Do gasoline expenditure shocks have different effects in recessions and expansions?

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Abstract

Using a structural VAR model for U.S. data covering the period 1973-2018, this paper documents that (i) an increase in gasoline expenditures reduces non-gasoline consumption, (ii) the response to a gasoline expenditures shock is stronger when it hits the economy during a recession rather than an expansion, and (iii) the asymmetry continues to hold in recent data. We argue that the asymmetry is consistent with differences in saving behavior and liquidity constraints in recessions.

JEL Classification: E21, E32, Q43

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1 Introduction

An important question in macroeconomics is how consumption responds to a gasoline expenditure shock.[1] One transmission mechanism is straightforward. If gasoline consumption is inelastic in the short run, a higher gasoline price will lead to higher gasoline expenditures, crowding out spending on other goods and services. Consumers will have less discretionary income available for other expenditures (Hamilton, 2009), requiring them to decide how much to reduce current expenditures on those goods and how much to reduce their saving. Higher gasoline expenditures also have an indirect effect on consumption, as the demand for goods that complement gasoline in consumption, most notably automobiles, will fall (Hamilton, 1988). 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. (2010) used scanner data to show that as gasoline expenditures rise, consumers shift towards groceries as a substitute for eating out, and switch existing grocery purchases to lower cost items.[3]

While the mechanisms described above can explain a shift in consumption from non-energy to energy goods, they do not imply that higher gasoline expenditures will reduce aggregate consumption. Figure 1 shows that in every month from January 1973 through May 2019, the U.S. was a net importer of crude oil.[4] As a result, increases in gasoline expenditures have historically caused a transfer of U.S. income to foreign oil producers, such that higher gasoline expenditures have a similar effect to a tax increase. This observation motivates our treatment of gasoline expenditures as having the same effect on consumption

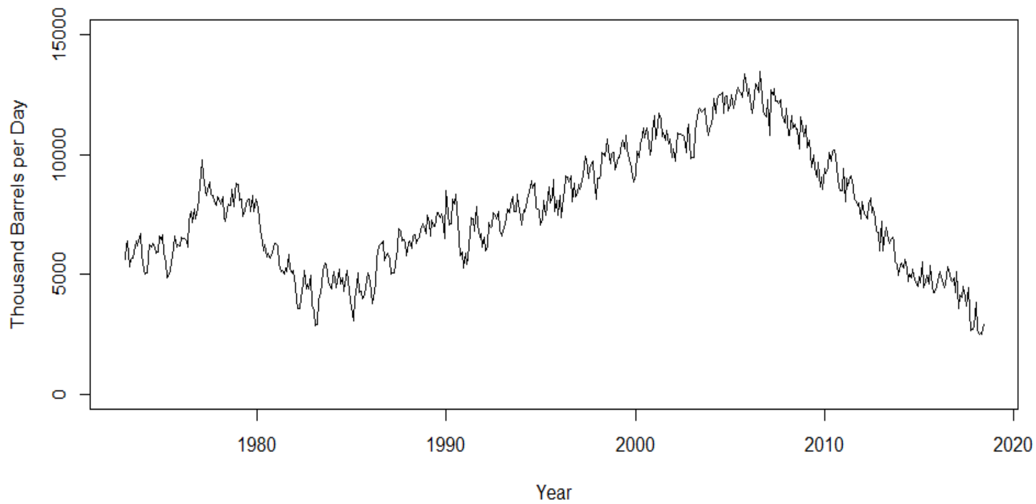
[1] The existing literature on the response of consumption to gasoline and oil price shocks includes Bernanke (1983), Hamilton (1988, 2009, 2016), Pindyck (1991), Mehra and Petersen (2005), Edelstein and Kilian (2009), Wang (2013), Baumeister and Kilian (2016), Alsalman and Karaki (2018), Kilian et. al. (2018), Herrera et al. (2019), De Michelis et al. (2020), Knotek and Zaman (2021), and Gelman et al. (2022).

[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] Anecdotal evidence of this mechanism can be found in the popular press: "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

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

Figure 1: U.S. net imports of crude oil and petroleum products



as a tax increase. Higher gasoline expenditures should therefore be expected to reduce aggregate consumption.

This idea is not new. In the words of Janet Yellen (2011): "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." A June 29, 2018 report by S&P Global economists Beth Bovino and Satyam Panday commented on higher oil prices: "This would be tantamount to a tax increase for American households. This is especially true for middle- to low-income Americans..."

The contribution of this paper is providing an estimate of the degree to which there has been asymmetry in the response of U.S. non-gasoline consumption expenditures to gasoline expenditure shocks across recessions and expansions. As noted above, due to the U.S. being a net oil importer over the entire sample, an increase in gasoline expenditures effects the economy in the same way as a tax increase. Some authors have found that fiscal policy is more effective when the economy is in a recession than when it is in an expansion. Tagkalakis (2008) found a stronger response of consumption to tax cuts during recessions. Auerbach and Gorodnichenko (2012) estimated fiscal multipliers in the range of 1.0-1.5 during recessions and 0.0-0.5 during expansions. Jorda and Taylor (2016) found that fiscal austerity is more contractionary when implemented in a recession. Auerbach and Gorodnichenko (2013) and Fazzari, Morley, and Panovska (2015) similarly found evidence that fiscal policy has asymmetric effects across states of the economy.[5]

If shocks to gasoline expenditures can be treated as if they are 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. This type of nonlinearity would be a stylized fact needing explanation in macroeconomic models that include energy prices. Modifications would need to be made to consumption forecasting models, such as those at the Federal Reserve, to account for the state of the business cycle when a gasoline expenditure shock hits the economy. In contrast, failure to find evidence of this type of nonlinearity would cast doubt on the treatment of a gasoline expenditure shock as a fiscal policy shock, 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 shocks on non-gasoline consumption in a linear model. Consistent with the existing literature, a positive shock to gasoline expenditures is followed by less spending on other goods. A shock that increases gasoline expenditures is accompanied by a decrease in spending on non-gasoline goods and services over the next year. Most of the response of consumption comes from the services and durable goods sectors. We then estimate a model that allows the effect to be different across expansions and recessions. Our estimates reveal a much stronger response of non-gasoline consumption to an increase in gasoline expenditures when the shock hits during a recession. Our findings are consistent with consumers having a higher probability of being

[5]Not all papers have found this type of asymmetry. Ramey and Zubairy (2018) and Alloza (2022) concluded that there was no asymmetry for their data and model specification.

liquidity constrained during a recession, leaving them with no option but to cut spending on other goods. We present evidence that saving behavior responds differently to gasoline expenditure shocks depending on the state of the business cycle. Finally, we show that the evidence for asymmetry is robust to reasonable changes in the model specification.

2 Imposing Symmetry

We begin by presenting estimates of the response of consumption to gasoline expenditure shocks in a linear model, which imposes a restriction of symmetry across recessions and expansions. The estimated effects are the average of the effects across two states of the economy. Other papers have analyzed this relationship using a linear model. The goal of this section is to establish a baseline for comparison with the results from a nonlinear model.

2.1 Recursive identification

It is common practice to assess the impact of energy price shocks using a linear VAR model; e.g. Edelstein and Kilian (2009) rely on a bivariate VAR model to examine the response of consumption to change in purchasing power associated with fluctuations in energy prices, and more recently Knotek and Zaman (2021) use a structural VAR model to calculate the response of consumption to energy price shocks. As a result, we begin the analysis by estimating the VAR model

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

where $f_t = (gas_t, c_t)'$, c_t is a measure of consumption growth in quarter t, gas_t is the percentage change in gasoline expenditures in quarter t, $e_t = (e_{gas,t}, e_{c,t})'$ is a vector of reduced form residuals, p represents the lag length,[6] α and β_i are vectors of coefficients.

