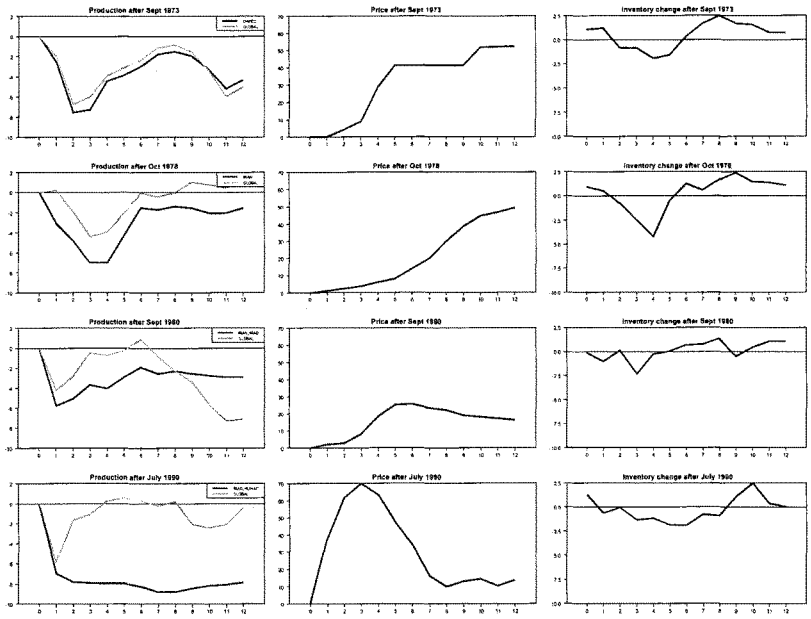
Notes. Calculated as 100 times nominal monthly consumption expenditures on energy goods and services divided by total personal consumption expenditures. Data source: BEA Table 2.3.5U, "Personal Consumption Expenditures by Major Type of Product and Expenditure," obtained from Econstats (http://www.econstats.com/nipa/ NIPA2u_2_3_6U_.htm).

Figure 4. Monthly oil production for Iran, Iraq, and Kuwait.



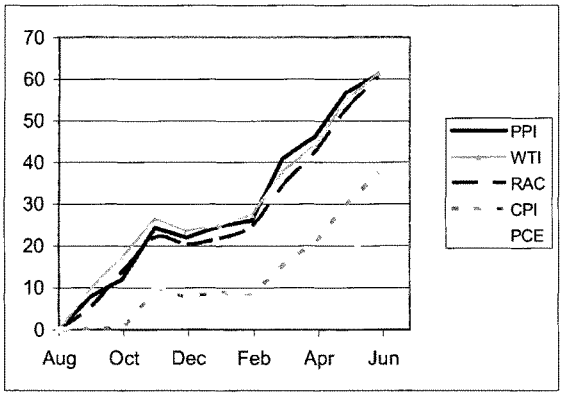
Notes. Monthly crude oil production, including lease condensate, in barrels per day, 1973:M1-2007:M6. Data source: Energy Information Administration, *Monthly Energy Review*, September 2007, Table 11.1a (http://tonto.eia.doe.gov/merquery/ mer_data.asp?table=T11.01a).

Figure 5. Changes in production, oil price, and inventories after 4 historical disruptions.



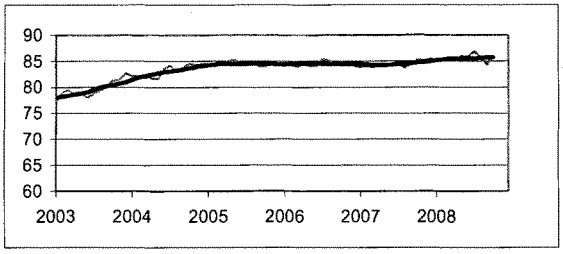
Notes. *First column.* Bold line shows change in monthly production of crude oil for: (a) OAPEC since Sept 1973 as a percentage of total world production in Sept 1973, plotted as a function of number of months since Sept 1973; (b) Iran since Oct 1978 as a percentage of total world production in Oct 1978; (c) Iran plus Iraq since Sept 1980 as a percentage of total world production in Sept 1980; (d) Iraq plus Kuwait since July 1990 as a percentage of total world production in July 1980. Dashed line shows corresponding percentage decline in total global production of crude oil relative to the indicated starting month. Data source: Energy Information Administration, *Monthly Energy Review*, July 2008, Table 11.1a (http://tonto.eia.doe.gov/merquery/mer_data.asp?table=T11.01a). *Second column.* 1973: change relative to indicated starting month in 100 times the natural log of seasonally unadjusted BLS producer price index for crude petroleum. 1978, 1980, and 1990: cumulative change in 100 times the natural log of monthly refiner acquisition cost for crude petroleum, from Energy Information Administration, http://tonto.eia.doe.gov/dnav/pet/pet_pri_rac2_dcu_nus_m.htm. *Third column.* change in end-of-month U.S. stocks of crude oil and petroleum products within the indicated month as a percentage of total world production. Data source: Energy Information Administration, http://tonto.eia.doe.gov/dnav/pet/pet_stoc_wstk_dcu_nus_m.htm.

Figure 6. Alternative measures of the size of the oil shock of 2007-08.



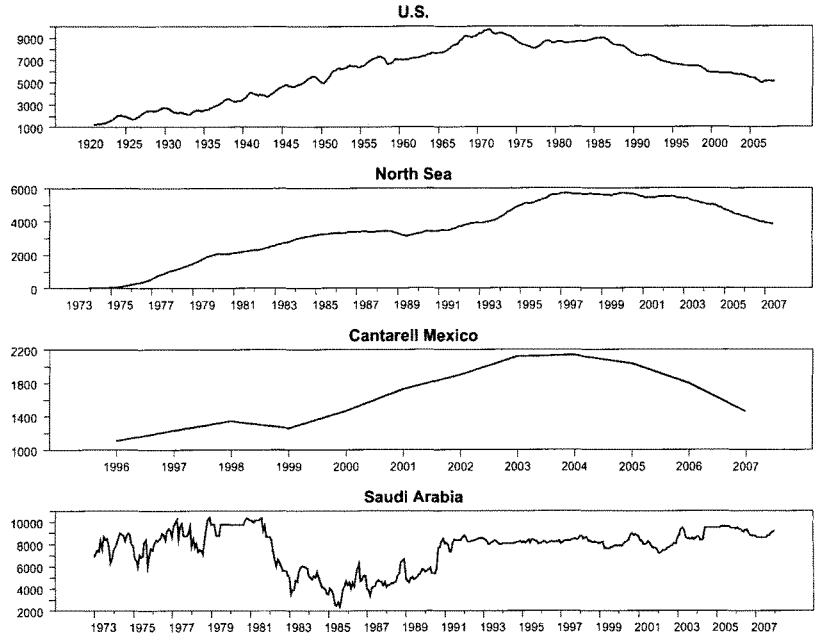
Notes. Cumulative change since August 2007 in 100 times the natural log of the indicated series. PPI = producer price index for crude petroleum. WTI = monthly average price of West Texas Intermediate. RAC = refiner's acquisition cost for crude petroleum. CPI = consumer price index for gasoline. PCE = implicit price deflator for personal consumption expenditures on energy goods and services.

