Do Gasoline Expenditure Shocks Have Different Effects in Recessions and Expansions?

Naafey Sardar* Lance Bachmeier†

December 24, 2019

JOB MARKET PAPER

Updated frequently. Click here for updated draft.

Abstract

A key question in macroeconomics is how aggregate consumption responds to a shock to gasoline expenditures. Using a structural VAR model for U.S. data covering the period 1973-2018, this paper shows that (i) an increase in gasoline expenditures reduces aggregate consumption, (ii) the response to a gasoline expenditures shock is much stronger in a recession than in an expansion, and (iii) the asymmetry in response over the business cycle is primarily due to differences in household savings behavior in recessions versus expansions. Our results are consistent with the literature showing larger effects of fiscal policy in recessions.

JEL Classification: E21, E32, Q43

Keywords: Business cycles; Consumption; Gasoline expenditures; Local Projections

*Department of Economics, 327 Waters Hall, Kansas State University, Manhattan, KS 66506. Email: naafeysardar@ksu.edu.

†Department of Economics, 321 Waters Hall, Kansas State University, Manhattan, KS 66506. Email: lanceb@ksu.edu.

1. Introduction

An important question in macroeconomics is how aggregate consumption responds to a shock to gasoline expenditures. In one sense, the mechanism by which consumption is affected is straightforward. If gasoline consumption is inelastic in the short run, a positive shock to the price of gasoline will lead to higher gasoline expenditures, crowding out spending on other goods and services.[1] Consumers will have to decide whether to continue buying the same amount of gasoline at the higher price, in which case there will be less discretionary income available for other expenditures (Hamilton, 2009). Higher gasoline expenditures have an indirect effect on consumption, as the demand for goods that complement gasoline in consumption, most notably automobiles, will fall (Hamilton, 1988). A recent study by Farrell and Greig (2015) concluded that the marginal propensity to consume non-energy goods out of a dollar saved on gasoline is roughly 0.8.[2] Gicheva et. al. (2008) use scanner data to infer that as gasoline expenditures rise, consumers shift towards groceries as opposed to eating out in order to offset this increase. This is also followed by switching to lower cost grocery items.[3]

Figure 1 represents consumer spending on gasoline and non-gasoline goods as a share of total consumption expenditures. Gasoline share of consumption peaked during the early 1980's when households were spending almost 6% of their total consumption expenditures on gasoline goods and services. Since the 1980s, the gasoline share of consumption has considerably gone down due to reasons like vehicle-fuel efficiency. Low and stable global oil prices throughout the 1990s meant that the share of gasoline expenditures was low, whereas

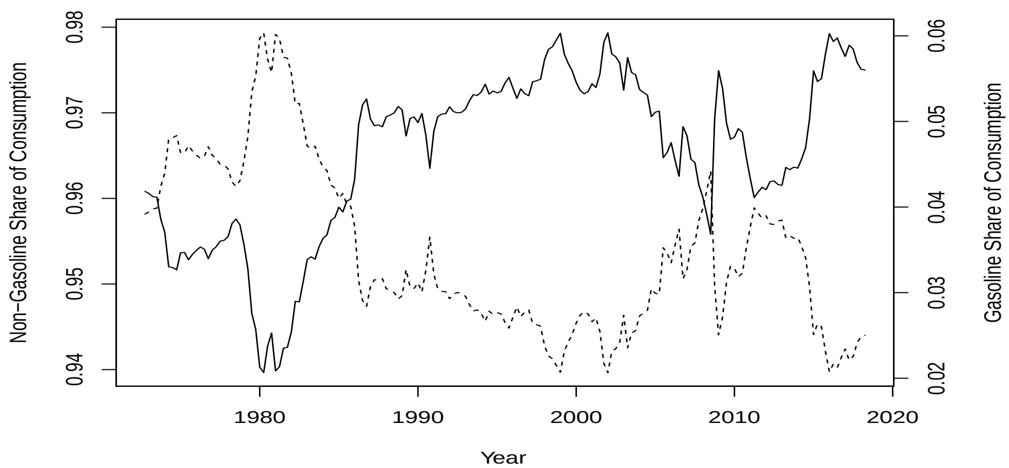
[1]For empirical evidence on the response of consumption to gasoline and oil price shocks, see Bernanke (1983), Hamilton (1988), Pindyck (1991), Bernanke (2006) , Hamilton (2009), Edelstein and Kilian (2009), Hamilton (2016), Kilian and Baumeister (2016), Kilian et. al. (2018), Herrera et al. (2019), Gorodnichenko et al. (2019).

[2]Another channel by which energy shocks can affect consumption is increasing uncertainty about future energy prices. In the presence of uncertainty, consumers have an incentive to delay purchases of durable goods such as cars and houses (Bernanke, 1983; Pindyck, 1991).

[3]"As many drivers struggle to cope with soaring fuel prices, working-class people like Ms. Lopez who commute long distances to their jobs are suffering the most..... Ms. Lopez looks for weekly specials at the supermarket. Salmon, her favorite fish is $7 a pound these days. So she buys the tilapia for $2.99 instead."

-- Full Tanks Put Squeeze on Working Class, NY Times, May 13, 2006 the share of non-gasoline spending was relatively higher compared to the previous decade. This figure suggests that gasoline and non-gasoline consumptions move in the opposite direction, with an increase in gasoline expenditures reducing discretionary income and decreasing non-gasoline spending.

Figure 1: Shares of Consumption for Gasoline and Non-Gasoline Goods and Services



Notes: The dashed line represents the gasoline share of consumption whereas the corresponding solid line represents the non-gasoline share of consumption.

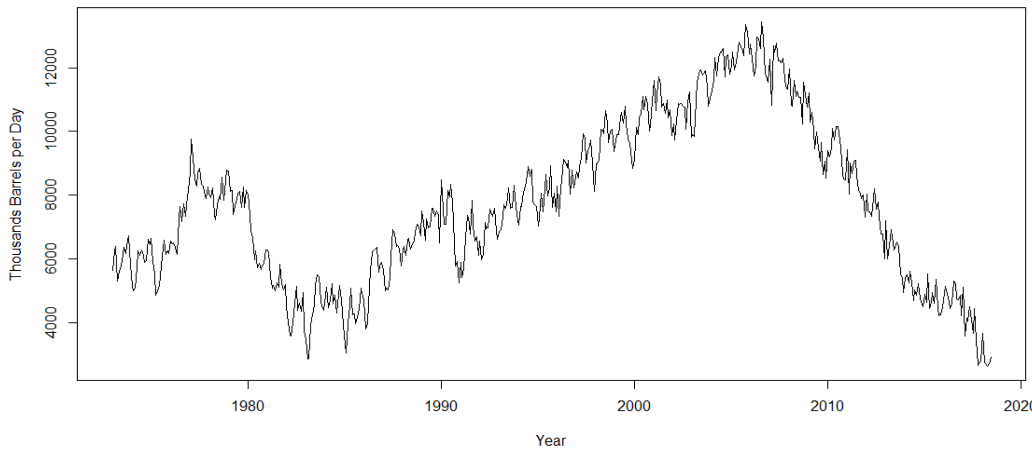
The mechanisms described previously can explain a shift in consumption from non-energy to energy goods, but not necessarily a change in the *level of aggregate consumption.* Figure 2 shows that in every month from January 1973 through May 2019, the U.S. was a net importer of crude oil.[4] Increases in gasoline expenditures have historically caused a transfer of U.S. income to foreign oil producers. Thus, higher gasoline expenditures have the same effect as a tax on the U.S. economy, and should be expected to reduce aggregate consumption.[5]

[4]Source: https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=mttntus2&f=m

[5]In the words of Janet Yellen, "Higher oil prices lower American income overall because the United States is a major oil importer and hence much of the proceeds are transferred abroad. . . . Thus, an increase in the price of crude oil acts like a tax on U.S. households, and . . .tends to have a dampening effect on consumer spending. ...Staff analysis at the Federal Reserve Board indicates that a[n]...increase in retail gasoline prices. . .reduces household disposable income ... and hence tends to exert a significant drag on consumer spending.,"

In a report on 29 June, 2018, S&P Global economists Beth Bovino and Satyam Panday stated the following about higher oil prices, "This would be tantamount to a tax increase for American households. This is especially true for middle- to low-income Americans,"

Figure 2: U.S. Net Imports of Crude Oil and Petroleum Products



This paper tests for an asymmetric response of consumption to gasoline expenditure shocks across recessions and expansions. The motivation for our analysis is the recent literature showing that the impact of fiscal policy depends on the state of the economy. Tagkalakis (2008) finds that tax cuts increase consumption by more in recessions as opposed to expansions. Auerbach and Gorodnichenko (2012) estimate that fiscal multipliers range from 1-1.5 in recessions and 0-0.5 in expansions. Jorda and Taylor (2016) find that fiscal austerity depresses the economy more when implemented in a slump as opposed to a boom.[6]

If shocks to gasoline expenditures have the same effect as a change in taxes, and fiscal policy has different effects in recessions and expansions, it follows that the effect of a gasoline expenditure shock should also depend on the state of the business cycle. A finding of economically meaningful nonlinearity of this type would require a change to empirical and theoretical macroeconomic models that include energy prices. The analysis would also emphasize the need for the Federal Reserve to consider asymmetries in the impact of gasoline expenditure shocks across recessions and expansions when it is forecasting consumption, as failure to do so might result in misleading conclusions about the effect of gasoline expenditures shock on the U.S. economy. On the other hand, a failure to find evidence of this

[6]See also Auerbach & Gorodnichenko (2013) and Fazzari, Morley, and Panovska (2015). Ramey and Zubairy (2018) disagree with the claims made by these authors.

type of nonlinearity would cast doubt on the treatment of a gasoline expenditure shock as a change in taxes, claims that the effect of fiscal policy depends on the state of the economy, or both.

We begin by documenting the impact of gasoline expenditure shock on non-gasoline goods and services. Consistent with expectations and the existing literature, we find that a positive shock to gasoline expenditures is followed by reduced spending on other goods. Following a 10% increase in gasoline expenditures over the course of a year (approximately $200)[7], an average household cuts spending by $389 over the same time period.[8] The vast majority of the consumption response comes from the services (47%) and durables (33%) sector.[9]

We then redo the analysis using a threshold (nonlinear) model that allows the response to gasoline expenditure shocks to be different in expansions and recessions. We establish the presence of an asymmetric response of consumption to an increase in gasoline expenditures between the two states of the economy. Following a 10% increase in gasoline expenditures for any year (about $200), total non-gasoline spending for an average household goes down by $1,545 in recessions and $383 in expansions over the same time period. The motor vehicles sector is responsible for driving a big proportion of the response. Spending on motor vehicles goes down by $345 per household in recessions as opposed to $85 in expansions over the same time period.

According to Kilian and Edelstein (2009), one of the mechanisms through which higher gasoline prices reduce discretionary income is the precautionary savings effect. As gasoline prices increase, consumers become uncertain about the future path of the economy and further reduce their consumption in order to increase precautionary savings. These savings

[7] The average household income before taxes for 2017 was $73,572, of which $60,060 was used by households for consumption expenditures. These numbers are derived from the latest Consumer Expenditure Survey released by the Bureau of Labor Statistics for the year 2017. Based on our sample, gasoline is on average 3.3% of consumption expenditures. Consumers on average spend $2000 on gasoline and other energy goods in a year. A 10% increase raises gasoline expenditures by $200 for the year.

Source: https://www.bls.gov/news.release/cesan.nr0.htm

[8] Non-gasoline spending is 2.65% less than its original level a year after the shock.

[9] Services PCE goes down by $182 while durables spending sees a decline of $123 over the course of a year.

act as an insurance against a greater likelihood of future unemployment and future income losses. We present evidence that the difference in the response of consumption is driven by an asymmetric response of personal savings to gasoline expenditure shocks across recessions and expansions. Following a 10% increase in gasoline expenditures over the course of a year (approximately $200), private savings for an average household increase by $398 in recessions as opposed to $60 in expansions.[10] This suggests that as gasoline expenditures increase, households increase their precautionary savings because they perceive a higher chance of future income losses with the response of savings stronger in recessions. As gasoline expenditures increase, households increase precautionary savings by more in recessions as opposed to expansions and the resulting drop in consumption is higher.

Our analysis further investigates whether gasoline expenditure shocks affect consumption differently depending on whether they are positive versus negative shocks. We find that negative gasoline expenditure shocks have large positive effects on consumption with the impact being amplified in recessions. This suggests that a decrease in gasoline expenditures is more effective in boosting private consumption during recessions as opposed to expansions. Households consume the extra income generated following unanticipated decreases in gasoline expenditures.