[6] 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 preceding two quarters to analyze the response of consumption to energy price shocks. Our results are robust to using other lag lengths.

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 (PCE), real PCE: services, real PCE: nondurables, and real PCE: durables.[7]

Data on different categories of nominal consumption during our sample period from 1973 Q1 to 2018 Q2 was downloaded from the National Income and Product Accounts released by the Bureau of Economic Analysis. To calculate our measure of non-gasoline 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). Total nominal consumption expenditures measure spending on durable goods, nondurable goods (excluding gasoline and other energy goods), and services. 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.

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.[8] The ordering of our variables in equation (1) imposes the following structure on the vector of reduced form residuals:

$$e_t = \begin{bmatrix} e_{gas,t} \\ e_{c,t} \end{bmatrix} = \begin{bmatrix} a_{11} & 0 \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} \varepsilon_{gas,t} \\ \varepsilon_{c,t} \end{bmatrix}$$

where $\varepsilon_{gas,t}$ is the shock to gasoline expenditures and $\varepsilon_{c,t}$ is the non-gasoline consumption shock. Some information about the plausibility of our identifying assumption can be found by looking at the contemporaneous correlations of the VAR residuals. If a shock to gasoline

[7]We conduct a variety of unit root tests, and find that the quarterly growth rate of real consumption variables are stationery.

[8]This is similar to the identification in Edelstein and Kilian (2009) and Knotek and Zaman (2021). We address other identification strategies below.

Table 1: Reduced-form residual correlations

Variables	Correlation
PCE	-0.35
Durables	-0.07
Nondurables	-0.26
Services	-0.45

Notes: This table represents the correlations between residuals recovered from the gasoline expenditures (gas_t) and consumption equations (c_t) in model (1).

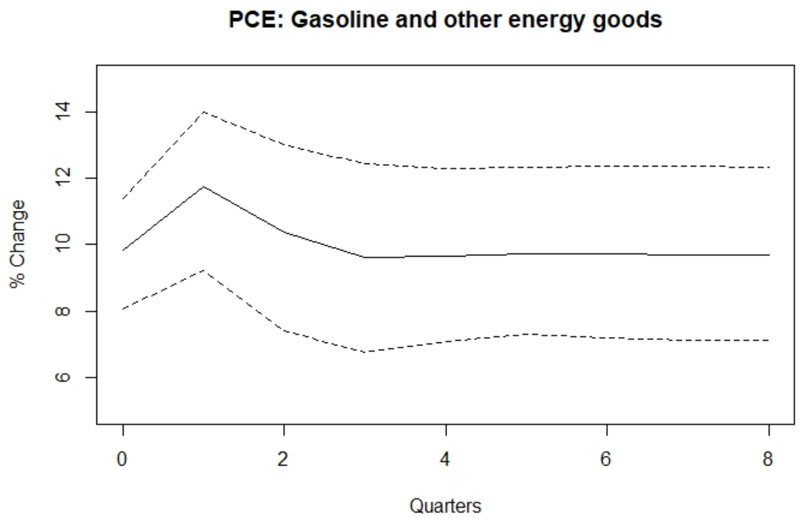
expenditures translates directly into a decrease in consumption of other goods, the residuals will be negatively correlated. If there are economic shocks that cause all consumption expenditures to rise, including gasoline expenditures, the correlation will be positive. If there is no effect in either direction, or the two effects offset one another, the correlation will be zero. The correlations are reported in Table 1. In all cases, the correlation coefficient is negative, covering a range from -0.07 to -0.45. While there is no way to confirm that our identification is correct, the signs of the correlations are consistent with our ordering of the variables, and we can rule out a recursive bivariate VAR model with consumption ordered first. Beyond these correlations is the fact that gasoline purchases are believed to be inelastic in the short run.

As an additional step to increase confidence in our identification strategy, we also did the analysis with a three-variable VAR model that added the real economic activity index of Kilian (2009) to the bivariate model described above. Doing so had little effect on our results. The correlation coefficient between the identified real economic activity and gasoline expenditure shock is -0.01.

2.2 Sources of gasoline expenditure shocks

The identified gasoline expenditure shock, $\varepsilon_{gas,t}$, may reflect many factors. The obvious, and almost certainly the most important, source of gasoline expenditure shocks is an unanticipated change in the price of gasoline. Other sources of gasoline expenditure shocks include

Figure 2: Cumulative response of gasoline expenditures to own shock



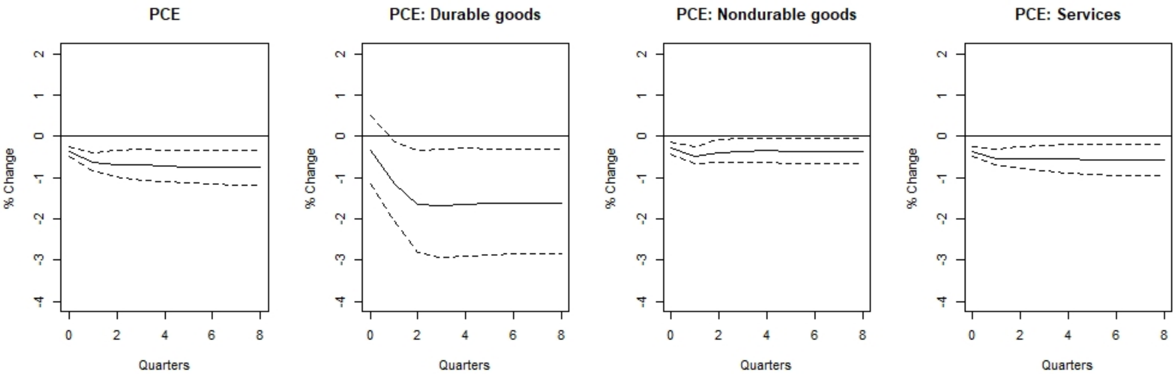
Notes: Solid line represents the cumulative response to a 10% shock to gasoline expenditures, while the corresponding dashed lines are the 95% confidence intervals.

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, changes in commuting behavior due to fluctuations in house prices, and the weather.

2.3 Impulse response functions

Figure 2 shows how the level of gasoline expenditures evolves over time following a 10% gasoline expenditures shock. We see that gasoline expenditures are about 10% higher at all times over the next eight quarters. In what follows, it's important for purposes of interpretation to understand that the *initial shock* is 10%, but that gasoline expenditures are about 10% higher in future quarters as well. A consumer with full knowledge of how gasoline expenditures will evolve would respond to not just the initial increase in gasoline expenditures, but potentially also future changes. A consumer with incomplete information will learn how gasoline expenditures are changing, creating a situation where the response to the initial shock is delayed, as consumption is repeatedly adjusted to account for new information about gasoline expenditures. The confidence bands in Figure 2 were computed

Figure 3: Cumulative impulse responses to a shock that increases gasoline expenditures by 10%



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

using a fixed-design wild bootstrap with the Rademacher pick distribution to account for conditional heteroskedasticity (Gonçalves and Kilian, 2004).

