How Sensitive are Consumer Expenditures to Retail Energy Prices?*

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Abstract

There is growing evidence that the primary effect of energy price shocks on the U.S. economy involves a reduction in consumer spending. We quantify the direct effect on real consumption of unanticipated changes in discretionary income, shifts in precautionary savings, and changes in the operating cost of energy-using durables. The possibility of asymmetries in the response of real consumption to energy price shocks is also considered. We demonstrate that linear models are consistent with the symmetric behavior of real consumption in 1979 (when energy prices increased sharply) and in 1986 (when they fell sharply). It is shown that historically energy price shocks have been an important factor in explaining U.S. real consumption growth, but by no means the dominant factor.

KEYWORDS: Energy prices; Consumption; Consumer Sentiment; Purchasing Power; Asymmetry.
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1 Introduction

Large fluctuations in energy prices have been a distinguishing characteristic of the U.S. economy since the 1970s. Between January 2002 and July 2006, for example, the PCE price index for energy goods increased by 68% in real terms. A common perception is that higher energy prices tend to reduce the discretionary household income available for the purchases of other goods and services. Despite the attention that such purchasing power losses have received in the media and in policy discussions, little is known about their magnitude, about their effect on real consumption and about the extent to which consumption patterns change in response to energy price fluctuations. Answers to these questions are important for understanding the transmission of energy price shocks to the U.S. economy. As noted in a recent survey by Hamilton (2009a), the key mechanism whereby energy price shocks affect the economy is through a disruption in consumers’ (and firms’) spending on goods and services other than energy. The view that energy price shocks are primarily demand shocks for the U.S. economy is also shared by policymakers. For example, Bernanke (2006a) stressed that an increase in energy prices slows economic growth primarily through its effects on consumer spending.

This paper studies the effect of unanticipated energy price changes on consumer spending. There are four mechanisms by which consumer expenditures may be directly affected by energy price changes. First, higher energy prices are expected to reduce discretionary income, as consumers have less money to spend after paying their energy bills.1 All else equal, this discretionary income effect will be the larger, the less elastic the demand for energy, but even with perfectly inelastic energy demand the magnitude of the effect of a unit change in energy prices is bounded by the energy share in consumption. Second, changing energy prices may create uncertainty about the future path of the price of energy, causing consumers to postpone irreversible purchases of consumer durables (see Bernanke 1983, Pindyck 1991). Unlike the first effect, this uncertainty effect is limited to consumer durables. Third, even when purchase decisions are reversible, consumption may fall in response to energy price shocks, as consumers increase their precautionary savings. This response may arise if consumers smooth their consumption because they perceive a greater likelihood of future unemployment and hence future income losses. By construction, this response will also embody general equilibrium effects on employment and real income otherwise not accounted for in partial equilibrium analysis of the demand channel. This precautionary savings motive implies

1 Implicit in this view is the assertion that higher energy prices are primarily driven by higher prices for imported energy goods, and that at least some of the discretionary income lost from higher prices of imported energy goods is transferred abroad and is not recycled in the form of higher U.S. exports. In the case of a purely domestic energy price shock (such as a shock to U.S. refining capacity), it is less obvious that there is an effect on aggregate discretionary income. First, the transfer of income to the refiner may be partially returned to the same consumers in the form of higher wages or higher stock returns on domestic energy companies. Second, even if the transfer is not returned, higher energy prices simply constitute an income transfer from one consumer to another that cancels in the aggregate.
a symmetric responses to energy price increases and decreases. Precautionary savings may also reflect greater uncertainty about the prospects of remaining gainfully employed, in which case any unexpected change in energy prices would lower consumption. Finally, consumption of durables that are complementary in use with energy (in that their operation requires energy) will decline even more than other durables, as households delay or forego purchases of energy-using durables. This operating cost effect is more limited in scope than the uncertainty effect in that it only affects specific consumer durables. It should be most pronounced for motor vehicles (see Hamilton 1988).²

In addition, there may be indirect effects related to the changing patterns of consumption expenditures. A large literature has stressed that shifts in expenditure patterns driven by the uncertainty effect and operating cost effect amount to allocative disturbances that are likely to cause sectoral shifts throughout the economy. For example, it has been argued that reduced expenditures on energy-intensive durables such as automobiles may cause the reallocation of capital and labor away from the automobile sector. As the dollar value of such purchases may be large relative to the value of the energy they use, even relatively small changes in energy prices (and hence in purchasing power) can have large effects on output and unemployment (see Hamilton 1988). A similar reallocation may occur within the same sector, as consumers switch toward more energy-efficient durables (see Hamilton 1988; Bresnahan and Ramey 1993). In the presence of frictions in capital and labor markets, these intersectoral and intrasectoral reallocations will cause resources to be unemployed, thus causing further cutbacks in consumption and amplifying the effect of purchasing power losses on the real economy. This reallocation effect could be much larger than the direct effects listed earlier, and is viewed by many economists as the primary channel through which energy price shocks affect the economy (see Davis and Haltiwanger (2001) and Lee and Ni (2002) and the references therein). Concerns over reallocation effects also help explain the preoccupation of policymakers with the effects of energy price shocks on the automobile sector (see, e.g., Bernanke 2006b). Unlike other effects, the uncertainty effect and the reallocation effect necessarily generate asymmetric responses of macroeconomic aggregates to energy price increases and decreases. They amplify the response to unexpected energy price increases, but dampen the response to unexpected energy price decreases.

In this paper, we provide a comprehensive look at the evidence for these channels of transmission based on a detailed analysis of BEA data on personal consumption expenditures (PCE) and Michigan Survey of Consumers data on consumer expectations. The remainder of the paper is organized as

²The effect of changes in operating costs on the consumption of energy-using durables is likely to be symmetric. This point deserves some elaboration. Hamilton (2009a) makes the case that consumers may postpone car purchases, when the price of energy rises, but will not buy a second car, when energy prices go down. However, there are likely to be consumers who used to think that purchasing their first (or second) car was beyond their means, and who may elect to buy a car after all, following a decline in energy prices. In addition, consumers will tend to replace their existing car with a new and less energy-efficient car.
follows. In section 2, we document how retail energy price fluctuations have affected consumers’ purchasing power since 1970. We construct time series of real energy prices and of the corresponding expenditure shares. Using these data, we construct a monthly time series of the losses and gains in purchasing power associated with changes in retail energy prices. That series indicates the required change in discretionary spending if households wish to purchase last month’s quantity of energy goods at the current month’s prices.