The paper proceeds as follows. Section 2 describes the methodology for the linear VAR model and its results. This section displays the impulse response functions to gasoline expenditure increases. Section 3 discusses how we model the difference in response across recessions and expansions. Discussion of results and the motivation for asymmetry is also included. Section 4 looks at the forecasting implications of our results, with a discussion about why the Federal Reserve's consumption forecasting models need to consider asymmetries. In section 5, we present robustness checks in which we use alternative recession dates and a different measure of shock. Section 6 looks at the response of consumption to decreases in gasoline expenditures. Section 7 concludes.

[10]Based on the savings rate across our sample, an average household saved $5,929 during 2017.

2. Linear Model

2.1. Specification

We begin the analysis by estimating a (linear) bivariate structural VAR model,

$$z_t = \alpha + \sum_{i=1}^{p} \beta_i z_{t-i} + e_t, \tag{1}$$

where $z_t = (gas_t, c_t)'$, c_t is a measure of consumption growth in quarter t, gas_t is the percentage change in gasoline expenditures in quarter t, $e_t = (e_{gas,t}, e_{ct})'$ is a vector of reduced form residuals, p represents the lag-length,[11] α and β_i are vectors of coefficients. Gasoline expenditures are defined as real personal consumption expenditures on gasoline and other energy goods. The four measures of consumption growth we use are real personal consumption expenditures (RPCE), RPCE: Services, RPCE: Nondurables, and RPCE: Durables. Estimation of the linear VAR model does not represent an original contribution, but it provides a benchmark for comparison with the results of the nonlinear model.

Data on different categories of nominal consumption was downloaded from the National Income and Product Accounts Table released by the Bureau of Economic Analysis.[12] To calculate our measure of total consumption, we subtract nominal consumption expenditures on gasoline and other energy goods (NIPA Table 2.3.5, Line 11) from total nominal consumption expenditures (NIPA Table 2.3.5, Line 1). This is followed by deflating it using the *Price Index for Personal Consumption Expenditures* (NIPA Table 2.3.4, Line 1), and expressing it in real terms. The other categories of consumption, namely durables (NIPA Table 2.3.5, Line 3), nondurables (NIPA Table 2.3.5, Line 8) and services (NIPA Table 2.3.5, Line 13) undergo a similar transformation. Table 3 presents the results of various stationary

[11] We impose a lag order of 2 throughout our analysis. The chosen lag order is larger than the estimates suggested by Schwarz Information Criterion conditional on an upper bound of 8 lags, which in most cases produces a lag order of only 1. The lag selection is in line with Edelstein and Kilian (2009), who use lags from the previous two quarters.

[12] NIPA Tables: https://apps.bea.gov/iTable/index_nipa.cfm

and unit root tests performed on real consumption series variables in levels and percentage changes. Panel A of Table 3 presents the results for the augmented Dicky-Fuller (ADF) test.[13] We also report the Elliot, Rothenberg and Stock (1996) modified Dicky Fuller (ERS) test along with the Phillips-Perron (Phillips and Perron, 1988) test. Panel A suggests that the real consumption variables are non-stationery in levels since we fail to reject the null ($|DF_\tau| < |critical|$). In panel B, we see that the percentage differences for our real consumption series are stationery as we reject the null at the 5% level using all tests. As a result, our measures of consumption are expressed in percentage change throughout the course of the paper.

The impulse response functions are identified by assuming the consumption shock does not have a contemporaneous effect on gasoline expenditures, which implies a recursive system with gasoline expenditures ordered first.[14] One metric for judging the plausibility of our assumption that gasoline expenditures do not respond immediately to consumption shocks (or other macroeconomic shocks that have an effect on consumption) is to look at the contemporaneous correlations of the VAR residuals. If gasoline expenditures are reacting immediately to macroeconomic shocks, it will cause a positive correlation between the two residuals. On the other hand, if consumption expenditures are reacting to gasoline expenditures, the correlation will be negative. The correlations are reported in Table 1. In all cases, the correlations are negative, ranging from -0.07 to -0.45. This does not confirm that our identification is correct, but it is consistent with our ordering of the variables, and we can rule out a recursive VAR with consumption ordered first.

Table 1: Correlations of Reduced Form Residuals

Variables	***Correlation***
RPCE	-0.35
Durables	-0.07
Nondurables	-0.26
Services	-0.45

[13]See Dicky and Fuller (1981).

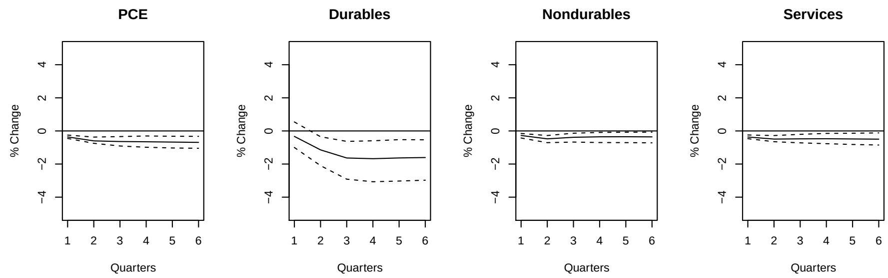
[14]This is similar to the identification in Edelstein and Kilian (2009).

What is the structural shock to gasoline expenditures capturing? The obvious, and almost certainly most important, source of gasoline expenditure shocks is an unanticipated change in the price of gasoline. Other sources of gasoline expenditure shocks include changes in preferences for larger or smaller vehicles, changes in travel patterns such as those witnessed in the aftermath of the 9/11 terrorist attacks, and changes in commuting behavior due to fluctuations in house prices.

2.2. Results

The responses of the four consumption series to a gasoline expenditures shock are found in Figure 3. As mentioned earlier, an increase in gasoline expenditures can explain a shift in consumption from energy to non-energy goods, but not necessarily a change in the *level of aggregate consumption*. Our total PCE measure consists of consumption expenditures on all goods and services except gasoline. Using such a measure will help us understand how non-gasoline consumption responds to a change in gasoline expenditures. When gasoline expenditures increase, total consumption (non-gasoline) decreases right away. In the long run, total consumption expenditures decrease by around 0.7% and the effect is statistically significant at the 95% confidence interval. As expenditures increase, durables PCE decrease by around 1.6% after the first year. The response, however, is also significant at the 95% confidence interval. The effect on nondurables (less gasoline) and services PCE is not as amplified as durables since the demand for such categories is relatively inelastic as opposed to durable goods. A year after the shock nondurables PCE decreases by 0.35%. Services PCE falls down by 0.5% in the long run.

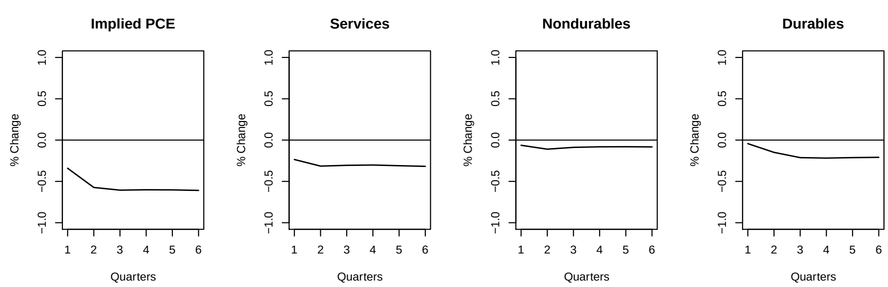
Figure 3: Response of Consumption Series



Notes: Solid line represents the cumulative response to a 10% increase in gasoline expenditures, while the corresponding dashed lines are the 95% confidence intervals.

In terms of explaining aggregate consumption expenditures, however, it should be noted that services are a much larger proportion of consumption than nondurables and durables consumption combined.[15] Figure 4 decomposes the response of total consumption into contributions made by different sectors. The contribution was calculated by accounting for the weight of durables, nondurables and services. This was followed by multiplying it with the estimates at each time horizon. Almost half of the drop in consumption is explained by the services sector. Durables contribute to almost one-third of the drop in RPCE, while nondurables play only a minor role. Thus, in order to explain the reaction of aggregate consumption, we need to focus on services and durables consumption.[16]

Figure 4: Contribution by Category



Notes: Solid lines represents the contribution of each category in driving the response of total consumption.

The average household income before taxes for 2017 was $73,572, of which $60,060 was

[15]For our sample, services was on average 64% of consumption, nondurables 23%, and durables only 13%.
[16]Kilian & Edelstein (2009) also suggest that durables play a significant role in the transmissions of energy price shocks.

used by households for consumption expenditures. These numbers are derived from the latest Consumer Expenditure Survey released by the Bureau of Labor Statistics for the year 2017.[17] Based on our sample, gasoline is on average 3.3% of consumption expenditures. Consumers on average spend $2000 on gasoline and other energy goods in a year. Durables make up $7,552, nondurables excluding gasoline $13,361 and services $37,179 of total consumption. When gasoline expenditures rise by approximately $200 (10% increase in gasoline expenditures) over the course of a year, total spending on non-gasoline goods and services decreases by $389 during the same time period. Durables spending goes down by $123, nondurables by $47 and services by $182.

We also consider the following disaggregated consumption measures our analysis. *Motor vehicles and parts* (NIPA Table 2.3.5, Line 4) consists of spending on new and used autos, and motor vehicle parts and accessories. *Furnishing and durable household equipment* (NIPA Table 2.3.5, Line 5) includes spending on furniture and furnishings, household appliances, glassware and household utensils, and tools and equipment for house and garden. *Other durable goods* (NIPA Table 2.3.5, Line 7) comprises of jewelry and watches, educational books, luggage and personal items, and telephone and related communication equipment. *Food and beverages* (NIPA Table 2.3.5, Line 9) is spending on food and nonalcoholic beverages purchased for off-premises consumption, and alcoholic beverages purchased for off-premises consumption. *Clothing and footwear* (NIPA Table 2.3.5, Line 10) is spending on garments. *Other nondurable goods* (NIPA Table 2.3.5, Line 12) comprises pharmaceutical and other medical products, recreational items, household supplies, personal care product and tobacco. *Housing and utilities* (NIPA Table 2.3.5, Line 15) consists of consumer expenditures on rent and household utilities. *Transportation services* (NIPA Table 2.3.5, Line 17) is spending on public transportation (air, rail and ground), and motor vehicle maintenance and repair. *Other Services* (NIPA Table 2.3.5, Line 21) comprises of communication, education services, professional services and household maintenance.

[17] https://www.bls.gov/news.release/pdf/cesan.pdf

Figures 11 and 12 present the response of various consumption series to an increase in gasoline expenditures. We find that the decline in motor vehicles CE is 2.78% in response to a 10% increase in gasoline expenditures after a year. Spending on furnishing and durable household equipment decreases by almost 1% at the end of the year. The effect is statistically significance at the 95% confidence bands. Consumption expenditure on other durables marginally decreases but the effect is not statistically significant. Food PCE initially decreases in response to consumers' spending more on gasoline and other energy goods. In the long run, however, spending on food returns to its original level. Consumption expenditure on household services and other nondurables decreases marginally and the effect is statistically significant as well.

In dollar terms, a $200 annual increase in gasoline expenditures will force an average household to reduce spending on motor vehicles by $82 over the course of a year. Spending on furnishings and other durable household equipment and clothing goes down by $16 and $10 respectively. Food spending initially goes down $12 but returns to its original level by the end a year. Spending on motor vehicle services decreases in response to gasoline expenditure shocks. Consumer spending on public transportation increases by $9 over the same time period. There are two reasons for this increase. First, rising gasoline expenditures increases the fares consumers pay for public transport. Second, higher gasoline expenditures mean that the cost of operating cars goes up, which might force some consumers to abandon the usage of their personal vehicles and shift to public transport. Money spent by consumers on food services and accommodation goes down by $12 over the entire year. This category includes money spent on vacations and food away from home. As gasoline expenditures increase, the average household faces budgetary constraints and has to cut down on holidays and other leisure. Expenditures on housing go down by $57. This suggests that consumers might be forced to switch to low-cost housing in response to higher gasoline expenditures. A $200 increase in gasoline expenditures over the course of a year increases utility bills by $11 per household. Spending on other services (communication, education, legal etc) decreases by \$23 whereas healthcare spending goes down by \$35.

The results are in line Edelstein and Kilian (2009) which suggests that spending on non-gasoline goods and services goes down in response to rising gasoline expenditures. As gasoline expenditures increase, consumers' discretionary income goes down since they have less to spend on other goods and services, resulting in a drop across most of the consumption categories. Results from the linear model results are that the response of goods for which the demand is relatively elastic (durables) is significantly more than goods for which the demand is relatively inelastic (nondurables).