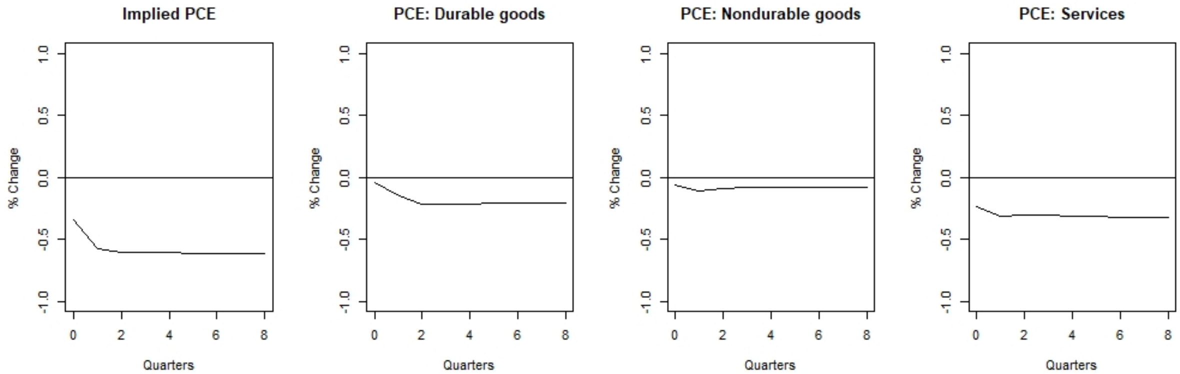
The cumulative impulse response functions for four consumption series are shown in Figure 3. The 10% gasoline expenditures shock causes non-gasoline consumption to decrease 0.8% over the next eight quarters. By far, the strongest effect is on durables PCE, which decreases by 1.6%. This is perhaps not surprising in light of motor vehicle sales being a large chunk of durables consumption. Nondurables PCE falls by 0.4% and services PCE falls by 0.6%. The smaller responses of nondurables and services are consistent with evidence that the demand for both categories is inelastic with respect to disposable income (Edelstein and Kilian, 2009).[9]

Although the response of durables consumption is considerably larger than for the other components, services are a much larger proportion of total consumption than either nondurables or durables, with services consumption being five times as large as durables consumption.[10] Figure 4 presents the consumption responses after weighting the responses in Figure 3 by share of total PCE. Almost half of the drop in consumption is explained by the

[9] These findings are in line with Edelstein and Kilian (2009), who calculated the elasticities of non-energy real consumption expenditures, and found that expenditures on durables decline more than four times as much as expenditures on both services and nondurables following a loss in purchasing power after a rise in energy prices.

[10] For our sample, services was on average 64% of consumption, nondurables 23%, and durables 13%.

Figure 4: Contribution by PCE component



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

services sector, about one third durables, and the small remaining amount by nondurables. Explanations for the response of aggregate consumption should focus on services and durables consumption.

2.4 Alternative identification strategy: Proxy SVAR

The results in the previous section were based on an assumption of a recursive VAR model. We assumed that gasoline expenditures do not contemporaneously respond to a shock to non-gasoline consumption. That assumption might be controversial. This section presents the results from a proxy SVAR that takes advantage of recent advances in the identification of SVAR models.

Our proxy SVAR models the reduced-form VAR innovations ($e_{gas,t}$ and $e_{c,t}$) as a combination of the structural shocks ($\varepsilon_{gas,t}$ and $\varepsilon_{c,t}$):

$$e_{gas,t} = a_{11}\varepsilon_{gas,t} + a_{12}\varepsilon_{c,t}$$

$$e_{c,t} = a_{21}\varepsilon_{gas,t} + a_{22}\varepsilon_{c,t}$$

The previous section imposed $a_{12} = 0$. This section does not impose any assumptions on the values of a_{ij} coefficients. Instead, identification of a_{12} and a_{21} is achieved using an external instrument (or proxy) not included in the VAR system (Stock and Watson, 2012; Mertens and Ravn, 2013; Montiel-Olea, Stock and Watson, 2016). We use the oil supply news shock in Känzig (2021) as an instrument for the structural gasoline expenditure shock $\varepsilon_{gas,t}$.

Figure 5 compares the impulse response functions for the two identification strategies. The solid lines are the cumulative impulse response functions for the recursive SVAR model and the dashed lines are the cumulative impulse response functions for the proxy SVAR. The shape and magnitude of the proxy SVAR impulse response functions are similar to those of the recursive SVAR. The response with the proxy SVAR case is stronger at all horizons than for the recursive SVAR.[11] On the basis of this, we conclude that the recursive SVAR model generally does a good job of capturing the effects of gasoline expenditure shocks, but we also cannot rule out that the responses of the recursive SVAR model are biased toward zero.

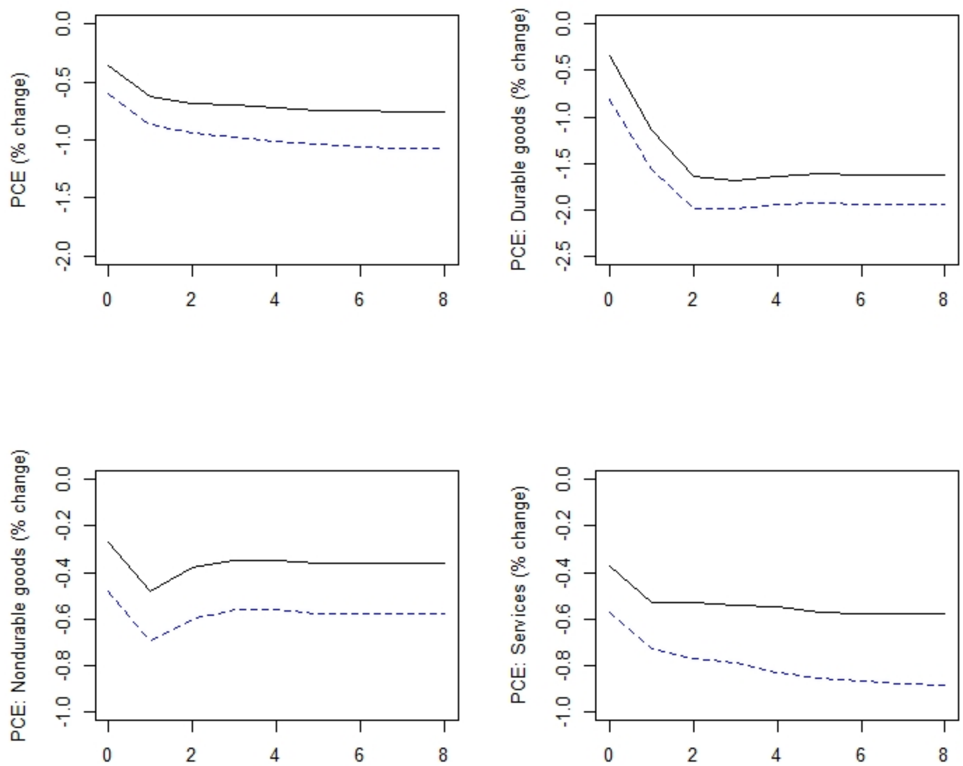
2.5 Sectoral analysis

Taking the analysis down another level of disaggregation, Table 2 contains the responses of motor vehicles and parts (NIPA Table 2.3.5, line 4), furnishing and durable household equipment (NIPA Table 2.3.5, line 5), recreational goods and vehicles (NIPA Table 2.3.5, line 6), other durable goods (NIPA Table 2.3.5, line 7), food and beverages (NIPA Table 2.3.5, line 9), clothing and footwear (NIPA Table 2.3.5, line 10), other nondurable goods (NIPA Table 2.3.5, line 12), housing and utilities (NIPA Table 2.3.5, line 15), healthcare (NIPA Table 2.3.5, line 16), transportation services (NIPA Table 2.3.5, line 17), which includes public transportation expenditures and maintenance and repair of motor vehicles, recreation services (NIPA Table 2.3.5, line 18), food services and accomodation (NIPA Table 2.3.5, line 19), financial services and insurance (NIPA Table 2.3.5, line 20), and other services (NIPA Table 2.3.5, line 21) which includes communication, education services, professional services and household maintenance.