Figure 7. World oil production, 2003-2008.



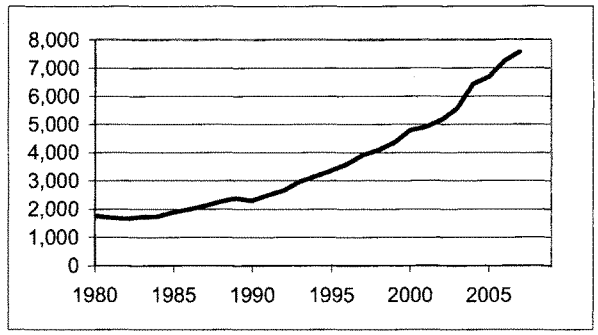
Notes. *Thin line.* Monthly global crude oil production, including lease condensate, natural gas plant liquids, other liquids, and refinery processing gain, in millions of barrels per day, 2003:M1-2008:M10. Data source: Energy Information Administration, "Total Oil Supply," January 2009, Table 1.4 (http://www.eia.doe.gov/emeu/ipsr/t14.xls). *Bold line*: 12-month moving average of values from thin line centered at indicated date, with end-of-sample values representing average of $\{x_{t-6},...,x_{t+s}\}$ for feasible s.

Figure 8. Crude oil production from selected countries or fields in thousands of barrels per day.



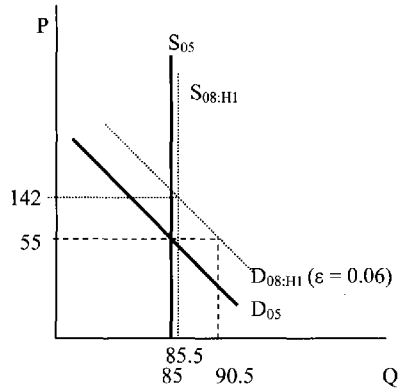
Notes. Adapted from Figures 11, 13, and 14 in Hamilton (2009). *First panel.* Moving average of preceding 12 months of monthly production figures for the United States, December 1920 to February 2008, from EIA, "Crude Oil Production." *Second panel.* Sum of U.K. and Norway crude oil production, monthly moving average of preceding 12 months, December 1973 to June 2007, from EIA, Table 11.1b. *Third panel.* Annual production from Cantarell complex in Mexico. Data for 1996 to 2006 from Pemex 2007 Statistical Yearbook. Data for 2007 from Green Car Congress (http://www.greencarcongress.com/2008/01/mexicos-cantare.html). *Fourth panel.* Saudi monthly production January 1973 to January 2008, from EIA, Table 11.1a.

Figure 9. Chinese oil consumption, 1980-2007, in thousands of barrels per day.



Notes. *Data source:* EIA, "World Petroleum Consumption, Most Recent Annual Estimates,1980-2007," (http://www.eia.doe.gov/emeu/international/ RecentPetroleumConsumptionBarrelsperDay.xls), December 2008.

Figure 10. Supply and demand, 2005-08.



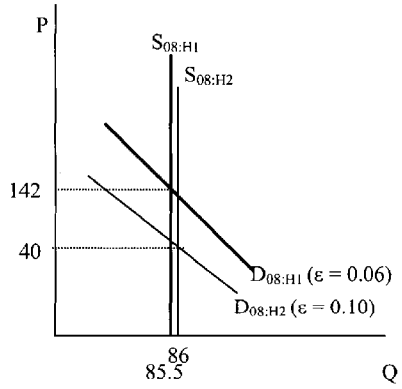
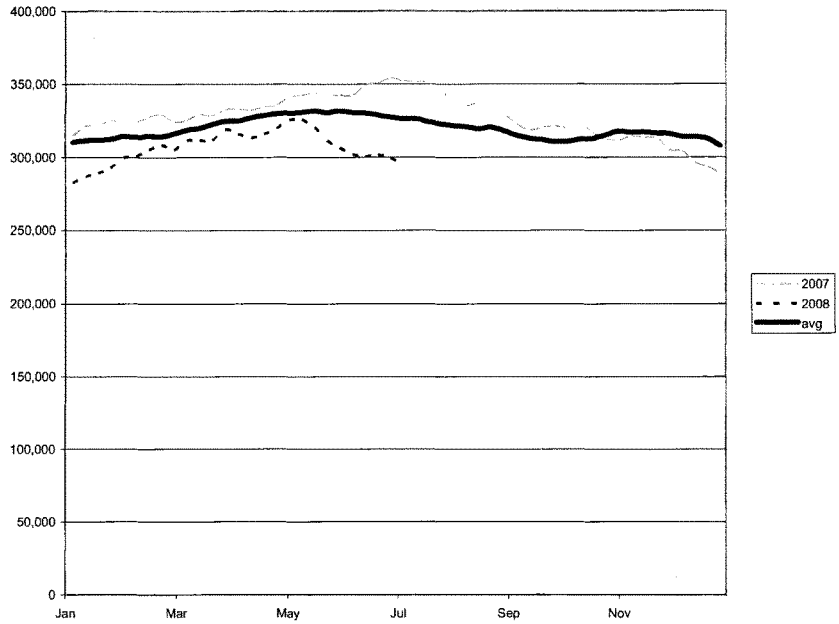
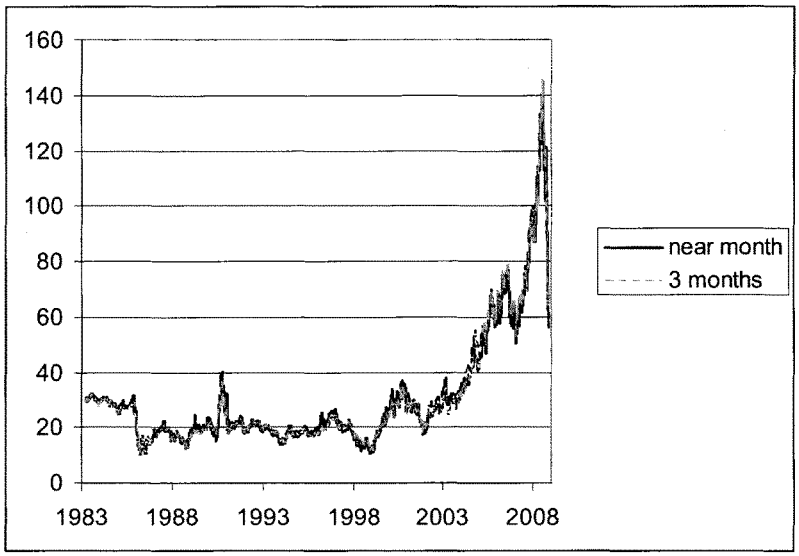