3. Asymmetric Effects Over Business Cycle

3.1. Specification

The impulse responses of different measures of consumption to gasoline expenditure shocks in recessions and expansions are calculated using local projections. Local projections have the ability to accommodate non-linear specification (Jorda, 2005). The key advantage of using a nonlinear model instead of estimating a VAR for each regime is that with the latter we do not have enough observations to make a precise analysis. In our case, the observations for a recessionary regime only comprise 20% of the entire sample. As a result, our estimates of the VAR model for recessions would not have been precise due to insufficient observations. Estimating a non-linear model allows us to utilize the entire dataset for our inference.

Assuming that consumption expenditures respond contemporaneously to an increase in gasoline expenditures, the immediate response of consumption, c_t to a gasoline expenditure shock can be estimated with the following regression:

$$c_t = \alpha + \sum_{i=0}^{k} \phi_i I_{t-i} + \sum_{i=0}^{k} \theta_i \triangle y_{t-i} + \sum_{i=1}^{k} \beta_i c_{t-i} + \sum_{i=0}^{k} \gamma_i \triangle gas_{t-i} + \sum_{i=0}^{k} \delta_i inter_{t-i} + \varepsilon_t \qquad (2)$$

where,

$$inter_{t-i} = I_{t-i} \times \triangle gas_{t-i}$$

and c_t is the percentage change in consumption in time period t, $\triangle gas_{t-i}$ is the change in gasoline expenditures in quarter $t-i$. $\triangle y_{t-i}$ is the GDP growth rate in quarter $t-i$. GDP growth rate and the recession dummy have been added to control for the state of the economy. $inter_{t-i}$ represents the asymmetric response of c_t when the economy is in a recession. Recession dates calculated using Auerbach and Gorodnichenko (2012) take the following value,

$$I_t = \begin{cases} 1 & F(z_t) \geq 0.8 \\ 0 & F(z_t) < 0.8 \end{cases}$$

where $F(z_t)$ is the transition function that indicates the state of the economy and takes the following functional form,

$$F(z_t) = \frac{exp(-\gamma(z_t - \bar{d}))}{1 + exp(-\gamma(z_t - \bar{d}))}, \gamma > 0$$

z_t is equal to the seven quarter moving average growth rate of output and the value of γ is calibrated to be equal to 3 so that the economy spends 20% of time in recession i.e. $Pr(F(z_t) \geq 0.8) = 0.2$ (Auerbach and Gorodnichenko, 2012). The value for the threshold $\bar{d}$ is defined to be 0.8. Recession dates are reconstructed using data available in the 'lpirfs' package which was provided by Phillip Adammer.[18] The Auerbach and Gorodnichenko (2012) sample period is 1947:Q1-2008:Q4. In order to identify periods of economic downturn for the sample period 2009:Q1-2018:Q2, we rely on the NBER's recession dates provided by the FRED St. Louis.

Defining $\triangle gas_0$ as the change in gasoline expenditure in recessions and expansions, and $inter_0$ as the change in gasoline expenditures in recessions, the contemporaneous response

[18] Adämmer P (2019). lpirfs: Local Projections Impulse Response Functions. R package version: 0.1.5, https://CRAN.R-project.org/package=lpirfs.

of c_t, c_0 is defined as

$$c_0 = \hat{\gamma}_0 \triangle gas_0 + \hat{\delta}_0 inter_0$$

Since the shock under study is a 10% increase in gasoline expenditures, $\triangle gas_0 = 10\%$. For a 10% shock in recessions, $inter_0 = 10\%$. For expansions, on the other hand, $inter_0 = 0$ since $I_t = 0$. After calculating the contemporaneous response, we define the response vector for each state of the economy. Response vector tells us the initial response of variables following a 10% increase in gasoline expenditures.

$$d_i^{rec} = \begin{bmatrix} c_0 & \triangle gas_0 & inter_0 \end{bmatrix}$$

and

$$d_i^{exp} = \begin{bmatrix} c_0 & \triangle gas_0 & 0 \end{bmatrix}.$$

The s-period impulse responses are then calculated by estimating a reduced form regression,

$$c_t = \alpha + \sum_{i=1}^{k} \phi_i I_{t-i} + \sum_{i=1}^{k} \theta_i \triangle y_{t-i} + \sum_{i=1}^{k} \beta_i c_{t-i} + \sum_{i=1}^{k} \gamma_i \triangle gas_{t-i} + \sum_{i=1}^{k} \delta_i inter_{t-i} + \varepsilon_t \tag{3}$$

for $s = 0, 1, \ldots .5$. The response for both regimes is calculated using the following,

$$\hat{IR}_s^{rec} = \Phi_s d_i^{rec} = \hat{\beta}_s c_0 + \hat{\gamma}_s \triangle gas_0 + \hat{\delta}_s inter_0$$

and

$$\hat{IR}_s^{exp} = \Phi_s d_i^{exp} = \hat{\beta}_s c_0 + \hat{\gamma}_s \triangle gas_0,$$

where

$$\Phi_s = \begin{bmatrix} \hat{\beta}_s & \hat{\gamma}_s & \hat{\delta}_s \end{bmatrix}.$$

Once we construct the impulse responses for both regimes, we can calculate the cumulative impulse response functions. The rationale to use cumulative impulse responses is that it allows us to calculate the deviation of consumption from its' long-run level.

$$CIR_s^{rec} = \sum_{j=0}^{s} \widehat{IR}_j^{rec}$$

$$CIR_s^{exp} = \sum_{j=0}^{s} \widehat{IR}_j^{exp}$$

for $j = 0, 1 \ldots 5$.

In order to calculate the asymmetric response of c_t to gasoline expenditure shocks, we take the difference between the impulse responses across recessions and expansions.

$$CIR_s^{rec} - CIR_s^{exp} = \sum_{j=0}^{s} \widehat{IR}_j^{rec} - \sum_{j=0}^{s} \widehat{IR}_j^{exp}$$

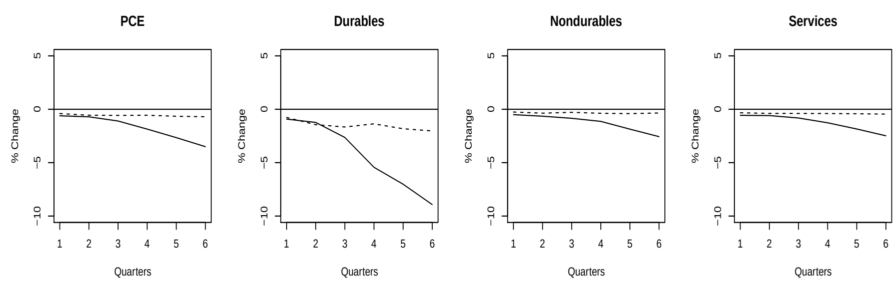
$$\triangle CIR_s = \sum_{j=0}^{s} \widehat{IR}_j^{rec} - \sum_{j=0}^{s} \widehat{IR}_j^{exp}$$

If $\triangle CIR_s < 0$, this means the response of consumption, c_t is stronger in a recession as compared to an expansion. $\triangle CIR_s > 0$ suggests the opposite. We present impulse responses constructed at the 95% confidence interval. Standard errors are calculated using the Newey-West correction method because successive leading of the dependent variable induces serial correlation in the error term (Equiza-Goñi and Gracia, 2018; Ramey and Zubairy, 2018). The covariance matrices are calculated by estimating the full system of equations using seemingly unrelated regression model. That is being followed by pulling out relevant terms. If zero lies within the 95% confidence intervals, that suggests the difference in response is not statistically significant.

3.2. Results

Table 4 in the appendix presents the contemporaneous responses of consumption and its categories to a 10% increase in gasoline expenditures across recessions and expansions. Results suggest a difference in the initial response of consumption across all sectors, with the response of consumption stronger in recessions as opposed to expansions. Figure 5 represents the cumulative response of consumption series following a 10% increase in gasoline expenditures. Total consumption expenditures decrease by 2.66% across the same time period in recessions. On the other hand, in expansions, the response of total consumption after a year is around -0.66%. Durables PCE decreases by almost 7% at the end of the year in recessions, whereas the response to the same shock in expansions is -1.82%. The cumulative change in nondurables during recessions is -1.86%, while the response to a shock of the same magnitude in expansions is -0.41%. Services sector loses out by 0.55% in recessions and by 0.35% in expansions.

Figure 5: Response of Consumption Series in Recessions & Expansions



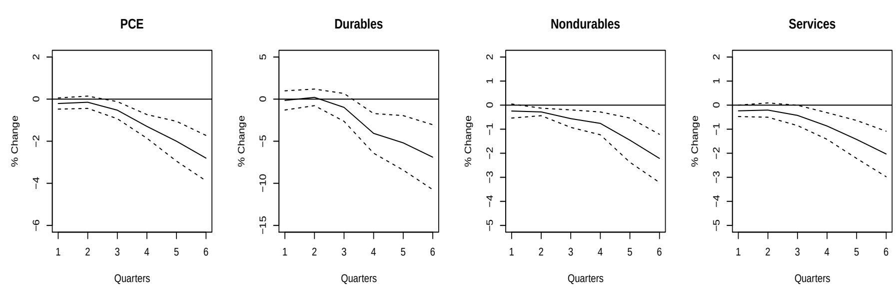
Notes: Solid line indicates the cumulative response of consumption series to a 10% increase in gasoline expenditures in recessions, while the corresponding dashed line is the cumulative response in expansions.

Figure 13-15 represent the response of different consumption categories to a gasoline expenditure shock. As gasoline expenditures increase by 10%, motor PCE drops by around 12% in recessions and by 2.93% in expansions across the same time period. The decline in furnishing goods expenditure is around 5.07% in recessions and 1.05% in expansions. The furnishing category includes spending on furniture and major household appliances. Expenditure on other durable goods category decreases by 3.71% after a year in a recessionary regime. In an expansion, the cumulative impact is -0.68%. Other durable goods category consists of spending on items like jewelery, watches and telephones. In the nondurable goods category, clothing PCE decreases by 3.10% in recessions and by 0.59% in expansions. Food PCE sees a marginal increase of 0.02% in expansions and a drop of -0.66% in recessions. Other nondurables PCE also takes a hit in response to gasoline expenditures increasing. This category includes spending on household supplies, medical products and tobacco which decreases by 3.01% in recessions and by 0.84% in expansions. Different components within the services sector also show a negative response across recessions and expansions with the effect being amplified in recessions.

3.3. Asymmetric Response

Following a gasoline expenditure shock, total non-gasoline PCE shows a difference in response of -2% in the long run. This suggests that consumption drops by 2 percentage points more in recessions as opposed to expansions over the course of a year. The difference in response is statistically significant since zero lies outside the confidence bands constructed at the 95% level. Durables show a statistically significant asymmetry with the difference in response of -6.89% across both regimes. Nondurables PCE also shows statistically significant asymmetry in the long run, with the difference in response of -2.17%. Services PCE drops by 2 percentage points more in recessions as opposed to expansions.

Figure 6: Difference in Response Across Regimes



Notes: Solid line indicates the difference in response across recessions and expansions, while the corresponding dashed lines are the 95% confidence intervals. Negative value implies that the response in recessions is stronger than the response in expansions.

In dollar terms, a \$200 increase in gasoline expenditures for any year reduces total non-gasoline spending for an average household by \$1,545 in recessions and \$383 in expansions over the same time period. Durables lose out by \$530 in recessions as opposed to \$137 in expansions, nondurables \$249 in recessions and \$55 in expansions while services spending declines by \$689 in recessions and \$156 in expansions.

The motor vehicles sector is responsible for driving a big proportion of the response. Spending on motor vehicles goes down by \$345 per household in recessions as opposed to \$85 in expansions over the course of a year. There are various reasons for this large drop in consumer spending on motor vehicles. First, is what Kilian and Edelstein (2009) call the *uncertainty effect*. Consumers postpone their purchases because motor vehicles represent big-ticket items and will only be bought when they are confident that they can afford them. Second, credit constraints and uncertainty during recessions forces consumers to reduce spending on consumer durables more aggressively. Other categories of consumption also show statistically significant asymmetry.

We do not see a one-to one relationship between gasoline expenditures and non-gasoline spending. The decrease in non-gasoline spending is larger than the increase in gasoline expenditures. Kilian & Edelstein (2009) argue that an increase in energy prices forces consumers to increase their precautionary savings.[19] We estimate the nonlinear model with personal savings rate[20] as the dependent variable to investigate whether consumers save more during recessions as opposed to expansions following a shock to gasoline expenditures. The estimates from our model suggest that a 10% increase in gasoline expenditures over the course of a year increases the savings rate by 0.54% in recessions as opposed to 0.08% in expansions. In dollar terms, a \$200 increase in gasoline expenditures over the course of a year increases private savings for an average household by \$398 in recessions as opposed to \$60

[19] Kilian & Edelstein (2009): "When purchase decisions are reversible, consumption may fall in response to energy price shocks, as consumers increase their precautionary savings. This response will arise if consumers smooth their consumption because they perceive a greater likelihood of future unemployment and hence future income losses."