In section 3, we discuss our econometric methodology. Since preliminary statistical tests did not provide evidence of statistically significant departures from the null hypothesis of symmetric impulse response functions, our analysis abstracts from all effects of energy price shocks that involve asymmetries such as the uncertainty and reallocation effect. Instead, in section 4, we rely on standard linear models that impose symmetry in the responses to unexpected increases and decreases in purchasing power. We quantify the three remaining symmetric effects based on the differential response of major components of real consumption to unpredictable changes in purchasing power driven by energy price fluctuations. We bound the magnitude of the discretionary income effect with the help of estimates of the short-run price elasticity of energy demand, and infer the precautionary savings effect from the excess response of nondurables and services consumption relative to this benchmark. We measure the effect of changes in operating costs on the consumption of energy-using durables by comparing the response of vehicles consumption to the consumption response for other durables. We relate these findings to the effects of purchasing power shocks on measures of consumer confidence. Finally, we study the role of fuel economy using disaggregate data on automobile purchases.

In section 5.1, we focus on the ability of our model to explain the 1979 episode (when energy prices increased sharply) and the 1986 episode (when they fell sharply). We demonstrate that the linear model is capable of explaining these key episodes in the data without introducing asymmetries, consistent with the lack of statistical evidence for the reallocation and uncertainty effects. In section 5.2, we study the declining importance of energy price shocks for consumption compared to the 1970s and early 1980s. The conclusions are discussed in Section 6.

2 Measuring Purchasing Power Gains and Losses

The quantitative importance of changes in energy prices for discretionary income is by no means self-evident. For one thing, the degree to which rising energy prices affect household purchasing power depends not only on how much energy prices increase, but also on the fraction of consumer expenditures devoted to energy. In this section, we construct a measure of the gains and losses
in purchasing power attributable to fluctuating energy prices. The thought experiment underlying this measure is that a household, when faced with rising energy prices, is unable to reduce its energy consumption in the short run, resulting in higher energy expenditures. The resulting loss in “purchasing power” causes households to curtail their discretionary expenditures on non-energy goods and services.

Let $E$ be the quantity of energy goods consumed, $N$ the quantity of non-energy goods consumed, $P^E$ the price of energy goods, $P^N$ the price of non-energy goods, and $P_{PCE}^E$ the price index for personal consumption expenditures. Real energy consumption in consumption units at date $t$ is given by $e_t \equiv E_t \cdot P^E_t / P_{PCE}^E$. Real total consumption at date $t$ is the sum of real energy consumption and real non-energy consumption $c_t \equiv E_t \cdot P^E_t / P_{PCE}^E + N_t \cdot P^N_t / P_{PCE}^E$. This leaves the household with $c_t - e_t$ to spend on non-energy goods at date $t$. Suppose that at date $t + 1$, the consumer requires the same quantity of energy as at date $t$, but now pays $P_{t+1}^E$. Then the consumer’s real energy consumption would be $e_{t+1} \equiv E_t \cdot P^E_{t+1} / P_{t+1}^{PCE}$, and he would have $c_t - e_{t+1}$ left to spend after paying his energy bill. The implied percent change in purchasing power between dates $t$ and $t + 1$ is:

$$\frac{(c_t - e_{t+1}) - (c_t - e_t)}{c_t - e_t} = \frac{e_t - e_{t+1}}{c_t - e_t} = \frac{E_t \cdot P^E_t / P_{PCE}^E - E_t \cdot P^E_{t+1} / P_{t+1}^{PCE}}{N_t \cdot P^N_t / P_{t+1}^{PCE}}$$

(1)

Multiplying this expression by $P^E_t / P^E_t$ and rearranging terms yields:

$$\frac{E_t \cdot P^E_t}{N_t \cdot P^N_t} \cdot \frac{P^E_{t+1} / P_{t+1}^{PCE} - P^E_t / P_t^{PCE}}{P^E_t / P_t^{PCE}}$$

(2)

The first term in this expression is the ratio of nominal energy expenditures to nominal non-energy expenditures. Since the fraction of energy expenditures in total expenditures is small, we can approximate this ratio with the nominal energy expenditure share. The second term is the monthly percent change in the real price of energy goods. Thus, the percent change in purchasing power approximately equals the product of the nominal expenditure share and the percent rate of change in real energy prices: $-\eta^E_t \cdot \% \Delta (P_{t+1}^E / P_{t+1}^{PCE})$, where $\eta^E_t \equiv E_t \cdot P^E_t / (C_t \cdot P_{t+1}^{PCE})$.

The BEA’s PCE price index for energy goods is comprised of four main components: gasoline (and other motor fuels), natural gas, electricity and all other energy goods (including heating oil, coal and oil lubricants). Figure 1a shows the monthly real energy price index for January 1970-July 1980.
2006. Figure 1b illustrates that, despite the importance attached to energy prices in the press, the energy share in consumption has never been large compared to the expenditure share of food or housing, for example. The overall energy share was stable at about 6.5% in the early 1970s. It rose to a peak of 9.6% in 1980, but fell steadily throughout the 1980s and 1990, reaching a low of 4.1% in 1999, only to rise back to its initial level of about 6.5% by 2006. Figure 1c plots the changes in purchasing power associated with the energy price fluctuations in Figure 1a. A negative value in Figure 1c denotes an increase in prices and thus a decline in purchasing power. Increases in energy prices left households with less money to spend on other goods in about 46% of the months in the sample. In the mid-1990s, most changes in purchasing power were in the range between plus and minus 0.1 percentage points. Since the late 1990s, when rising global demand for oil and constraints in refining capacity began pushing up gasoline prices, however, the volatility and amplitude of purchasing power losses has greatly increased. The largest monthly loss in purchasing power (-0.66 percentage points) is associated with Hurricanes Rita and Katrina in late 2005, and the largest monthly gains in purchasing power were 0.46 percentage points in March of 1986 (associated with the collapse of OPEC in late 1985) and 0.54 percentage points in November 2005 in the wake of Hurricanes Rita and Katrina. Our measure of purchasing power losses abstracts from all margins of adjustment that might reduce the impact effect of energy price changes. In reality, the quantity of energy demanded is unlikely to be completely inelastic. Our empirical methodology in the sections below is designed to incorporate such endogenous responses.

