Oil, Automobiles, and the U.S. Economy: How Much have Things Really Changed?

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Abstract

This paper re-examines whether the impact of oil shocks on the aggregate economy, and on the motor vehicle industry in particular, has changed over time. We find remarkable stability in the response of aggregate real variables to oil shocks once we account for the additional cost of shortages and rationing during the 1970s. To understand why the response of aggregate real variables has not changed, we focus on the motor vehicle industry, because it is considered to be the most important channel through which oil shocks affect the economy. We find that, contrary to common perceptions, the share of motor vehicles in the goods-producing sector of the economy has shown little decline over time. Moreover, within the motor vehicle industry, the recent oil shocks had similar effects on segment shifts and capacity utilization as the shocks during the 1970s.

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I. Introduction

Between 2002 and mid-2008, the average real price of gasoline in the United States increased more than two fold after having risen only modestly in the preceding 15 years. Not surprisingly, this run-up led to renewed interest in the effects of oil shocks on the U.S. aggregate economy. Hamilton's (1983) seminal paper documented the negative effects of oil shocks on the aggregate economy, and numerous papers since that time have extended or questioned the strength of these effects.[1] Most recently, several authors have argued that the effects of oil price shocks on U.S. aggregate activity have declined since the mid 1980s (e.g. Herrera and Pesavento (2009), Blanchard and Galí (2008), Blanchard and Riggi (2009), Edelstein and Kilian (2009)). These papers have variously attributed the decline to improved monetary policy, a smaller share of oil in production, or more flexible labor markets. Empirical work has also shown that a more-muted response in the consumption of motor vehicles to energy price shocks has played a large role in obtaining these results (Edelstein and Kilian (2009)).

This paper re-examines the extent to which the impact of oil shocks on the aggregate economy, and on the motor vehicle industry in particular, has changed over time. We first discuss the array of energy cost measures that authors in the literature have used to define oil price shocks, and then we survey the theoretical contributions from a number of DSGE macro models that include various roles for oil in the economy. Using these models, there are a number of structural parameters that reasonably could

[1] See, for example, Mork (1989), Hooker (1996), Hamilton (1996), Barsky and Kilian (2002), and Hamilton (2003).

have changed over time in ways that would reduce the potency with which oil price fluctuations can impinge aggregate output.

All of these models assume, however, that the price of oil reflects the true cost of energy for firms and consumers. While much of the recent empirical work uses published measures of oil and/or gasoline prices as an indicator of the strength of the oil price shocks, we find that these measures neglect some of the important non-price rationing situations that occurred in the critical 1973-74 and 1979 oil shock episodes due to price controls.

Using two oil shock measures that include the effects of both price and non-price rationing, we re-examine the evidence from vector autoregressions that oil disturbances have had less impact on the real economy in the past twenty years than in the preceding decades. The results show that the responses of motor vehicle consumption and aggregate output to rationing-adjusted oil price shocks appear just as great during the past two and a half decades as they were in the 1970s and early 1980s. On the other hand, even the new measures imply that the impact on *nominal* variables has become noticeably muted.

Why has there been so little change over time in the response of motor vehicle consumption to oil price changes? We find that, despite the many innovations in the way the U.S. economy produces and uses motor vehicles that have occurred over the past 40 years, the primary channels through which oil prices directly affect motor vehicles have not changed much over time. Namely, we present evidence that the recent increases in gasoline prices have caused just as much anxiety in consumers now as was observed 30 years ago, and the shifts in demand across vehicle size classes have also been as equally disruptive to motor vehicle capacity utilization since 2000 as they were in the 1970s and early 1980s. Finally, the adjustments made to U.S. light vehicle production capacity during the recent period resembled the adjustments made in the early 1980s, a time when the shifts in demand were judged to have been quite persistent.

The paper proceeds as follows. Section II reviews the data available on various measures of oil prices and discusses how modern DSGE models have accommodated the role of oil in the economy. We also present evidence that energy price controls and gasoline rationing in the 1970s may have caused problems in empirical work, because published prices in that era did not reflect the true cost of energy. Sections III shows the ways in which vehicle demand responds to changes in gasoline prices, and Section IV shows the ways in which these shocks affect production. We show that only part of the slump in light vehicle sales that typically follow gasoline price shocks is likely related to direct gasoline-specific effects, and we also show that these effects have been relatively stable over time. Section V discusses the adjustments to motor vehicle capacity across vehicle size categories, and section VI concludes.

II. Oil shocks and the U.S. economy: A review of the theory and the evidence for structural change

We begin by reviewing the behavior of several key measures of oil prices over the past few decades. After describing how macro DSGE models have been used to understand the role of energy costs in the economy, we present evidence that rationing may have led to a wedge between the published price of oil and the true cost of oil during the large oil price shocks in the 1970s. Using vector autoregressions that are similar to those estimated by Blanchard and Gali (2008) and Edelstein and Kilian (2009), we then show how mismeasurement of the true cost of oil in the 1970s may have caused the appearance of structural instability in the impulse response functions of real output to oil price shocks. Using cost measures that account for rationing, we find that the impulse response functions have not changed much over time.

A. Overview of oil prices

Figure 1 displays three oil price measures: the producer price index for crude petroleum (PPI-oil), the refiner acquisition cost of imported oil (RAQ), and the consumer price index for gasoline (CPI-gas). Hamilton (2003, 2009b) typically uses the PPI-oil measure and Mork (1989) and Barsky and Kilian (2002) use versions of the RAQ measure.[2] Unfortunately, the RAQ measure starts only in 1974.[3] We include the CPI-gas measure because several authors have shown that gasoline is a large share of U.S. petroleum consumption, and gasoline prices are also the most relevant energy price measure for the automobile sector.[4]

Oil and gas prices—displayed in log current dollars in the upper panel of Figure 1 and as the log of a real index in the lower panel—have risen notably at several points in history. Four episodes stand out in particular: First, the real price of gasoline rose 27 percent between October 1973 and May 1974, a result of an even larger rise in the price of crude oil after the Yom Kippur War. After falling back a bit over the next four years, the price of crude oil began to rise again at the end of 1978. By the spring of 1980, the Iranian Revolution and the Iran-Iraq war led to losses in crude oil production that

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[2] Blanchard and Galí (2008) use the price of West Texas intermediate oil, available from FRED. This series shares the same problems with the PPI measure that we will discuss below.

[3] Barksy and Kilian (2002) extend it back to 1971, but we are worried about this extension, for reasons given below.

[4] Also, Kilian (2009) highlights the importance of studying gas prices separately from crude oil prices.

pushed the price of oil imports up 71 percent and fuel prices up 46 percent. Between 1982 and 1985, the nominal price of gasoline grew only modestly until Saudi Arabia abandoned production quotas and the price of crude oil plunged.

Real gasoline prices after 1985 continued to trend lower, and by the end of the 1990s, real gasoline prices had fallen to record-low levels. This pattern changed abruptly at the beginning of 1999, when OPEC member countries phased in several cuts to production quotas. The real price of gasoline surged 43 percent by the summer of 2001 before the weakening world economy put downward pressure on crude oil prices. The relief was short-lived, however. Gas prices began to rise again in early 2002, when political turmoil in Venezuela shut down much of the country's crude oil production; real crude prices climbed 588 percent and gasoline prices climbed 127 percent by summer 2008, and then collapsed with the rest of the economy as the financial crisis spread from the housing sector and interrupted aggregate demand.

B. Oil shocks in macro DSGE models

Economists take a keen interest in oil prices because these episodes of steep price increases were often followed by recessions. The literature has introduced into macro models four principle channels through which oil or energy shocks can lead to recessions: (i) Energy serves as an important input to production; (ii) energy is an important consumption good; (iii) changes in energy prices lead to costly shifts in demand across sectors; and (iv) the policy response to oil price shocks includes monetary tightening, a move that depresses output. Often layered on top of these effects are additional forces that multiply and propagate the effects, such as real wage rigidities (e.g. Bruno and Sachs (1982), Blanchard and Galí (2008), Blanchard and Riggi (2009)), imperfect competition

(Rotemberg and Woodford (1996)), variable utilization rates (Finn (2000)), vintage capital effects (Atkeson and Kehoe (1999), Wei (2009)), and multiplier effects created by externalities across firms (Aguiar-Conraria and Wen (2007)). We will discuss each of these channels and point out which parameters in these DSGE models are suspected to have changed over time.

Energy as an input to production

Berndt and Wood (1975), Bruno and Sachs (1982), and Pindyck and Rotemberg (1983) were among the first to study the effects of energy price shocks in a framework in which the key role of energy was as an input to production. In the subsequent literature, many researchers have argued that the production-side impact of energy prices is limited by the small share of energy in costs.[5]

Finn (1991, 2000) modifies the standard model to reflect the notion that the energy requirements of installed capital are often fixed, and thus energy must be used in fixed proportions to capital services. Capital services are determined by the utilization of the capital stock. This feature yields a stronger effect on output of an increase in energy prices.[6] Aguiar-Conraria and Wen (2007) obtain even greater effects by augmenting Finn's model with monopolistic competition and firm externalities.

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[5]Examples of papers making this argument are Rotemberg and Woodford (1996), Barsky and Kilian (2001, 2004), Aguiar-Conraria and Wen (2007), Blanchard and Galí (2008), and Hamilton (2009).

[6] A standard RBC model with constant capital utilization produces a fall in output of only 0.05 percent. On the other hand, Finn's variable capital utilization model produces a fall of 0.17 percent at the trough. Thus, Finn's model can explain two-thirds of the observed decline in output.

In many of these models, a decrease in the share of oil in output implies that an oil shock should have less effect on the aggregate economy, a finding that suggests the increase in the fuel efficiency of productive capital over time may have lowered the impact of oil shocks on real output. In Finn's model, however, it is not as clear that an increase in energy efficiency would weaken the relationship between energy price shocks and the rate of output.

Structural parameters not directly related to the use of energy can also affect the transmission of energy price shocks in DSGE models. For example, Blanchard and Gali (2008) show that a decline in the rigidity of wages in these types of models would reduce the effects of oil price shocks on output.

Energy as consumption good

Apart from the general equilibrium effects from the production side, oil price also have direct effects on demand. First, oil shocks can lead to declines in demand for goods for which consumption is complementary with purchases of oil. Hamilton (1988) and Wei (2009) show this effect in models oriented towards motor vehicles. Second, oil shocks introduce uncertainty into the outlook for future energy prices, and increases in uncertainty can dampen demand for goods when the purchase decision is costly to reverse. Bernanke (1983) analyzes a model of irreversible investment, in which energy shocks lead to a rise in uncertainty which then dampens investment; the same argument can be applied to consumer durables. Third, for energy-consuming capital goods, large increases in the price of energy change the desired characteristics of the capital in use. With the energy efficiency of the existing stock of consumer durables largely fixed at intermediate horizons, demand for new goods often shifts in an exaggerated fashion to reflect a widening differential in the relative costs of ownership between different types of goods. For the case of motor vehicles, smaller and more fuel-efficient vehicles naturally become more desirable.

One parameter that has likely changed over time is the energy efficiency of consumer durable goods—motor vehicles and other appliances. When energy efficiency rises or the share of these types of goods in consumption falls, then we would expect the impact of oil shocks on output to diminish over time.

It is not clear whether the effects of the uncertainty channel have become weaker over time. This would only be the case if oil price shocks have been generating less uncertainty now than they did in the past.

Sectoral shifts and costly factor mobility

Several papers have investigated sectoral shifts as a potential way in which oil price shocks could affect the economy. Davis (1987) and Hamilton (1988) suggest that the effects of oil price shocks can be amplified if they induce sectoral shifts and factor adjustment is costly. For example, Hamilton (1988) presents a two-sector model in which one of the consumer goods was very energy intensive. By introducing costly mobility of factors across sectors, Hamilton is able to find larger effects of oil price shocks than would be the case in a model with flexible factors. Bresnahan and Ramey (1993) postulate that oil shocks would lead to disruptive sectoral shifts even within narrowly defined industries. They present empirical evidence that this was the case for size classes of automobiles within the U.S. automobile industry during the 1970s.

It is not clear that the structure of the economy has necessarily changed in a way that would weaken the sectoral shifts channel of oil shock transmission. We find evidence in the motor vehicle sector that this channel remains quite potent.

Monetary Policy Reaction Functions

Bernanke, Gertler and Watson (1997) have argued that the endogenous response of monetary policy is an important part of the outsized effect of oil prices on output. They use a structural vector autoregression to estimate the historical responses and then perform counterfactual experiments involving different monetary policy responses. Using this method, they find that monetary policy plays an important role.[7] Leduc and Sill (2004) study the potential effect of monetary rules in a calibrated DGE model that uses Finn's (2000) production structure. They find that 40 percent of the decline in output in the wake of an oil price increase is due to the systematic component of monetary policy.

To look for changes in policy-related parameters over time, a number of papers have simulated monetary DGE models or estimated monetary structural vector auto regressions to determine whether changes in monetary policy have diminished the impact of oil shocks over time. Herrera and Pesavento (2009), Blanchard and Galí (2008), and Blanchard and Riggi (2009) all find evidence that oil price shocks have less impact now in part because of the changes to the response of monetary policy.

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[7] Hamilton and Herrera (2004) question details of the specification, which they argue leads to those results. Bernanke, Gertler and Watson (2004) respond by re-estimating their model in a way that attempts to deal with this critique and find results only slightly less strong than in their original paper.

To summarize, the theoretical literature has suggested a variety of ways in which oil shocks can affect the economy. Some of these effects should be expected to be weaker now, while other effects can easily be as strong.

C. The importance of rationing in the 1970s

In the models described above, it is assumed that the price of oil reflects the true acquisition cost of energy for firms and households. While the literature on the effects of oil shocks has debated the merits of various measures of oil prices and whether the effects are nonlinear,[8] much of it has missed a potentially important change in the degree to which oil *prices* reflect oil *disruptions*. In particular, other than Mork (1989), modern researchers have not paid much attention to the embargoes, price controls, and rationing that marked the oil price disturbances in the 1970s. Helbling and Turley (1975) document that price controls were first imposed on the U.S. domestic oil industry in August 1971 as part of the general imposition of price controls. The controls on other sectors of the economy were phased out, but the controls were made more stringent on the domestic oil industry in response to the OPEC embargo of October 1973. These complex controls, which imposed lower price ceilings on "old" oil than on "new" oil, led to significant disruptions in the production of domestic oil and average prices below the world price of crude oil. For example, from November 1974 to March 1975, production of oil at "old" wells declined by 12 percent. Helbling and Turley argue that the differential price controls and a complex array of entitlements for refiners served to tax domestic energy production and subsidize imported oil.

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[8] For example, see the debate between Kilian and Vigfusson (2009) and Hamilton (2009b).