[20] Personal savings rate is defined as the proportion of household income that is used to provide funds to capital markets or to invest in real assets.

in expansions.[21] This suggests that as gasoline expenditures increase, households increase their savings because they perceive a higher chance of future income losses, with the response of savings being stronger in recessions. As gasoline expenditures increase, households increase savings by more in recessions as opposed to expansions and the resulting drop in consumption is higher.

3.4. Response of Gasoline Expenditures to Own Shock

Figure 16 shows the response of gasoline expenditures to its own shock in recessions and expansions. Following the initial increase of 10%, gasoline expenditures decrease in recessions and increase in expansions. This suggests that there is evidence of asymmetry in the response of gasoline expenditures to own shock which then feeds through to create asymmetry in the responses of consumption as well. Table 2 compares the response of gasoline expenditures and personal savings rate to a 10% increase in gasoline expenditures. In recessions, gasoline expenditures increase by 2.98% one quarter after the shock. This increase is due to the inelastic nature of gasoline expenditures in the short run. However, two quarters after the shock consumers reduce spending on gasoline goods and services in recessions, which frees up a portion of their income and consequently increases savings as evident from Table 2.

Table 2: Point Estimates

t	0	1	2	3	4
Gasoline Prices	12%	3.78%	-4.64%	-2.03%	-2.47%
Gasoline Expenditures	10%	2.98%	-3.97%	-2.47%	-1.66%
Savings Rate	-0.04%	-0.29%	0.06%	0.20%	0.26%

Notes: This table represents the response of the real gasoline price, gasoline expenditure series and personal savings rate to an increase in gasoline expenditure in recessions.

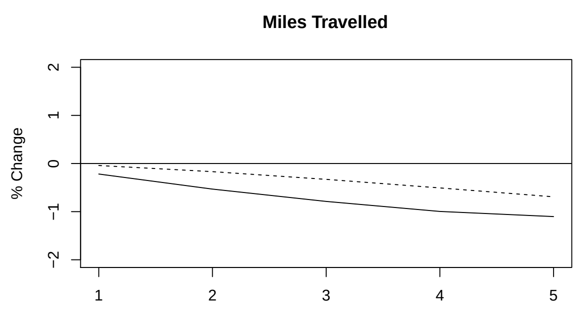
To help us understand why the response of gasoline expenditures to its own shock varies across the state of the economy, we look at the responses of gasoline consumption by sectors

[21] Based on the average savings rate across our sample, consumers saved $5,929 during 2017. Savings increase to $6232 in recessions and $6033 during expansions over the course of a year.

and the real price of gasoline. Data on gasoline consumption series by sector was downloaded from the Energy Information Administration website. The real price of gasoline was calculated by obtaining the average gasoline price/gallon across all cities in the U.S. (APU000074714),[22] and deflating it with U.S. CPI. We then estimate the nonlinear model with gasoline consumption series and the real price of gasoline as dependent variables. Impulse responses in Figure 15 suggest that the real price of gasoline and gasoline expenditures respond similarly to a 10% increase in gasoline expenditures across recessions and expansions.

As gasoline expenditures increase by 10%, gasoline consumed by the transportation sector is 1.02% less than its original level in recessions as opposed to 0.56% in expansions across the same time period. We also estimate the response of total miles traveled to gasoline expenditure increases between recessions and expansions. Data on miles traveled was downloaded from the Travel Volume Trends released by the U.S. Federal Highway Administration. Estimation of the nonlinear model with total miles traveled as our dependent variable suggests a decrease of 1.10% in recessions as opposed to 0.69% in expansions. As the cost of operating vehicles increases, traffic volume goes down with the impact being amplified during recessions.

Figure 7: Response of Miles Traveled



Notes: Solid line indicates the cumulative response to a 10% increase in gasoline expenditures during recessions. The corresponding dashed line is the cumulative response in expansions.

As gasoline expenditures increase by 10%, residential consumption of gasoline increases

[22]This series was downloaded from the Bureau of Labor Statistics database.

by 1.94% in expansions while it decreases by 0.47% in recessions during the same time period. The asymmetric response of gasoline expenditure to its own shock is explained by how gasoline consumption responds between recessions and expansions. The increased demand for gasoline by the residential sector drives up the price of gasoline which then feeds into higher gasoline expenditures in expansions. On the other hand, the drop in gasoline consumption by the residential and transportation sectors in recessions puts a downward pressure on gasoline prices and reduces gasoline expenditures.

4. Forecasting Implications

Since the U.S. was an oil-importer throughout the course of our sample period, higher gasoline expenditures caused a transfer of U.S. income to foreign oil producers. This reduction in disposable income lead to the depression of non-gasoline consumption, which is evident from the results of our linear VAR model. This paper find that the effect of a gasoline expenditure shock on U.S. consumption depends on the state of the economy, with the effect pronounced in recessions.

The analysis, thus emphasizes the need for the Federal Reserve to consider asymmetries in the impact of gasoline expenditure shocks across recessions and expansions when it is forecasting consumption or other macro variables, as failure to do so might result in misleading conclusions about the effect of gasoline expenditures shock on the U.S. economy. To make this point, we present forecasts of our consumption variables following a 10% increase in gasoline expenditures using a model that accounts for asymmetries (nonlinear), and a model that doesn't (linear). The nonlinear model is,

$$\hat{c}_T^{NL} = \alpha + \sum_{i=0}^{k} \phi_i I_{T-i} + \sum_{i=0}^{k} \theta_i \triangle y_{T-i} + \sum_{i=1}^{k} \beta_i c_{T-i} + \sum_{i=0}^{k} \gamma_i \triangle gas_{T-i} + \sum_{i=0}^{k} \delta_i inter_{T-i} + \varepsilon_t$$

whereas the linear model is,

$$\hat{c}_T^L = \alpha + \sum_{i=0}^{k} \theta_i \triangle y_{T-i} + \sum_{i=1}^{k} \beta_i c_{T-i} + \sum_{i=0}^{k} \gamma_i \triangle gas_{T-i} + \varepsilon_t$$

$\hat{c}_T^{NL}$represents the forecasts of consumption from the nonlinear model whereas $\hat{c}_T^L$ represents the forecasts from the linear model. The shock under consideration is a 10% increase in gasoline expenditures so $\Delta gas_T = 10\%$, while values for other variables are taken from the data. We compute the difference in forecasts from both models and define $\hat{d}_t^F$in the following manner,

$$\hat{d}_t^F = \hat{c}_T^{NL} - \hat{c}_T^L$$

If $\hat{d}_t^F < 0$, this suggests that the linear forecasting model is underestimating the effect of a gasoline expenditure shock on our measures of consumption. $\hat{d}_t^F > 0$ suggests the opposite, whereas $\hat{d}_t^F = 0$ indicates that forecasts from both models are the same.

The upper columns in Figures 17-20 at the end of the paper represent the forecasts of our consumption variables using the linear and nonlinear models. The difference between nonlinear and linear forecasts is represented in the lower columns, with a negative value indicating that the effect of gasoline expenditure shocks on consumption is underestimated using the linear model. The red dashed line in Figure 17 represents the forecasts of non-gasoline consumption following a 10% increase in gasoline expenditures using the linear model, whereas the corresponding solid blue line represents the forecasts to the same shock using the nonlinear model.

Lets consider the example of 1979 Q4, our linear model forecast suggests that non-gasoline consumption is expected to increase by 0.10% following a 10% increase in gasoline expenditures. On the other hand, the nonlinear forecast suggests that non-gasoline consumption is expected to decrease by 0.4% in the same quarter. Forecasts with the linear model are underestimating the effect of a gasoline expenditure shock on non-gasoline consumption by around 0.5% during the last quarter of 1979. This pattern can be seen throughout our entire sample period with the difference in forecasts being negative, especially during recessions which is represented by the shaded areas. Because the linear model is nested in the nonlinear model, the forecasts for both models are usually the same when the economy is going through an an expansion since both the recession dummy I_T and interaction term $inter_T = 0$. Referring to Figure 19, the linear model is forecasting spending on nondurables to increase by around 0.2%, and decrease by 0.6% based on the nonlinear model forecasts during 1990 Q2. This suggests that the linear model is underestimating the effect of a gasoline expenditure shock on nondurables consumption by a magnitude of 0.8%. A similar difference in forecasts can be seen for other consumption categories, i.e. durables, and services throughout the entire sample period.

5. Robustness Analysis

This section explores the robustness of our results to alternative specification choices.

5.1. Alternative Measure of Recession

Different measures of recessions have been proposed in the literature. Ramey and Zubairy (2018), Owyang et. al (2013) use unemployment rate to define the state of the economy and use 6.5 as the threshold. Other measures include NBER recession dates, capacity utilization and output gap. Hamilton argues that instead of relying on the NBER's subjective judgment of the committee members for recessions, it would be a better idea to estimate recession probabilities using the data.[23] Since this proposed definition of recessions by Hamilton is entirely mechanical, we rely on it as an alternative measure to the Auerbach and Gorodnichenko (2012) recession dates. Hamilton's measure corresponds to the probability that

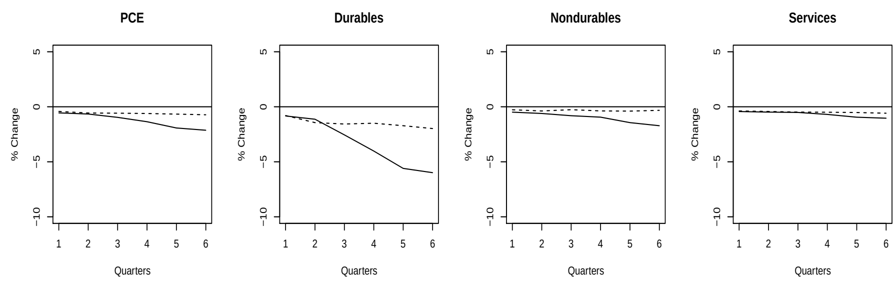
[23]See Chauvet and Hamilton (2005) for further information on the advantages of using formal quantitative algorithms to identify business cycle turning points. They introduce a measure for dating business cycle turning points namely "quarterly real-time GDP-based recession probability index". This index denotes the probability of recession if all we observe is one quarter's GDP growth as a function of the observed rate of GDP. Their findings are consistent in simulation with real-time databases.

the underlying true economic regime is one of recession based on the available data. It is calculated in the following manner,

$$P(Recession|GDP) = \frac{P(Recession \bigcap GDP)}{P(GDP)}$$

This equation gives us the conditional probability of the economy being in a recession given the value for GDP growth is observed. The numerator gives the joint probability of observing GDP growth and the occurrence of a recession, whereas the denominator measures the probability of observing the value of GDP growth.[24]

Figure 8: Response of Consumption Series in Recessions & Expansions



Notes: Solid line indicates the cumulative response of consumption series to a 10% increase in gasoline expenditures in recessions, while the corresponding dashed line is the cumulative response in expansions.

Our results in Figure 8 suggest that changing the definition of recession does not alter the results. The response of consumption is stronger in recessions as opposed to expansions, with this effect seen throughout the durables, nondurables and services sector.

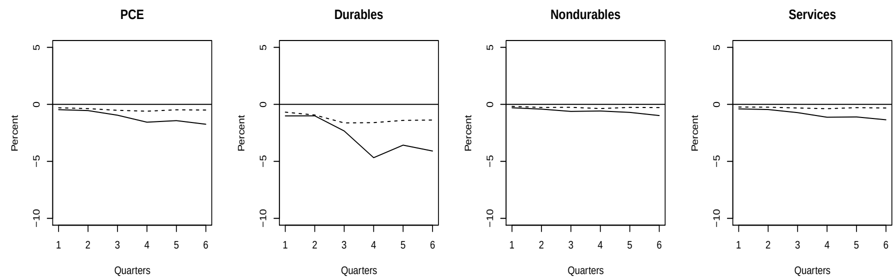
5.2. Real Price of Gasoline

We use gasoline prices as an alternative measure of shock to make sure that our interpretation of the structural shock to gasoline expenditures is accurate. Variation in gasoline expenditures could be caused by fluctuations in the price of gasoline, changes in vehicle fuel efficiency, changes in the stock of vehicles resulting from changes in preferences for larger or

[24]For more details, see https://econbrowser.com/recession-index

smaller vehicles, changes in travel patterns as witnessed in the aftermath of the 9/11 terrorist attacks, and changes in commuting behavior as a response to fluctuations in house prices.