3 Methodology

The fact that the purchasing power losses and gains induced by energy price fluctuations are small, even under the extreme assumption of perfectly inelastic demand for energy, does not necessarily mean that they cannot have large effects on real consumption. Our empirical strategy is to identify these effects by estimating the differential responses of major components of real consumption to unpredictable changes in purchasing power driven by energy price fluctuations. Our main focus is on aggregate real consumption and its major components (durables, nondurables, and services). Durables are further disaggregated into vehicles (defined to include automobiles, motorcycles, recreational vehicles, aircraft and boats) and other durables. This distinction is important for assessing the operating cost effect. While the use of many durables requires some energy input, our rationale

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4 It can be shown that changes in gasoline prices tend to have a disproportionate impact on this measure of household purchasing power. This result is driven by the relatively high amplitude of changes in gasoline prices and the relatively high expenditure share for gasoline. Because natural gas and electricity each comprise a smaller fraction of total expenditures, and because their prices are more stable, their impact on purchasing power is much smaller.
is that vehicles are much more energy intensive than, say, appliances, and that effectively operating costs will not matter much for durables other than vehicles. More disaggregated results on motor vehicles will be discussed in section 5 (also see Edelstein and Kilian 2007a).

### 3.1 The Baseline Linear Model

For each consumption aggregate, we construct the response of consumption to purchasing power shocks from bivariate vector autoregressive (VAR) models. We focus on monthly measures of purchasing power changes, as opposed to unweighted changes in energy prices, because the purchasing power changes incorporate the effects of changes in the expenditure share for energy. This allows us to avoid a potential source of structural instability in the relationship between energy prices and the economy. Each VAR model includes the purchasing power loss series described in the previous section (or a suitable transformation of that series) and the percent growth rate of the measure of real consumption of interest. The sample period is 1970.2-2006.7, unless noted otherwise. The monthly real consumption data are from the BEA’s National Income and Product Accounts.\(^5\)

The VAR models are identified recursively with the change in purchasing power series ordered first, implying that its innovations are not affected contemporaneously by innovations to real consumption growth. The advantage of using a VAR model is that it isolates the linearly unpredictable component of losses in purchasing power and allows for reverse causality. The identifying assumption that energy prices are predetermined with respect to the U.S. macroeconomy at monthly frequency has a long tradition in both empirical and theoretical work (see, e.g., Rotemberg and Woodford 1996; Leduc and Sill 2004; Blanchard and Galí 2008). Recent empirical work by Kilian and Vega (2009) lends support to this identifying assumption. The assumption of predeterminedness permits the consistent estimation of the expected response of real U.S. macroeconomic aggregates to an innovation in energy prices. In conjunction with the assumption that there are no other exogenous events that are correlated with the exogenous energy price innovation, these impulse responses can be interpreted as the causal effect of the energy price innovation. More generally, we can interpret these responses as the expected change in consumption associated with energy price shocks.\(^6\)

There is no loss of generality from restricting ourselves to a bivariate model under the maintained

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\(^5\)Throughout the paper, we impose a VAR lag order of 6. This lag order tends to be larger than the estimates suggested by the Akaike Information Criterion conditional on an upper bound of 12 lags, which in some cases produces implausibly low lag order estimates. While our qualitative results are not sensitive to the lag order choice, given the well-known dangers of underfitting a VAR model, we adopt a conservative approach (see Kilian 2001; Hamilton and Herrera 2004).

\(^6\)Our approach does not allow us to differentiate between energy price changes driven by demand and by supply shocks in energy markets. The distinction between demand and supply shocks can be important, as these shocks tend to have very different effects on macroeconomic aggregates (see Kilian 2009). The impulse responses shown below hence are best viewed as an average reflecting the composition of demand and supply shocks over the sample period.
assumption of predetermined energy price innovations, if we are only interested in consistently
estimating the causal effects of energy price innovations on macroeconomic aggregates. This result
differs sharply from standard VAR models of monetary policy. In such models the monetary policy
reaction function is typically ordered last, making the monetary policy shock sensitive to the omission
of contemporaneous variables that the policymaker responds to. In contrast, changes in energy
prices in our bivariate model are ordered first, which ensures that the resulting responses to energy
price shocks are asymptotically invariant to the inclusion of additional variables ordered between
energy price changes and consumption growth, if the lag order is chosen appropriately. Given the
short sample, however, we rely on the most parsimonious representation of the data in the form of
the bivariate model. In the figures below, we show responses of the level of real consumption to
a one-time, one standard-deviation purchasing-power shock. The maximum horizon of the impulse
response functions is 18 months. All figures show point estimates as well as 90% bootstrap confidence

3.2 Possible Asymmetries in the Consumption Responses

The standard linear regression framework that treats energy price increases and energy price de-
creases symmetrically will only be appropriate, if we can rule out the presence of an allocative
channel of transmission and of the asymmetric effects arising from shifts in uncertainty and from
precautionary motives. Hence, it is essential that we investigate the evidence for potential asym-
metries in the response of real consumption to energy price shocks, before choosing the appropriate
regression model. Preliminary statistical tests reported in Edelstein and Kilian (2007a) did not pro-
vide evidence of statistically significant departures from the null hypothesis of symmetric impulse
response functions for any of the real consumption aggregates, suggesting that any uncertainty ef-
fects and reallocation effects are too weak to be detected by formal statistical tests. Nor is there
any evidence for the asymmetric version of the precautionary savings effect.\footnote{This empirical finding is also consistent with more sophisticated econometric tests of the hypothesis of symmetric responses recently developed by Kilian and Vigfusson (2009) who, for a variety of energy price measures and macroeconomic aggregates, found no statistically significant departures from the null hypothesis of symmetric response functions.} In addition, we will
demonstrate in section 5 that the linear symmetric model is capable of explaining key episodes in
the data without introducing asymmetries, consistent with the lack of statistical evidence in favor
of the reallocation and uncertainty effects. This fact allows us to focus on quantifying the effect of
changes in discretionary income, changes in precautionary savings and changes in operating costs
based on the standard linear VAR model described in section 3.1.
4 Interpreting the Consumption Responses

Consider the response of selected U.S. real consumption aggregates to unanticipated purchasing power losses. A convenient way of summarizing and comparing the response estimates from the pairwise bivariate regression models is to express them in the form of one-year elasticities with respect to the overall price of energy, evaluated at the average energy share.\(^8\) The upper panel of Table 1 shows that the elasticity of energy consumption is \(-0.45\) (with confidence bands of \(-0.27\) and \(-0.66\)). The lower panel summarizes the corresponding elasticities of major non-energy real consumption aggregates. All estimates have the expected negative sign and most are statistically significant at the 5% level. By far the largest elasticity estimates are obtained for durables. This result suggests that durables play an important role in the transmission of such shocks.\(^9\) Table 1 demonstrates that the overall elasticity of \(-0.15\) is driven mainly by a reduction in vehicles purchases. The elasticity of demand for vehicles is \(-0.84\). There is much weaker evidence of reduced demand for other durables.