Anecdotal evidence also suggests that rationing may have raised the true cost of energy for other petroleum products above their published prices: According to newspaper reports in the fall of 1973, numerous industries from chemicals to fast food to semiconductors feared having to curtail production because of imminent shortages of energy. However, our reading of newspaper accounts in the first half of 1974 suggests that shortages to producers were not too common, and it appears that the greatest shortages were in gasoline and diesel. According to some estimates, 20 percent of the gasoline stations ran out of gas during the height of the crisis (Frum (2000)).

Multiple oil and gas price controls also helped produce shortages after the Iranian Revolution of 1979. In April 1979, President Carter announced gradual decontrol of oil prices, but proposed a windfall profits tax. In January 1981, President Reagan signed an order leading to the complete deregulation of oil and gas prices.

To quantify the additional cost imposed on consumers by non-price rationing in this era, Frech and Lee (1987) use data from California and estimate that the time cost of the queues added between 13 to 84 percent to the price of a gallon of gasoline between December 1973 and March 1974. The estimated additional time cost varied between 6 and 33 percent Between May 1979 and July 1979. Thus, the price index for gasoline shown in Figure 1 potentially understates the true cost of gasoline quite severely in periods affected by the two oils shocks of the 1970s.

The producer price index for crude petroleum suffers from the same problem because of the price controls on domestic crude oil. Barsky and Kilian's (2002) refiner acquisition cost of imported oil comes closer to measuring the true market price of oil, but it does not capture all of the additional costs imposed on the economy by distortions caused by price controls and the entitlement system.

In order to capture the true cost of gasoline during these episodes, we propose two new variables: The first variable augments published gas prices with estimates of the additional time cost during the periods of gasoline lines. In particular, we use the average of the rural and urban estimates from Table 1 in Frech and Lee (1987), which compares the time costs per gallon to the published price per gallon of gasoline for the months of December 1973 through March 1974 and May 1979 through July 1979. These factors add between 8 percent (in July 1979) to 67 percent (in March 1974) to the shadow price of a gallon of gasoline.[9]

Because the rationing cost estimates likely capture the effect of rationing imperfectly, we also consider a second measure—the special question posed by Thomson Reuters/University of Michigan in the Survey of Consumer Attitudes. Respondents to the monthly survey are asked several questions related to car-buying conditions. The survey tracks the portion of respondents who cite the price of gasoline or possible fuel shortages as the reason that car-buying conditions are poor.[10] This measure is shown in Figure 2. The portion of consumers that expressed anxiety over fuel prices ramped up

[9] Frech and Lee's estimates are based on data from only California, so the question arises as to how California's shortages compared to the rest of the nation. According to the Feb. 8, 1974 *Wall Street Journal*, there was no rationing in "New England north of Boston, much of the Midwest, Denver, Nevada, and Southern California. In Northern California, the word was okay on weekdays and in daylight, but otherwise watch out. There were long lines in Washington, D.C., and the Philadelphia area…and in New York and New Jersey, where things have been tough for quite a while now."

[10] Other reasons consumers can give for this being a bad time for buying a car are: (1) prices of cars are too high; (2) interest rates are too high; (3) can't afford to buy; (4) uncertain future; and (5) poor selection or quality of cars.

sharply at the time of the oil price shocks in the 1970s and early 1980s. Interestingly, these same levels were reached again in 2006 and 2008. Thus, from the consumers' perspective, the recent increases in the price of gasoline were equally as noticeable as were the oil shocks of the 1970s.

D. The responses of output, consumption, and prices to oil price shocks

Using the published measures of energy prices and the two variables that account for non-price rationing in the 1970s, we now revisit some of the evidence that shows the response of aggregate activity to energy price shocks has declined over time. The energy price measures we consider are the following: (1) The consumer price index for gasoline; (2) Hamilton's (2003,2009b) "net oil price increases"[11]; (3) the CPI index for gasoline that has been augmented with the time cost of rationing; and (4) the measure of consumer attitudes toward gasoline prices and fuel shortages. Our strategy is as follows: First we show that the impulse response functions from vector autoregressions estimated by Blanchard and Gali (2008) and Edelstein and Kilian (2009) do not change much if published gasoline prices are used in place of the authors' original oil price measures. Second, we show that the impulse response functions based on gasoline price measures that account for the effects of rationing do look quite different.

We begin by estimating a vector autoregression (VAR) that is similar to the one used by Blanchard and Galí (2008). The VAR system we estimate is given as follows:

$$Y_t = A(L)Y_{t-1} + U_t .$$

[11] The Hamilton measure is defined as the log change in the price index for gasoline relative to its previous three-year high if it is positive, or zero if it is negative

In the VAR estimated by Blanchard and Gali, Y_t included quarterly data on the nominal price of oil, the CPI, the GDP deflator, nominal nonfarm compensation, real GDP and nonfarm business hours. In other specifications, they also included the federal funds rate. In our version of their analysis, Y_t is built from monthly observations of the following variables (in order): (i) A selected version of one of the oil shock variables, (ii) the CPI, (iii) nominal wages of private production workers, (iv) industrial production, (v) civilian hours, and (vi) the federal funds rate. *A(L)* is a matrix of polynomials in the lag operator *L*. *U* is a vector of disturbances. All variables except the sentiment variable and the federal funds rate are in logs. The shock to oil prices is identified using a standard Choleski decomposition. We include a linear time trend and six lags of the variables. The data are monthly from 1967:1 to 2009:12.

Blanchard and Galí (2008) compare samples that are split between 1983 and 1984, which is the typical split for studies of the Great Moderation. Edelstein and Kilian (2009) study samples split between 1987 and 1988. We choose a split between 1985 and 1986 because it is the average of the two splits, and because the nature of the oil market seemed to change dramatically in 1986.

As an alternative to showing dozens of different impulse response functions from the various permutations on oil shocks measures and time periods, we summarize the results in table 1, which compares the response of each of these variables in the two periods to a shock to the oil shock variable. The shock has been normalized so that the size of the increase at its peak is the same across periods. It is important to note, however, that the unnormalized standard deviation of the shock to the published nominal gas price and Hamilton's measure is substantially *higher* in the second period. In contrast, the shock to the augmented gas price is roughly constant across the periods whereas the shock to the consumer sentiment variable is about 33 percent higher in the second period.

The key comparison in Table 1 is the ratio in the last column. For a given shock in the oil cost variable, it shows the ratio of the peak response of the other variables in the second period to the peak response in the first period. The results for both the standard nominal gas price measure and the Hamilton nonlinear measure show that the responses of both industrial production and hours are less than half in the second period. The response of inflation is even smaller in the second period. In contrast, both the gas price index augmented with the cost of rationing and the consumer sentiment about gas variable show that the response of industrial production is *greater* in the second period. For hours, the response is slightly less in the second period if we use the augmented gas price index but even greater if we use the consumer sentiment variable. However, both new indices indicate that the response of inflation is still lower in the second period.[12]

In similar research, Edelstein and Kilian (2009) find that much of the decline in aggregate activity (or aggregate consumption, more specifically) that follows a jump in oil prices comes through demand for motor vehicles. They also show that the weakening over time in the potency of the motor vehicle demand channel likely played a significant role in reducing the effect of oil shocks on aggregate activity. Because this result is the most likely to have been affected by effects of gasoline rationing in the 1970s, we also re-

[12] We do not show the response of nominal wages and the funds rate because their responses are not significantly different from zero and the dynamic patterns swing from positive to negative in some cases.

estimate a VAR similar to the Edelstein and Kilian (2009) model, using our rationing-adjusted measures for the true cost of gasoline.

We estimate a trivariate VAR, in which Y_t is defined by (i) one of the oil cost shock variables, (ii) the log of real total consumption excluding motor vehicles, and (iii) the log of real consumption of motor vehicles. In the first set of results, we use as an energy price shock the Edelstein and Kilian (2009) measure of the purchasing power lost to increases in oil prices: This measure scales the changes in real energy prices by the share of energy in consumption expenditures. In the second set of results, we use shocks to consumer sentiment about gasoline. In each set of results, we estimate the VAR on two samples: 1967:1 – 1985:12 and 1986:1 – 2009:12. We normalize each shock so that the peak responses of the shock variable are equal to one in each sample period.

Figure 3 shows the estimates, with dots indicating when the estimated response is more than 1.96 standard deviations from zero. The panels on the left use the Edelstein and Kilian purchasing power shock, and the responses are largely consistent with those originally reported by Edelstein and Kilian. Specifically, the response of total consumption to energy price shocks is reduced in the second period, though the relationships are not precisely estimated in either sample period. To the degree that the response has changed, the bottom panel shows that most of the change occurs through the consumption of motor vehicles: The response in the consumption of motor vehicles is much less in the second period (the dashed red line) than the first period (the solid blue line).

The column to the right in figure 3 shows the impulse responses obtained when the consumer sentiment measure of gasoline prices and availability serve as the shock.

Several comparisons stand out: First, the responses of total consumption excluding motor vehicles and of motor vehicle consumption no longer appear to have declined between the early and late periods. Moreover, the responses in the second period appear to be more persistent. Second, the statistical significance of the responses indicate that relationships between consumer perceptions of gasoline prices and availability and real activity appear more precisely estimated than is the relationship between published fuel prices and real activity. And third, the decline in consumption of motor vehicles after a gasoline price sentiment shock is many times larger than the response of consumption excluding motor vehicles.

For comparison, we also estimated the impulse response based on other measures of energy prices: Using the Hamilton measure of net oil price increases, the responses show a significant muting between the early and the late samples. If we use the measure of gasoline prices that has been augmented with the Frech and Lee cost of rationing, we do not find that the response is much diminished; the peak impact on total consumption is 0.9 in the second period relative to the first, and on motor vehicle consumption is 0.8.

To summarize, when oil price shocks are measured as the shocks to either the published price index for gasoline, Hamilton's net oil price increase variable, or Edelstein and Kilian's purchasing power variable, we confirm the results from the literature that oil shocks have much less impact post-1985 than pre-1985. In contrast, when we measure the oil shock as either the shock to the price of gasoline augmented with rationing costs or to consumer sentiment about gasoline, we find that the impact has diminished only slightly or actually grown in the later period. Lastly, all measures of energy price shocks suggest that the motor vehicle industry is a key part of the transmission mechanism between oil shocks and real activity. Thus, the remainder of the paper presents evidence that, although the motor vehicle industry has changed in many ways over the past 40 years, this sector continues to act as an important propagation mechanism between oil price shocks and real activity.

III. Oil shocks and the demand for motor vehicles: Theory and evidence

Sales of light motor vehicles (which include cars, vans, pickups and utility vehicles) are an important piece of consumer spending, and they are one of the economic indicators that financial markets and business economists use to gauge movements in aggregate demand. The prominent role the motor vehicle sector also plays in U.S. manufacturing means that disruptions to vehicle demand are likely to have consequences for the broader economy.

This section describes how gasoline prices affect vehicle demand for rational consumers, and then turns to some detailed auto industry data to show that consumers do appear to shift vehicle buying patterns in response to gasoline price changes. In addition, this behavior has not changed much over the past 40 years.

A. Models of motor vehicle demand and gasoline prices

A rather large literature has developed—much of it in the late 1970s—to analyze how households respond to changes in gasoline prices by make adjustments to their vehicle stock and to their driving behavior.[13] For example, Dahl (1979) describes the demand for gasoline as a stock-flow decision, in which consumers first purchase a

[13] The CBO study from January 2008, "Effect of Gasoline Prices on Driving Behavior and Vehicle Markets," surveys much of the literature from the 1970s.

vehicle and then they decide how much gasoline to purchase by varying the intensively of its use. More recent papers, such as Wei (2009), cast the vehicle purchasing decision in a general equilibrium framework, in which households invest in transportation capital with a chosen fuel efficiency and then combine it with gasoline to produce the good that ultimately enters their utility functions—personal vehicle travel.

Fuel efficiency is one of the technological characteristics that is embodied in a motor vehicle, and households in the Wei (2009) model combine the vehicle stock with gasoline in a putty-clay nature to produce vehicle travel. Because consumers are forward looking, changes in gasoline prices and expectations about future gasoline prices can lead to adjustments in the vehicle stock and average fuel efficiency that have rich dynamics. After a gasoline price shocks, households respond in the short run mostly by reducing their travel. Over long horizons, households, households adjust their vehicle technology, a move that has a larger impact on total gasoline consumption. Using the DSGE model calibrated to US fuel and vehicle consumption data, Wei finds that the short-run elasticity of gasoline consumption is about -0.2, and the sensitivity increases in the longer run to -0.5, figures that largely correspond with conventional wisdom. Vehicle consumption and total miles traveled also decline after a permanent shock to gasoline prices, though the equilibrium fuel efficiency of new vehicles increases.

B. Evidence that consumers respond to gasoline prices

The theory presented above suggests that permanent increases in gasoline prices cause households to cut back on vehicle travel in the short run and then to make appropriate adjustments to their vehicle stock in the longer run. Hughes, Knittel and Sperling (2006) estimate that the long-run price elasticity of gasoline consumption is about -0.4, a figure that is seven times larger than the short-run elasticity.[14] In the very-long run, gasoline prices can also impact where households choose to live and work.

To see the effects these decisions have had on vehicle travel over the past 40 years, figure 4 plots total vehicle miles traveled per household in the United States between 1970 and 2009. Two features in the figure are noteworthy: First, households nowadays consume a significantly larger amount of travel than they did in the early 1970s: The average household drove approximately 1,500 miles per month in 1970, and that figure has increased 50 percent, to almost 2,200 miles per month in the period 2000-2007. Second, households appear to cut back on travel after gasoline price shocks, though part of the decline at these times likely also reflect the deterioration in labor demand and household incomes that have often occurred at these times as well. Using natural experiments and more detailed data, estimates from this literature suggest the response of vehicle miles to gas price changes is low—Hughes, Knittel and Sperling (2006) estimate that a 10 percent increase in gasoline prices reduces fuel consumption in the short run by about 0.6 percent.[15]

While households now drive more each month than they did in the early 1970s, they do so in vehicles that are, on average, more fuel efficient than was the case in the early 1970s. Figure 5 shows data from the U.S. Department of Transportation on the

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[14] Graham and Glaister (2002) present a range of long-run elasticity estimates in their survey. Li, Timmins and von Haefen (2008) examine patterns in vehicle replacement and scrappage and find that average fuel economy eventually increases by 2 percent after a permanent 10 percent increase in gasoline prices.

[15] The measurement of gasoline price elasticity in the 1970s is complicated by the price controls and the queuing. Studies that take this effect into account include Deacon and Sonstelie (1985), and Frech and Lee (1986).

average fuel efficiencies of the stocks of registered cars and light trucks (which include SUVs and vans). As seen in the plot, the average fuel economies for both types of vehicles have increased over the sample, though much of the gains occurred in the 1980s, after the United States introduced Corporate Average Fuel Economy (CAFE) standards that were met by reducing the average weight of cars and introducing some technological improvements to engine design.