Figure 11. U.S. crude oil stocks: 2007, 2008, and average over 1990-2007



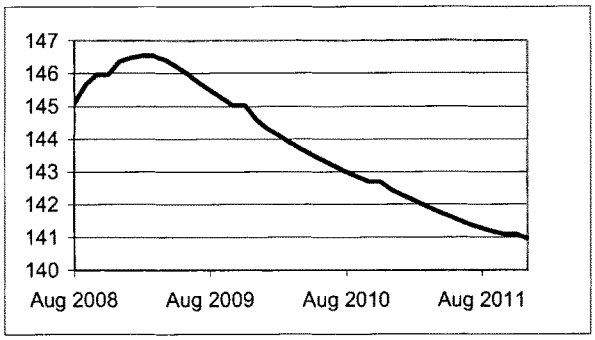
Notes. Bold line: average U.S. stocks of crude petroleum (excluding Strategic Petroleum Reserve) at indicated week of year over 1990 to 2007. Data source: EIA, http://tonto.eia.doe.gov/dnav/pet/xls/pet_stoc_wstk_dcu_nus_w.xls. Thin dashed line: values for 2007. Short-dashed line: values for 2008.

Figure 12. Daily price of futures contracts for nearest month (1-month forward) and 3-months forward, in dollars per barrel.



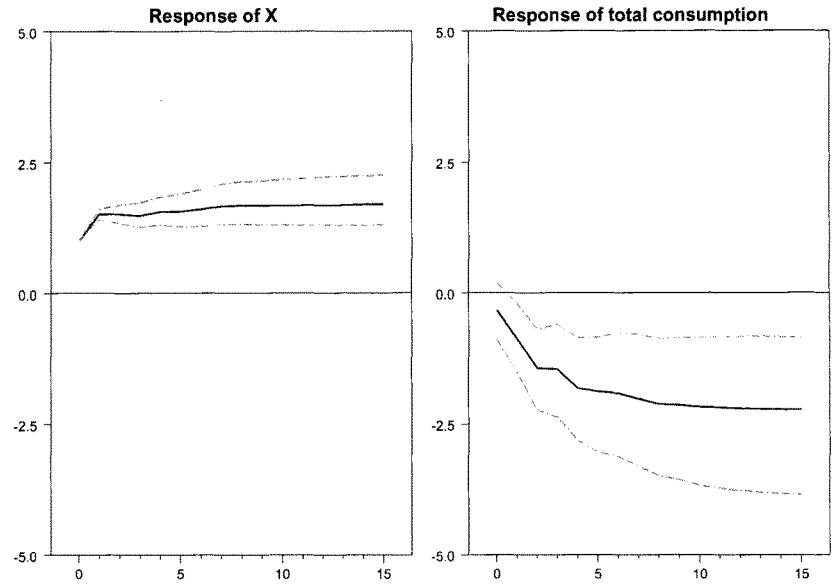
Data source: Energy Information Administration, "NYMEX Futures Prices," http://tonto.eia.doe.gov/dnav/pet/pet_pri_fut_s1_d.htm.

Figure 13. Futures term structure in July 2008.



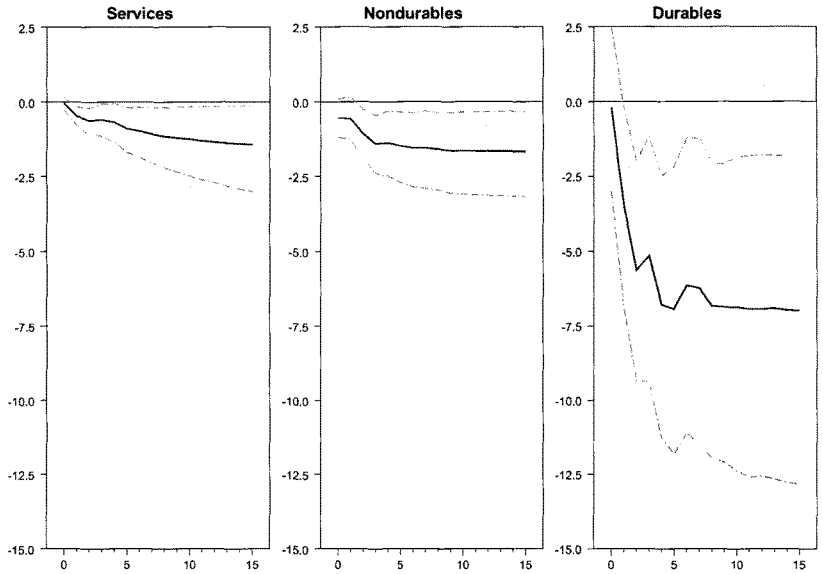
Notes. Closing price on July 11, 2008 of NYMEX light sweet crude contract for settlement in indicated month. Data source: Norma's Historical Data (http://normashistoricaldata.com/).

Figure 14. Response of real personal consumption expenditures to an increase in energy prices that would have reduced disposable income by 1%.



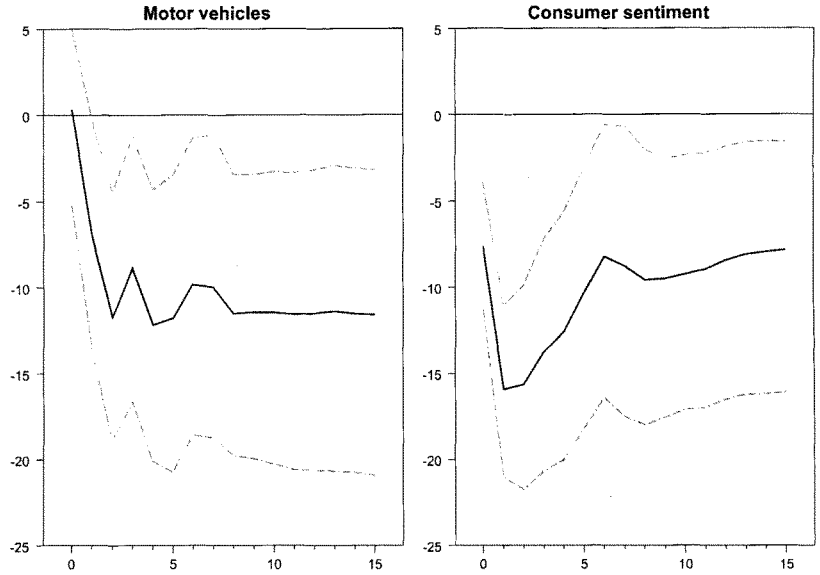
Notes. Impulse-response functions and 95% confidence intervals as estimated from data 1970:M7 to 2006:M7. First panel: response of $X_t = \sum_{j=0}^{t} x_j$ to a one-unit shock to x_{t-s} plotted as a function of s. Second panel: response to 100 times the log of real personal consumption expenditures at time t to a one-unit shock to x_{t-s} plotted as a function of s. Second panel reproduces (with re-normalization) Figure 8a in Edelstein and Kilian (2007).