The following thought experiment provides a better understanding of the magnitude of the response of total real consumption. Consider the likely consequences of an energy price increase based on the discretionary income effect alone. Given that households may choose to borrow or to dissave as a short-run response to higher energy prices, it is quite possible for the impact effect of such a shock on consumption to be smaller than consumers’ loss in purchasing power, even when energy demand is inelastic. Such consumption smoothing is likely to be short-lived, however, and in the long run the response should be bounded by the magnitude of the purchasing power loss. Hence, a reasonable upper bound on the discretionary income effect is the initial reduction in purchasing power. In practice, the long-run response could be much smaller than this bound to the extent that demand for energy declines over time, as households increasingly utilize extensive and intensive margins of adjustment in response to purchasing power losses driven by higher energy prices. It stands to reason that such efforts at energy conservation will increase over time. Thus, a tighter bound may be obtained by taking account of the elasticity of energy demand obtained in the upper panel of Table 1. Taking account of the estimated price elasticity of energy demand, the reduction in discretionary income associated with a 1% increase in energy prices is bounded by \(-0.04\)%.

The response of total consumption in Table 1 is about four times as large and hence too large to be accounted for by the discretionary income effect alone.

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\(^8\) For a more detailed analysis of the individual components of energy consumption and a comparison with alternative estimates in the literature see Kilian (2008).

\(^9\) We would also expect households to reduce their expenditures on home improvements and other forms of household residential fixed investment, given the durables goods nature of this form of investment. The latter series is only available at quarterly frequency. Additional results (not shown) confirm that the response of real residential fixed investment after six quarters is large and highly significant, not unlike that of consumer durables.
Where does the excess decline come from? One reason is that consumers reduce expenditures on durables that are complementary in use with energy. The most prominent example of such durables are motor vehicles. The excessively high response of vehicles compared to other durables is an indication of the presence of such an operating cost effect. The difference amounts to about -0.65 percentage points in Table 1 and is statistically significant. Expenditures on vehicles decline about four times as much as expenditures on other consumer durables. They decline more than seven times as much as expenditures on nondurables and services.

The other possible reason for the disproportionate response of real consumption is the presence of a precautionary savings effect. In this view, households respond not only to the immediate loss of discretionary income, but they also respond in anticipation of the delayed effects on unemployment and real household income triggered by such a shock. As the likelihood of becoming unemployed increases, households increase their precautionary savings at the expense of consumption. The cutbacks in consumption need not be spread evenly across all forms of consumption, but will depend on how essential a given expenditure item is. Table 1 allows us to quantify the precautionary savings effect. For example, a decline in nondurables and services consumption by more than −0.04% can be interpreted as an indication that consumers reduce expenditures because they increase their precautionary savings. The data imply a marginally statistically insignificant precautionary savings effect of -0.08 percentage points for nondurables and a statistically significant effect of -0.07 percentage points for services. The corresponding precautionary savings effect of -0.16 percentage points implied for durables other than vehicles is not statistically significant. Taken together, the effects of changes in discretionary income, precautionary savings and operating costs imply a much larger reduction in real consumer expenditures in response to an unanticipated energy price increase than would be expected based on the small share of energy in consumption.

4.1 The Effects on Consumer Sentiment

The evidence in Table 1 suggests that consumer expectations play an important role in the propagation of purchasing power shocks. Indeed, rising energy prices are often associated with pessimism and uncertainty about one’s financial situation and the broader economy. If households are fearful of the economic outlook, they may curtail their consumption on a variety of goods and services driven by a precautionary savings motive. The importance of this channel has also been recognized.

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10 For example, in a report on the February 2006 Survey of Consumers at the University of Michigan, Richard Curtin noted that “the February loss in confidence was due to higher energy costs, higher interest rates, and a heightened concern about potential future increases in the unemployment rate”. The same report stated that one-in-five families cited higher prices, mainly for energy, as the cause of their decreased living standards. Such attitudes could lead to a decline in non-energy consumption, even if the discretionary income effect of the purchasing power loss is miniscule.
by policymakers. For example, Bernanke (2006b) in a recent speech on the U.S. economic outlook
stressed that “recent declines in energy prices ... have boosted household purchasing power and consumer confidence”[emphasis added]”. Below we investigate the empirical support for this explanation using data from the Michigan Survey of Consumers. These results complement the evidence in Table 1 on the precautionary savings and operating cost effects. We estimate the responses of measures of consumer confidence and consumer expectations to a negative one-time, one standard-deviation purchasing-power shock. Our data set includes the overall index of consumer sentiment as well as individual series. One set of expectations data relates to households’ perceptions about the future evolution of the economy and includes expected changes in business conditions and expected changes in unemployment. Another set of measures relates to households’ precautionary savings motives and includes expected changes in households’ personal financial situation and expected changes in real family income. A third set of expectations measures relates directly to households’ decisions about major durables purchases and includes current buying conditions for large household goods and current buying condition for vehicles.11

The sample period is 1978.1-2006.5. No monthly expectations data are available prior to 1978. The impulse response functions are estimated in the same fashion as in the previous sections. Our identifying assumption is that purchasing power innovations are predetermined with respect to innovations in consumer sentiment within the month. While the scale of the responses is not comparable, given the way survey responses are represented, the qualitative patterns of the responses are. Figure 2 shows the response of each sentiment series to an unexpected one standard deviation loss in purchasing.12 This shock decreases the overall index of consumer sentiment by 1.6 points. The fall in the index is immediate. While the index begins to rise again a few months after the shock, it remains below its initial level even 18 months after the shock. The observed decline in consumer sentiment compares to a standard deviation of 12.3 for this series, suggesting that an unusually large shock such as Hurricane Katrina, all else equal, could move consumer sentiment nearly one standard deviation away from its mean.