Figure 9: Response of Consumption Series in Recessions & Expansions



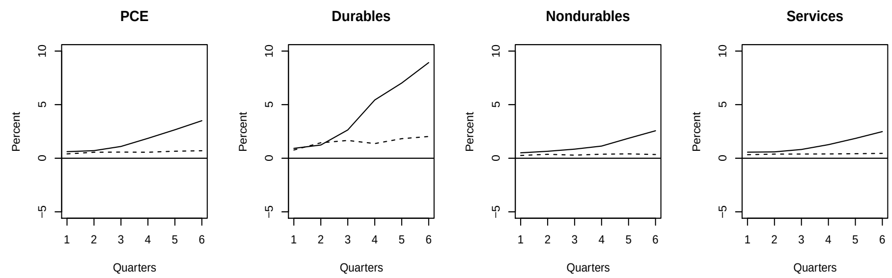
Notes: Solid line indicates the cumulative response of consumption series to a 10% increase in the real price of gasoline in recessions, while the corresponding dashed line is the cumulative response in expansions.

A 10% increase in the price of gasoline over the course of a year that leads to an increase of \$110 in gasoline expenditures across the same time period in recessions, will lead to a decline in total consumption spending by \$831. Spending on durables, nondurables and services declines by \$270, \$95 and \$409 in recessions respectively. On the other hand, a 10% increase in the price of gasoline over the course of a year that increases gasoline expenditures by \$141 during the same time period in expansions, will reduce total consumption by \$279. The drop in expansions for durables is \$27, nondurables is \$36 and services is \$108. Consistent with the asymmetric responses of consumption, the effect of a gasoline expenditures shock is stronger in recessions as opposed to expansions.

6. Positive versus Negative Shocks

We also examine whether positive and negative shocks affect consumption differently. Figure 10 indicates the response of consumption to a 10% decrease in gasoline spending. A portion of household's income frees up when gasoline expenditures decrease. As a result, discretionary income increases since consumers now have more to spend on non-gasoline goods and services. A 10% decrease in gasoline expenditures increases non-gasoline consumption by 2.66% in recessions and 0.65% in expansions. This suggests that unanticipated decreases in gasoline expenditures are more effective in boosting consumption during recessions. Households tend to consume more of the extra income generated during recessions as opposed to expansions.

Figure 10: Response of Consumption Series in Recessions & Expansions



Notes: Solid line indicates the cumulative response of consumption series to a 10% decrease in gasoline expenditures in recessions, while the corresponding dashed line is the cumulative response in expansions.

Since the U.S. was an oil-importing country in every month from January 1973 to May 2019 (refer to Figure 2), gasoline expenditure declines have large and positive effects on consumption.[25] As oil prices decrease, wealth is transferred away from oil-exporting to oil-importing countries (Iacoviello, 2016). This result is also in line with the empirical work on the effects of fiscal policy on consumption in recessions and expansions. Tagkalakis (2008) presents evidence that unanticipated tax cuts are more potent in boosting consumption during recessions.

7. Conclusion

The inelastic demand for gasoline in the short run translates higher gasoline prices into higher gasoline expenditures which causes a shift in consumption fron non-gasoline to gasoline goods. Since the U.S. was a net importer of crude oil from January 1973 through May 2019, increases in gasoline expenditures cause a transfer of U.S. income to foreign oil producers. Thus, higher gasoline expenditures have the same effect as a tax on the U.S. economy, and should be expected to reduce aggregate consumption. The motivation for our analysis comes from the literature showing that the impact of fiscal policy depends on the state of

[25]See Iacoviello (2016) working paper https://www2.bc.edu/matteo-iacoviello/research_files/OPAC.pdf

the economy. This paper investigates the following, i) what happens to consumption when gasoline expenditures increase, ii) does the response of consumption to gasoline expenditures shock depend on the state of the economy, and iii) why does the response of consumption to gasoline expenditures shock differ across the state of the economy?

We present evidence that higher gasoline expenditures reduce spending on non-gasoline goods and services considerably. Empirical results suggest that when gasoline spending increases by approximately $200 (10% increase in gasoline expenditures) over the course of a year, an average household will have to cut down spending on non-gasoline goods and services by $389 during the same time period. This response is primarily driven by the durables and services sector. Our estimation of the nonlinear model suggests the presence of an asymmetric response of consumption to gasoline expenditures between states of the economy. Gasoline expenditure shocks have a stronger effect on non-gasoline consumption in recessions as opposed to expansions. The asymmetry in the response of consumption over the business cycle is driven by the difference in household savings behavior in recessions versus expansions. Our central estimates are robust to alternate measures of recession and shock as well. We also explore the response of consumption to gasoline expenditure decreases. Our estimates suggest that gasoline expenditure decreases are more effective in boosting private consumption during recessions. Households consume the extra income generated following unanticipated decreases in gasoline expenditures.

Our paper provides evidence that shocks to gasoline expenditures have the same effect as a change in taxes, and if fiscal policy has different effects in recessions and expansions, it follows that the effect of a gasoline expenditure shock should also depend on the state of the business cycle. A finding of economically meaningful nonlinearity of this type requires a change to empirical and theoretical macroeconomic models that include energy prices. The analysis, thus emphasizes the need for the Federal Reserve to consider asymmetries in the impact of gasoline expenditure shocks across recessions and expansions when it is forecasting consumption or other macro variables, as failure to do so might result in misleading conclusions about the effect of gasoline expenditures shock on the U.S. economy. We present forecasts from both linear and nonlinear models, and find that the linear model might underestimate the effect of a gasoline expenditure shock on consumption which is why it is imperative for the Federal Reserve's forecasting models to account for this kind of asymmetry.

References

[1] Auerbach, Alan, and Yuriy Gorodnichenko (2012). “Measuring the Output Responses to Fiscal Policy,” *American Economic Journal: Economic Policy*, 1–27.

[2] Auerbach, Alan, and Yuriy Gorodnichenko (2013). "Output Spillovers from Fiscal Policy," *American Economic Review*, 103(3), 141-46.

[3] Bernanke, Ben S. (1983) “Irreversibility, Uncertainty, and Cyclical Investments,” *The Quarterly Journal of Economics*, 97(1), 85-106.

[4] Dickey, D. and W. Fuller (1979) “Distribution of the Estimators for Autoregressive Time Series With a Unit Root,” *Journal of the American Statistical Association,* 74(366), 427-431.

[5] Edelstein, Paul, and Lutz Kilian (2009) “How Sensitive Are Consumer Expenditures to Retail Energy Prices?” *Journal of Monetary Economics,* 56(6), 766–79.

[6] Elliott, G., T. Nuremberg, and J. Stock (1996) “Efficient Tests for an Auto regressive Unit Root,” *Econometrica,* 64(4), 813-836.

[7] Equiza-Goñi, Juan, and Fernando Perez De Gracia (2018) “Impact of State-Dependent Oil Price on U.S. Stock Returns Using Local Projections,” *Applied Economics Letters,* 26(11), 919–26.

[10] Farrell, Diana, and Fiona Greig (2015) "How Falling Gas Prices Fuel the Consumer: Evidence from 25 Million People," *J.P. Morgan Chase Institute*, https://www.jpmorganchase.com/ corporate/institute/report-how-falling-gas-prices-fuel-the-economy.htm.

[8] Fazzari, Steven M., James Morley, and Irina Panovska (2015) “State-Dependent Effects of Fiscal Policy,” *Studies Nonlinear Dynamics and Econometrics,* 19(3), 285–315.

[9] Gelman, Michael, Yuriy Gorodnichenko, Shachar Kariv, Dmitri Koustas, Matthew D Shapiro, Dan Silverman, and Steven Tadelis (2016) “The Response of Consumer Spending to Changes in Gasoline Prices,” *NBER Working Paper Series:22969.*

[10] Gicheva, Dora, Justine Hastings, and Sofia Villas-Boas (2010) “Investigating Income Effects in Scanner Data: Do Gasoline Prices Affect Grocery Purchases?” *American Economic Review: Papers & Proceedings, 100: 480-484.*

[11] Hamilton, James, and Marcelle Chauvet (2006) "Dating Business Cycle Turning Points," *Nonlinear Time Series Analysis of Business Cycles*, 1-54.

[12] Hamilton, James D. (1983) “Oil and the Macroeconomy Since World War II,” *Journal of Political Economy,* 91(2), 228–48.

[13] Hamilton, James D. (1988) "A Neoclassical Model of Unemployment and the Business Cycle," *Journal of Political Economy,* 96, 593-617.

[14] Hamilton, James D. (2003) "What is an Oil Price Shock?" *Journal of Econometrics*, 113(2), 363-398.

[15] Hamilton, James D. (2009). "Oil and the Macroeconomy," *The New Palgrave Dictionary of Economics*, 1–7.

[16] Hamilton, James D. (2016). Comment on "Lower Oil Prices and the U.S. Economy: Is This Time Different?" *Brookings Paper on Economic Activity*, 337-343.

[17] Herrera, Ana María, Mohamad B.Karaki, and Sandeep Kumar Rangaraju (2019) "Oil price shocks and U.S. economic activity," *Energy Policy,* 129, 89-99.

[18] Jorda, Oscar. (2005) "Estimation and Inference of Impulse Responses by Local Projections," *American Economic Review,* 95(1), 161–82.

[19] Jorda, Oscar, and Alan Taylor (2015) "The Time for Austerity: Estimating the Average Treatment Effect of Fiscal Policy" *The Economic Journal,* 126(2), 219-55.

[20] Kilian, Lutz (2009) "Not All Oil Price Shocks Are Alike: Disentangling Demand and Supply Shocks in the Crude Oil Market," *American Economic Review,* 99(3), 1053–69.

[21] Kilian, Lutz, and Clara Vega (2011) "Do Energy Prices Respond to U.S. Macroeconomic News? A Test of the Hypothesis of Predetermined Energy Prices," *Review of Economics and Statistics*, 93(2), 660-671.

[22] Kilian, Lutz and Christiane Baumeister (2016) "Lower Oil Prices and the U.S. Economy: Is This Time Different?" *Brookings Paper on Economic Activity*, 287-336.

[23] Kilian, Lutz, Christiane Baumeister, and Xiaoqing Zhou (2018) "Is the Discretionary Income Effect of Oil Price Shocks a Hoax?" *Energy Journal*, 39, 117-137.

[24] Li, Shanjun, Christopher Timmins, and Roger H. von Haefen (2009) "How Do Gasoline Prices Affect Fleet Fuel Economy?" *American Economic Journal: Economic Policy*, 1(2): 113-37.

[25] Molloy, Raven, and Hui Shan (2013) "The Effect of Gasoline Prices on Household Location," *The Review of Economics & Statistics*, 95(4), pp. 1212-1221.

[26] Phillips, P., and P. Perron (1988) "Testing for Unit Root in Time Series Regression," Barometric, 75(2), 335-346.

[27] Pindyck, R.S. (1991) "Irreversibility, uncertainty and investment," *Journal of Economic Literature,* 29, 1110–1148.

[28] Ramey, V., and Sarah Zubairy (2018) "Government Spending Multipliers in Good Times and in Bad: Evidence from U.S. Historical Data," *Journal of Political Economy,* 126(2), 850-901.

[29] Tagkalakis, Athanasios (2008) "The Effects of Fiscal Policy on Consumption in Recessions and Expansions," *Journal of Public Economics* 92(5), 1486-508.