One feature of figure 5 that receives lots of attention is the marked slowdown (or near halt) in the pace of the fuel economy improvements that occurred in the 1990s. As shown earlier, this was an era of relatively cheap gasoline, and, as a likely result, demand in this period shifted away from cars and toward larger sports utility vehicles.[16] Studies that more carefully take into account vehicle size and engine horsepower, such as Knittel (2009), conclude that the technological frontier of fuel-economy/vehicle-weight/engine-power possibilities continued to expand over this period, but these improvements are obscured in aggregate data by the shift in sales across vehicle size classes.

As mentioned earlier, segment shifts are an important channel through which energy price shocks affect demand for durable goods such as motor vehicles.[17] Shifts in vehicle demand across vehicle size classes often occur when gasoline prices move

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[16] The average fuel efficiency of vehicles flowing into the stock each year (ie., new sales) actually decreased over much of the 1990s, as the mix in sales shifted towards light trucks. Some studies have concluded that unequal treatment of cars and light trucks in the CAFE standards may have actually increased the average vehicle size in this period.

[17] Vehicle replacement typically accounts for 65 to 75 percent of new vehicle sales each year, a figure that is calculated as the ratio of vehicle scrappage to new vehicle sales.

dramatically, a stylized fact that was discussed by Bresnahan and Ramey (1993). To see evidence of this, figure 6 shows the domestic market shares of vehicles of various sizes.[18]

The panel to the left shows key market shares for the 1970s and early 1980s. The domestic market share for standard-size cars fell noticeably in 1973 and did not stabilize until almost two years later.[19] When the second oil price shocks hit in 1979, the market share fell even further. The market share for small cars, which were the primary alternative to standard cars at the time, moved in the opposite direction on both occasions.

The panel to the right shows market shares of key vehicle segments in the 2000s. The patterns in segmentation during the gas price increases since 2000 have been similar to those observed in earlier decades, though the scope of the variety of products available has grown considerably. The market share of full-size pickups, utility vehicles and vans fell more than 15 percentage points between its peak in 2004 and early 2009. Small cars and the new cross utility vehicle segment picked up most of this market share.[20]

C. The empirical relationship between motor vehicle consumption and gasoline prices

As was shown above, gasoline prices affect vehicle sales in many ways. In empirical applications, however, sales of light motor vehicles are affected by several other factors in addition to gasoline prices. A key question is how much of the decline in

[18] This graph focuses on the market for domestically produced goods. An additional effect not shown in the graph is the shift to imported cars when oil prices increase.

[19] The domestic market share excludes vehicles imported from outside North America.

[20] A cross-utility vehicle is a utility vehicle that is assembled on a car chassis. They are classified by the industry as a light truck.

automobile purchases around the time of oil shocks is due to the macroeconomic effects of oil on income and interest rates, which then affect automobile purchases, and how much is due to a direct effect of oil shocks on the market for motor vehicles.

To answer this question, we perform the following experiment: We estimate a VAR with the consumer sentiment about gasoline prices, log real disposable income, total hours worked, the log of the CPI, the federal funds rate, and the log of real consumer expenditures on motor vehicles. We estimate it for the 1967:1 – 2009:12 sample and include a linear time trend. We then compare two impulse response functions. The first is the response of motor vehicle expenditures to a shock to consumer sentiment (ordered first) as estimated by the VAR, allowing all of the variables to respond to the oil shock and to each other. The second response is calculated by shutting down the direct effects of the oil shock on motor vehicles. In this system, motor vehicles only respond to oil shocks through their effects on income, hours, prices, and the funds rate. To the extent that income and hours are driven in part by happenings in the automobile industry, this procedure gives an over-estimate of the indirect effects of oil shocks. Hence, the difference between this response and the total response gives a lower bound on the direct effects of oil shocks on the motor vehicle industry.

Figure 7 shows the standard impulse responses of all six variables, as well as the counterfactual experiment for motor vehicles. The graph shows that an increase in consumers' concerns about gas prices leads to an immediate fall in real disposable income and an immediate increase in prices. Hours change little during the first year and then gradually fall. The funds rate gradually increases. Consumption of motor vehicles drops immediately and then continues dropping.

The lower right graph shows the impulse responses from the full model as well as the counterfactual model in which oil prices have no direct effects on motor vehicles. By comparing the distance between the two impulse responses, it appears that at least half of the decline in the consumption of motor vehicles during the first 12 to 18 months reflects the direct effects of oil prices. After the first year and a half, the indirect effects of oil price shocks through disposable income, interest rates, hours worked, and the aggregate price level become the prominent source of the decline. Thus, part of the response of motor vehicles to oil shocks is through the same channel as any other shock: motor vehicles are particularly sensitive to any changes in income and interest rates. However, during the first part of the decline there appears to be an important role for direct effects.

In summary, oil shocks appear to have a direct effect on consumer expenditures on motor vehicles apart from the usual macroeconomic channels. Thus, to understand the impact of oil shocks on the economy, it is useful to understand two key parts of the transmission mechanism from the production side: (1) why oil shocks disrupt the market for motor vehicles and how that might have changed over time; and (2) the role of motor vehicle production in the U.S. economy and how that may have changed over time. We turn to these questions in the next section.

IV. The response of motor vehicle output to oil price shocks

Shocks that affect motor vehicle sales often lead to changes in the rate of production that are quite abrupt, and the high level of volatility in motor vehicle production has been studied extensively in the literature on inventories and production scheduling. The factors that contribute to the excessive volatility of the sector include (1) the high fixed costs of production that lead to important nonconvexities in the cost function, and (2) a strong accelerator effect that reflects the prominent role of inventories in the distribution of vehicles to final consumers.

In this section we first present some measures of the contribution of the domestic motor vehicle industry to the U.S. economy and to the business cycle, and then we show the theory of how segment shifts can lead to a decline in overall output. Using detailed auto industry data by vehicle size class, we then show that segment shifts have always been an important part of the volatility of U.S. output and that this importance has not declined much over time.

A. The contribution of the motor vehicle sector to the U.S. Economy

Motor vehicles are a sufficiently important piece of the U.S. business cycle that they receive special treatment in the National Income and Product Accounts. Figure 8 shows two measures of the contribution of motor vehicle output to U.S. GDP: Panel A shows quarterly values for a statistic commonly referred to as "gross motor vehicle output", and panel B shows annual estimates of the domestic value added of motor vehicle and parts manufacturing, a much narrower view of the industry's contribution to GDP.[21] The lower line in each of these graphs displays each measure of output as a share of total GDP, and the upper lines plot these measures as a share of either goods GDP (for gross motor vehicle output) or total value added from goods manufacturing (for motor

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[21] "Gross motor vehicle output" in the NIPAs is the retail value of motor vehicles sold to final consumers (households, businesses, and governments) and the wholesale value of vehicles invested in inventories. This series is adjusted for net exports of motor vehicles and has the advantage of capturing all of the value added from the production process as well as from the distribution of motor vehicles to final demand, including the wholesale and retail margins. This measure is not the same as "gross output of motor vehicles and parts" in the U.S. industry accounts, which is the sum of all sales and receipts in the industry, including sales of intermediate inputs to firms in other (or in the same) industries.

vehicle and parts manufacturing value added). Shares are calculated from nominal expenditures data reported in the National Income and Product Accounts (NIPAs). The dashed lines in the figure represent the 95 percent confidence interval for the sample mean of each line in two sample periods: 1967 to 1985, and 1986 to 2007 (before the current crisis had affected vehicle sales).

Two features of the graphs in figure 8 stand out. First, motor vehicle output often drops abruptly during recessions and after large increases in gasoline prices. As shown in table 2, the motor vehicle sector alone can account for between 14 and 22 percent of the variance of the quarterly changes in real GDP, depending on the time period. Even after the great moderation, these figures continue to exceed the moderate size of the motor vehicle sector.

The second feature of the graph that stands out is that the size of the motor vehicle industry—at least relative to goods-producing sectors of the U.S. economy—has not declined much over time, at least for the period before the financial crisis. Motor vehicles represented about 4 percent of total GDP between 1967 and 1985, and that figure declined to 3½ percent between 1986 and 2007. As a share of goods GDP, motor vehicle output increased between the two periods, from about 10½ percent in the early sample, to about 11½ percent in the more recent sample. Manufacturing value added gives a similar picture: Motor vehicle and parts manufacturers accounted for 5.7 percent of U.S. manufacturing value added in the 1970s and early 1980s, and this share slipped to

5.2 percent in the more recent period. However, as shown by the dashed lines, the decline between the two periods is not very pronounced relative to its high volatility.[22]

All told, the motor vehicle sector has been a modest but relatively stable share of the goods-producing sector over the past 40 years. The potency of the industry to induce swings in aggregate activity, however, exceeds its modest size.

In the rest of this section, we analyze more carefully the role energy price shocks have played in causing the volatility in motor vehicle production. We begin with a discussion of the theory of production scheduling and apply it to an environment in which oil shocks lead to segment shifts, but production capacity is fixed in the short-run.

B. Segment shifts and the constraints on capacity

Motor vehicles are a produce-to-stock industry, and output decisions are guided by the inventory-sales ratio, or "days' supply." A drop in vehicle sales is reflected as a clear increase in days' supply that results in a clear cutback in production. Following a sharp increase in gasoline prices, however, demand also shifts away from larger vehicles and toward more fuel efficient models. As discussed by Bresnahan and Ramey (1993), this segment shift can lead to a mismatch between demand and supply that restricts total production when capacity in each segment is fixed.

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[22] One additional measure of motor vehicle output that we examined (but do not report) is motor vehicle and parts output. This wider view of the industry is intended to help control for the value of imported intermediate inputs to motor vehicle production that have risen over time. (See Kurz, and Lengermann (2008), and Klier and Rubenstein (2009).) Using this adjusted measure, motor vehicle output was 12½ percent of goods GDP in both the early and late periods, and it declined from 4¾ percent of total GDP in the early period, to 3¾ percent in the later period.

Bresnahan and Ramey (1993) speculated that a shift in demand from one segment to another, with no decline in overall demand, can lead to an equilibrium decrease in production and capacity utilization. In order to formalize this hypothesis, we consider a simple model of a profit-maximizing monopolist that sells cars to two segments of demand. The monopolist chooses prices, sales, production and inventories given a particular structure of cost and demand.

The monopolist maximizes the expected present discounted value of profits, given as:

$$(1) \qquad \Pi_0 = E_0 \sum_{t=0}^{\infty} \beta^t [P_{1t} S_{1t} + P_{2t} S_{2t} - Cost_t]$$

where

$$(2) \qquad \begin{aligned} Cost_t = {} & \gamma \cdot RH_{1t} + \gamma \cdot RH_{2t} + \gamma \cdot \omega \cdot OH_{1t} + \gamma \cdot \omega \cdot OH_{2t} \\ & + \frac{1}{2}\alpha_1 (I_{1t-1} - \phi_1 S_{1t})^2 + \frac{1}{2}\alpha_2 (I_{2t-1} - \phi_2 S_{2t})^2 \end{aligned} .$$

In equation (1), P_{it} is the price of a vehicle in segment i in time t, and S_{it} represents the pace of sales of each type of vehicle in each period. β is a discount factor. In the cost function shown in equation (2), RH_{it} is the number of vehicles produced for each segment in each period using straight-time (or regular) hours, OH_{it} reflects the number of vehicles produced using overtime hours. Marginal costs for producing in each market segment are equal to γ if the firm uses regular hours, and they increase to $\gamma\omega$ after the firm has reached its full-time capacity constraint and must use overtime hours or extra shifts, OH. We assume that ω is greater than unity.

The last two terms in the cost expression account for inventory-holding costs. I_{it} is the stock of inventories left at the end of each period of segment i vehicles, and inventory-holding costs rise when the firm allows inventories to deviate too far from an optimal level; this optimal level is proportional to the pace of sales in each period. In other words, there is a desired inventory-sales ratio that is the same for both segments. The variance of days' supply across segments, a measure that Bresnahan and Ramey (1993) suggest reflects mismatches across segments between capacity and demand, is zero in equilibrium.

The profit maximization above is subject to the identity that links sales, production and inventories across periods, shown in equation (3),

(3) $$I_{it} = I_{it-1} + RH_{it} + OH_{it} - S_{it}, \quad i = 1, 2,$$

the capacity constraint shown in equation (4), where K represents regular-hours capacity,

(4) $$RH_{it} \leq K, \quad i = 1, 2,$$

and the two sales processes in equations (5) and (6).

(5) $$S_{1t} = \theta_0 - \theta_1 P_{1t} + u_t^{seg} + u_t^{agg}, \qquad \text{where } u_t^{seg} = \rho \cdot u_{t-1}^{seg} + \varepsilon_t$$

(6) $$S_{2t} = \theta_0 - \theta_1 P_{2t} - u_t^{seg} + u_t^{agg}, \qquad \text{where } u_t^{agg} = \rho \cdot u_t^{agg} + \eta_t$$

There are two types of demand shifts in the sales equations: The first, u_t^{seg} is a variable that shifts demand away from one segment and towards the other, while the second, u_t^{agg}, is a variable that shifts the demand curves for all vehicle types in the same direction at the same time. We assume that each of these shift variables follows an *AR(1)* process with autocorrelation parameter ρ and with shocks ε and η being white noise. Increases in gasoline prices affect vehicle sales through both u_t^{agg} and u_t^{seg} with the effects on overall automobile demand being manifested in u_t^{agg}, and the shifts in demand across size classes being manifested in u_t^{seg}.

To study the effects of each type of shock on production and inventories, we simulate the model to find the optimal path of the choice variables for a monopolist. The model is calibrated as follows. The monthly discount rate, β, is set at 0.997, which yields an annual interest rate of 4 percent. We set φ_i equal to 2.5 for both vehicle segments, as the average days' supply of small cars and trucks, vans and utilities each hovered about that level during the 1990s, a time when oil prices were very stable. We choose the other parameters so that in the steady state, the marginal revenue curve crosses marginal cost at an output equal to K and price elasticity of demand of -1.5. This value of the price elasticity of demand is in the range of short-run estimates of the elasticity of car demand to price.[23] To achieve these matches, the parameters of the model are set so that K= 40, $\theta_0 = 100$, $\theta_1 = 1$, and $\gamma = 19.85$. The qualitative features were not affected much by the values of α_i, so we set this parameter equal to 0.1 for both segments. Whether a firm actually uses overtime hours depends on the size of the shock as well as the overtime premium. We show simulations in which $\omega = 1.1$, so the firm does use some overtime hours.[24] We solve the model using GAMS, and investigate shocks that shift the intercept of the demand curve by 10 percent, with *AR(1)* parameter equal to 0.75.

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[23] This range of estimates is for overall vehicle demand. Berry, Levinsohn, and Pakes (1995) find much higher elasticities (in absolute value) for particular models.