11 All series are constructed such that a fall in the index indicates a worsening of conditions from the consumer’s point of view. The indices for consumer sentiment, expected change in one’s personal financial situation, and expected changes in business conditions measure the difference between the number of respondents who expect a better situation and the number who expect a worse situation. A decline in the index suggests that more respondents expect a worsening situation, fewer expect a better situation, or both. Similarly, a decline in the index for buying conditions for large household goods and vehicles suggests that an increasing proportion of respondents think it is currently a bad time to make these purchases. A decline in the indices for unemployment, interest rate, and real family income expectations suggests that a greater proportion of survey respondents expect more unemployment, higher interest rates, and a decline in real family income, respectively.

12 This shock corresponds approximately to a 1.5% increase in energy prices. Historically, the average change in prices has been 1.2% in absolute terms. The largest monthly energy price increase in our sample is 11% and occurred following Hurricane Katrina in September of 2005. This corresponds to a purchasing power loss of -0.66% evaluated at the 2005 energy share.
The indices for expected changes in one’s personal financial situation and for general business conditions fall by 1.4 and 2.3 points, respectively, suggesting that an increasing number of people expect general business conditions and their personal financial situation to deteriorate over the coming year in response to an unanticipated loss in purchasing power. Whereas the response of the expected change in one’s personal financial situation is quite persistent and statistically significant even after 18 months, the response of the expected change in general business conditions, while larger in magnitude, reverts back to zero more quickly and is statistically insignificant after only four months. Given this evidence, one would expect households to cut back on nonessential consumption and to increase precautionary savings.

Of particular interest in judging the empirical plausibility of an operating cost effect is the response of expectations about current buying conditions for durables. Figure 2 shows that the index for buying conditions for large household goods falls by 1.9 points. An even larger decrease is observed for vehicles. The latter index falls by 2.8 points. This implies that a shock of the size associated with Hurricane Katrina would move the vehicle index by nearly one standard deviation. The relatively strong reaction of the index for buying conditions for vehicles in particular is qualitatively consistent with theories stressing energy complementarities in use.

The remaining results in Figure 2 provide additional insight into why rising energy prices cause households to curb their consumption. Increased pessimism about buying conditions in response to purchasing power losses is associated with expectations of higher unemployment, higher interest rates, and lower real family income. First, the index for expected changes in unemployment falls by 2.1 points, indicating that an increasing number of people expect higher unemployment. This response is consistent with households perceiving an increased risk of unemployment, as required for the existence of a precautionary savings effect. Second, the index for expected interest rates falls by 1.1 points, indicating that an increasing number of people expect higher interest rates in the future. This suggests another channel of transmission. To the extent that consumers (rightly or wrongly) expect interest rates to rise in response to higher energy prices, their expected liabilities would increase as credit card rates and mortgage rates increase, making it necessary to cut back on consumption. This second channel, however, is short-lived and the responses are largely insignificant, suggesting that it is of minor importance. Third, the index for changes in expected real family income falls by 1.2 points, indicating that a greater number of survey respondents expects real family income to fall in the future. These results are fully consistent with the view that the effect of purchasing power shocks on real consumption operates in part through changes in precautionary savings and through changes in the operating cost of vehicles.
4.2 Automobile Consumption: How Much Does Fuel Economy Matter?

We have already shown that declines in real motor vehicles consumption are one of the main causes for the disproportionate fall in real total consumption in response to purchasing power losses. This result is consistent with the automobile sector playing a crucial role in the transmission of energy price shocks. In fact, the bulk of the vehicles response is driven by automobile consumption. If we are interested in whether there is an effect from reduced demand for automobiles on the automobile industry, the relevant metric is the effect of unanticipated purchasing power losses on the demand for new automobiles. The estimated short-run elasticity of demand for new automobiles is about -0.71, which is close to the fuel cost elasticity of -0.5 reported in Goldberg (1998) based on a structural model and micro data, but the response is barely statistically significant.

One possible explanation is that the consumer response reflects not so much an overall reduction in the demand for cars, but an increase in the demand for energy-efficient small cars at the expense of energy-inefficient large cars. While we do not have data on the consumption of automobiles broken down by energy efficiency, we can contrast the consumption of new domestic automobiles with that of new foreign automobiles.\textsuperscript{13} To the extent that U.S. automobile manufacturers tend to produce less energy-efficient cars, as was certainly the case in the 1970s, considering the larger share of pickup trucks and SUVs in U.S. automobile production, a disproportionate decline in the consumption of domestically produced new cars would be evidence in favor of a shift in demand. VAR models indicate a strong and highly significant decline in new domestic automobile consumption. In contrast, consumption of new foreign automobiles initially increases, albeit insignificantly. After four months, consumption of new foreign cars slumps as well, although the effect is not as persistent, insignificant, and smaller in the long run than for domestic autos. The excess response of the consumption of domestically produced automobiles over its foreign-produced counterpart is statistically significant for months 2, 3 and 4. The excess decline reaches its maximum of -1.34% after two months. The model implies that a permanent energy price increase of the magnitude associated with Hurricane Katrina would wipe out 10.3% of the domestic demand for U.S. automobiles.\textsuperscript{14}

\textsuperscript{13}Domestic cars are defined by the BEA to include cars assembled in the United States, Canada, or Mexico.
\textsuperscript{14}The consumption data on new automobiles do not include light trucks or trucks. A different approach to determining the importance of shifts among different types of automobiles is to focus on unit sales reported by the BEA. While these data ignore the price of a given car (and hence differences in quality), they do allow us to assess whether consumption of light trucks (including minivans, SUVs or pickup trucks) responds differently to unanticipated losses in purchasing power than regular automobiles. There has been much discussion of the softening market for SUVs in recent years. We find no significant decline in unit auto sales (consistent with the evidence on new auto consumption), but a significant decline in both unit light truck sales and unit heavy truck sales, with long-run responses of -1.6% and -1.3%, respectively. This evidence strengthens the case for the operating cost channel. Assuming that all producers of light trucks are equally affected by such a shock, a shock associated with an event such as Hurricane Katrina (if sustained forever) would reduce the number of light trucks sold by about 11.2%, making this channel economically significant for U.S. companies such as Ford, GM and Chrysler, which devote between 35% and 80% of their production to trucks.
Our results in section 4.2 confirm Hamilton’s (1988) conjecture that automobile purchases are very sensitive to energy price fluctuations. However, there is no evidence in the real consumption data that changes in the demand for vehicles cause a sectoral reallocation effect that amplifies the effect of energy price increases and counteracts the effect of energy price decreases, as postulated in Hamilton’s model. This conclusion may seem surprising, but is consistent with the fact that the U.S. automobile industry only accounts for about 1% of aggregate U.S. employment and 1% of real U.S. GDP. Thus, even if there is a drastic decline in the demand for U.S. automobiles, the effect on other parts of the economy is likely to be small in scale, which may account for our inability to detect a statistically significant reallocation effect in the data.