Table 3: Unit Root and Stationarity Tests

A. Tests for Variables in Levels

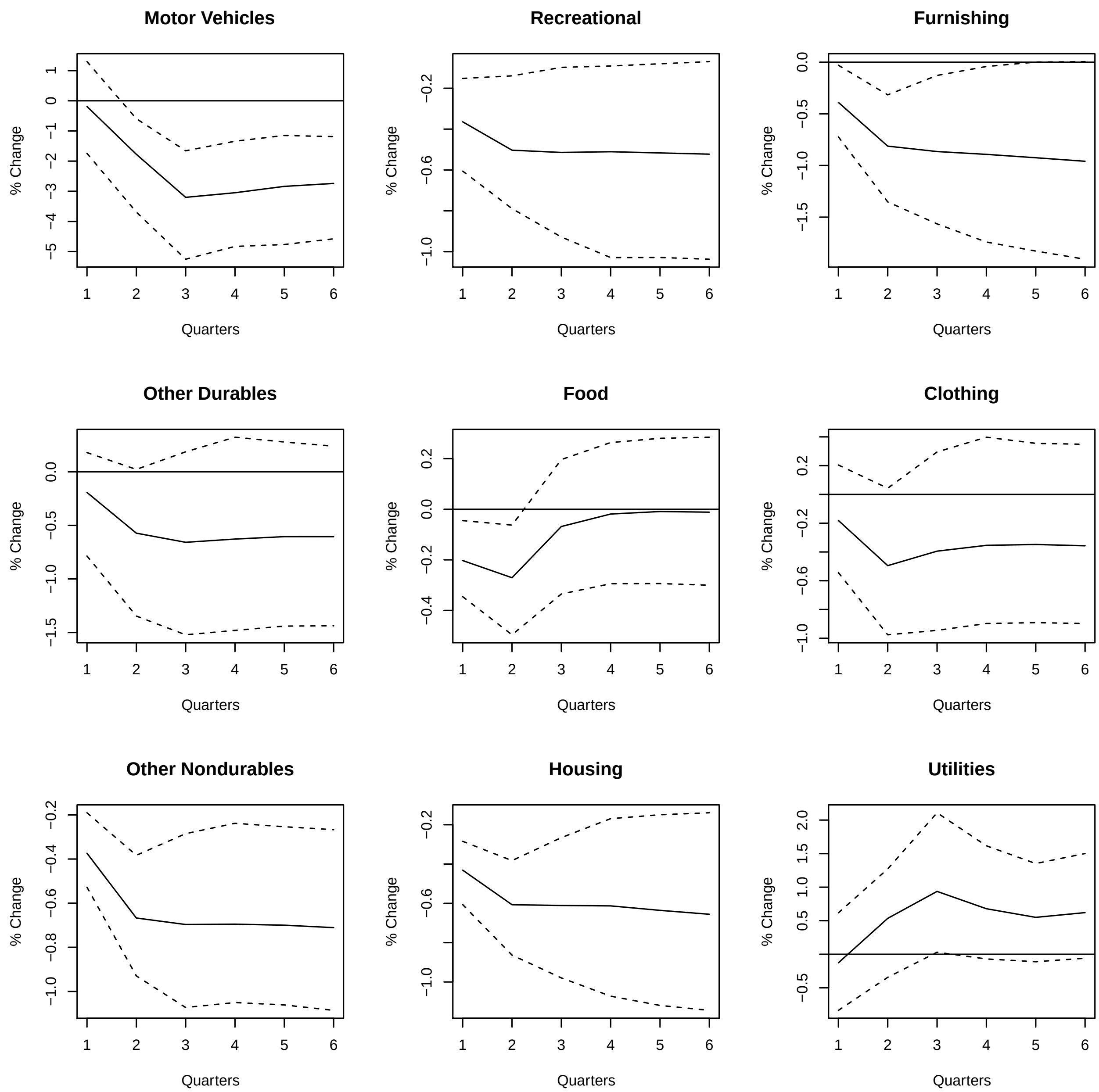
Variables	*ADF*	*ERS*	*PP*
PCE	-2.2491	-1.1359	-2.0918
Durables	-1.7479	-2.2510	-1.9288
Motor Vehicles	-1.9162	-2.1404	-2.1699
Furnishing	-1.8016	-2.5069	-1.6846
Other Durables	-2.2868	-2.0202	-2.2535
Nondurables	-1.8588	-1.2780	-1.7361
Food	-0.7110	-0.8757	-0.7486
Clothing	-1.4820	-2.0279	-1.6621
Gasoline	-2.7770	-2.1776	-2.4077
Other Nondurables	-2.3964	-0.9019	-2.2589
Services	-2.1087	-0.6554	-2.1506

B. Tests for Variables in Percentage Difference

Variables	*ADF*	*ERS*	*PP*
PCE	-6.2370	-3.9626	-10.3800
Durables	-8.2022	-3.4850	–13.8494
Motor Vehicles	-9.5612	-4.2604	-16.1017
Furnishing	-5.8940	-2.3034	-9.4246
Other Durables	-8.9879	-2.9123	-12.8551
Nondurables	-8.5289	-3.9772	-11.3639
Food	-7.9926	-3.9039	-13.2261
Clothing	-8.1043	-3.2376	-12.9987
Gasoline	-10.2514	-6.1760	-10.9401
Other Nondurables	-7.1876	-4.4654	-10.9716
Services	-6.5719	-4.6473	-9.5524

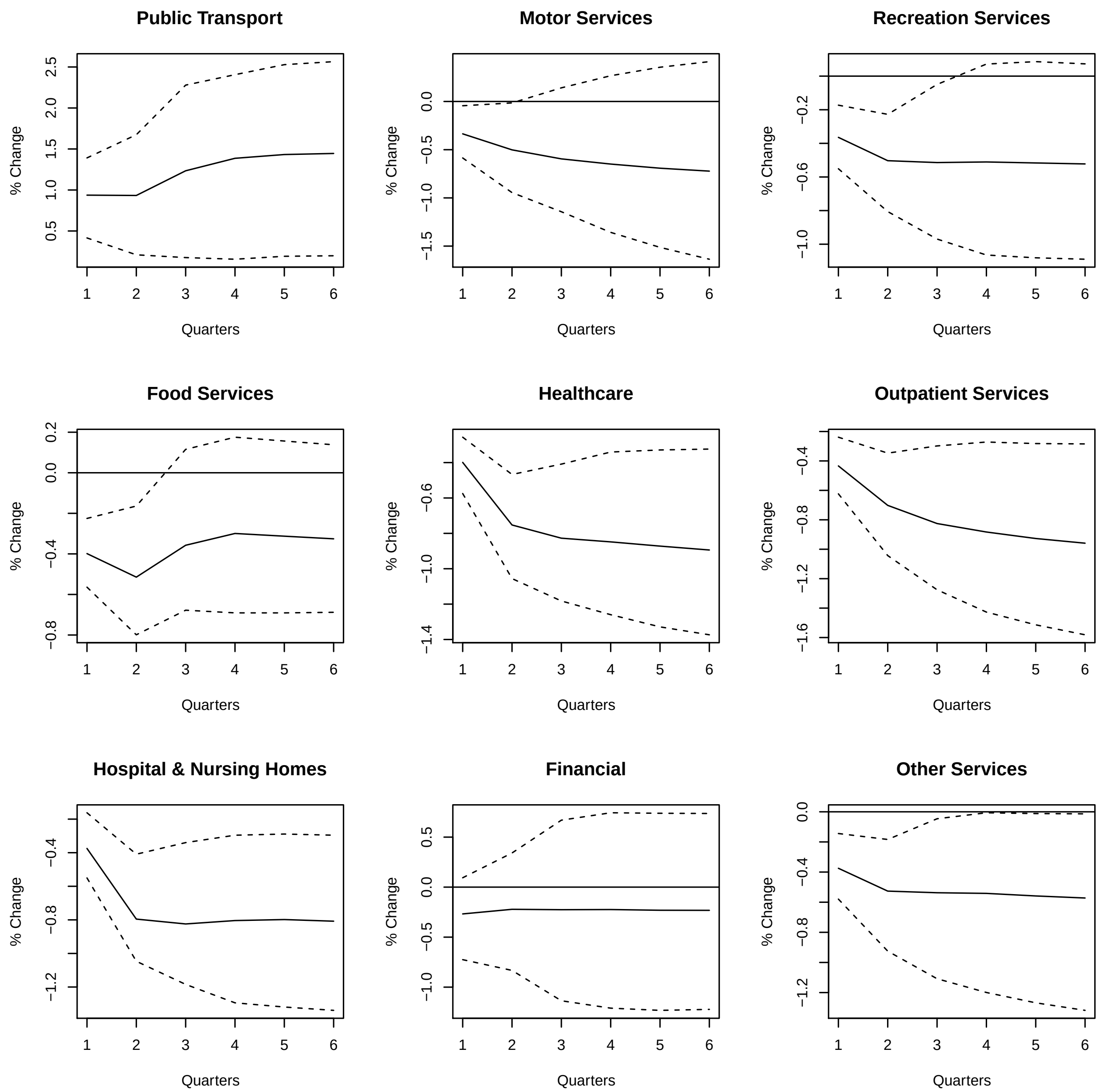
Notes: All tests include an intercept and a linear trend. 5% critical values for the respective tests are: -3.42, -2.89, -3.42.

Figure 11: Response of Consumption Series



Notes: Solid lines represent the cumulative responses to a 10% increase in gasoline expenditures, while the corresponding dashed lines are the 95% confidence intervals.

Figure 12: Response of Consumption Series

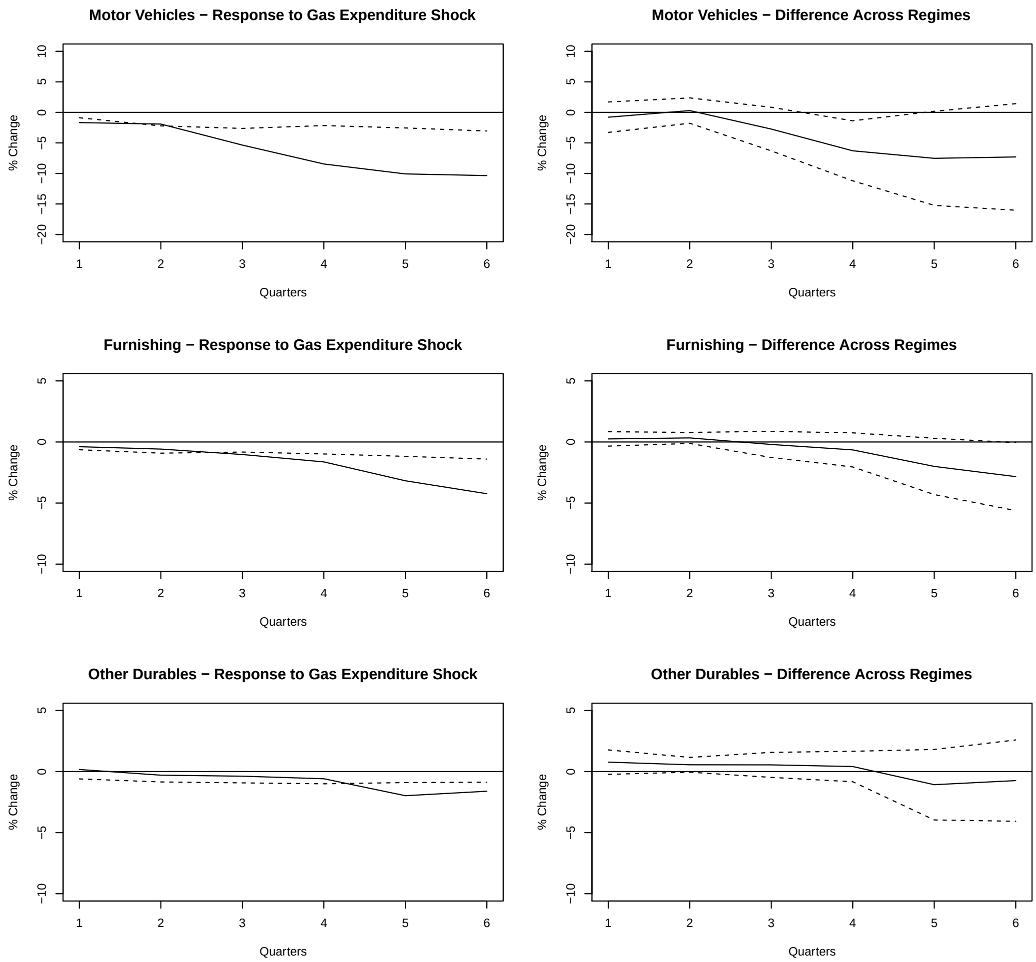


Notes: Solid lines represent the cumulative responses to a 10% increase in gasoline expenditures, while the corresponding dashed lines are the 95% confidence intervals.