[24] The statutory overtime premium is 50 percent, whereas shift premia are typically 5 to 10 percent. Trejo (1991) has found that the implicit overtime premium is substantially lower than 50 percent. Thus, our assumption of a 10 percent premium is within the relevant range.

Because plants in both segments face the same cost function, it is clear that the effects on inventories and production of an aggregate shock would be the same in both segments. And, because the inventory-sales ratio changes by the same amount in each sector, the dispersion of the inventory-sales ratios between segments would remain zero. This is not the case for shocks that affect demand differently in each segment, a scenario that is shown in figure 9. Demand shifts up for segment 1 cars and down by an equal amount for segment 2 cars. However, because of rising costs due to capacity constraints, the rise in output in segment 1 is less than the fall in output in segment 2. Mirroring this pattern, the rise in prices in segment 1 is greater than the fall in prices in segment 2. Total production, sales, and total capacity utilization fall. The segment shifts also drive up the dispersion of the inventory-sales ratio across segments.

The increase in the slope of marginal cost that occurs when the capacity-level of production has been reached is critical for some of these results. If, alternatively, costs were quadratic in the level of output as is assumed in the standard production smoothing model, then marginal costs would be linear and segment-shifting shocks would not affect aggregate capacity utilization. The reason is that output should respond symmetrically in each segment when marginal costs are linear: High gasoline prices would reduce truck production by the same magnitude as it would boost small car demand.[25] The dispersion of days' supply would still increase, but for output to respond asymmetrically to positive and negative demand shifts, the marginal cost function must exhibit some curvature.

[25] See, for example, equation (7) of Ramey and Vine (2006).

Interestingly, several authors in the capacity utilization literature have used cost functions that exhibit this kind of curvature to define capacity.[26]

It should be noted that while total production would not change in response to segment shifts in a standard quadratic cost production smoothing model, the variance of the inventory-sales ratio would rise in such a model. The curvature of marginal cost is necessary only for the effect on total production, not for the effect on the variance of the inventory-sales ratio.

C. Evidence of capacity constraints and segment shifts in the auto industry

To see the effects of segment shifts in the detailed auto industry data, figure 10 plots day's supply for the market segments whose sales shares were shown in Figure 6. In the earlier period, days' supply of standard cars grew to uncomfortably high levels at the time of both oil shocks, while days' supply for small cars moved down. Similarly, in the later period, days' supply for full-size trucks, vans and utilities climbed to critical levels between 2000 and 2008 while days' supply for small cars and cross-utility vehicles moved down between 1998 and 2000 before edging back up in 2002. As the segment shift in demand once again accelerated at the end of 2004, days' supply for small vehicles receded, and several models were reported to be in short supply.[27] With the onset of the

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[26] See Klein (1960) and Corrado and Mattey (1996).

[27] The patterns in sales and days' supply between 2000 and 2009 were influenced by occasional inventory-clearance events at the major Detroit Three manufacturers. These firms dominate the full-size truck market segments and therefore faced significant loss in market share as sales of these vehicles sagged over this period. The large dip in days' supply in late 2001 reflects the advent of zero-interest financing, and the plunge in stocks in 2005 coincides with the extension of these firms' employee-discount programs to all customers.

financial crisis in the second half of 2008, days' supply in all categories climbed dramatically.

To measure these tensions on a more general scale, we calculate the variance of days' supply across size categories $\left(V^{DS}\right)$, as was described above in the theory section. This calculation is shown in equation (7). *INV* denotes inventories, INV^A is the aggregate inventory stock, DS_i is days' supply for each segment, DS^A denotes aggregate days' supply, and i ranges from 1 to 11, denoting five car segments (subcompact, compact, intermediate, full-size and luxury) and six truck segments (compact pickups, full-size pickups, small vans, large vans, cross utility vehicles, and full-size utility vehicles). A high dispersion in days' supply across segments indicates that an imbalance exists between the composition of capacity and the composition of demand.

(7) $$V_t^{DS} = \sum_{i=1}^{11} \frac{INV_{it}}{INV_t^A} \left(DS_{it} - DS_t^A\right)^2$$

The variance of days' supply across segments between January 1972 and March 2009 is plotted in Figure 11. Large spikes in the variance correspond quite closely with the increases in fuel prices discussed earlier. Interestingly, the magnitude of the supply-demand imbalance that arose after 2002 appears even greater than the magnitudes observed in the early 1980s.

Next, we investigate in the data the effect of gasoline prices on industry-wide capacity utilization. Specifically, we compare the response of capacity utilization to the run up in gasoline prices in recent years with the responses observed in utilization during the 1970s and early 1980s. As shown in the previous section, if firms face convex marginal cost curves, an increase in the dispersion of days' supply across size classes would be expected to decrease aggregate capacity utilization.

To investigate the extent to which gasoline price increases acted to lower capacity utilization both through effects on aggregate vehicle demand as well as through shifts in demand across segments, we analyze the data using a VAR and look for evidence of structural change in the mid 1980s. Y_t in this VAR includes four variables: (i) consumer sentiment about gasoline prices or shortages (G); (ii) days-supply of domestic cars (*DS*); (iii) the variance of days supply (defined in equation (7)) (*VDS*); and (iv) capacity utilization (*CU*). The production theory presented above suggests that one should also include vehicle prices for each segment, but unfortunately we lack data on segment-specific vehicle prices over much of the necessary history.

We would expect oil shocks to reduce capacity utilization by reducing overall automotive sales and by driving up the level of days-supply. This would be analogous to the aggregate shock in our model. In addition, we would also expect high gas prices to cause segment shifts from large vehicles to small vehicles. This would lead to a capacity mismatch manifested in a high variance of days supply. Our model shows that this segment shift can also reduce capacity utilization if the structure of marginal costs is such as to lead to asymmetric effects of sales changes.

We include six monthly lags in the VAR. Our analysis studies the effect of a shock to the sentiment variable (ordered first in the VAR) on the other variables in the system.

Figure 12 shows the impulse responses functions for the VAR estimated over the full sample from January 1972 to March 2009. The shock analyzed is a normalized positive shock to the consumer sentiment variable (meaning a higher percentage of consumers were worried about high gas prices). This shock leads to an increase in the level of days-supply and an increase in the variance of days-supply across size classes. According to the last panel, capacity utilization falls significantly.

Has the relationship between these variables changed over time? To answer this question, Figure 13 shows the effect of the same size shock for the VAR estimated for the 1972 to 1985, and 1986 to 2009. The peak effect on days-supply and the variance of days-supply is about 30 percent bigger in the first period. In contrast, the effect on capacity utilization is similar across the two periods.

In order to understand the relative importance of the aggregate effect channel versus the segment shift channel on capacity utilization, we perform the following counter-factual experiments. In the first experiment, we simulate the effect of a shock to the consumer sentiment variable on capacity utilization when the level of days' supply channel is shut down. To shut down this channel, we use the estimated coefficients from the VAR, but assign zero values to the coefficients in the days' supply equation, so that days-supply remains at its long-run level and is unaffected by gas prices or feedback from the other variables. The difference between the baseline impulse response and this counter-factual impulse response reveals how important the decline in the average level of days supply across all vehicle segments is in the transmission of gas price increases to capacity utilization. In the second experiment, we shut down the channel through which the variance of days' supply is allowed to affect utilization. The difference between the baseline impulse response and the one in this experiment reveals the quantitative importance of the induced segment shifts on capacity utilization. The third experiment shuts down both the level and variance of days' supply channels. If this simulation were to show that gas prices still had an impact on capacity utilization, it would suggest that some omitted channel was at work. Fortunately, the declines in utilization left unexplained by these attributes of days' supply after an oil shock are relatively small.

Figure 14 shows the results of the three experiments. Each panel shows the baseline impulse response in addition to the counter-factual impulse response. Consider the first panel, which shows the impact of a shock to consumer sentiment about gas prices on capacity utilization in which the level of days-supply channel is shut down. The response is only half as large as the baseline response, suggesting that shocks that affect all vehicle segments are important part of the story. The second panel shows the importance of the variance of days-supply. Again, the response is only half as large when this channel is shut-down, indicating that segment shifts are also an important channel. The third panel shows the experiment in which both the level and variance of days-supply channels are shut down. In this case, there is hardly any response of capacity utilization, suggesting that a third channel is not important.

The counter-factual exercises indicate that the level and variance of days-supply channels are about equally important for transmitting gas price increases to capacity utilization. These results imply that gas price shocks have both aggregate effects and segment shifts effects. Moreover, the relationship between these variables appears to be stable over the entire sample.

V. The reallocation of production capacity between vehicle segments

In the short run, automakers have limited options in responding to the shifts in demand among vehicle segments that occur when gasoline prices increase—they can reduce the workweek of underutilized plants, perhaps idle them temporarily, and they can schedule overtime hours at plants that produce the new favored vehicles. Over the longer-run, however, automakers shift capacity between market segments by transforming their production capacity.

Figure 15 shows U.S. production capacity over time for motor vehicles in different size segments. The top panel plots production capacity for three vehicle segments that are classified as passenger cars: small cars, compact and intermediate cars, and large and luxury cars. The lower panel plots production capacity for three vehicle segments that are classified as light trucks: crossovers (small utility vehicles, built on car chassis), small pickups, vans, and utilities; and large pickups, vans and utilities.

Capacity in these graphs is defined as the number of vehicles that the assembly plants operating in each segment are designed to produce over the course of a model year, using regular-time hours. Automakers can adjust capacity in each segment by (a) building new plants and permanently shuttering old plants, (b) refitting assembly lines to produce vehicles of a different class, and (c) by raising or lowering the linespeeds on each assembly line. The full capacity workweek of each plant is usually considered to consist of two shifts, though some plants have modified their supply chains to accommodate a third crew. Data on linespeeds, the number of shifts, and the types of vehicles produced at each plant were collected from *Ward's Automotive Yearbooks*. The capacities of plants that have the flexibility to produce in more than one segment are included in each of their relevant segments in figure 15, so capacity in each segment is not mutually exclusive.

The plots in figure 15 show that the U.S. auto industry has over the years adapted its capacity to consumer tastes and other market forces many times. Focusing on the shocks to energy prices, the reaction of the auto industry to the oil price shocks in the early 1970s was to reduce quite substantially the capacity to produce large cars and boost capacity to produce compact cars, a move that is reflected in figure 15 as a drop in the dotted “large and luxury car” line of the upper panel and a sharp rise in the dashed “compact and intermediate car” line. After gasoline prices had stabilized in the mid 1970s, full size and intermediate cars again gained share between 1976 and 1978.

However, when gasoline prices shot up again in 1979, the shifts in capacity that followed were more pronounced than in the earlier episode: Capacity to produce large and luxury cars fell by more than half between 1979 and 1982, and the capacity to produce large pickups, vans and utility vehicles, a segment that had been growing through the early 1970s, was also abruptly curtailed, as shown by the dashed line in the lower panel. Increases in the capacity to produce small cars, compact pickups, and minivans eventually made up for some of these losses. However, the total capacity fell 1 million units (about 8 percent) between 1979 and 1982.

As seen in the lower panel of the capacity figure, one market segment that continued to expand in the 1980s was compact pickups, minivans utility vehicles. After gasoline prices fell back sharply in the mid 1980s, capacity to produce full size pickups, vans, and utilities began to increase sharply as well. As real gasoline prices receded to record low levels through the late 1990s, light trucks of various sizes came to dominate the U.S. light vehicle market, and capacity to produce some popular large SUVs was often reported as tight. Even as some car plants were converted to truck production over this period, some manufacturers boosted capacity a bit further by scheduling 3rd shifts, a move that required some investment in reorganizing and improving the supply chain.

When gasoline prices began rising in 2002, the industry once again eventually increased the share of total capacity to produce smaller and more fuel efficient vehicles and reduced the capacity to produce large vehicles, much in line with the rise in fuel costs that was recorded.[28] Specifically, for the 74 U.S. assembly plants that were open between the 2002 and 2010 model years, 12 SUV or pickup plants, on net, were closed or converted. Over the same period, 14 assembly plants began producing vehicles in the crossover market segment, and the number of plants assembling vans fell by four. The number of plants producing small cars was unchanged during this period, while 3 fewer plants assembled full-size or luxury cars.

VI. Conclusions

This paper has studied how the impact of oil shocks on the U.S. economy and its motor vehicle industry has changed over time. We have shown that once one includes the additional cost of rationing due to price controls during the 1970s, a particular size oil shock has similar effects on real variables now as before. The effect on nominal variables, however, has diminished over time.

Turning to a study of the motor vehicle market in particular, we find that, despite the many innovations in the way the U.S. economy produces and uses motor vehicles that have occurred over the past 40 years, the primary channels through which oil prices

[28] The process through which the Detroit Three firms cut their capacity to produce large pickups and utility vehicles between 2002 and 2009 in response to the shifts in demand and declines in their market shares was arduous. Significant financial losses near the end of this period led to tense negotiations with the labor union in 2003 and 2007 and resulted in several plant closings. Other broad restructuring initiatives were introduced in 2008 and 2009, when some of the firms received significant government support and were forced to restructure.

directly affect motor vehicles have not changed much over time. Namely, we present evidence that the recent increases in gasoline prices have caused just as much anxiety in consumers now as was observed 30 years ago, and the shifts in demand across vehicle size classes have also been as equally disruptive to motor vehicle capacity utilization since 2000 as they were in the 1970s and early 1980s. Finally, the adjustments made to U.S. light vehicle production capacity during the recent period resembled the adjustments made in the early 1980s, a time when the shifts in demand were judged to have been quite persistent.

Work Cited

Automotive News. Crain Communications, Inc. Detroit, MI. Various issues.

Atkeson, Andrew, and Patrick J. Kehoe. "Models of Energy Use: Putty-Putty versus Putty-Clay." *The American Economic Review*, Vol. 89, No. 4 (September 1999): 1028-1043.

Aguiar-Conraria, Luis, and Yi Wen. "Understanding the Large Negative Impact of Oil Shocks." *Journal of Money, Credit and Banking*, Vol. 39, No. 4 (June 2007): 926-944.

Barsky, Robert B. and Lutz Kilian, "Do We Really Know That Oil Caused the Great Stagflation? A Monetary Alternative," *NBER Macroeconomics Annual 2001*, 16 (2002): 137-183.

Berry, Steven, James Levinsohn, and Ariel Pakes, "Automobile Prices in Market Equilibrium," *Econometrica* 63 (July 1995): 841-890.

Blanchard, Olivier J., "The Production and Inventory Behavior of the American Automobile Industry," *Journal of Political Economy* 91 (June 1983): 365-400.

Blanchard, Olivier J. and Jordi Gali. "The Macroeconomic Effects of Oil Shocks: Why are the 2000s so Different from the 1970s?" Working Paper, October 2008.

Blanchard, Olivier J. and Marianna Riggi, "Why are the 2000s so Different from the 1970s? A Structural Interpretation of Changes in the Macroeconomic Effects of Oil Prices," NBER working paper 15467, October 2009.