There are other reasons, however, for the popularity of models that embody a reallocation effect. One reason is that there was no noticeable economic expansion in U.S. real GDP after the sharp fall in the price of crude oil in 1986. This evidence seems hard to reconcile with the perception that rising crude oil prices in 1979 contributed to a sharp economic downturn, unless one appeals to a model with asymmetric responses to energy price changes (see, e.g., Gramlich 2004). The theoretical model of Hamilton (1988) seemed to provide an explanation for this puzzling asymmetry. A common view is that this asymmetry in the data simply necessitates the existence of a large reallocation effect. Although this view is appealing upon casual inspection of the data, it misses important pieces of the puzzle.

It is useful to be explicit about the counterfactual. The implicit premise in this literature is that it suffices to compare the U.S. economic performance before and after the collapse of OPEC. Clearly, however, we need to compare what actually happened in 1986 to what would have happened without the sharp fall in energy prices (rather than to the status-quo-ante). This question may be answered based on historical decompositions of the real consumption data. Historical decompositions measure the cumulative effect of the historically observed sequence of purchasing power shocks on the level of real consumption at each point in time. Quantifying this effect is important because it conveys information that cannot be gleaned from impulse response estimates. Sometimes energy price increases come in clusters, and at other times energy price increases may alternate with decreases. The cumulative effect on real consumption is a weighted average of the entire history of shocks up to a given point in time. We compute this effect based on the bivariate VAR model estimates of section 4. Figure 3 shows the actual (demeaned) U.S. real consumption growth rates and the consumption growth rates predicted based on the cumulative effect of the purchasing power shocks alone. The difference between the two series measures the extent to which consumption growth is not explained.
by purchasing power shocks. To improve the readability of the plot, we have converted all growth rates to annual averages.

It is instructive to compare the annual results for 1979 and 1986. In 1979, purchasing power declined by 1.69% due to energy price increases, whereas in 1986 purchasing power increased by 1.43% due to energy price decreases. Thus one would expect the effect on real consumption to be roughly symmetric. As shown in Figure 3, the VAR model implies that unexpectedly rising energy prices (all else equal) lowered real consumption growth by -1.92% in 1979, and unexpectedly falling energy prices raised it by +2.02% in 1986, making these effects nearly symmetric. Moreover, actual real consumption growth in 1979 was -2.20% relative to its mean, whereas in 1986 it was +1.44%.

Thus, energy prices alone are capable of explaining a substantial part of observed real consumption growth in 1979 and 1986.

Figure 3 also provides two additional insights. First, energy price shocks were responsible for substantial declines (defined as an effect on the real consumption growth rate in excess of -0.65%) in consumption growth in 1974, 1979/80, 1990 and 2004/05, but they also caused large increases in real consumption growth (defined as an effect on the growth rate in excess of +0.65%) in 1986, 1991, 1998 and 2001. Second, a substantial part of real consumption growth is not associated with energy prices. Notably, the pattern of excess consumption growth in the 1970s is consistent with go-and-stop monetary policies of the type described in Barsky and Kilian (2002) and the unusually low growth in 1980-82 and 1990-91 is at best partially explained by energy prices and suggests an important role for monetary policy under Paul Volcker. Likewise, the unusually high growth of 1984-85, 1996-1999, and 2004 cannot be attributed mainly to energy prices.

5.1 An Alternative Explanation of the 1986 Episode

The observed behavior of real consumption growth in 1979 and 1986 contrasts sharply with that of real GDP growth. Real GDP growth was -1.81% relative to its mean in 1979 and -0.31% relative to its mean in 1986. Thus, the apparent asymmetry alluded to earlier does exist in real GDP growth, but is not reflected in real consumption growth. A systematic comparison of the 1979 and 1986 growth rates of real GDP and its components reveals that the source of the asymmetry in real GDP growth lies in private investment. More specifically, real nonresidential investment in equipment and structures are the two key components that caused real GDP growth in 1986 to be so low. In 1979, they grew by -2.80% and +7.54% relative to their means, respectively, whereas in 1986 they grew by -4.65% and -16.35%. The behavior of firms’ investment expenditures in 1986 contrasts sharply with that of private residential fixed investment and consumption.
There are two potential explanations for this pattern. One explanation is that energy price shocks have asymmetric effects on firms' fixed investment expenditures. Such an explanation seems implausible for several reasons. First, while there is some evidence of asymmetries in the point estimates of the nonresidential fixed investment responses (not shown), as discussed in Edelstein and Kilian (2007b), the type of asymmetry found in these responses (and of business investment in structures in particular) does not conform to what we would expect to see if these responses were driven by the uncertainty effect of Bernanke (1983). Specifically, the response to purchasing power losses is near zero, whereas the response to gains is strongly negative. Second, Edelstein and Kilian (2007b) found no statistically significant evidence against symmetry in the nonresidential fixed investment responses. Third, the mechanisms commonly discussed in support of an asymmetric response of nonresidential fixed investment (such as the Bernanke (1983) uncertainty effect on durables) should apply equally to consumer durables and to firms' purchases of durables. If firms' fixed investment responds much more asymmetrically to energy price changes than durables consumption and real residential fixed investment, then it must do so for unrelated reasons. It is unclear what economic mechanism would explain such an asymmetry in the responses of firms' fixed investment expenditures. Finally, one would expect an asymmetric effect on nonresidential fixed investment to be reflected in similarly asymmetric responses of aggregate unemployment and therefore consumer expectations, consumer expenditures and residential fixed investment. We have already observed that formal statistical tests do not support this conjecture.