Table 2 shows a large decline in motor vehicle spending at various forecast horizons,

[11] Impulse response function confidence bands tend to be large, so it is possible that the differences can be explained by sampling error.

Figure 5: Cumulative impulse responses to a shock that increases gasoline expenditures by 10%



Notes: Cumulative responses to a 10% gasoline expenditure shock. Solid black lines indicate the impulse response functions from the SVAR specified in Section 2.1. The blue dashed lines represent the impulse response functions identified using the external instrument.

and smaller declines in consumer spending for other types of goods, including furnishings, recreational, other durable, food, clothing, other nondurables, and most categories of services. This suggests that an increase in gasoline expenditures reduces discretionary income, which then leads to a broad-based reduction in consumer spending. Consumption expenditure on utilities rise after two quarters, likely due to a combination of higher utilities prices and inelastic demand for utilities. There is an immediate and pronounced increase in public transportation spending that remains for the full eight quarters after the initial shock. Public transportation expenditures rise by 1% in response to higher gasoline expenditures, while motor services expenditures fall, consistent with a shift from driving cars to public

Table 2: Cumulative impulse response functions to a shock that increases gasoline expenditures by 10%

Major Type of Product	Forecast horizon 0	4	8
Motor vehicles and parts	-0.20%	**-2.85%**	**-2.80%**
Furnishings and durable household equipment	-0.39%	**-0.94%**	**-1.02%**
Recreational goods and vehicles	**-0.56%**	-1.05%	-1.07%
Other durable goods	-0.19%	-0.61%	-0.61%
Food and beverages	**-0.20%**	-0.02%	-0.01%
Clothing and footwear	-0.18%	-0.35%	-0.36%
Other nondurable goods	**-0.38%**	**-0.70%**	**-0.72%**
Housing	**-0.43%**	**-0.64%**	**-0.68%**
Utilities	-0.13%	0.55%	0.63%
Healthcare	**-0.40%**	**-0.88%**	**-0.92%**
Motor vehicle services	**-0.34%**	-0.68%	-0.75%
Public transportation	**0.94%**	**1.44%**	**1.47%**
Recreation services	**-0.37%**	**-0.52%**	**-0.53%**
Food services and accommodations	**-0.40%**	-0.31%	-0.32%
Financial services and insurance	-0.27%	-0.23%	-0.23%
Other services	**-0.38%**	-0.56%	-0.59%

Notes: Cumulative impulse responses to a 10% gasoline expenditure shock. Bold indicates statistical significance at the 5% level.

transportation.

3 Relaxing the Assumption of Symmetry Over the Business Cycle

3.1 Model specification

Some authors, notably Auerbach and Gorodnichenko (2012) (hereafter, AG (2012)), have found evidence that fiscal policy has a greater effect on the economy in recessions than in expansions. To the extent that changes in gasoline expenditures have similar effects as changes in taxes, one should also expect gasoline expenditure shocks to have different effects depending on the state of the business cycle. This motivates an empirical model that relaxes the assumption that the response to a gasoline expenditures shock is symmetric over the business cycle:

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

where c_t is the percentage change in non-gasoline consumption expenditures, gas_t is the shock to gasoline expenditures, I_t is a dummy variable equal to one if the economy is in a recession and zero otherwise, $inter_t$ is the interaction term $gas_t I_t$, and y_t is GDP growth in quarter t.

The first specification decision that has to be made is choosing a measure of the state of the business cycle. We follow AG (2012).[12] Define the variable I_t to be

$$I_t = \begin{cases} 1 & F(z_t) \geq 0.8 \\ 0 & F(z_t) < 0.8 \end{cases}, \qquad (3)$$

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

$$F(z_t) = \frac{exp(-\gamma(z_t - \bar{d}))}{1 + exp(-\gamma(z_t - \bar{d}))}, \gamma > 0. \qquad (4)$$

The variable z_t is equal to the seven quarter moving average growth rate of output, $\bar{d}$ is set to 0.8, and γ is calibrated to be equal to 3, so that the economy spends 20% of time in recession i.e. $Pr(F(z_t) \geq \bar{d}) = 0.2$. The calibated values are taken from AG (2012), and the transition function is estimated using real gross domestic product (chained 2012 Dollars) as the measure of output. The estimated recession dates are presented in Table 3.

As with the symmetric model, the identifying assumption is that gasoline expenditures do not respond to non-gasoline consumption expenditures contemporaneously. Defining gas_0

[12] We discuss other measures later in the paper.

Table 3: Recession reference quarters

Recession	Recessionary periods implied following AG (2012)
1973-74	1974:Q1-1975:Q1
1979-80	1979:Q3-1980:Q1
1980-82	1980:Q3-1982:Q3
1990-91	1990:Q1-1991:Q3
2001	2001:Q2-2001:Q4
2007-09	2007:Q4-2009:Q2

and $inter_0$ to be the change in *gas* and *inter* during the quarter of a gasoline expenditures shock, and assuming that the gasoline expenditures shock does not cause the state of the economy to change, the contemporaneous response of non-gasoline consumption expenditures is

$$c_0 = \widehat{\gamma}_0 gas_0 + \widehat{\delta}_0 inter_0. \tag{5}$$

Once we condition on the state of the economy, equation (2) is linear. Although we report impulse response functions for a shock that increases gasoline expenditures by 10% in the rest of the paper, that quantity is arbitrary, since a different shock size would scale the impulse response functions proportionately.

Let the initial response vectors for the two states of the economy be

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

and

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

The s-period impulse responses are computed by estimating the regression

$$c_t = \alpha + \sum_{i=s}^{k-s+1} \beta_i c_{t-i} + \sum_{i=s}^{k-s+1} \gamma_i gas_{t-i} + \sum_{i=s}^{k-s+1} \delta_i inter_{t-i} + \sum_{i=s}^{k-s+1} \theta_i y_{t-i} + \varepsilon_t \tag{6}$$

for $s = 1, \ldots, 8$, collecting the parameter vector

$$\Phi_s = \begin{bmatrix} \hat{\beta}_s & \hat{\gamma}_s & \hat{\delta}_s \end{bmatrix} \tag{7}$$

and calculating

$$\hat{IR}_s^{rec} = \Phi_s d_i^{rec} = \hat{\beta}_s c_0^{rec} + \hat{\gamma}_s gas_0 + \hat{\delta}_s inter_0 \tag{8}$$

and

$$\hat{IR}_s^{exp} = \Phi_s d_i^{exp} = \hat{\beta}_s c_0^{exp} + \hat{\gamma}_s gas_0. \tag{9}$$

The cumulative impulse response functions are then

$$CIR_s^{rec} = \sum_{j=0}^{s} \widehat{IR}_j^{rec} \tag{10}$$

$$CIR_s^{exp} = \sum_{j=0}^{s} \widehat{IR}_j^{exp} \tag{11}$$

for $s = 1, \ldots, 8$. Asymmetry in the response of consumption over the business cycle is measured as

$$\triangle CIR_s = CIR_s^{rec} - CIR_s^{exp} = \sum_{j=0}^{s} \widehat{IR}_j^{rec} - \sum_{j=0}^{s} \widehat{IR}_j^{exp}. \tag{12}$$

Standard errors on the impulse response functions are calculated by estimating the full system of equations as a seemingly unrelated regressions (SUR) model, then applying the Newey-West correction for serial correlation to the block of the matrix corresponding to each individual equation.[13] [14]

[13] No adjustment was done to the cross-equation covariance matrix terms.