Bernanke, Ben S., "Irreversibility, Uncertainty, and Cyclical Investment," *Quarterly Journal of Economics,* vol. 98 (February 1983): 85-106.

Bernanke, Ben S., Mark Gertler, and Mark Watson. "Systematic Monetary Policy and the Effects of Oil Price Shocks." *Brookings Papers on Economic Activity,* Iss. 1, (1997): 91-142.

Berndt, Ernst R., and David O. Wood. "Technology, Prices, and the Derived Demand for Energy." *Review of Economics and Statistics,* vol. 57 (August 1975): 259-68.

Bresnahan, Timothy F. and Valerie A. Ramey, "Segment Shifts and Capacity Utilization in the U.S. Automobile Industry," *American Economic Review* 83 (May 1993): 213-218.

-------------------------------------, "Output Fluctuations at the Plant Level," *The Quarterly Journal of Economics,* 109 (August 1994): 593-624.

Bruno, Michael and Jeffrey Sachs, "Input Price Shocks and the Slowdown in Economic Growth: The Case of UK Manufacturing," *Review of Economic Studies* , 49 (1982): 679-705.

Congressional Budget Office, "Effects of Gasoline Prices on Driving Behavior and Vehicle Markets," January 2008.

Corrado, Carol and Joe Mattey, "Capacity Utilization," *Journal of Economic Perspectives*, Winter 1997, vol. 1. pp. 151—167.

Dahl, Carol A., "Consumer Adjustment to a Gasoline Tax." *Review of Economics and Statistics*, 1979, 61(3), pp. 427-432.

Davis, Steven, "Fluctuations in the Pace of Labor Reallocation," *Carnegie Rochester Conference Series on Public Policy,* 27 (August 1987): 335-402.

Deacon, Robert T. and Jon Sonstelie, "Ratiomning by Waiting and the Value of Time: Results from a Natural Experiment." *Journal of Political Economy*, 1985, 93(1), pp. 627-647.

Edelstein, Paul and Lutz Kilian, "How Sensitive are Consumer Expenditures to Retail Energy Prices?" *Journal of Monetary Economics* 56 (2009): 766-779.

Feenstra, Robert C., and J. Bradford Jensen, "Evaluating Estimates of Materials Offshoring from U.S. Manufacturing." Unpublished manuscript, October 2009.

Finn, Mary G. "Energy Price Shocks, Capacity Utilization and Business Cycle Fluctuations." Discussion Paper 50, Institute for Empirical Macroeconomics, Federal Reserve Bank of Minneapolis, September 1991.

Finn, Mary G. "Perfect Competition and the Effects of Energy Price Increases on Economic Activity." Journal of Money, Credit and Banking, Vol. 32, (August 2000): 400-416.

Frech III, H.E. and William C. Lee, "The Welfare Cost of Rationing-by-Queue Across Markets: Theory and Estimates from the U.S. Gasoline Crises," *Quarterly Journal of Economics,* 102 (February 1987): 97-108.

Frum, David. *How We Got Here: the 70s.* Basic Books. New York, NY, 2000.

Graham, Daniel and Stephen Glaister, "The Demand for Automobile Fuel: A Survey of Elasticities." Jounral of Transport Economics and Policy, 2002, 36, pp. 1-26.

Hall, George J., "Nonconvex Costs and Capital Utilization: A Study of Production Scheduling at Automobile Assembly Plants," *Journal of Monetary Economics,* 45 (June 2000): 681-716.

Hamilton, James, "Oil and the Macroeconomy since WWII," *Journal of Political Economy* 91 (April 1983): 228-248.

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

----------------, "What Is an Oil Shock?" *Journal of Econometrics,* April 2003, vol. 113, pp. 363-398.

----------------, "Causes and Consequences of the Oil Shock of 2007-08," *Brookings Papers on Economic Activity,* Spring 2009a, 215-261.

----------------, "Yes, the Response of the U.S. Economy to Energy Prices is Nonlinear," UCSD working paper, December 2009b.

Hamilton, James D., and Ana Maria Herrera. "Oil Shocks and Aggregate macroeconomic Behavior: The Role of Monetary Policy." *Journal of Money, Credit and Banking,* April 2004: 265-86.

Helbling, Hans H. and James E. Turley, "Oil Price Controls: A Counterproductive Effort," *Federal Reserve Bank of St. Louis,* November 1975, pp. 2-6.

Herrera, Ana María and Elena Pesavento, "Oil Price Shocks, Systematic Monetary Policy, and the 'Great Moderation'," *Macroeconomic Dynamics* 13 (2009): 107-137.

Hetrick, Ron L. "Analyzing the Recent Upward Surge in Overtime Hours - 1990s' Economic Expansion." *Monthly Labor Review*, February 2000.

Hooker, Mark A. "What Happened to the Oil Price-Macroeconomy Relationship?" *Journal of Monetary Economics*, 38(2), October 1996: 195-213.

Hughes, Jonathan E., Christopher R. Knittel, and Daniel Sperling, "Evidence of a Shift in the Short-Run Price Elasticity of Gasoline Demand," Research Report UCD-ITS-RR-096-16, University of California, Davis: Institute of Transportation Studies, 2006.

Kahn, James, "Gasoline Prices and the Used Automobile Market: A Rational Expectations Asset Price Approach." *Quarterly Journal of Economics*, 1986, 101(2), pp. 323-340.

Kilian, Lutz, "Explaining Fluctuations in Gasoline Prices: A Joint Model of the Global Crude Oil Market and the U.S. Retail Gasoline Market," *The Energy Journal* 31 (2010): 103-128.

Kilian, Lutz and Robert J. Vigfusson, "Pitfalls in Estimating Asymmetric Effects of Energy Price Shocks," April 2009 working paper.

Klein, Lawrence R., "Some Theoretical Issues in the Measurement of Capacity," *Econometrica*, April 1960, 28:2, pp. 272—286.

Klier, Thomas H., and James M. Rubenstein, "Imports of Intermediate Parts in the Auto Industry—A Case Study." Paper prepared for the conference: "Measurement Issues Arising from the Growth of Globalization." October, 2009.

Knittel, Christopher R., "Automobiles on Steroids: Product Attribute Trade-offs and Technological Progress in the Automobile Sector," NBER working paper 15162, July 2009.

Kurz, Christopher, and Paul Lengermann., "Outsourcing and U.S. Economic Growth: The Role of Imported Intermediate Inputs." Paper prepared for the 2008 World

Congress on National Accounts and Economic Performance Measures for Nations, May 2008.

Leduc, Sylvain, and Keith Sill. "A Quantitative Analysis of Oil-Price Shocks, Systematic Monetary Policy, and Economic Downturns." Journal of Monetary Economics, Vol. 51, (2004): 781-808.

Li, Shanjun, Christopher Timmins, and Roger von Haefen. "How do Gasoline Prices affect Fleet Fuel Economy?" NBER Working Paper W14450, October 2008.

McAlinden, Sean P., Kim Hill, and Bernard Swiecki., "Economic Contribution of the Automotive Industry to the U.S. Economy—An Update." Center for Auotmotive Research, Fall 2003.

McConnell, Margaret M., and Gabriel Perez-Quiros. "Output Fluctuations in the United States: What has Changed Since the Early 1980s?" *American Economic Review*, 90(5), December 2000, 1464-76.

Mork, Knut Anton, "Oil and Macroeconomy When Prices Go Up and Down: An Extension of Hamilton's Results." *Journal of Political Economy*, 97(3), June 1989, 740-44.

Pindyck, Robert S., and Julio J. Rotemberg. "Dynamic Factor Demands and the Effects of Energy Price Shocks." *American Economic Review,* 73(5), December 1983, 1066-79.

Ramey, Valerie A. and Daniel J. Vine. "Declining Volatility in the U.S. Automobile Industry." *American Economic Review*. December 2006.

Rotemberg, Julio J., and Michael Woodford. "Imperfect Competition and the Effects of Energy Price Increases on Economic Activity." *Journal of Money, Credit and Banking*. 28(4), November 1996, 550-77.

U.S. Department of Energy, Transportation Energy Databook: Edition 28. 2009.

Wei, Chao. "A Dynamic General Equilibrium Model of Driving, Gasoline Use and Vehicle Fuel Efficiency." Unpublished working paper, George Washington University, August 2009.

Table 1

The Effects of Oil Shocks in a Large Aggregate VAR

	Jan. 1967 to Dec. 1985		Jan. 1986 to Dec. 2009		Ratio
	Peak effect	Month of peak	Peak effect	Month of peak	
	(1)	(2)	(3)	(4)	(3)/(1)
Nominal gas price	1.000	3	1.000	2	
Industrial production	-0.202	24	-0.091	20	0.45
Hours	-0.099	26	-0.035	32	0.35
CPI	0.184	19	0.051	25	0.28
Hamilton measure	1.000	1	1.000	1	
Industrial production	-0.005	24	-0.002	11	0.41
Hours	-0.002	26	-0.001	24	0.39
CPI	0.003	13	0.001	2	0.25
Gas price augmented with rationing	1.000	1	1.000	2	
Industrial production	-0.072	25	-0.091	20	1.27
Hours	-0.038	27	-0.035	32	0.92
CPI	0.084	20	0.051	2	0.61
Consumer sentiment about gas	1.000	3	1.000	1	
Industrial production	-0.002	27	-0.003	31	1.67
Hours	-0.001	27	-0.002	37	1.97
CPI	0.002	15	0.001	2	0.30

Note: This table summarizes the impulse response functions from VARs estimated over the two periods. The VARs contain an oil shock, industrial production, hours, CPI, nominal wage, and the federal funds rate, with the oil shock ordered first. The VARs are estimated using monthly data with six lags and a linear time trend.

Table 2

Fluctuations in Real Gross Domestic Product (GDP)

		Share of GDP *(percent)*	Standard deviation *(quarterly percent changes, annual rate)*	Share of GDP volatility *(percent)*
Goods and services	1967 to 1985+	100	4.3	100
	1986 to 2007	100	2.1	100
	1986 to 2009Q3	100	2.5	100
. . Goods	1967 to 1985+	37	9.2	54
	1986 to 2007	30	5.0	51
	1986 to 2009Q3	30	5.6	50
. . Motor vehicles	1967 to 1985+	4.0	38.1	22
	1986 to 2007	3.5	19.2	14
	1986 to 2009Q3	3.3	24.9	16

[*] Data are from the *National Income and Product Accounts*. Share of GDP volatility attributable to each component is calculated as 100 less the variance of growth contribution of GDP excluding each component relative to the variance of total GDP.

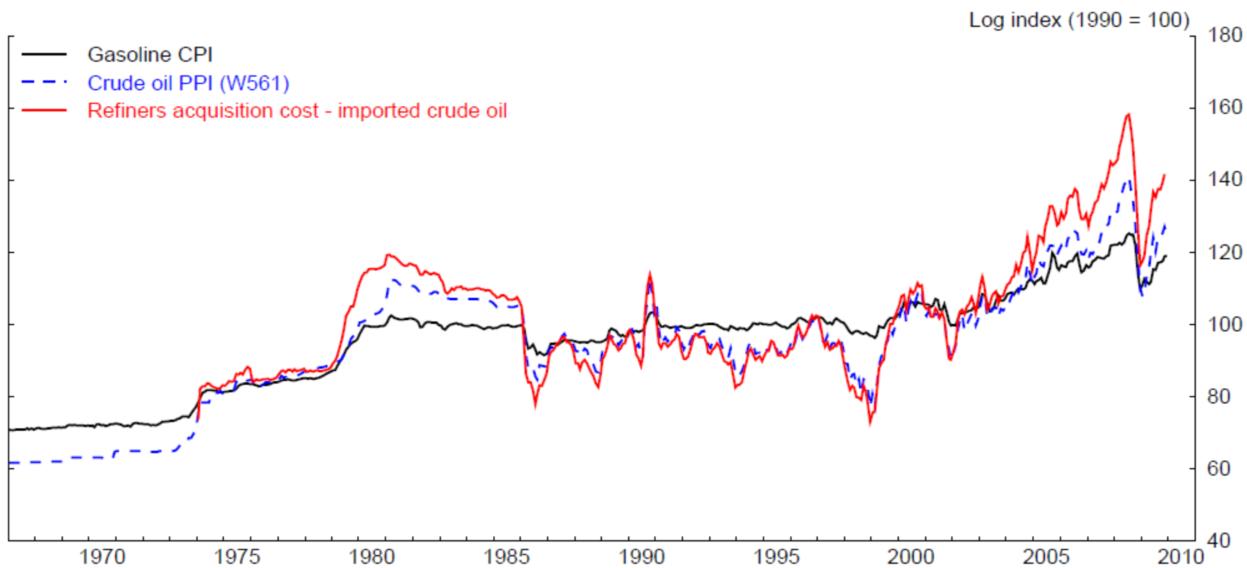
[+] Figures for the early period exclude 1970Q4, when a long strike severely impacted motor vehicle output and sales.