An alternative and more plausible explanation is that a drop in firms' investment expenditures not related to the preceding fall in energy prices caused the 1986 expansion to fizzle. That explanation is consistent with the fact that the growth rate of firms' real investment expenditures fell much more in 1986 than in 1979. Such a pattern is inconsistent with conventional explanations of asymmetric investment responses. In related work, Edelstein and Kilian (2007b) have shown that the unprecedented drop in U.S. investment expenditures in 1986 was limited to specific components of business investment expenditures. They make the case that these specific declines represented in large part an exogenous shift in nonresidential investment expenditures associated with the removal of the investment tax credit and the elimination of real estate tax shelters in the course of the 1986 Tax Reform Act. Edelstein and Kilian (2007b) also provide evidence that the energy sector reduced its investment in structures more strongly than it would have based on the fall of energy prices alone. Together these factors explain the seeming asymmetry in nonresidential investment growth.

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15 Standard theoretical models of asymmetries imply that the response to purchasing power gains cannot be larger in absolute terms than the response to purchasing power losses and typically will be smaller. In contrast, the data show that firms' real investment in structures actually increased by 7.54% relative to trend in 1979 (which is completely at odds with the uncertainty effect), but fell by -16.35% relative to trend in 1986. Investment expenditures on equipment declined in both years, but they declined much more in 1986 than in 1979.
(and hence real GDP growth) between 1979 and 1986. They also help explain why real consumption
did not grow quite as much in 1986 as predicted by the econometric model on the basis of falling
ergy prices alone and why unemployment remained higher than it would have been otherwise.

5.2 Has Real Consumption Become Less Responsive to Purchasing Power
Shocks?

Recently, it has been suggested that perhaps the importance of energy price shocks for the U.S.
economy has declined (see, e.g., Hooker 1996, p. 222; Davis and Haltiwanger 2001, p. 482; Bernanke
2004). Figure 4 quantifies this phenomenon by comparing responses of consumption aggregates
Otherwise, the models are identical to those used in section 4. The scale of the impulses has been
normalized to be the same across the two samples as for the full sample. Compared to the first half
of the sample, in the second half the long-run response of total real consumption drops from -0.46%
to -0.12%. The corresponding decline for durables is from -1.27% to -0.37%. The response of vehicles
consumption declines from -1.99% in the first half to -0.74% in the second half of the sample. The
decine in durables consumption excluding vehicles shrinks from -0.67% in the first half of the sample
to -0.02% in the second half. The response of nondurables shrinks from -0.44% to -0.03% and that
of services from -0.28% to -0.10%. A similar reduction occurs in the response of real residential fixed
investment (not shown). The long-run response drops from -7.1% to -2.0%. Similarly, it can be
shown that the rise in unemployment associated with an unanticipated purchasing power loss drops
from 2.32% to 0.55%.

There are several possible explanations for the declining importance of energy price shocks. One
conjecture is that this result is related to fluctuations in the share of energy in consumption. Because
our results are based on innovations in purchasing power changes rather than innovations in energy
price changes, unlike previous estimates in the literature, they already control for changes in the
expenditure share of energy, so this explanation can be ruled out. A second conjecture is that the
variability of purchasing power shocks may have declined in the second half of the sample. Our
analysis shows that actually the variability of both total changes and linearly unpredictable changes
in purchasing power has increased in the second half of the sample. The innovation standard
development increased from 0.08 to 0.11. The average size of positive innovations increased from 0.056
to 0.076, and the average size of negative innovations increased from -0.049 to -0.073. Moreover,
both the maximum and the minimum of the innovations increased.

A third and more plausible explanation is that the structure of the U.S. automobile industry
has changed. In the 1970s, U.S. auto manufacturers were simply not producing any small, energy-
efficient cars, leaving consumers with no choice but to buy small cars from abroad. Thus, the U.S.
auto industry was hit particularly hard by rising energy prices and falling demand for large cars. In
contrast, by the late 1980s and 1990s the differences between domestic and foreign auto producers
had been greatly reduced, as domestic auto manufacturers offered small and energy efficient cars
of their own, while foreign manufacturers were beginning to branch out into the market for jeeps,
SUVs, vans and pickup trucks. Thus, the U.S. auto industry became relatively less vulnerable to
energy price increases than in the 1970s.

This point is illustrated by comparing the responses of new domestic and foreign automobiles
in each subsample (see Figure 5). Whereas in the first subsample expenditures on new domestic
automobiles drop by -4.2% after two months and by -2.6% in the long run, in the second half the
short-run response drops to -1.1% and the long-run response to -0.5%. The strongly significant short-
run decline in the first sample is only marginally significant in the second sample. In contrast, in the
first half of the sample, after one month expenditures on new foreign automobiles rise significantly
by 2.0%, followed by an insignificant decline of -1.5% after five months and a long-run response of
-0.5%. In the second half of the sample, the initial increase in the response has become small and
insignificant, the decline after 5 months has shrunk to -0.6% and the long-run response to -0.2%.
While it is still true that the consumption of new domestic autos is more responsive to energy price
shocks than the consumption of new foreign autos, the differences are much smaller than they used
to be.

There is also a fourth and complementary explanation. As the U.S. automobile industry re-
structured itself after the energy price increases of the 1970s, the share of domestically produced
automobiles in total U.S. real expenditures on new cars declined (from 88% in 1970 to 60% in 1988
and 57% in 2006), as did the employment share of the industry (from a peak of 1.3% in 1973 to
0.9% in 1988 and 2005).16 Thus, the relative importance of the auto industry for the U.S. economy
and the potential for spillovers from the automobile industry to other sectors has declined relative
to the 1970s, further reducing the precautionary savings effect.