Figure 15. Responses of real consumer spending on services, nondurables, and durables.



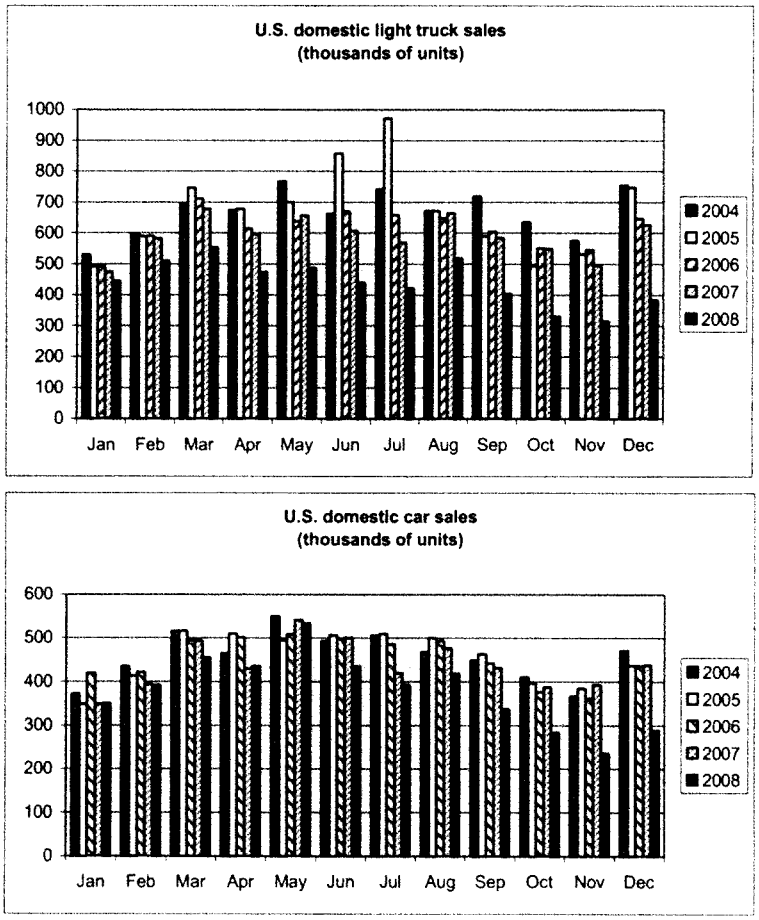
Notes. Impulse-response functions (and 95% confidence intervals) for bivariate VARs based on energy prices and indicated component of consumption spending. Reproduces with renormalization Figure 8b-d in Edelstein and Kilian (2007).

Figure 16. Responses of real consumption spending on motor vehicles and parts and consumer sentiment.



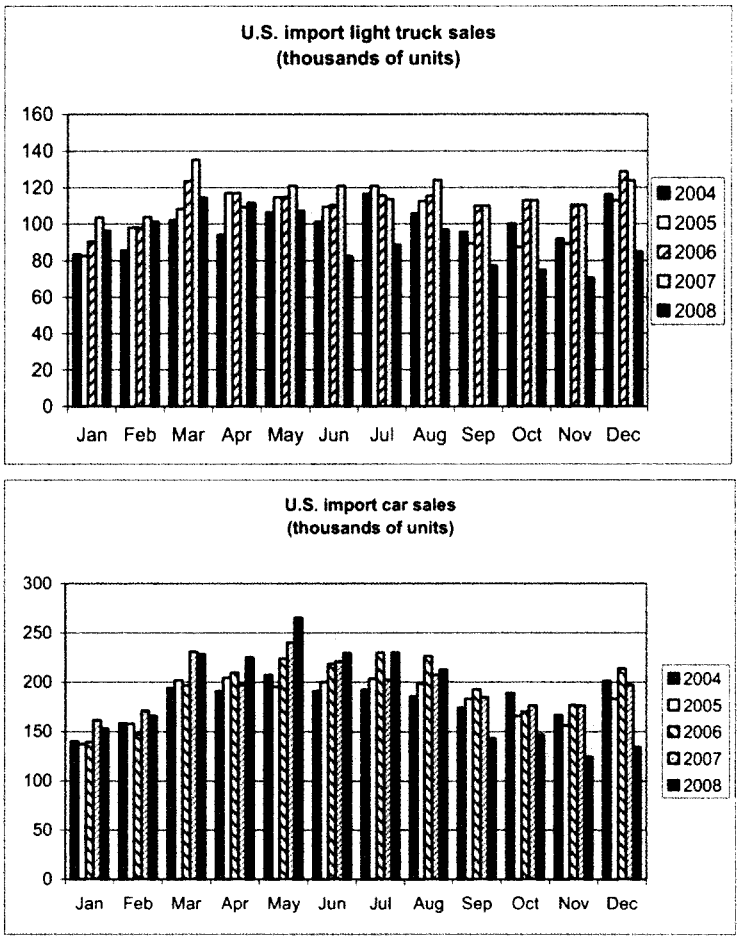
Notes. Impulse-response functions (and 95% confidence intervals) for bivariate VAR based on energy prices and (a) real personal consumption expenditures on motor vehicles and parts or (b) University of Michigan index of consumer sentiment. See also footnote 10. Reproduces with renormalization Figures 8e and 11a in Edelstein and Kilian (2007).

Figure 17. U.S. sales of domestic cars and light trucks.



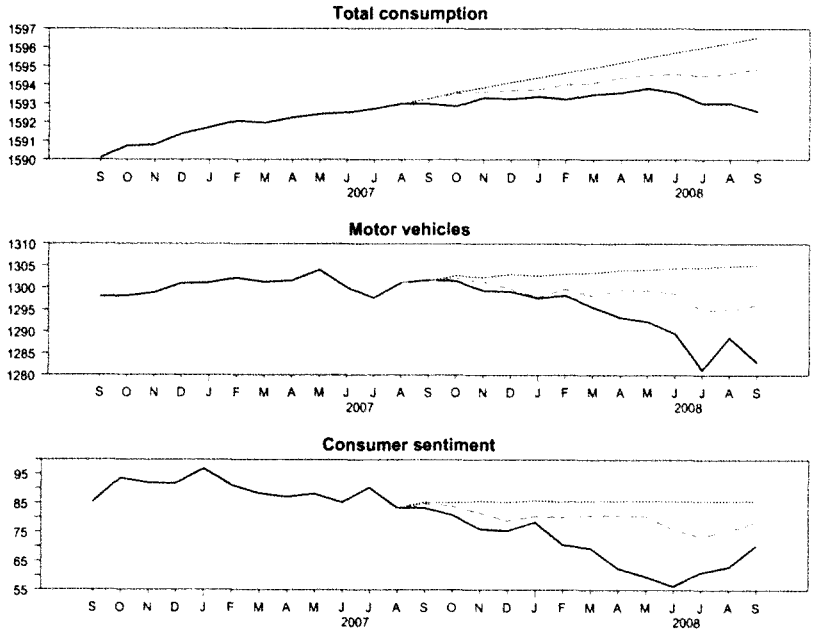
U.S. sales of cars and light trucks manufactured in North America, in number of units sold per month. Source: http://wardsauto.com/keydata/.