Figure 1

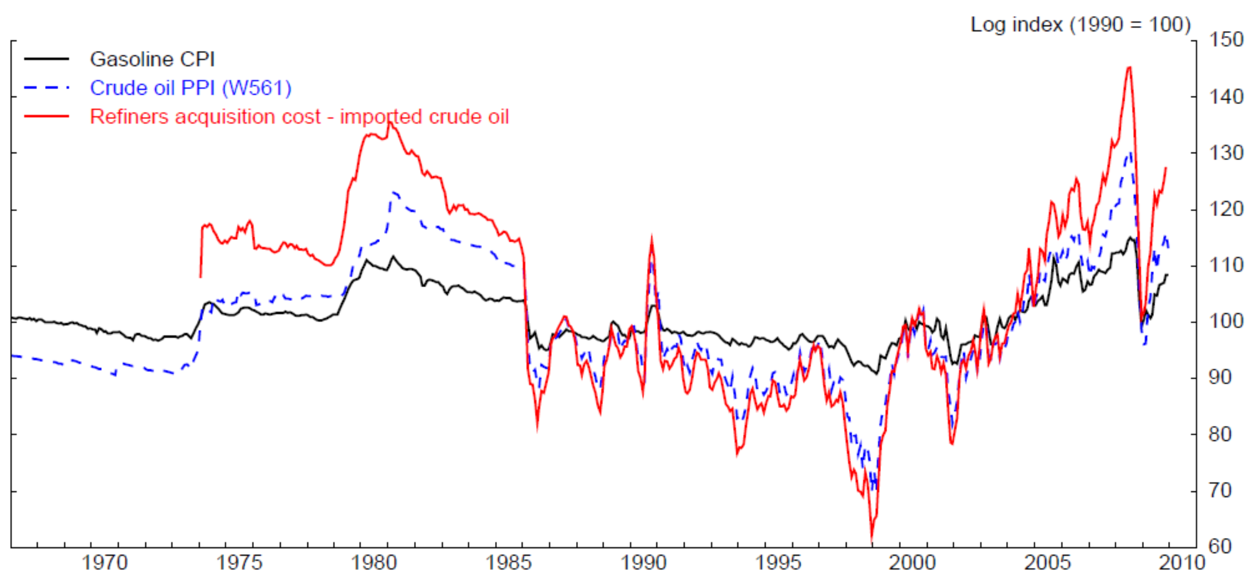
Petroleum Prices

January 1967 through July 2009

Panel A: Price indexes



Panel B: Real price indexes



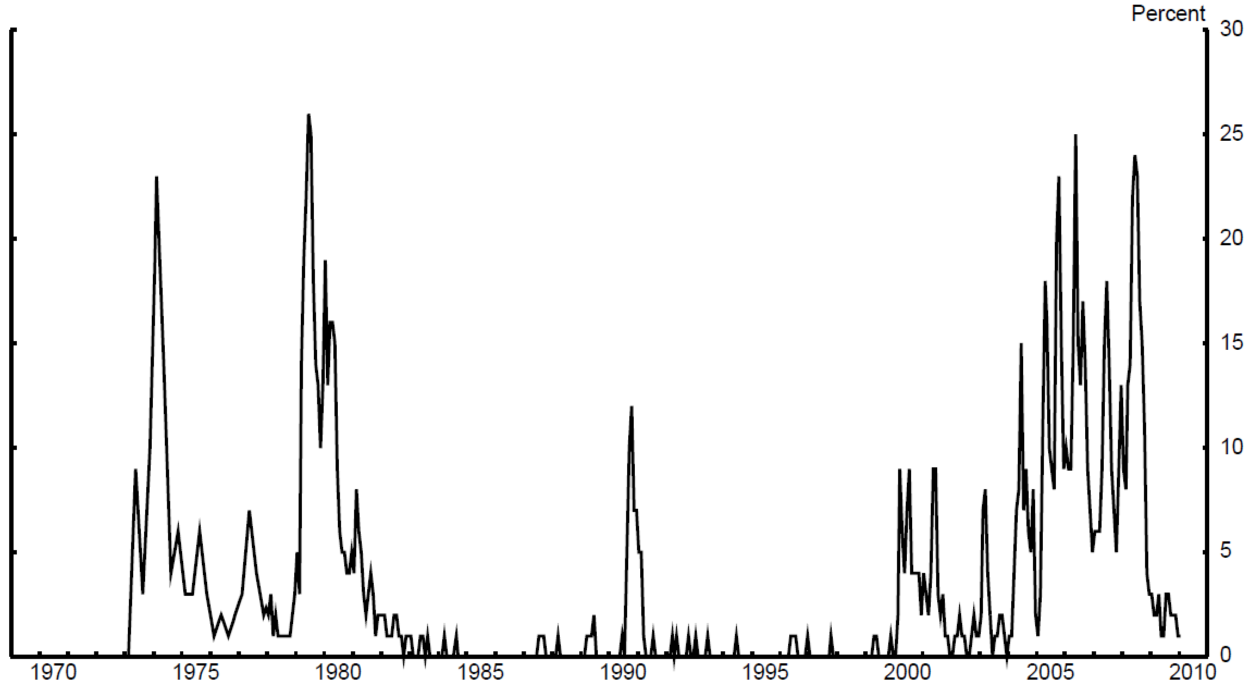
Note: Data come from the Bureau of Labor Statistics. The real indexes normalize the changes in petroleum prices by the changes in headline consumer price inflation. Refiners acquisition cost data begin in 1974.

Figure 2

Consumer Sentiment for Car-buying Condition: Gasoline Prices/Shortages

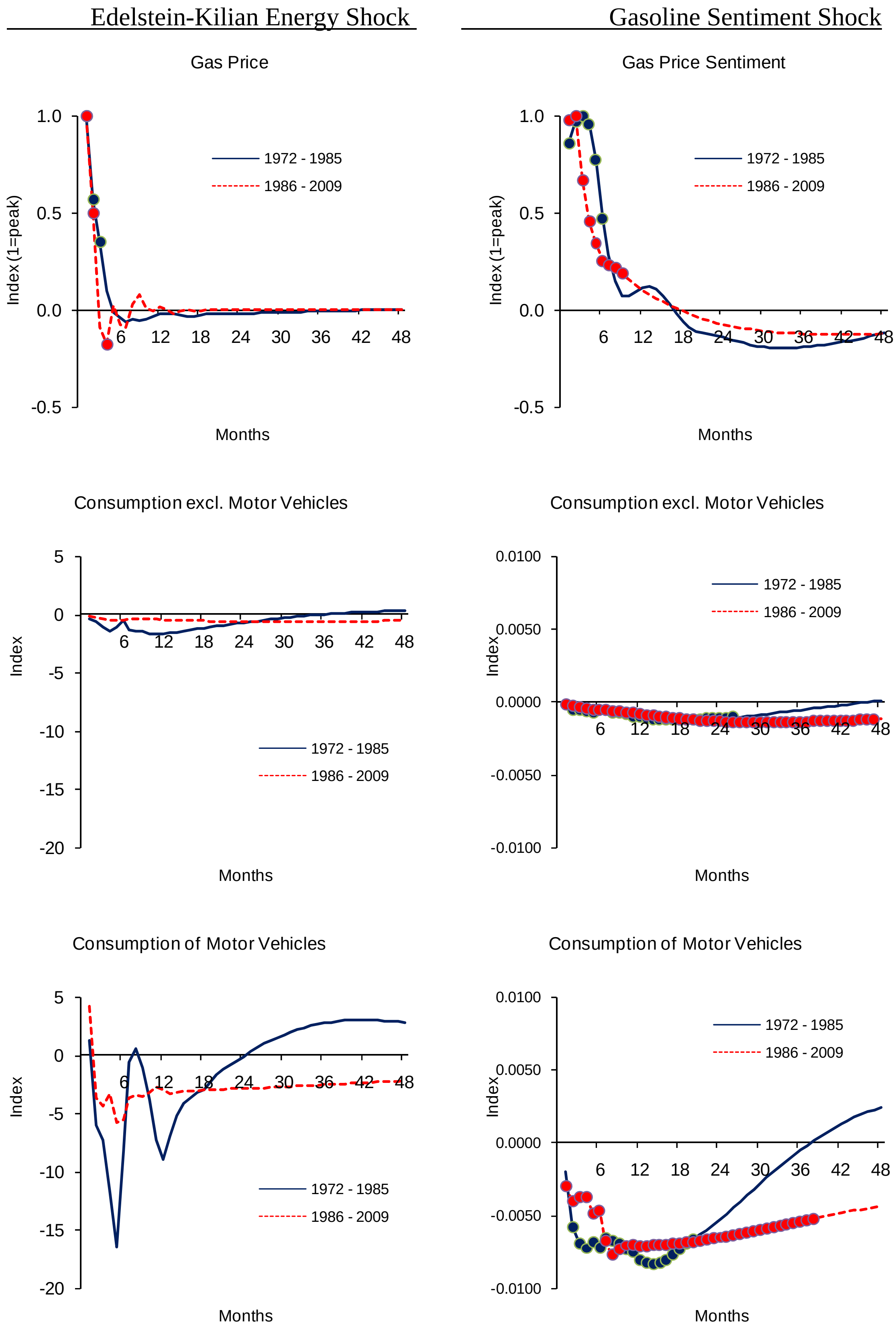
Share of respondents to the Thomson Reuters/University of Michigan Survey of Consumer Sentiment that cite high gasoline prices or shortages of gasoline as reasons that car-buying conditions are poor

January 1970 through January 2010



Note. The gasoline price question was asked on a quarterly basis prior to January 1978 and the series was extrapolated to a monthly frequency by the authors.

Figure 3. Effects of Oil Price Shocks on Consumption (Trivariate VAR)

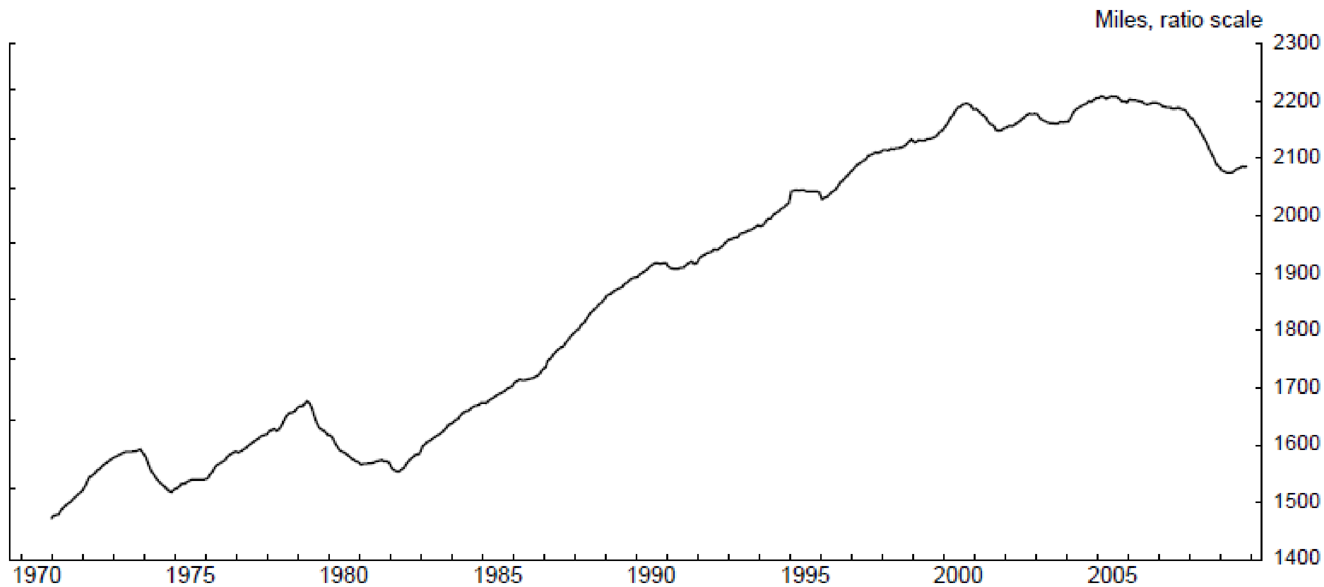


Note. Dots indicate periods in which the responses are more than 1.96 standard deviations from zero.

Figure 4

Vehicle Distance Traveled per Household

January 1970 to October 2009

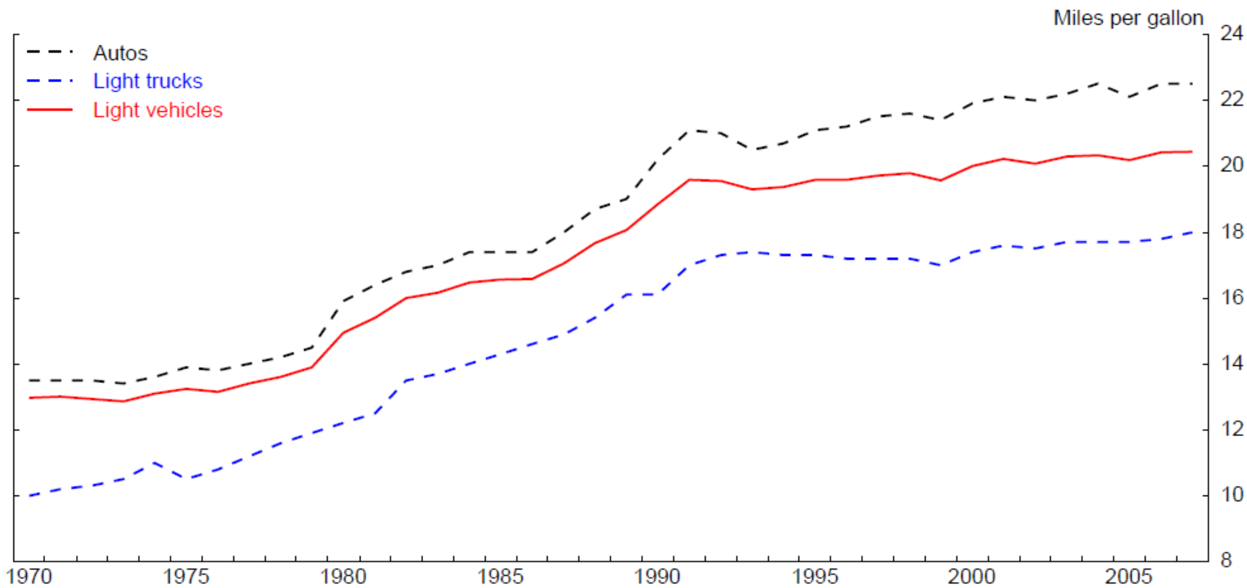


Note. Data on vehicle miles are from *Traffic Volume Trends*, Office of Highway Policy Information in the Department of Transportation. Data on the number of households in the United States are from the U.S. Census Bureau. Data were smoothed with a 12-month moving average.

Figure 5

Average Fuel Economy for the U.S. Light Vehicle Stock

December 1970 to December 2009

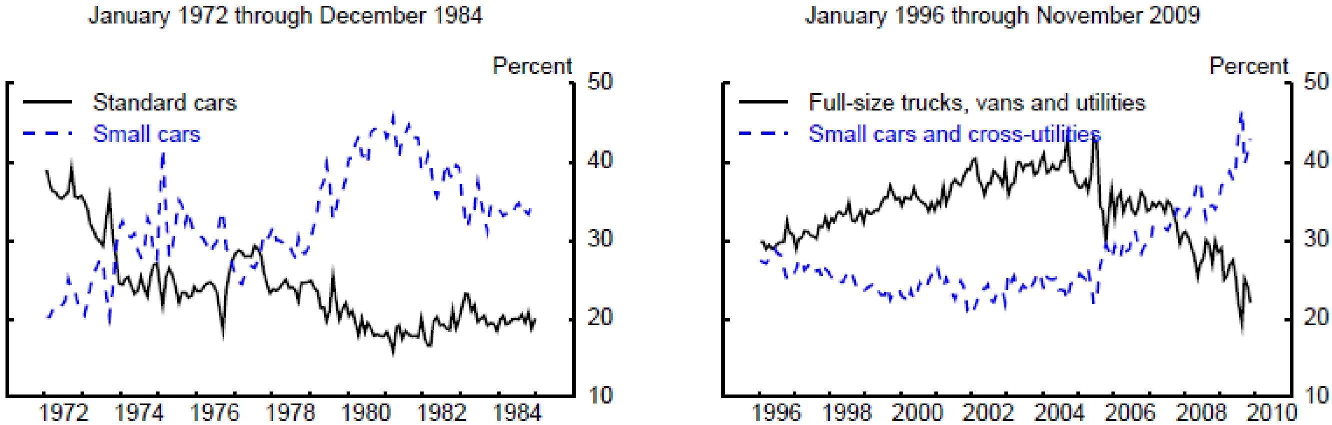


Note. Data from the *Transportation Energy Databook: Edition 28*, U.S. Department of Energy. Data points for light trucks for 2003 and 2004 were interpolated to correct an error in the original source data. Light trucks include pickups, vans, crossovers, and utility vehicles. Light vehicles are the total of cars and light trucks.