While these observations help explain our results, they cannot be the primary explanation of
the observed decline because they are specific to the United States, whereas the reduced sensitivity
to energy price shocks is a global phenomenon. Perhaps the single most important explanation of
the observed global decline in the responses to energy prices shocks is a change in the composition
of these shocks, as discussed in Kilian (2009). Kilian shows that, to the extent that more recent
energy price shocks have been associated almost exclusively with unexpected increases in global
demand, their effect has been cushioned by the stimulative effect of higher global demand on the
U.S. economy.17

6 Conclusion

On the basis of the evidence presented in this paper, the standard view of how energy price shocks
affect the U.S. economy has to be reconsidered. The conventional wisdom is that a fall in energy
prices will have only weak effects on output and employment, as the increase in aggregate demand
will be offset by the reallocation effect of changing expenditure patterns. In contrast, when the
price of energy increases, both effects work in the same direction, amplifying the response of output
and unemployment. This explanation rationalized both a sharp contraction following energy price
increases, and the absence of an economic expansion following energy price decreases. While we did
find evidence of changing expenditure patterns, as required for the existence of a reallocation effect,
the absence of statistically significant departures from symmetry in the responses to positive and
negative energy price shocks suggests that reallocation effects are not a quantitatively important
channel of transmission. One possible explanation is the comparatively small share of the U.S.
automobile industry in domestic real GDP and employment. Without this allocative channel it
is difficult to rationalize the severe economic downturns of 1974 and 1979/80 as a consequence of
adverse energy price shocks.

Even in the absence of asymmetric effects such as the reallocation effect, however, the cumulative
effects on real consumption associated with energy price shocks are quantitatively important. We
showed that the responses of real consumption aggregates are too large to reflect the effects of
unanticipated changes in discretionary income alone. Our analysis suggests that the excess response
can be attributed to shifts in precautionary savings and to changes in the operating cost of energy-
using durables. The latter finding is consistent with evidence that an unexpected loss in purchasing
power due to rising energy prices has a significantly negative impact on a wide array of consumer
expectations. Specifically, rising energy prices tend to make consumers pessimistic about the state
of the economy and about their own personal financial situation. They also cause consumers to
expect worsening future economic conditions, and they heighten concerns about current buying
conditions. Thus, deteriorating consumer confidence is likely to be an important additional link in

17 Possible competing explanations include structural changes in the form of reduced real wage rigidities or improved
monetary policy (see, e.g., Blanchard and Gali 2008; Herrera and Pesavento 2009). It remains to be shown that these
alternative explanations can account for the U.S. experience as well as the cross-country differences in economic
performance following major oil price shocks.
the relationship between energy price shocks and household consumption.

A one-time 1% increase in energy prices in a given month is associated with a statistically significant decline in real total consumption of -0.15% a year later. Historical decompositions suggested that the energy price shocks of 1974, 1979-81, 1990, and 2003-2007 were an important factor in explaining U.S. real consumption growth, but by no means the dominant factor. In particular, energy price shocks were shown to have contributed substantially both to the decline in consumption in 1979, amidst sharply rising energy prices, and to its recovery in 1986 after the collapse of OPEC. This result runs counter to the conventional wisdom that the U.S. economy’s response to the decline in energy prices in 1986 was muted, whereas its response to the 1979 energy price increases was strong. We showed that this perception is at odds with the largely symmetric pattern of real consumption growth in 1979 and 1986. This pattern contrasts sharply with the asymmetric pattern of real GDP growth in 1979 and 1986 for reasons discussed in Edelstein and Kilian (2007b).

Our analysis also shed light on the declining importance of energy price shocks for the U.S. economy. We documented the extent to which consumption aggregates have become less responsive to energy price shocks since the mid-1980s after controlling for fluctuations in the energy share. The effect of an unanticipated 1% increase in energy prices on total real consumption one year later drops from -0.30% in the first half of the sample to only -0.08% in the second half. We traced the declining importance of energy price shocks relative to the 1970s in part to changes in the composition of U.S. automobile production and to the declining overall importance of the U.S. automobile sector, but noted that much of this apparent regression instability is likely to be driven by changes in the composition of energy price shocks, as discussed in Kilian (2009).

The sharp rise in gasoline prices after 2002 has renewed interest in the question of how much higher energy prices affect consumer expenditures. Our analysis allows us to assess the overall effect of such a price increase on household consumption. Suppose, for example, that gasoline prices unexpectedly and permanently increased by 25 cents per gallon (which translates into a 6.85% increase in the overall price of energy, assuming all other energy prices remain unchanged). If a typical household spends $200 a month on gasoline at the January 2007 price of $2.29 per gallon, this would raise the household’s gasoline bill by almost $22 a month, if the household continued to consume the same amount of gasoline. In response to such a shock, a typical household with about $4000 to spend per month will have cut back its expenditures one year later by $35 based on the full-sample estimates (or by $17 based on the post-1987 estimates). Most of the adjustment will take place in the first six months following the gasoline price increase. Given a share of consumption in GDP of about 72%, this implies that, all else equal, real GDP will have fallen by 0.63% one year after the shock. This example illustrates that it takes repeated surprise increases in gasoline prices to
generate large effects on household consumption, but over time the effects will add up. The regression models investigated in this paper are useful not only for understanding historical episodes. Their predictive power for understanding the post-2007 period has recently been investigated by Hamilton (2009b).

References


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NOTES: VAR estimates based on the purchasing power loss associated with a change in weighted retail energy prices. The elasticities have been computed based on the average share of energy in the sample period. Boldface indicates statistical significance at the 5% level.
Figure 1: U.S. Real Price of Energy, Energy Share and Changes in Purchasing Power 1970.1-2006.7

NOTES: (a) Inflation-adjusted chain indices of the retail price of different forms of energy consumption based on expenditure data provided by the BEA. (b) Monthly nominal expenditures share energy consumption computed based on expenditure data provided by the BEA. (c) Purchasing power gains in percent computed as weighted average of change in retail energy prices weighted by their respective share in total consumption. A negative value indicates a loss in consumer purchasing power.
Figure 2: Response of Consumer Expectations to Purchasing Power Shocks
1978.1-2006.5

NOTES: VAR estimates based on the purchasing power loss associated with an unanticipated change in weighted retail energy prices. All series are constructed such that a fall in the index indicates a worsening of conditions from the consumer’s point of view.
NOTES: Based on a historical decomposition of the full-sample quarterly VAR estimates. The results have been aggregated to annual frequency to improve the readability of the plot.
Figure 4: Selected Responses by Sample Period

NOTES: Split-sample VAR estimates for U.S. data based on the purchasing power loss associated with an unanticipated change in weighted retail energy prices.
Figure 5: Response of U.S. Consumer Expenditures on New Automobiles to Purchasing Power Shocks

NOTES: Split-sample VAR estimates based on the purchasing power loss associated with an unanticipated change in weighted retail energy prices.