Figure 18. U.S. sales of cars and light trucks manufactured outside of North America.



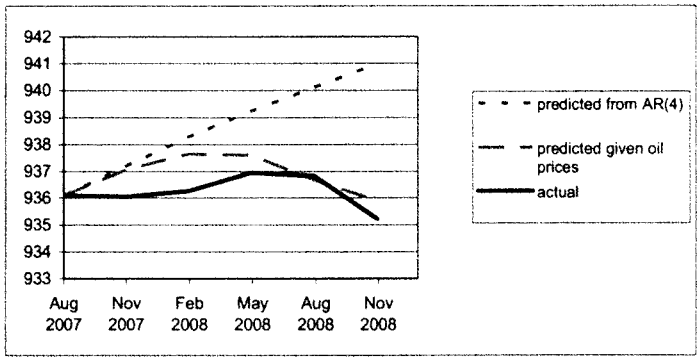
U.S. sales of cars and light trucks manufactured outside of North America, in number of units sold per month. Source: http://wardsauto.com/keydata/.

Figure 19. Contribution of energy prices and other factors to total real consumption spending, spending on motor vehicles and parts, and consumer sentiment, 2007-2008.



Notes. In each panel, solid line is the actual value of the series over 2006:M9 through 2008:M9, dotted line is the forecast for 2007:M9 through 2008:M9 formed on the basis of information available as of 2007:M8, and dashed line is the forecast for 2007:M9 through 2008:M9 conditional on information available as of 2007:M8 plus innovations in the energy price measure over 2007:M9 through 2008:M9. Top panel: real personal consumption expenditures. Middle panel: real personal consumption expenditures on motor vehicles and parts. Bottom panel: Michigan/Reuters index of consumer sentiment.

Figure 20. Dynamic forecasts of GDP formed as of 2007:Q3 with and without knowledge of the ex-post values of oil prices, 2007:Q4-2008:Q4.



Notes. Solid line: 100 times the natural log of real GDP. Dotted line: dynamic forecast (1- to 5-quarters ahead) based on coefficients of univariate AR(4) estimated 1949:Q2 to 2001:Q3 and applied to GDP data through 2007:Q3. Dashed line: dynamic conditional forecast (1- to 5-quarters ahead) based on coefficients reported in equation (8) (which was estimated over 1949:Q2 to 2001:Q3) applied to GDP data through 2007:Q3 and conditioning on the ex-post realizations of the net oil price increase measure o^*_{t+s} for $t + s$ = 2007:Q4 through 2008:Q3.

THE LONG AFTERSHOCK: OIL AND ENERGY SECURITY AFTER THE PRICE COLLAPSE

TESTIMONY TO THE JOINT ECONOMIC COMMITTEE OF THE U.S. CONGRESS

PREPARED REMARKS

Dr. Daniel Yergin

Chairman

IHS Cambridge Energy Research Associates (IHS CERA)

May 20, 2009

Washington, DC

Daniel Yergin is Chairman of IHS Cambridge Energy Research Associates. Dr. Yergin received the Pulitzer Prize for his work *The Prize: The Epic Quest for Oil, Money and Power*, which has been translated into 17 languages and appears in a new updated edition in 2009. His book is *Commanding Heights: The Battle for the World Economy* has been translated into 13 languages. He is writing a new book on energy and geopolitics. He chaired IHS CERA's most recent study, *Growth in the Canadian Oil Sands: Finding the New Balance*. Dr. Yergin is a member of the National Petroleum Council and vice chair of its "Hard Truths" study. He is a board member of the United States Energy Association. He serves as CNBC's Global Energy Expert.

Dr. Yergin received the United States Energy Association's Award for "lifelong achievements in energy and the promotion of international understanding." He is a Trustee of the Brookings Institution, a Director of the New America Foundation and of the US-Russia Business Council, and on the Advisory Board of the Peterson Institute for International Economics and of the MIT Energy Initiative.

Dr. Yergin received his BA from Yale University and his PhD from Cambridge University, where he was a Marshall Scholar.

I want to thank Chair Maloney, Vice Chair Schumer, Ranking Member Brownback, and the entire Joint Economic Committee for the invitation to participate in this timely hearing. Midst the crowded and pressing economic agenda, the Committee is to be commended for its focus on energy during a period of lower prices. For the issues of energy prices and availability are integral to our nation's economic well being, its security, and to the safeguarding of the environment.

When I had the opportunity to testify to the Committee almost a year ago, oil prices were on a sharp upward trajectory. Sixteen days after that very timely hearing, oil prices reached an all-time peak of $147.27. Although some people were then talking about $200, $250 or $500 a barrel oil, it seemed clear at the time to us at IHS CERA that a "break point" was nearing on prices that would mark the beginning of a reversal—which we have since seen.

It is noteworthy that the peak price day, July 11, was more than two months before the historic morning of September 15, 2008, when the collapse of Lehman Brothers took the economy from "moral hazard" to the far more frightening world of "systemic risk"—credit freeze, economic free fall, and the threat of overall breakdown.

It is well-recognized that the main driver of the deepest recession since the Great Depression was the failure in the U.S. and global debt and credit systems. But the surge in commodity prices—notably oil—was a very significant contributing factor. These high energy prices hit consumers hard, especially lower-income consumers, constraining their budgets and reducing their spending. They also put an unexpectedly heavy burden on many businesses, large and small—including airlines. Most notably, the very high oil prices did much to knock the automobile industry flat on its back—both reducing the ability of people to buy cars and leaving Detroit stranded with a product mix that could not quickly change at a time when consumers were moving away from the existing product mix at very high speed.[1]

The experience over the last two years underlines the wisdom of the Committee in looking out beyond the recession to how the oil market and the overall energy picture will evolve in the future.

---

1 IHS CERA, *"Recession Shock" The Impact of the Economic and Financial Crisis on the Oil Market*, December 2008. Our view concurs with that of Professor James Hamilton, who writes, "It is clear that something other than housing deteriorated to turn slow growth into a recession. That something includes the collapse in automobile purchases, slowdown in overall consumption spending, and deteriorating consumer sentiment, in which the oil shock was indisputably a contributing factor." James Hamilton, "Causes and Consequences of the Oil Shock of 2008-2009," February 2009.

Today, I would like to address three questions:

1. ***How and why did the oil market move so quickly from the Demand Shock, with very high prices, to the current Recession Shock?*** The answer demonstrates the way in which oil prices are a barometer of the world economy; for the number one reason is the shift from the "best global economic growth in a generation" to the "deepest recession since the Great Depression".