Figure 6

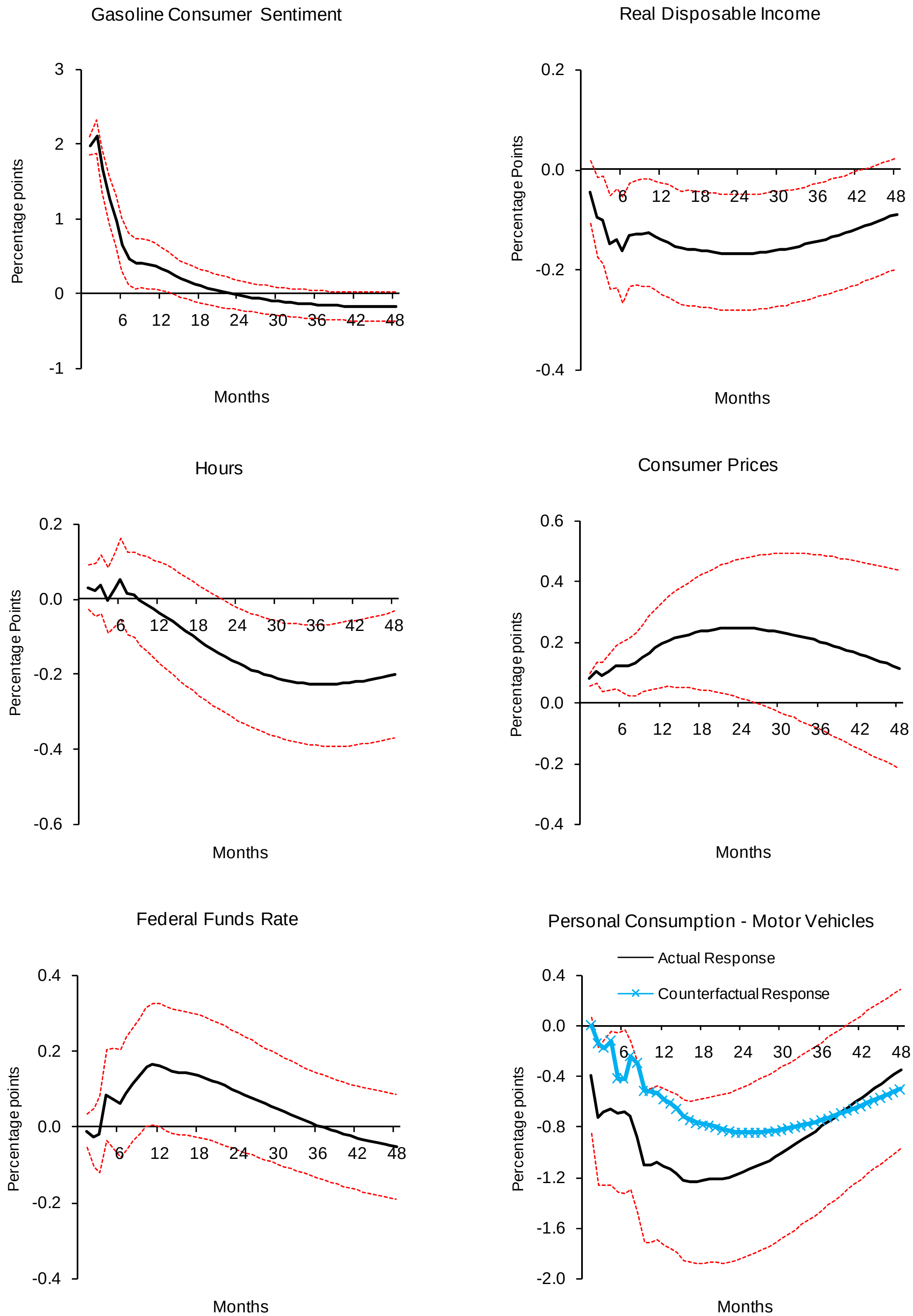
Domestic Sales Shares of Selected Vehicle Segments

Percentage of domestic vehicles sold



Note: Shares are calculated from U.S. sales of domestic light vehicles. Domestic light vehicles are defined as vehicles produced in North America. Cross-utility vehicles are smaller utility vehicles assembled on a car chassis.

Figure 7. Effects of Oil Shocks on Consumption of Motor Vehicles



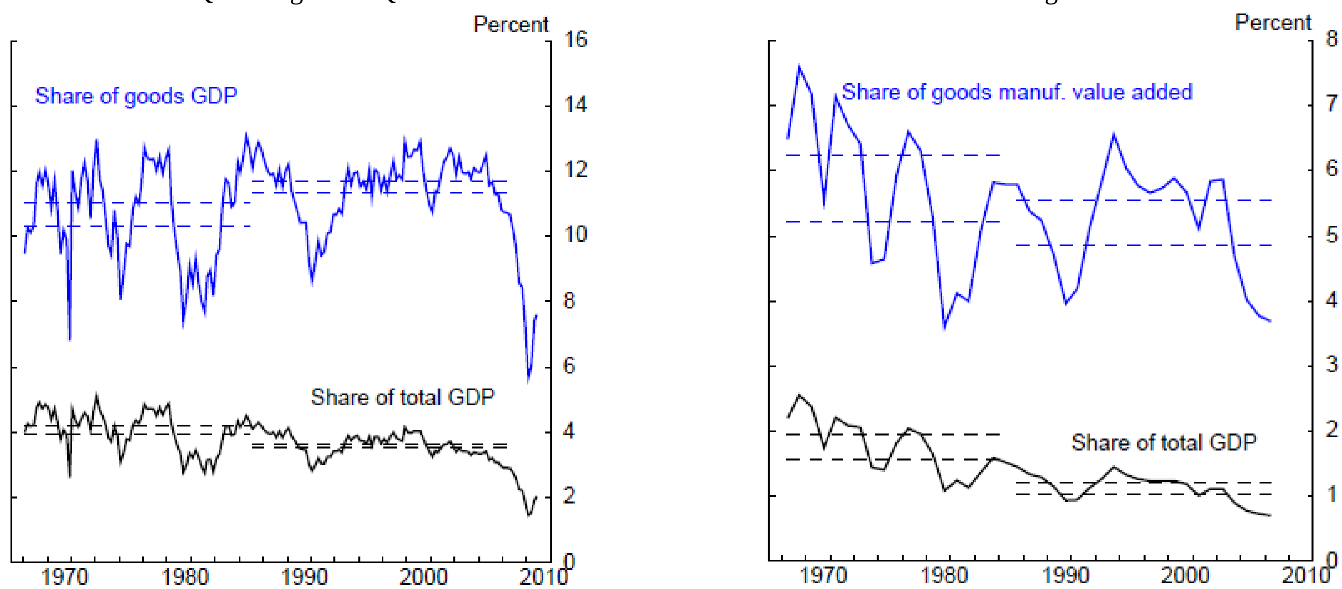
Note. Impulse responses based on a 6-variable. Dashed lines show 95 percent confidence intervals. The counter-factual response for motor vehicle consumption refers to an exercise in which the direct effects of oil shocks on consumption are set to zero.

Figure 8

Motor Vehicles in the U.S. Economy

Panel A: Output
1967Q1 through 2009Q4

Panel C: Manufacturing Value Added
1967 through 2007



Note. Dashed lines represent 95% confidence intervals for the sample means in two periods: 1967 to 1985, and 1986 to 2007. Expenditure shares are based on nominal data. For value added, motor vehicles and parts is defined on a NAICS basis from 1977 through 2007; earlier periods are plotted as best changes from the SIC definition. Goods manufacturing includes agriculture, forestry, fishing, and hunting; mining; construction; and manufacturing.

Figure 9

Impulse Responses in the Production Model from a Segment-shifting Shock to Sales between Vehicle Segments

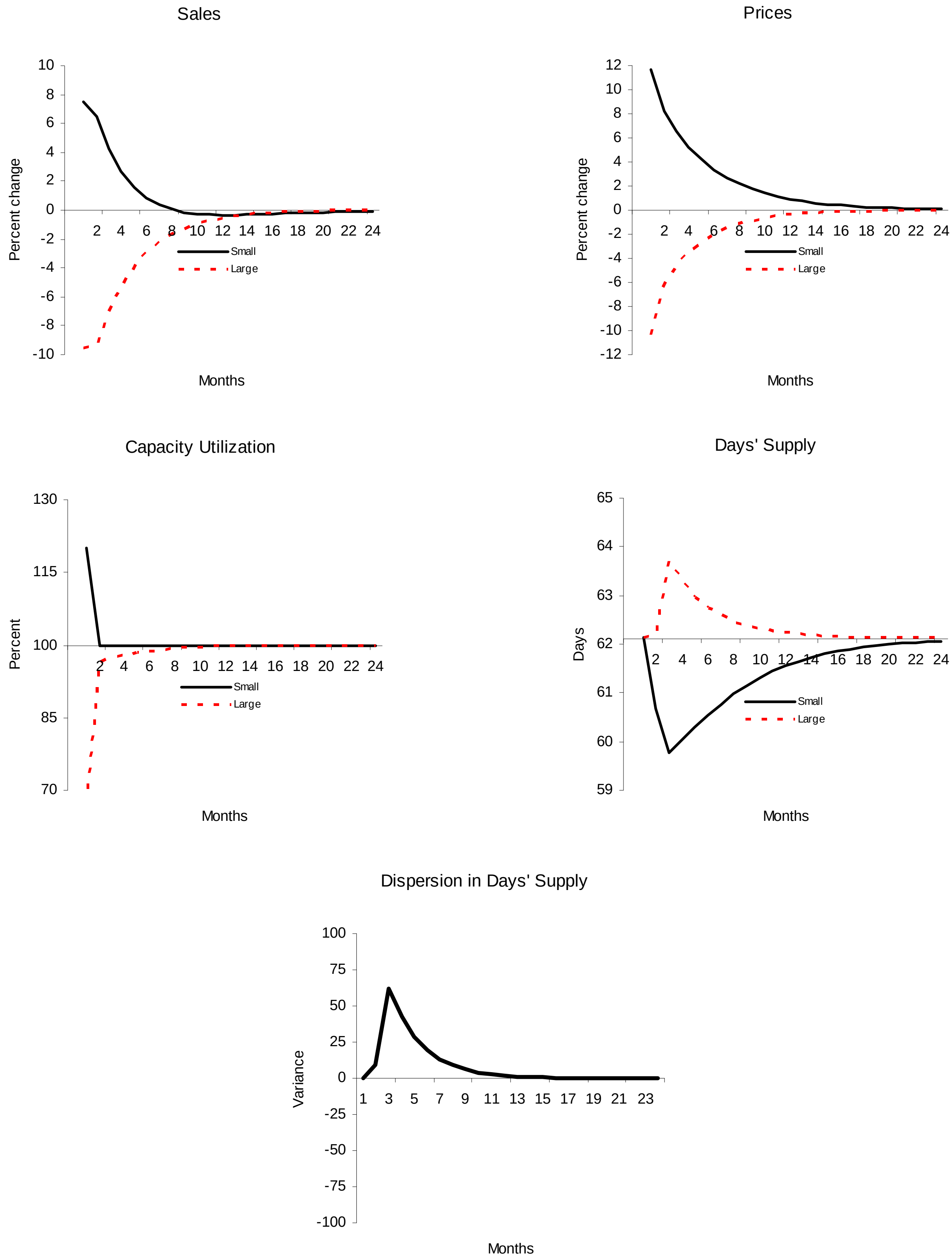
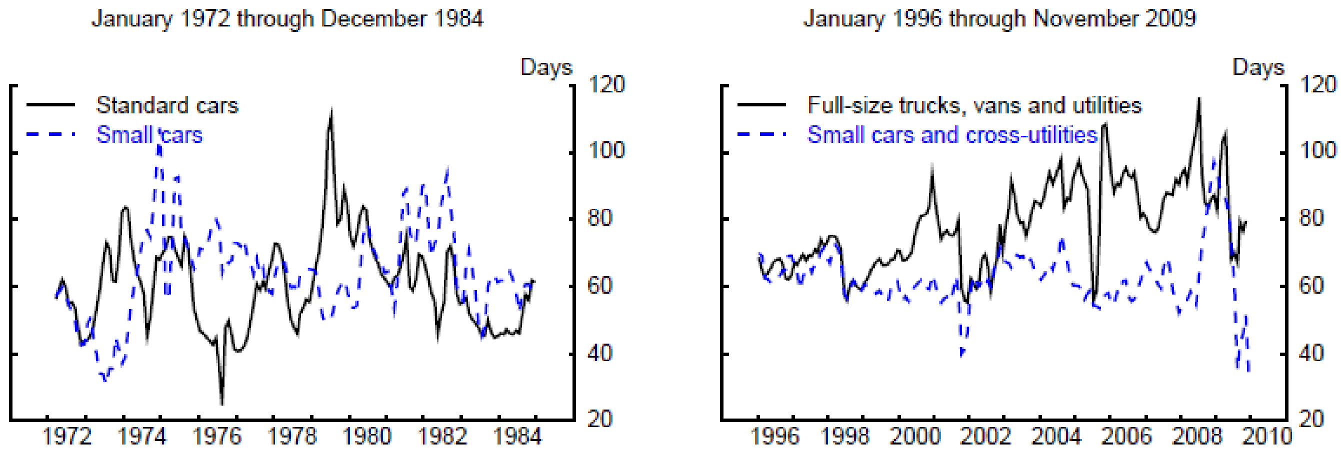


Figure 10

Domestic Days' Supply of Selected Vehicle Segments

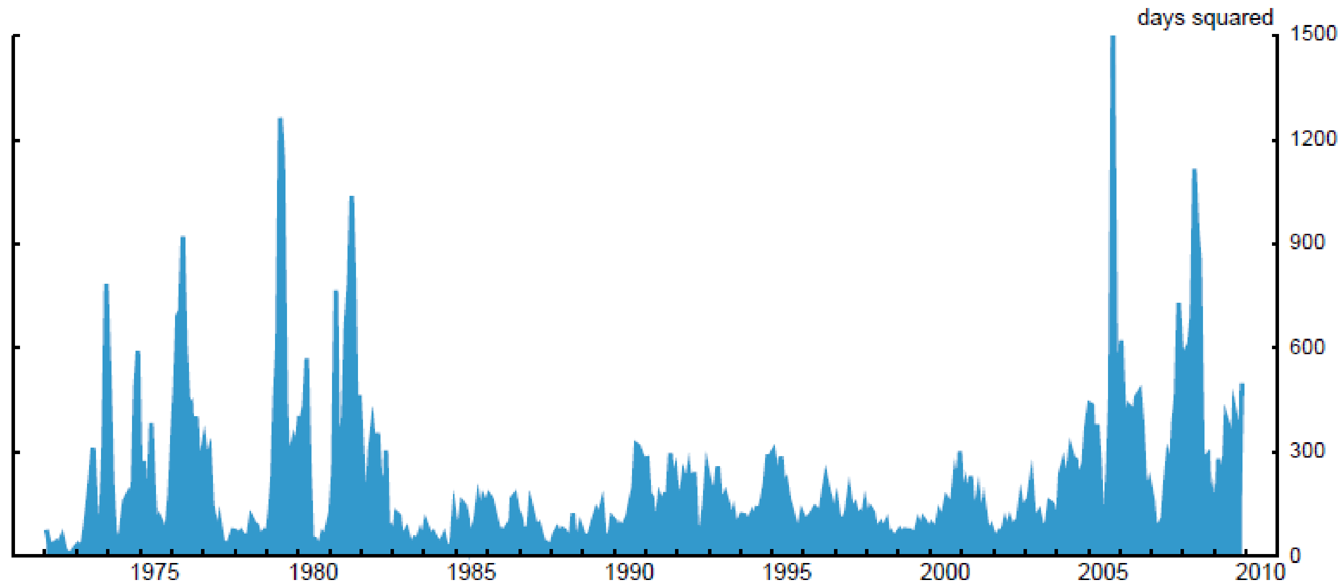


Note: Days' supply is calculated with reported month-end inventories, which include stocks at dealerships, finished vehicles at assembly plants and vehicles in transit, and the three-month moving average of sales. Domestic light vehicles include vehicles are defined as vehicles produced in North America. Cross-utility vehicles are smaller utility vehicles assembled on car chassis.