Table 4: Contemporaneous Responses

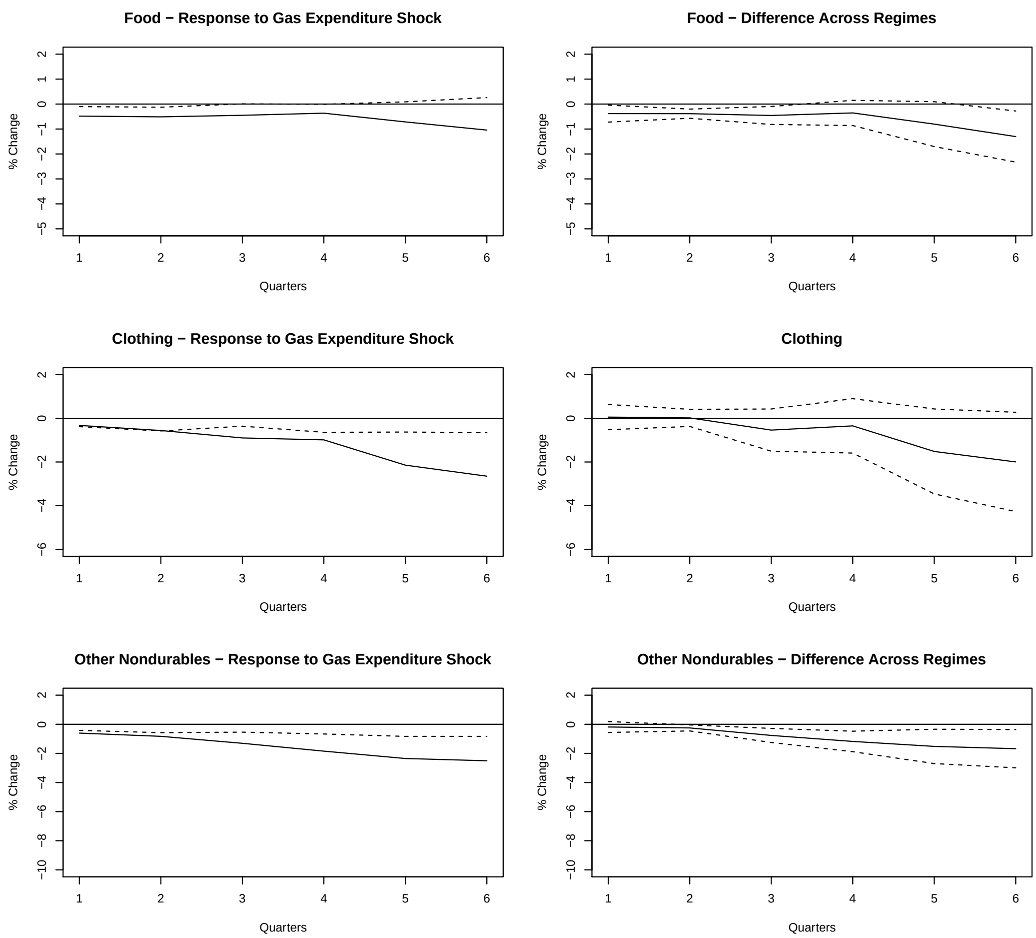
Variable	Recession	Expansion
PCE	-0.61%	-0.40%
Durables	-0.92%	-0.77%
Nondurables	-0.50%	-0.26%
Services	-0.57%	-0.33%
Motor Vehicles	-1.59%	-0.97%
Furnishing	-0.53%	-0.58%
Other Durables	-0.18%	-0.43%
Food	-0.46%	-0.09%
Clothing	-0.34%	-0.38%
Other Nondurables	-0.62%	-0.42%
Housing & Utilities	-0.59%	-0.35%
Transportation	-0.11%	0.00%
Other Services	-0.78%	-0.32%

Figure 13: Response of Consumption to Gasoline Expenditures Shock



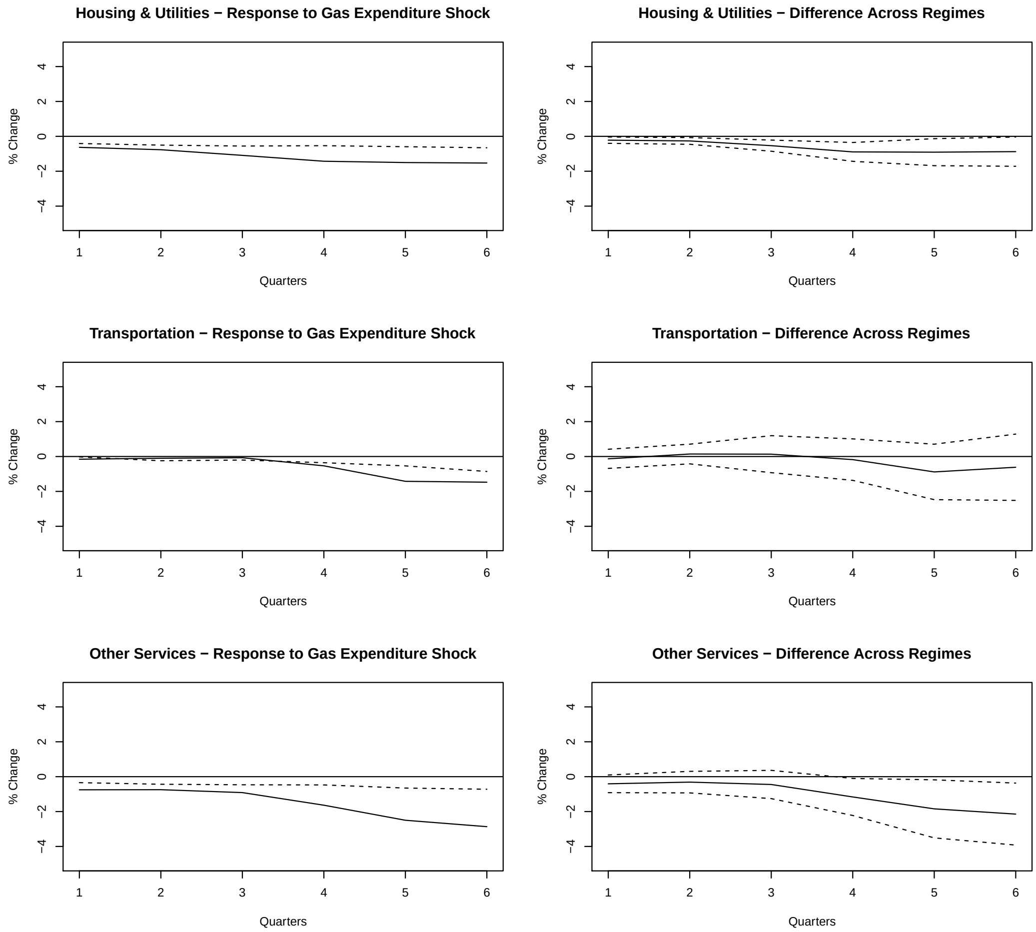
Notes: Solid line in the left column indicates the cumulative response to a 10% increase in gasoline expenditures during recessions while the corresponding dashed line is the cumulative response in expansions. Solid line in the right column indicates the difference in response across recessions and expansions, while the corresponding dashed lines are the 95% confidence intervals. Negative value implies that the response in recessions is stronger than the response in expansions.

Figure 14: Response of Consumption to Gasoline Expenditures Shock



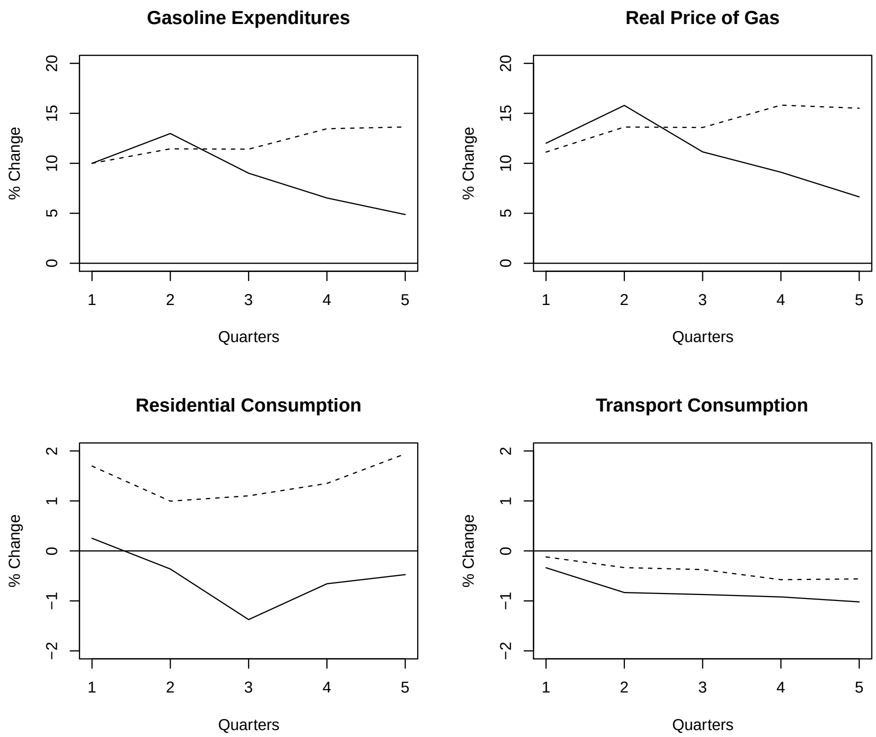
Notes: Solid line in the left column indicates the cumulative response to a 10% increase in gasoline expenditures during recessions while the corresponding dashed line is the cumulative response in expansions. Solid line in the right column indicates the difference in response across recessions and expansions, while the corresponding dashed lines are the 95% confidence intervals. Negative value implies that the response in recessions is stronger than the response in expansions.

Figure 15: Response of Consumption to Gasoline Expenditures Shock



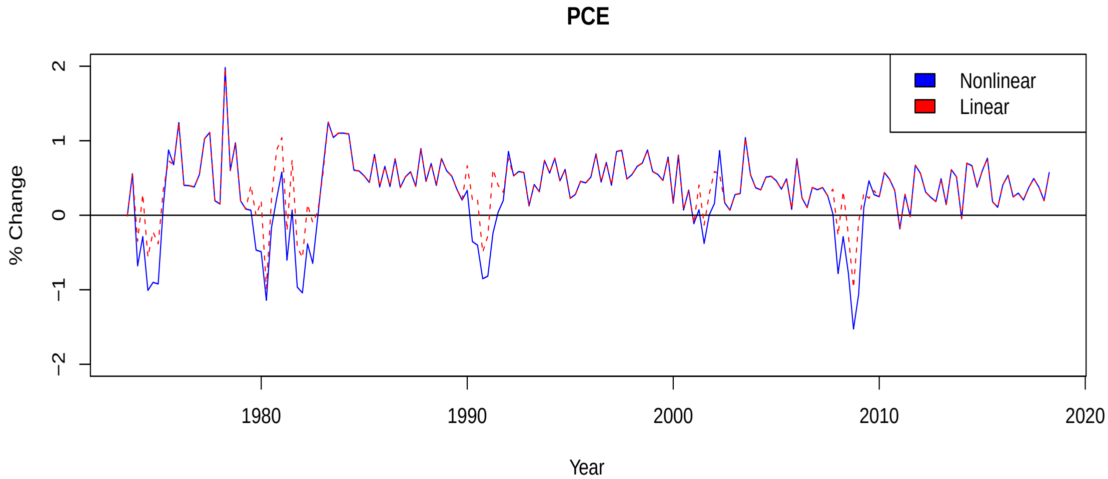
Notes: Solid line in the left column indicates the cumulative response to a 10% increase in gasoline expenditures during recessions while the corresponding dashed line is the cumulative response in expansions. Solid line in the right column indicates the difference in response across recessions and expansions, while the corresponding dashed lines are the 95% confidence intervals. Negative value implies that the response in recessions is stronger than the response in expansions.

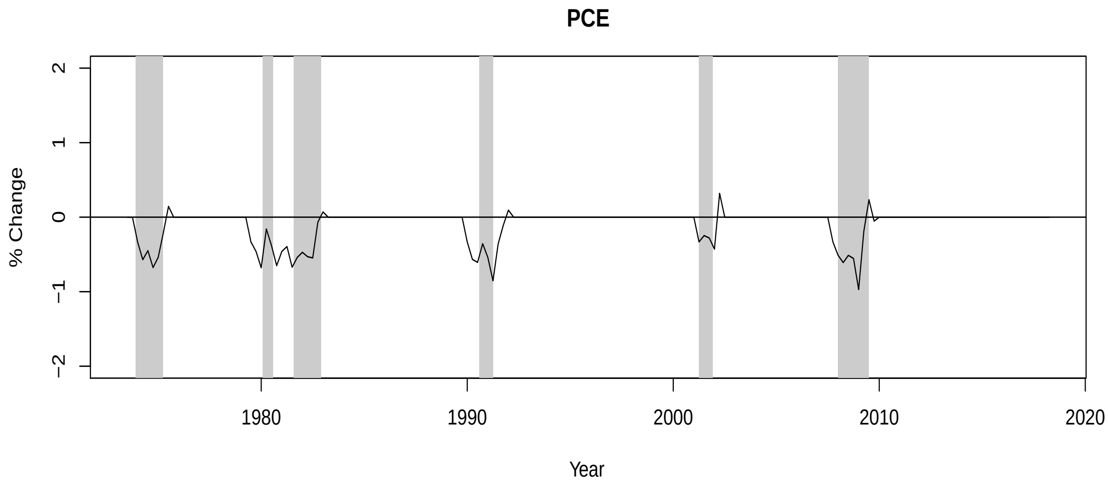
Figure 16: Response of Gasoline Expenditures and Gasoline Consumption



Notes: Solid line represents the cumulative response to a 10% increase in gasoline expenditures during recessions while the corresponding dashed line is the cumulative response in expansions.