2. ***What are the prospects for another shock—what we call the Long Aftershock—in terms of lower investment and what might this mean in terms of sharp future increases in price?*** What will be the effects on future demand and supply, on investment, and on energy security? Spare production capacity—already at about 6.5 million barrels per day—will increase in the short term due to falling oil demand and increasing supply from investments already under way. In the medium term, however, low prices and financial constraints will hinder investment. Consequently, as the economy picks up, spare capacity will start to erode, and the oil market could tighten again in the first half of the next decade. Another era of strong global economic growth would also accelerate tightness. The result could be another adverse shock to the U.S. economy and global energy security.

3. ***What are the implications for what has become a critically important source for U.S. energy security—Canada's oil sands—and the issues around them?*** Our new IHS CERA study, Growth in the Canadian Oil Sands: Finding the New Balance, addresses some of these questions.[2] In talking about U.S. energy security, particular attention has to be given to Canada, which is the source of almost 20 percent of our total oil imports, as well as significant supplies of natural gas, and is also the largest buyer of U.S. exports of goods and services. The study also seeks to put the GHG emissions of the oil sands in a comparative framework, showing that on a "well-to-wheels" framework, their emissions are 5 to 15 percent higher than the "average" barrel.

---

[2] IHS CERA Special Report, *Growth in the Canadian Oil Sands: Finding the New Balance*, May 2009.

The Reality of Cycles

The essential point is the reality of cycles. Decisions made by governments and companies today will affect the availability of supply half a decade from now. The recession will not last. Nor will the large overhang of supply. That is why it is so important to focus on the energy future. Major initiatives are now being launched by the U.S. government to help further diversify and strengthen our energy system—from smart grids and transmission, to electric batteries for cars, to renewables and alternatives. There is also the opportunity to make real advances in the efficiency with which we use energy. Altogether, there will be a significant impact from the new commitment to much larger and more sustained research and development that will bring talent, existing and new, to work on our energy problems.

But we still face the challenges of lead time and scale. Currently, our total national energy use is the equivalent of 46 million barrels of oil a day. Even if the medium and long-term ambitions for electrification of our auto fleet are fully achieved, it will take some years for this impact to be felt. We will have a more efficient automobile fleet in terms of the internal combustion engine, augmented by yesterday's announcement of the accelerated fuel efficiency standards. Even so, that too will take time. Meanwhile, the major growth in oil demand will characterize emerging markets. We are already there. New sales of automobiles in China have, during this deep decline, exceeded those in the United States for each of the last three months.

Once global economic growth resumes, so will growth in oil demand. And that will once again put energy security—and the relation of energy to economic well-being—back at the top of the agenda. Given the lead times to develop new supplies, policy decisions made today should take into account the likelihood of future cycles—and what they mean to the American economy and to American consumers.

Beyond "Either-Or"

As part of that longer-term view, we need to get beyond the "either/or" energy debate and take a more ecumenical approach—ensuring that a combination of conventional energy, renewables and energy efficiency are all developed with appropriate environmental and climate-change considerations. As already noted, the major initiatives in research and development, innovation, and the "green stimulus" can have significant long-range impact. Moreover, the new recognition of the potential for energy efficiency is wholly welcome. Indeed, we have never seen anything like the embrace of energy efficiency that is taking place today all across the spectrum. But there is no single answer to the energy needs of our $14 trillion economy. Today, fossil fuels—oil, natural gas, and coal—supply over 80 percent of our total energy. Oil by itself is about 40

percent. That alone makes clear the importance of oil—and the evolution of the oil market—to our economy and security in the decade ahead. That is precisely why the focus of this Committee today is so significant.

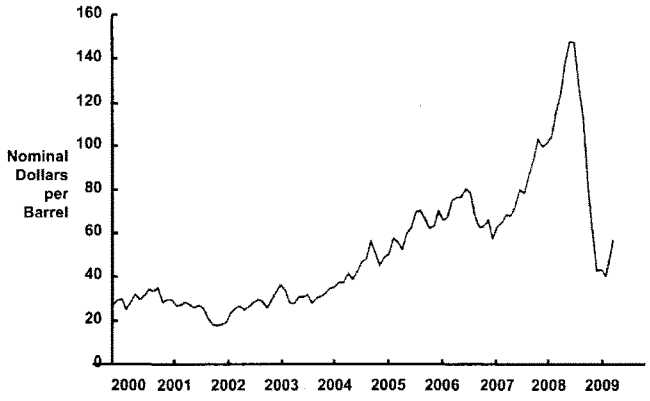
How Did We Get Here? From Demand Shock to Recession Shock

The last two years have seen extraordinary volatility in oil prices—scaling heights approaching $150 per barrel followed by a plunge to less than $40 per barrel and now rising back, at least for now, into the high $50s. (See Figure 1)

Oil prices are a barometer of the world economy. Rising prices between 2003 and 2007 reflected the best global economic growth in a generation—growth that led to overleveraging in terms of debt on a global scale, which fueled unsustainable economic growth. This economic growth translated into strong growth in oil consumption, especially in emerging markets. This was the Demand Shock. Between 2003 and 2007, oil demand grew by 7.6 mbd—compared to 4.3 mbd growth in the preceding five years. With this surge, the balance between supply and demand tightened.

Figure 1

Crude Oil Price Volatility: WTI Prices



Source: Platts, IHS Cambridge Energy Research Associates.
Note: 2009 prices are through the 15th of May.

While demand was rising sharply in these years, supply was affected by a variety of disruptions—sometimes in aggregate by as much as 2 million barrels per day (mbd), or even more.

Then there was the timing of investment. The oil industry is a long-term industry with regard to its investment horizons. It can take 10 years or more to find, develop and start production from a new field. Thus, there is no quick supply response. As it turned out, there were also delays in stepping up investments in new capacity, arising from several factors. There was skepticism about the durability of high and rising prices. Resource-holding countries tightened their terms for investment; and, as their financial reserves grew, they felt less urgency to encourage new investment.

Moreover, there was a dramatic increase in the costs for upstream, downstream, and energy-related services to more than twice their level at the start of the decade. This cost issue, while very prominent within the energy industry, was largely unrecognized outside the industry. But a series of IHS CERA cost indices clearly established their impact: The cost of developing a portfolio of upstream assets more than doubled from the beginning of 2005 to late 2008. What this meant was that a dollar of investment only bought half as much in 2008 as it did in 2005. That too slowed down the investment response.

The tightening balance between rapidly-growing demand and more constrained supply created a shrinking of "spare capacity"—the production capacity not in use—to as low as one million barrels a day in 2005. This is a very tight balance for the oil market, and the inevitable response is higher prices.

But the tight balance between supply and demand in 2003–07 was not the only factor driving the increase in oil prices. Prices were also caught up in an increasingly unsustainable commodity boom. The final explosion in oil and other commodity prices began late in the summer of 2007—as a weakening dollar set off a "flight to commodities" and there developed an increasing emphasis among investors on oil and other commodities as an asset class and storehouse of value. This was the period when financial markets had their greatest impact on oil prices—reflected variously in hedging, speculation, and asset allocation. High oil prices in turn played, as already noted, an important contributing role as a trigger in the economic downturn by undermining consumer spending and confidence, by burdening businesses, and by hitting hard at certain industries, notably automobiles and airlines.