Figure 11

Variance of Domestic Days' Supply across Segments

January 1972 through November 2009

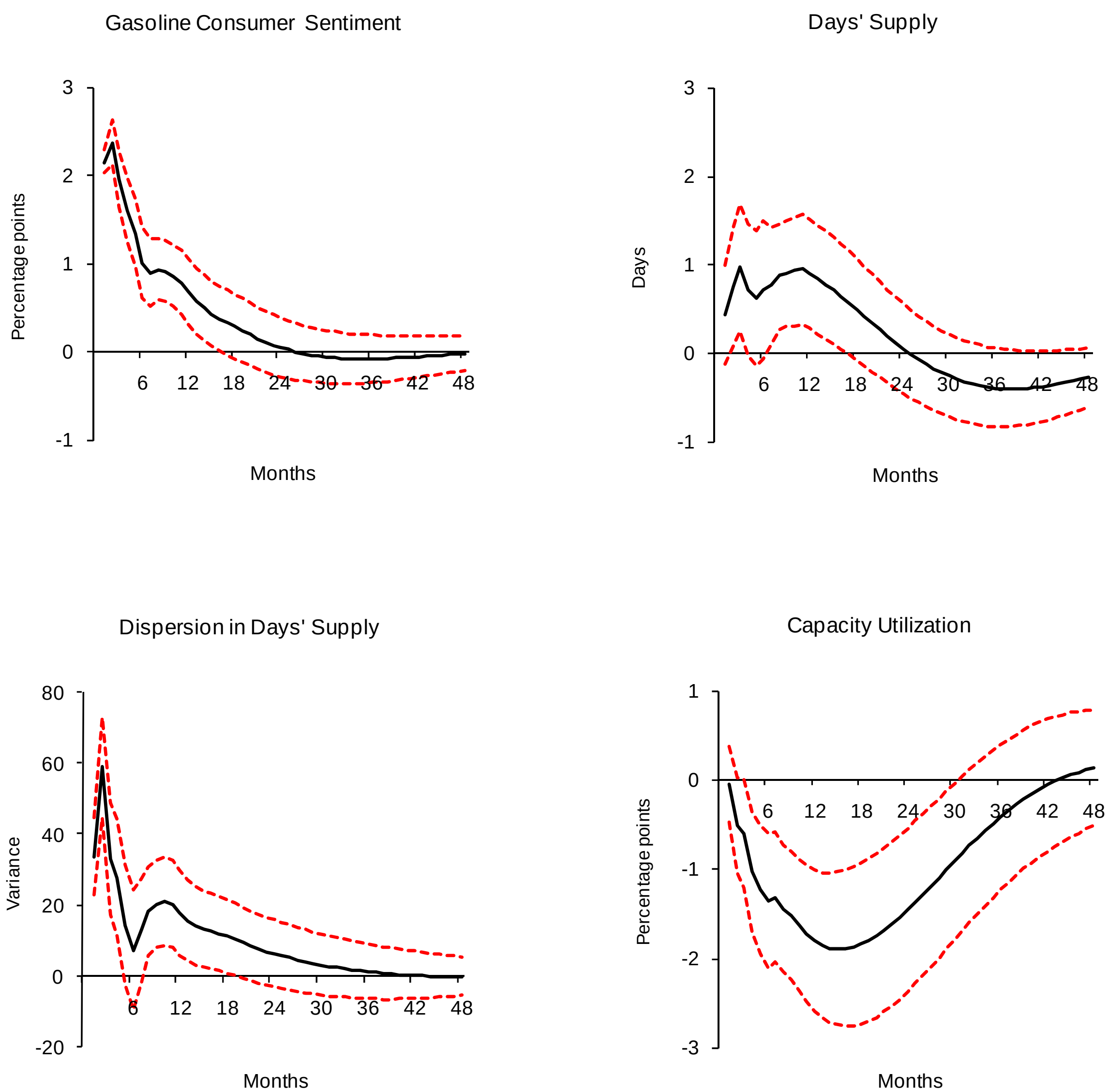


Note: Domestic days' supply is calculated with U.S. sales and stocks of vehicles assembled in North America. Variance is calculated across 5 car segments (subcompact, compact, intermediate, full-size, and luxury) and 6 light truck segments (compact vans, full-size vans, compact pickups, full-size pickups, cross-utility vehicles, and standard utility vehicles).

Figure 12

Impulse Responses to a Shock to Consumer Sentiment towards Gasoline Prices

VAR estimated with data from January 1972 through December 2009



Note. Red dashed lines enclose 95% confidence intervals.

Figure 13

Impulse Responses to a Shock to Consumer Sentiment towards Gasoline Prices

VAR estimated with a split sample: 1972 through 1985, and 1986 through 2009

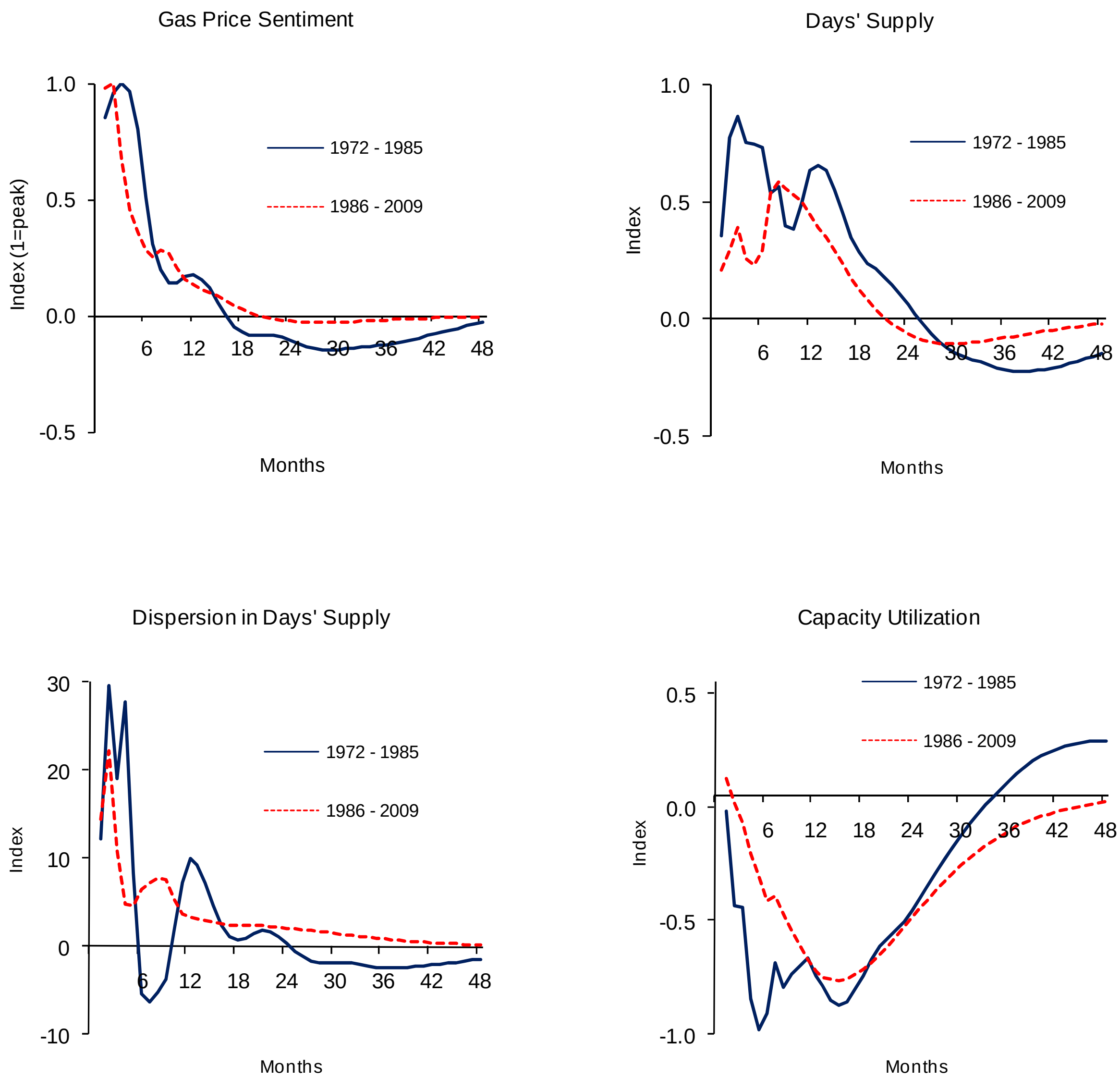


Figure 14

Response of Capacity Utilization to Shocks in Consumer Sentiment towards Gasoline Prices in Counterfactual Simulations

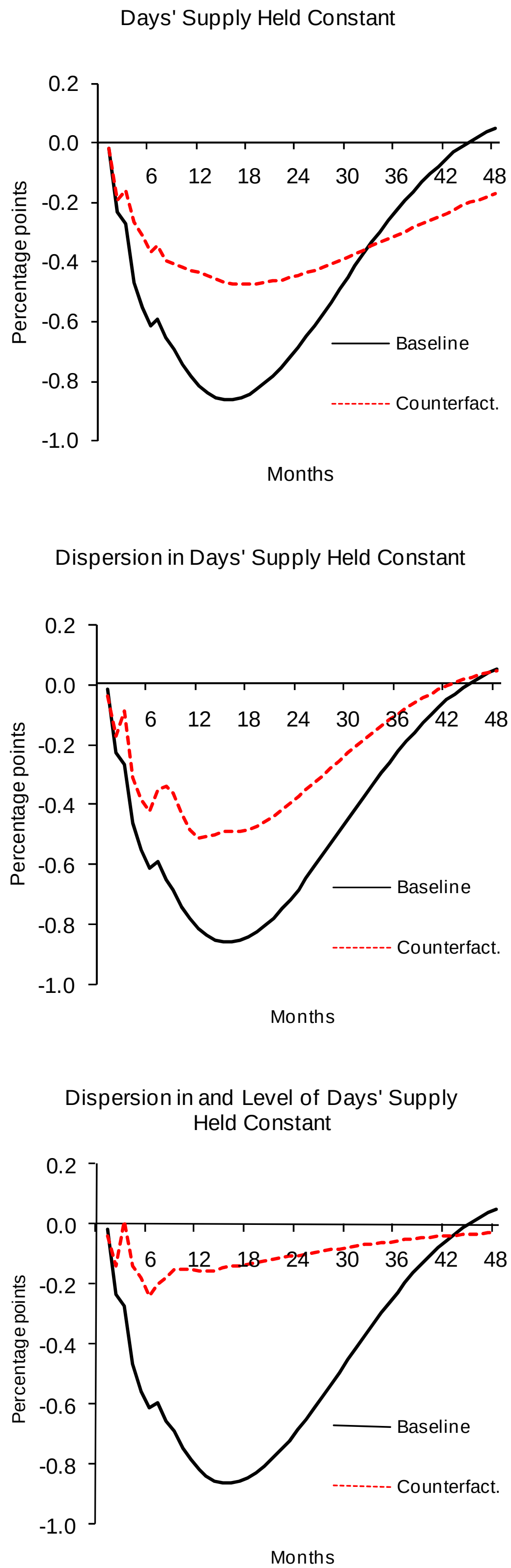
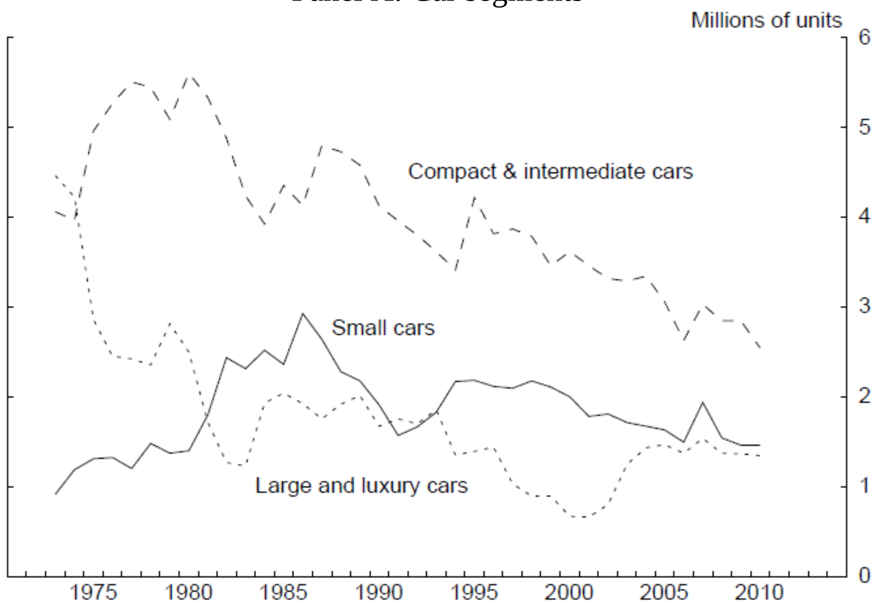


Figure 15

U.S. Vehicle Production Capacity by Vehicle Segment

Model years, 1972 to 2010

Panel A: Car segments



Panel B: Light truck segments