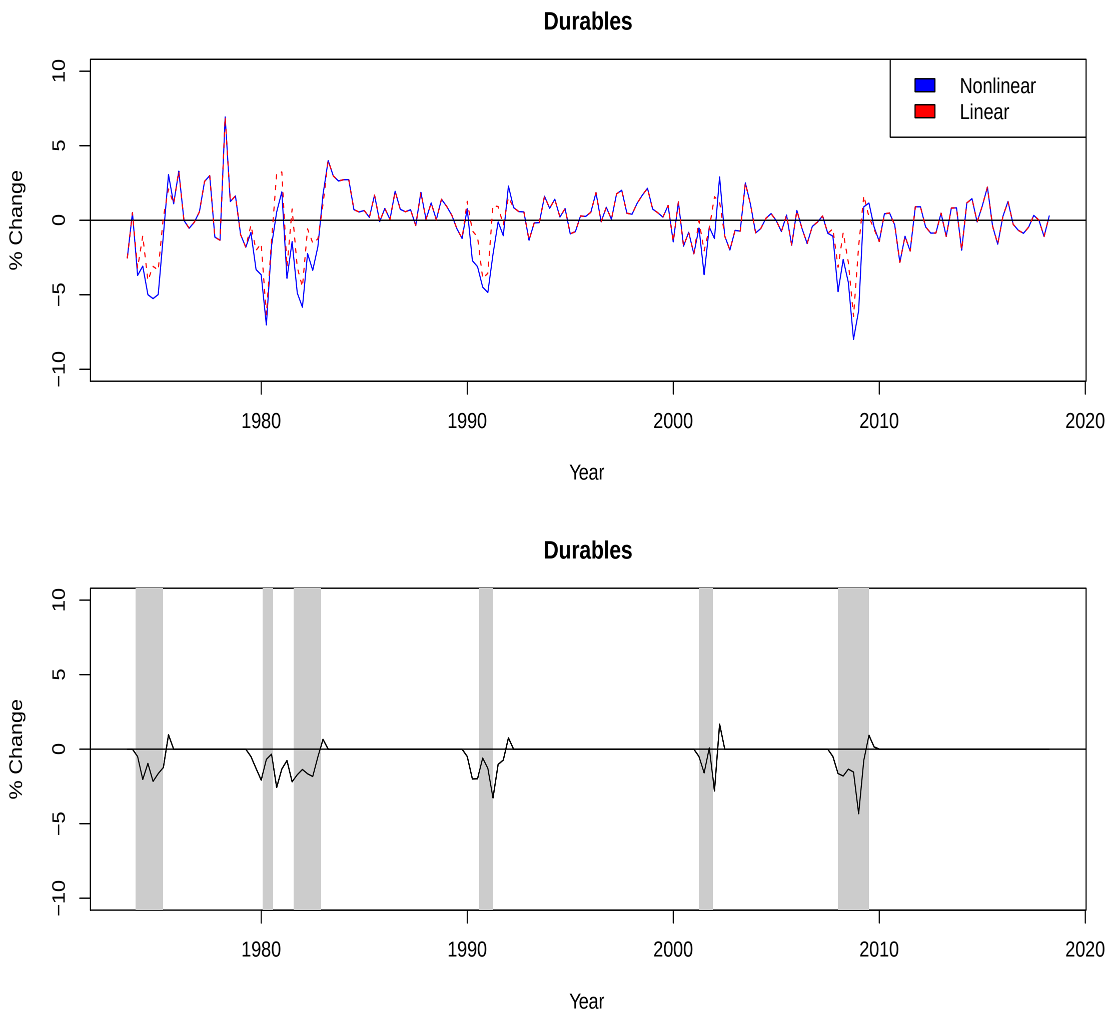
Figure 17: Comparison of Consumption Forecasts





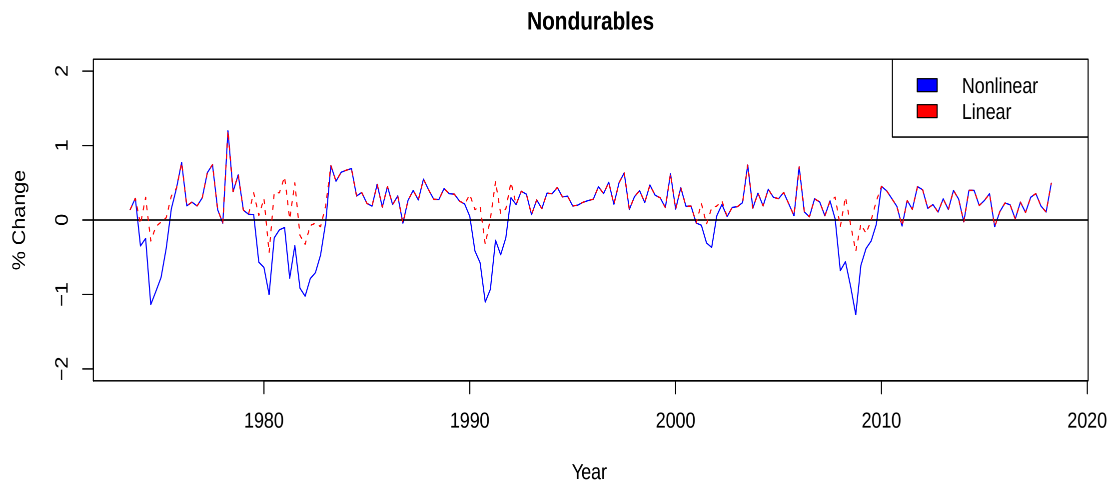
Notes: The upper-column indicates the linear and nonlinear consumption forecasts, and the lower-column indicates the difference in forecasts with the shaded area representing U.S. recessions. The red dashed line represents the forecast of consumption following a 10% increase in gasoline expenditures in the same time period using the linear model, whereas the solid blue line represents the forecasts of consumption using the nonlinear model. The solid line in the lower-column represents the difference in consumption forecasts, with a negative value suggesting that the forecasts with the linear model are underestimating the effect of a gasoline expenditure shock.

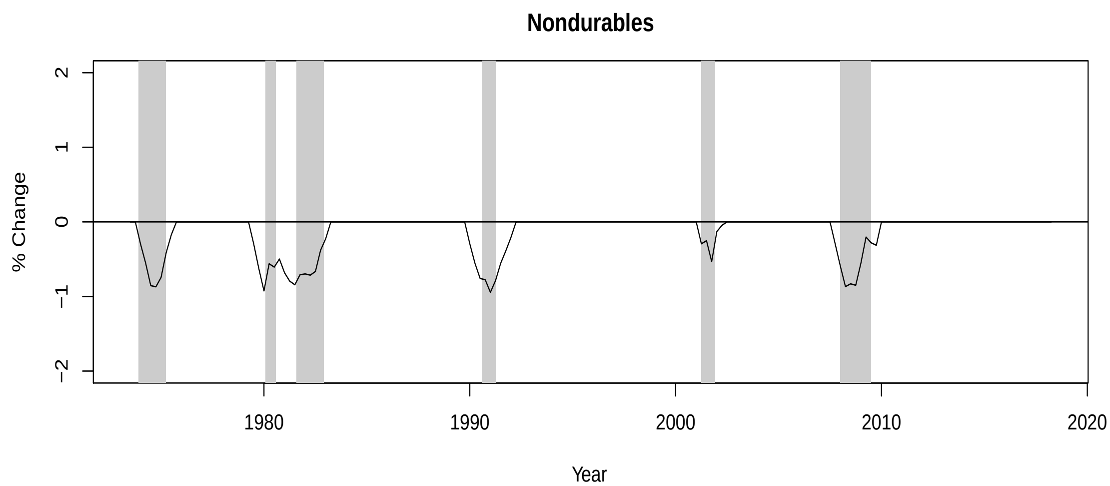
Figure 18: Comparison of Consumption Forecasts



Notes: The upper-column indicates the linear and nonlinear consumption forecasts, and the lower-column indicates the difference in forecasts with the shaded area representing U.S. recessions. The red dashed line represents the forecast of consumption following a 10% increase in gasoline expenditures in the same time period using the linear model, whereas the solid blue line represents the forecasts of consumption using the nonlinear model. The solid line in the lower-column represents the difference in consumption forecasts, with a negative value suggesting that the forecasts with the linear model are underestimating the effect of a gasoline expenditure shock.

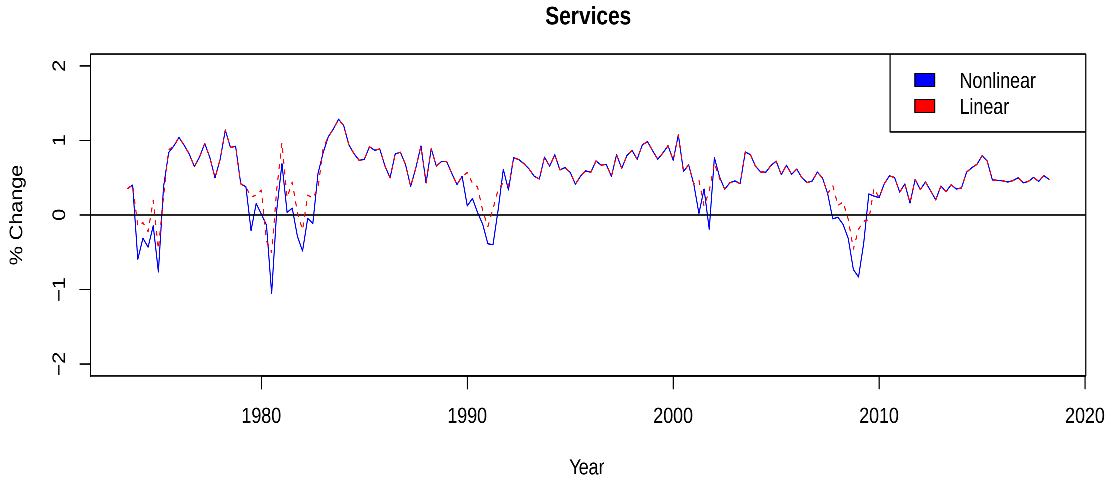
Figure 19: Comparison of Consumption Forecasts

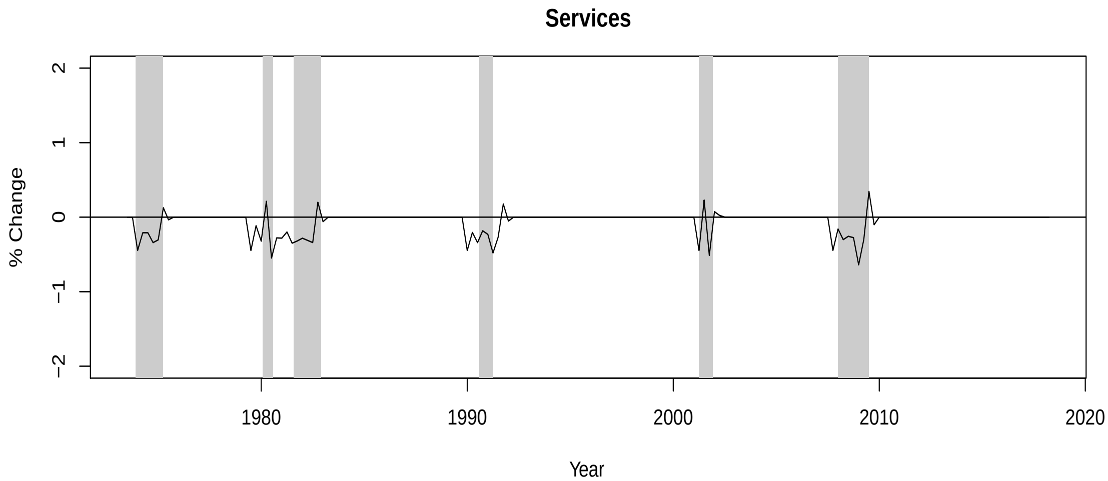




Notes: The upper-column indicates the linear and nonlinear consumption forecasts, and the lower-column indicates the difference in forecasts with the shaded area representing U.S. recessions. The red dashed line represents the forecast of consumption following a 10% increase in gasoline expenditures in the same time period using the linear model, whereas the solid blue line represents the forecasts of consumption using the nonlinear model. The solid line in the lower-column represents the difference in consumption forecasts, with a negative value suggesting that the forecasts with the linear model are underestimating the effect of a gasoline expenditure shock.

Figure 20: Comparison of Consumption Forecasts





Notes: The upper-column indicates the linear and nonlinear consumption forecasts, and the lower-column indicates the difference in forecasts with the shaded area representing U.S. recessions. The red dashed line represents the forecast of consumption following a 10% increase in gasoline expenditures in the same time period using the linear model, whereas the solid blue line represents the forecasts of consumption using the nonlinear model. The solid line in the lower-column represents the difference in consumption forecasts, with a negative value suggesting that the forecasts with the linear model are underestimating the effect of a gasoline expenditure shock.