In addition, a triad "belief system" evolved that supported the rise to $147 oil. The first element was a belief in what became known as "decoupling"—the conviction that the world economy had evolved to the point where Europe and emerging markets would be insulated or even immune

from a US economic downturn. That conviction lasted right through the summer of 2008 and was only jettisoned with the truly global downturn that became so evident in the autumn of 2008. The second was the widespread embrace of various versions of "running out" theories—that the emerging markets would consume all the world's marginal resources or that the world had hit "peak oil." The third element was an underlying, if unstated, assumption that price did not matter -- that both demand and supply would not budge as prices soared. Yes, it was possible that price had become irrelevant, but this would have been the first time in economic history. As it turned out, prices did matter. They just had lags—meaning it took some time for their impact to work their way through the system and be recognized.

Rise of Spare Capacity

But now the Demand Shock has completely given way to the Recession Shock. What had seemed unthinkable to many—declines in global demand—have become reality. The fall in oil demand in 2008 (0.7 mbd) and what we expect as the decline in 2009 (2.2 mbd), means a total decline of 2.9 mbd. This wipes out the oil demand growth over the last 4 years, and takes us back to the global demand level pre-2005.

Oil prices are half of what they were a year ago. As demand shrunk, new supply continued to come into the system. As a result, the formerly tight balance between world oil demand and the world's capacity to produce oil has given way to the largest volume of surplus production capacity in 21 years—about 6.5 million barrels per day. We are back to 1988 in terms of spare capacity. The oil market, like the broader global economy, has undergone a sea change. Today's oil prices are once again showing us a barometer of a weak global economy.

In the near term, this amount of spare capacity provides a significant cushion of security. Most of this decade saw the oil market's shock absorber—spare production capacity—shrink to the point where any actual supply disruption—or fear of one—pushed prices higher. This supply anxiety was part of the price. With spare capacity this year expected to average about 6.5 mbd—up from 2.5 mbd last year—fears of a disruption leading to a supply shortfall are considerably reduced. The current spare capacity is equivalent to the combined total output of Iran and Venezuela—or the combined exports of Iran,

Venezuela, and Nigeria together. This is important because these three countries have led the headlines when it comes to the geopolitical risk premium in oil prices during this decade. This is a major contrast to the period of tight capacity of the previous few years.

One result of this kind of shift is that energy security tends to slide down the agenda and fall away as a concern. In reflecting on this for the new edition of *The Prize*, I sketched out how the

focus on energy security fluctuates with the market. But, even in this down market, the energy security agenda deserves continuing attention. Two new requirements for global energy security are the inclusion of China and India in the energy security system, and greater concentration on the physical security of the supply chains and infrastructure.[3]

The Long Aftershock: When will the Market Tighten Again?

With the build-up of spare capacity, concerns are shifting to the demand and supply balance in the next 3 to 5 years, when the impact of today's lower oil prices on investment could result in what CERA calls the *Long Aftershock*—a tightening balance between world oil demand and production capacity and rising oil prices.[4]

Why has spare capacity increased just as oil prices collapsed from a record high last July? Oil demand can—and does—change abruptly in response to shifts in global economic conditions. Oil production capacity, however, does not. New capacity additions in 2009—including one of the largest ever recorded in Saudi Arabia—reflect investment decisions made several years earlier when prices were high and world oil demand was strong. In fact, in 2009 capacity is actually increasing by over 2 mbd as demand contracts by over 2 mbd.

The long lead times needed to bring new oil-producing capacity online mean that production capacity is expanding amid the biggest downturn in demand in a generation. This overhang of spare production capacity discourages further investment and simultaneously puts downward pressure on oil prices.

Investment decisions are rooted in expectations about future value. A company's investment strategy depends on its long-term view on future oil prices. This view—whether $20 or $100-plus per barrel—shapes investment decisions. Long-term oil price expectations are critical, but so is the other side of the coin: upstream development costs. Over the life of a project, $50 per barrel oil is not necessarily less attractive than oil at $80 per barrel—at least from the perspective of an international investor.

---

3 Daniel Yergin, *The Prize: The Epic Quest for Oil, Money, and Power* (New York: Free Press, 2009), Epilogue, new edition.

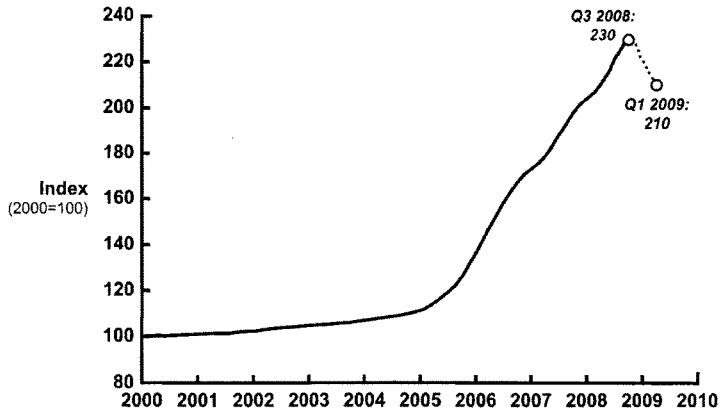
4 IHS CERA Private Report, *The Long Aftershock: Project Deferrals Put 7.6 mbd of Production Capacity Growth at Risk*, March 2009

What matters to a company is how development and operating costs measure up to the oil price and the specific fiscal terms that govern a project. In other words, what matters is the project's expected rate of return, which is determined by revenue, costs, and fiscal terms.

For oil companies, the last year has seen oil prices tumble by more than $100 per barrel at times, but the cost of developing new oil fields, by comparison, has seen a much slower decline. Oil prices in the first half of May were 63 percent lower than their peak, but costs are down only 9 percent. (See Figure 2) With prices at much lower levels than a year ago, and industry costs still stubbornly elevated, a number of new supply projects are no longer economically attractive.

In addition to challenging economics, the large amount of excess production capacity brought on by decreasing demand hinders new development projects. Even projects that look like winners today may not proceed—because short-term cash flow problems and tight credit markets limit the amount of capital available for investment. For these reasons, some deferral of investment in oil producing capacity is inevitable. Also, in a more-relaxed oil market, obstacles to new investment may be tougher to overcome.

Figure 2
IHS CERA Upstream Capital Costs Index (UCCI)
First Downturn of the Decade



Source: IHS Cambridge Energy Research Associates.