[14] A recent paper by Gonçalves et al., (2022) shows the potential for bias in local projections impulse response estimates in this type of model when the state of the economy is endogenous. We do not believe the bias is likely to be large in our application. In contrast to the fiscal policy literature, where the goal of

3.2 Interpretation of the impulse response functions

This section briefly clarifies the interpretation of the impulse response functions we report. There are multiple impulse response functions that can be computed and different ways to estimate and calculate them. The quantities CIR^{exp} and CIR^{rec} are the cumulative responses to gasoline expenditure shocks that occurred during an expansion or recession, respectively. We do not impose any assumption on the future path of the economy. In particular, CIR^{exp} is not computed under the assumption that the economy remains in an expansion in all future periods, and CIR^{rec} does not assume the economy remains in recession in all future periods. Our methodology does not provide any way to compute those quantities, and as a practical matter, we believe CIR^{exp} and CIR^{rec} to be of greater interest because they correspond to the actual behavior of the economy.

It is possible that our two-state threshold model (expansion versus recession) is not rich enough to capture all nonlinearity in the response to gasoline expenditures. In particular, consumption may respond differently to a shock that hits in a mild recession rather than a severe recession. The reported CIR^{exp} can be interpreted as the average responses to shocks that hit in an expansion and CIR^{rec} the average responses to shocks that hit in a recession. We leave it to future work to investigate more elaborate nonlinear models, with the caveat that the limited number of full U.S. business cycles since 1973 makes it hard to estimate more sophisticated nonlinear models.

Table 4: Impact responses to a 10% gasoline expenditure shock

	Expansion	Recession
PCE	-0.41%	-0.61%
PCE Components		
Durables	-0.77%	-0.92%
Nondurables	-0.26%	-0.50%
Services	-0.33%	-0.57%
By Major Type of Product		
Motor vehicles and parts	-0.97%	-1.59%
Furnishings and durable household equipment	-0.58%	-0.53%
Recreational goods and vehicles	-0.68%	-0.66%
Other durable goods	-0.41%	-0.18%
Food and beverages	-0.09%	-0.46%
Clothing and footwear	-0.38%	-0.34%
Other nondurable goods	-0.42%	-0.62%
Housing	-0.41%	-0.63%
Utilities	0.36%	-0.15%
Motor vehicle services	-0.35%	-0.62%
Public transportation	0.66%	1.08%
Other services	-0.32%	-0.77%

3.3 Results

3.3.1 Impact responses

Table 4 presents the impact responses of consumption and its components following a 10% increase in gasoline expenditures across recessions and expansions. Roughly speaking, an increase in gasoline expenditures will have to be offset by decreases in other consumption expenditures and net savings.[15]

The immediate aggregate PCE response is greater when the shock hits during a recession

fiscal policy is to change the state of the economy from recession to expansion, we view it as implausible that gasoline expenditure shocks are a major factor in switching the economy from recession to expansion and vice versa. In addition, and also in contrast to the fiscal policy literature, to the extent that our estimates are biased, the bias should not generate a finding of asymmetry that is not in the data. The story is different for the fiscal policy literature, due to the use of fiscal policy as a tool to stabilize the economy only during recessions.

[15]This ignores the effect of the gasoline expenditure shock on aggregate income. If the shock causes a decrease in aggregate income, other consumption expenditures and net saving would have to fall by more than the shock.

than otherwise. Breaking the results down by major type of PCE component, we see that durables exhibits the strongest response in recessions, followed by services and nondurables. Looking at product-level consumption, the largest component of durable goods spending, motor vehicles,[16] responds negatively in a recession. This is partially offset by the less negative response of other durables to gasoline expenditures in a recession, which is consistent with a shift in the composition of consumption away from goods such as motor vehicles, which are less desirable when the price of gasoline is high, to those that are not. This shift is likely to be more pronounced during recessions, when there is a larger fall in motor vehicle expenditures. For most of the other categories, consumption exhibits a larger decline in recessions as opposed to expansions. Interestingly, public transporation spending increases in recessions and expansions, which is consistent with the results from the symmetric model.

3.3.2 Cumulative responses

We now discuss the impulse response functions. Interpretation of the estimated nonlinear impulse response functions needs to be done carefully. The asymmetric model described above allows the response of gasoline consumption and non-gasoline consumption to be different across states of the business cycle. Suppose gasoline expenditures are more persistent when a shock hits during an expansion. As a result, the cumulative h-quarter change in gasoline expenditures will be greater following a shock that hits during an expansion. The response of non-gasoline consumption expenditures to a gasoline expenditure shock will be greater in an expansion *even if non-gasoline consumption expenditures respond symmetrically to gasoline expenditure shocks in the two regimes.* The larger observed response would simply be reflecting the higher gasoline expenditures that followed the shock during expansions.

We avoid this problem by normalizing all of the time-h impulse response functions so that they capture the response to a 10% cumulative increase in gasoline expenditures through the first h quarters after the shock. If the symmetric model is correct, sampling error will be the

[16]On average over the sample, motor vehicle spending as a share of durable goods was 38.7%, while furnishings, recreational goods, and other durable goods were 24.7%, 12.8%, and 23.7%, respectively.

only source of differences in the impulse response functions across recessions and expansions.

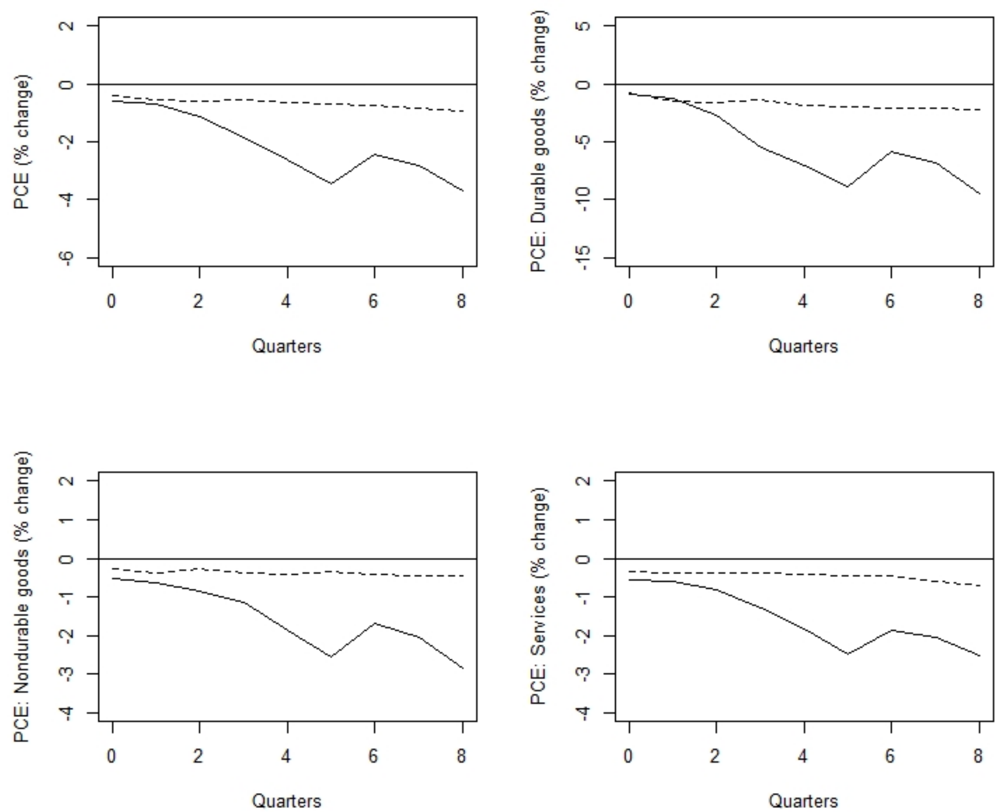
Figure 6 shows the cumulative responses of aggregate PCE and each of its major components in recessions and expansions. The dashed lines are the response to shocks that hit in an expansion and the solid lines are the response to shocks that hit in a recession. Most of the effect on aggregate PCE happens immediately if the shock hits in an expansion, with all subsequent movements being small. In contrast, shocks that hit during a recession have an effect on aggregate PCE for more than a year. The same shock that causes aggregate PCE to fall by 2.7% after a year if it hits in a recession causes aggregate PCE to fall by only 0.7% if it hits in an expansion. The same is true for each of the components of consumption. The one-year respective responses in recessions and expansions for durables PCE are -7.0% and -1.8%, for nondurables -1.9% and -0.4%, and for services -1.9% and -0.4%. The difference in response at each time horizon and associated confidence bands are presented in Figure 7.