The vital question is, how much will investment decrease? IHS CERA has attempted to answer that question by considering the economic outlook for oil projects around the world and estimating which ones are at risk in today's environment. The analysis shows that slightly more than half of the expected growth in oil production capacity over the next five years is "at risk" of deferment or cancellation in today's economic environment. About 7.6 million barrels per day, out of potential net growth of 14.5 million barrels per day, may not materialize due to the economic downturn. The emphasis is on "at risk". They may go ahead, they may also be postponed or delayed or cancelled altogether, but they cannot be counted upon.

How Soon?

The long lead times for exploration and development of new oil fields means that a slowdown in investment today will be felt in coming years. However, eventually economic growth and growth in oil demand will return and the market will tighten. But how soon will this happen? On the supply side, it will depend on the extent of cutbacks in oil capacity investments. On the demand side, it will depend on the speed and strength of the world's economic recovery, and on the results of energy efficiency, "green stimulus," and climate change measures designed to decrease energy demand, increase supplies of renewable energy, and decrease the world's emissions of greenhouse gases.

Some things are fairly predictable. The future U.S. automobile fleet will be more efficient. As automakers retool and as buyers return, the impact of the new fuel efficiency standards passed in December 2007—the first in 32 years– will make their impact felt. Yet auto sales will grow substantially in other parts of the world, which means more vehicles will need fuel. If exploration and investment decrease too much today, we envisage a situation where even moderate demand growth could bring about tight oil market conditions, setting the stage for another cycle of strongly increasing oil prices. How high prices get will be determined by the fundamentals of supply and demand, geopolitics and disruptions, government policies, costs, and the interests of investors. They will also be affected by how long memories last in the minds of policymakers, industry decision makers, and investors—about cycles and about how the balance of supply and demand changes.

If, however, future demand does not recover lost ground, the market could be in for a long period of low prices. A long-term overhang of spare capacity is possible if oil demand reductions move from a temporary response to a long slowdown brought on by extended economic malaise. In this case, demand increases and field declines would only slowly, and over many years, reduce the amount of spare oil production capacity available in the market.

All this underlines the reality of cycles. During this downturn, there is a natural tendency for memories to fade about the acute concerns of a year ago—and the impact of such dramatic price increases as seen in 2007 and 2008. But it is important to keep a longer term perspective that accords with the longer-term investment horizons and the long lead times that are inherent in developing oil and other energy resources.

Canadian Oil Sands and the Fabric of U.S. Energy Security

One resource that has become increasingly important to U.S. consumers is the oil sands of Canada. The Canadian oil sands encapsulate many of the challenges facing the world oil industry today. The oil sands give Canada the world's second largest recoverable reserve of petroleum—currently estimated at 173 billion barrels. This is second only to Saudi Arabia. Technological advance has made possible a more than doubling of production from 2000 to 2008—to 1.3 million barrels per day. This has turned the oil sands into an increasingly important source of world oil supply, and they are a key reason why Canada is now the largest foreign supplier of oil to the US market—representing close to 20 percent of our total imports. Canada is one of only two Western Hemisphere countries among IHS CERA's "O-15"—the top 15 countries in terms of supply growth over the next ten years.

Because of their immensity and their adjacency, the oil sands have become a key element in the fabric of North American and global energy security. They are part of the dense network of economic, political, and energy relations (which includes flows of natural gas and electric power) between the United States and Canada. The oil sands themselves are a significant element in the trade links between the two countries. Canada is the largest trading partner of the United States, and Canada is, by far, the largest market for American exports of goods and services.

But investing in the oil sands is a high cost venture. At the peak of industry costs last year, an oil price of roughly $60 to $85 per barrel— depending on the type of project—was needed to justify investment. Costs are under downward pressure, but the lightning-quick fall in oil prices means about 70 percent of oil sands projects that were planned last summer have been delayed because of today's low oil prices.

Emissions: 5 to 15 Per Cent More on a Life Cycle Basis

Another major uncertainty is future regulations on greenhouse gas emissions (GHG). Production of the oil sands, like other energy sources, has an impact on the environment. There is much attention to their carbon footprint. The key metric is their life-cycle "well-to-wheel" greenhouse gas (GHG) emissions, which covers all GHG emissions beginning with the production of oil

sands through their combustion in gasoline in the engines of our cars. Oil sands have lifecycle GHG emissions that are 5 to 15 percent greater than the average crude oil consumed in the United States. However, one of the things that became clear in our study is that there is really no "average" barrel. This means oil sands' GHG emissions can be higher, lower or on par with other crude oil consumed in the United States. Cooperation between the United States and Canada on greenhouse gas regulation would provide a much more stable environment for oil sands investment. Additionally, opportunities exist to reduce the oil sands' greenhouse emissions—particularly in the realm of energy efficiency—and this is an important area of research and development activity for the Canadian government to lead.

An Ecumenical Approach

The importance of the oil sands emphasizes a larger point: when we think about U.S. energy security, we need to think about resources on a regional and global scale and thus about the importance of diversification. Today, with new policies, the concept of "diversification" is itself being diversified. At the same time, diversification requires timely and steady investment in existing resources, and thus attention to the barriers to that investment.

The scale and complexity of the energy foundation of our $14 trillion economy underline the importance of an ecumenical approach for meeting the energy challenges ahead.

PREPARED STATEMENT OF REPRESENTATIVE MICHAEL BURGESS

Thank you Madam Chair for holding this hearing. I commend the JEC for taking this opportunity to engage in such a timely subject.

Three weeks ago we heard from Chairman Bernanke who stated that the U.S. economy has contracted sharply since last autumn. Real gross domestic product has dropped at more than six percent in the fourth quarter of 2008—as well as the first quarter of this year—resulting in the loss of some 5 million jobs over the 15 months.

Furthermore, the available indicators show overall business investment remains weak. The Federal Reserve found restrained capital spending plans, net declines in new orders and further weakening in the demand for commercial and industrial loans.

A number of factors have contributed to this situation; however, rising commodities prices are clearly capable of prolonging this current recession, foremost on that list being oil.

Clearly the United States needs oil to sustain our economic growth, but our supply here in the U.S. is limited and so we have turned our attention to developing countries such as Venezuela, Nigeria and Russia. But so have the hungry oil consumers around the globe, each eager to amass the formidable scope of even our currently troubled economy. For instance, China and India together account for 100 million new consumers of oil EACH year.

And while no one can tell us with perfect clarity the correlation between low prices of oil and the ability for our businesses to earn increased profits, any nominal economists can explain colloquially the basic laws of supply and demand. The U.S.' desire for oil has not been whetted by high oil prices. We still drive our cars to work, to home and to play. Match this with the competing consumption demands for those seeking to mimic the America lifestyle and what we end up with is a scarce commodity . . . thus driving up costs.

Furthermore, we know that we are heading towards a time in the year when oil prices, and subsequently transportation fuel prices, are seasonally higher, which can only add to our economic troubles.

Madam Chair, make no mistake, I am interested in hearing from the experts in our panel today regarding specific metrics of analysis to determine whether our economy's recovery is dependent upon the rest of the globes consumption of oil, but what we need are solutions for THIS country's oil needs rather than a mere minimization of costs.

○