Figures 8-10 are the responses of select consumption categories. Spending on motor vehicles drops by 11.9% when the shock hits in a recession, and by 2.9% when it hits in an expansion. The decline in furnishings expenditure, which includes furniture and major household appliances, is about 5.0% for a recession shock versus 1.1% otherwise. Expenditures on other durable goods, such as jewelry, watches, and telephones, decrease by 3.6% after one year for a recession shock and 0.7% for an expansion shock. Similar asymmetries are seen for other major type of products.

3.4 Why is the response asymmetric?

The results above show clear evidence of asymmetry in the response to gasoline expenditure shocks across recessions and expansions. Consider the results for motor vehicle spending. It's hardly surprising that consumption shifts away from motor vehicles in the aftermath of a gasoline expenditures shock, but it's less obvious why there is so much asymmetry in the response. The one-year response is more than three times as large when the gasoline expenditures shock hits during a recession.

Figure 6: Cumulative response of consumption to a 10% gasoline expenditure shock in recessions & expansions



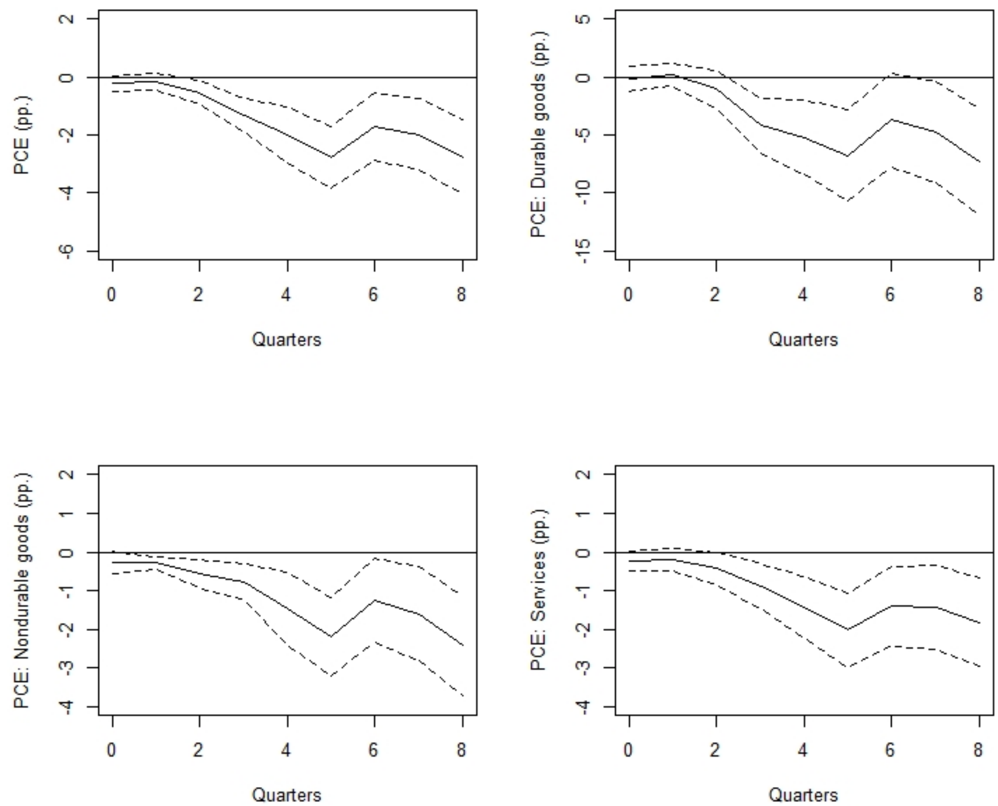
Notes: Solid line indicates the cumulative response of consumption series to a 10% gasoline expenditure shock in recessions, while the corresponding dashed line is the cumulative response in expansions.

Kilian and Edelstein (2009) have offered one possible explanation for the asymmetry, which they call the "uncertainty effect". Consumers are more likely to postpone their purchases of big-ticket items during a recession due to the higher probability of being or becoming unemployed in the short run during a recession. Another explanation is that credit is more likely to be constrained during a recession.[17] Consumers more adversely affected by credit constraints during a recession will have no choice but to reduce other types of spending in response to an exogenous increase in gasoline expenditures.

A third, not necessarily distinct, explanation is that savings behavior is different when a gasoline expenditure shock hits during a recession. We estimated equation (2) with the

[17]In some cases, a tightening of credit markets may be the source of the recession.

Figure 7: Cumulative difference in response

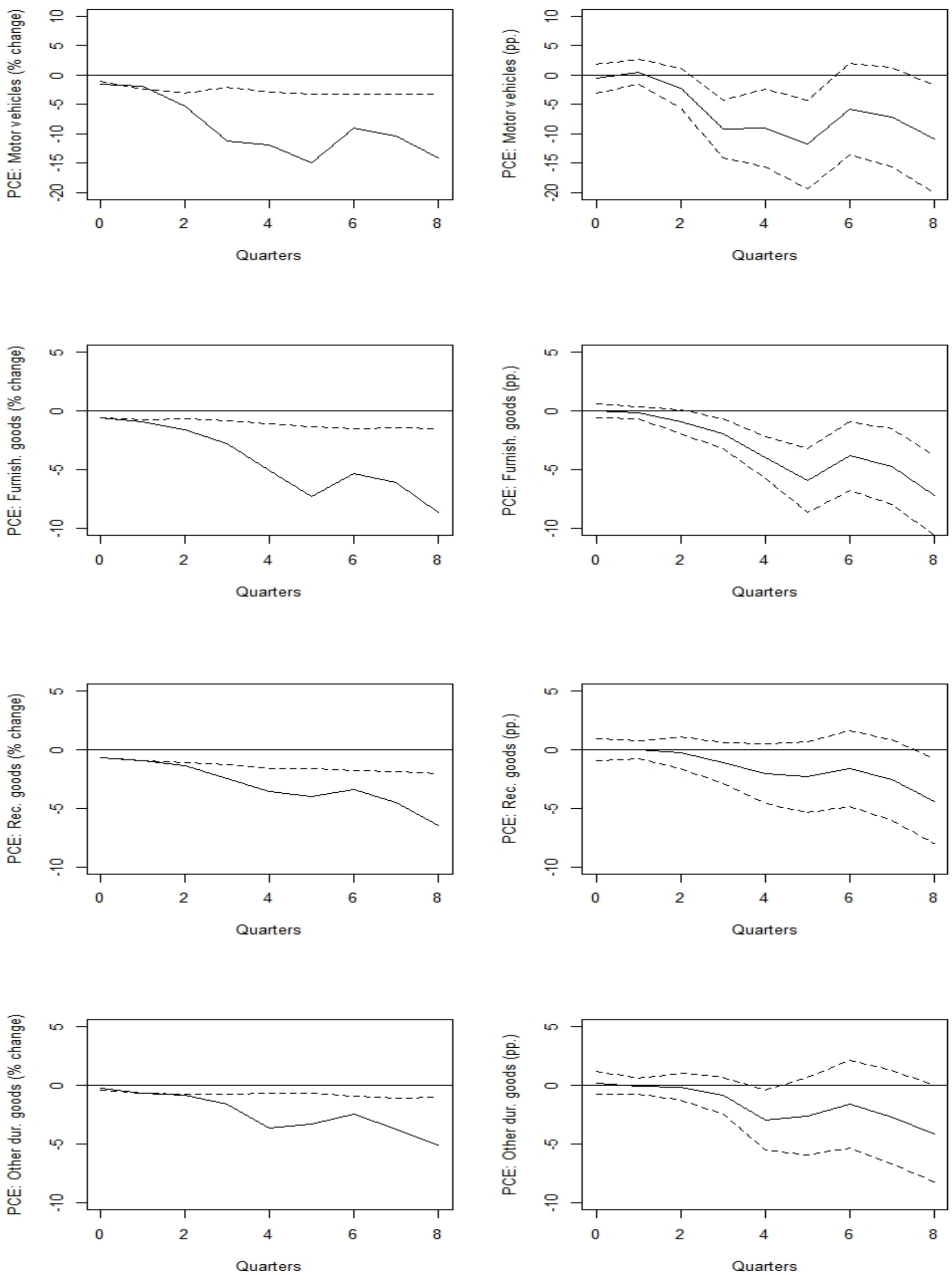


Notes: Solid line indicates the difference in response across recessions and expansions, while the corresponding dashed lines are the 95% confidence intervals. Negative value implies that the response in recessions is stronger than the response in expansions.

growth rate of net private saving as the dependent variable, where net private savings is defined as disposable income (NIPA Table 2.1, line 27) less personal outlays (NIPA Table 2.1, line 28) deflated by the GDP deflator. A 10% increase in gasoline expenditures leads to an increase in net private savings over the next year of 3.5% during a recession versus a 0.9% during an expansion. Economic theory does not provide much guidance about the response to a gasoline expenditures shock.[18] If the shock is temporary and there are no credit constraints, households will smooth consumption by decreasing their savings to offset most of the increase in gasoline expenditures. If the shock is viewed as persistent, or if there

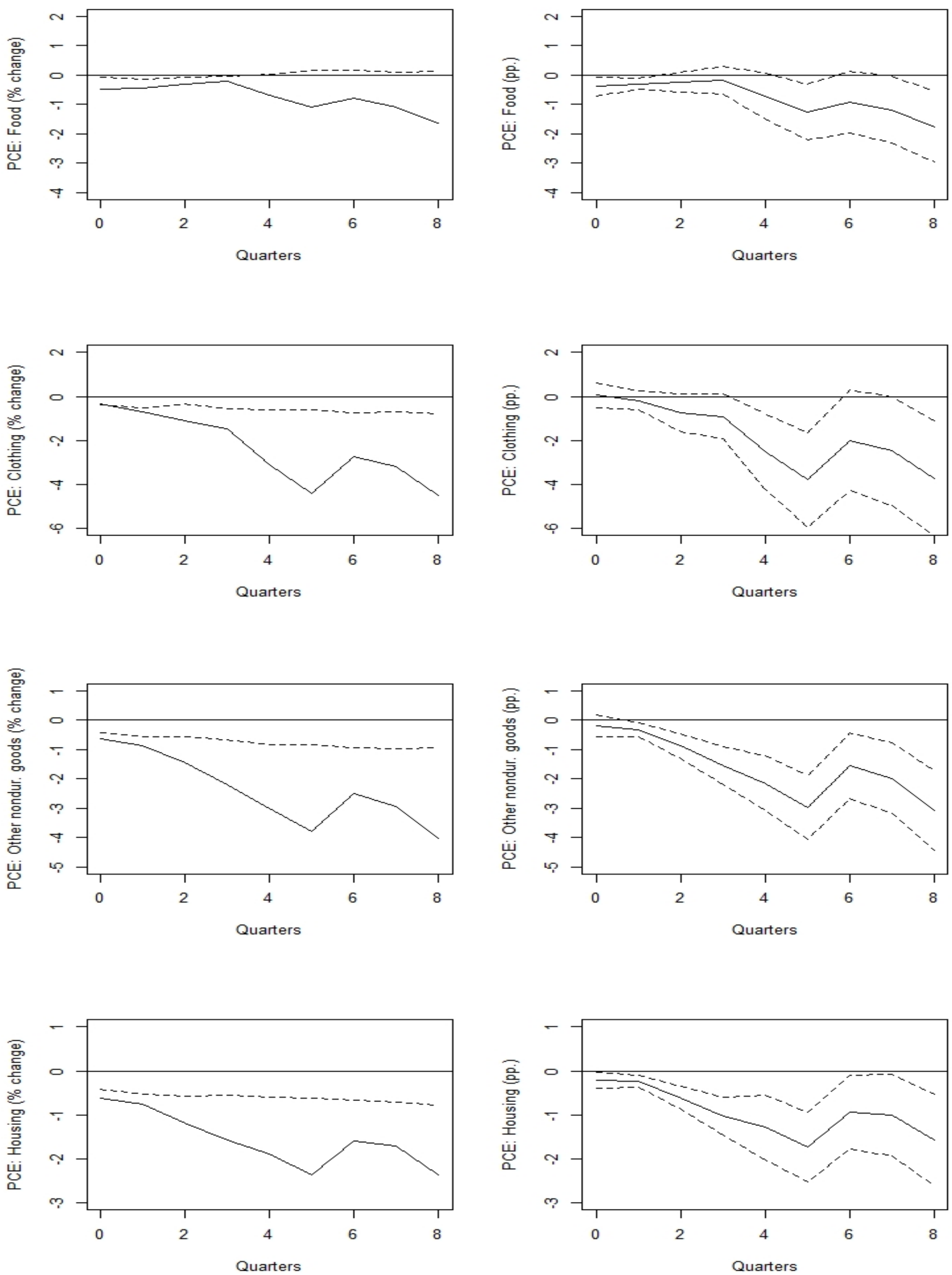
[18]The responses of consumption and savings we have reported are short-run responses. We have therefore documented a *temporary postponement* of consumption, as opposed to a *permanent reduction*.

Figure 8: Cumulative response of consumption to a 10% gasoline expenditure shock in recessions and expansions



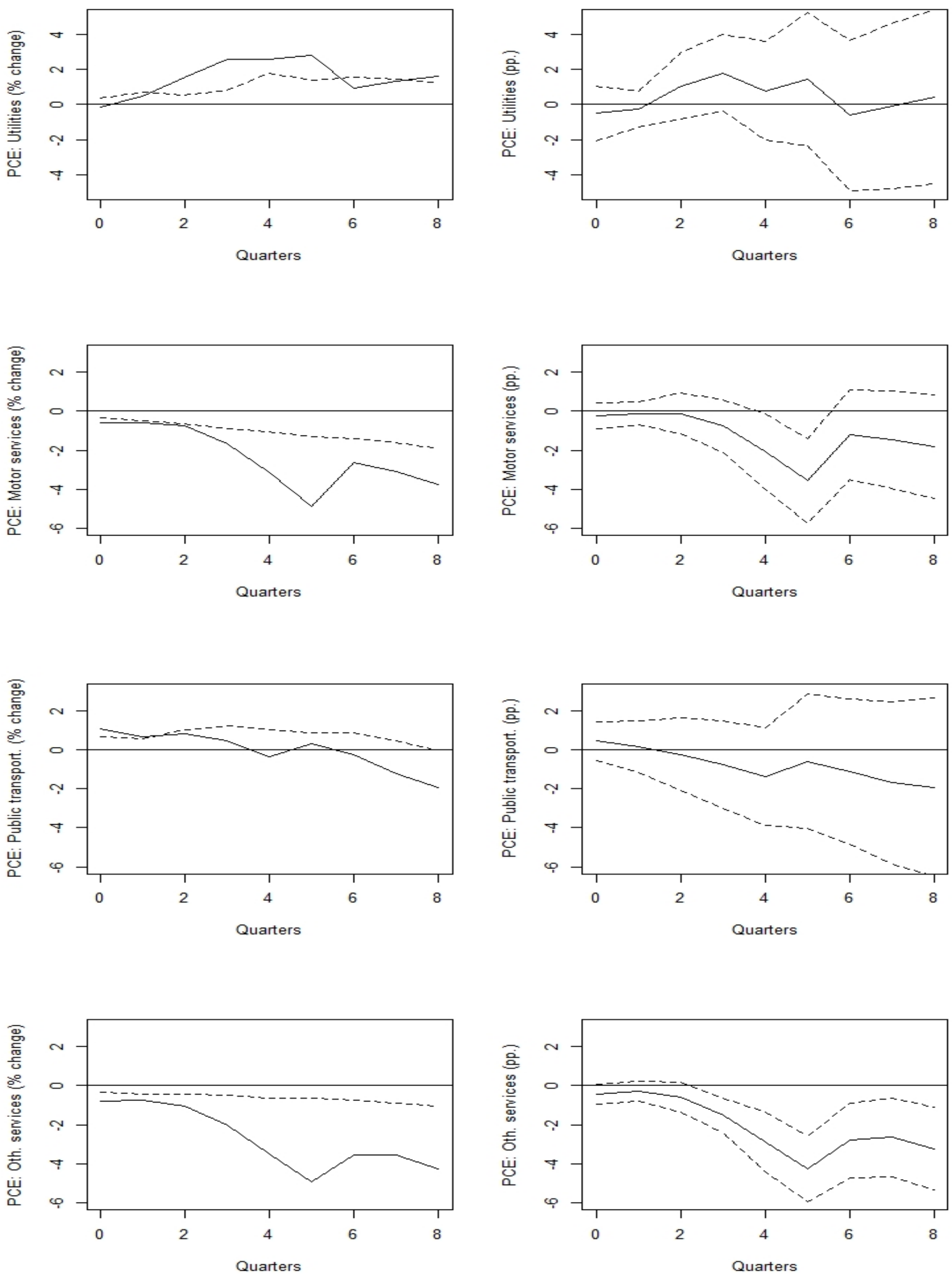
Notes: Solid line in the left column indicates the cumulative response to a 10% gasoline expenditure shock during recessions while the corresponding dashed line is the cumulative response in expansions. Solid line in the right column indicates the difference in response across recessions and expansions, 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 9: Cumulative response of consumption to a 10% gasoline expenditure shock in recessions and expansions



Notes: Solid line in the left column indicates the cumulative response to a 10% gasoline expenditure shock 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 10: Cumulative response of consumption to a 10% gasoline expenditure shock in recessions and expansions



Notes: Solid line in the left column indicates the cumulative response to a 10% gasoline expenditure shock 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.

are credit constraints preventing households from borrowing, higher gasoline expenditures may crowd out other expenditures. As we elaborate below, precautionary savings is another channel that can explain the asymmetric response over the business cycle.[19]

Carroll and Kimball (2008) present a buffer stock model for which the consumption function is concave. The concavity of the consumption function reflects the changing value of savings over different wealth levels. At high levels of wealth, additional savings provide little in the way of an insurance policy against income risk, so consumption decisions are similar to those made in a world without uncertainty. An unexpected increase in gasoline expenditures for those individuals is mostly offset by a decrease in savings. In contrast, at low levels of wealth, savings are valuable as a buffer against shocks. It is more costly (in terms of expected lifetime utility) for a consumer with low wealth to decrease savings in response to a gasoline expenditures shock. The optimal choice for those consumers is to offset a larger share of the gasoline expenditures shock by cutting back on consumption of other goods.

These effects can be seen in Figure 11. The top line is the consumption function for the agents in Carroll and Kimball's model in the absence of uncertainty. A decrease in discretionary income caused by a shock to gasoline expenditures will cause a movement from point A to point B. Consumption falls by the same amount no matter where point A is located; the only thing that matters is the distance between A and B. In the presence of uncertainty, precautionary savings behavior leads to very different responses of consumption. Due to savings being more valuable at lower values of discretionary income, consumption falls more when moving from point E to point F than when moving from point C to point D. One example of a household moving from point C to point E is a worker becoming unemployed as the economy switches from expansion to recession. Table 5 reports the solution for consumption associated with points A, B, C, D, E, and F in Carroll and Kimball's model when a gasoline expenditures shock causes discretionary income to fall by 0.82. Moving from

[19] This is not a new result. We believe it is worthwhile to be explicit about how a standard consumption model with precautionary savings predicts this type of asymmetry.

Figure 11: Consumption function $c(m)$

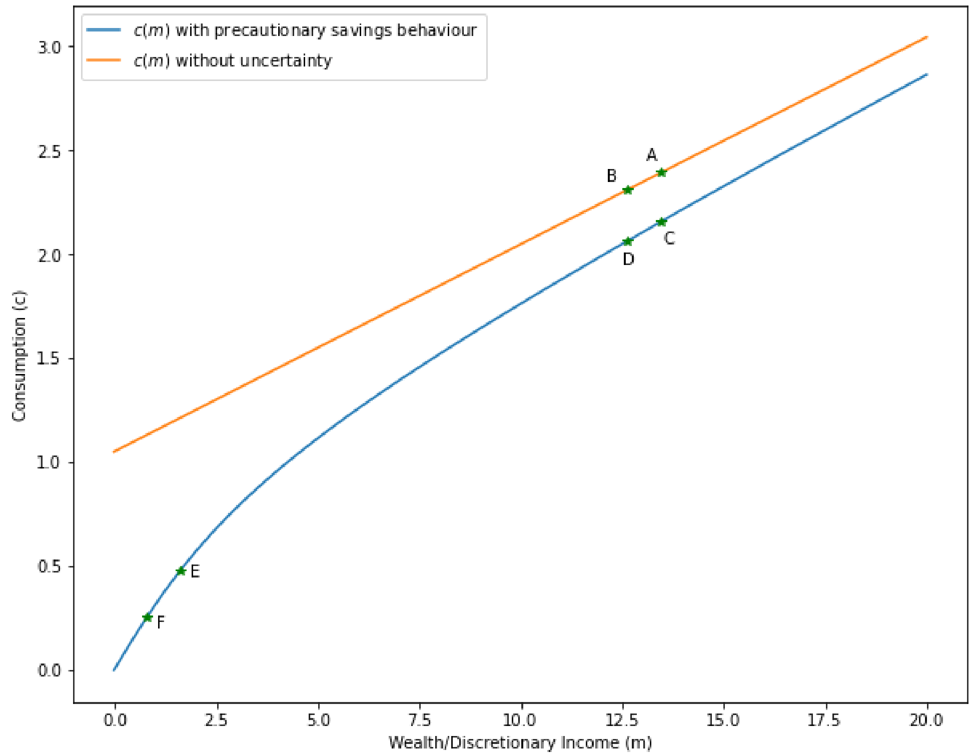
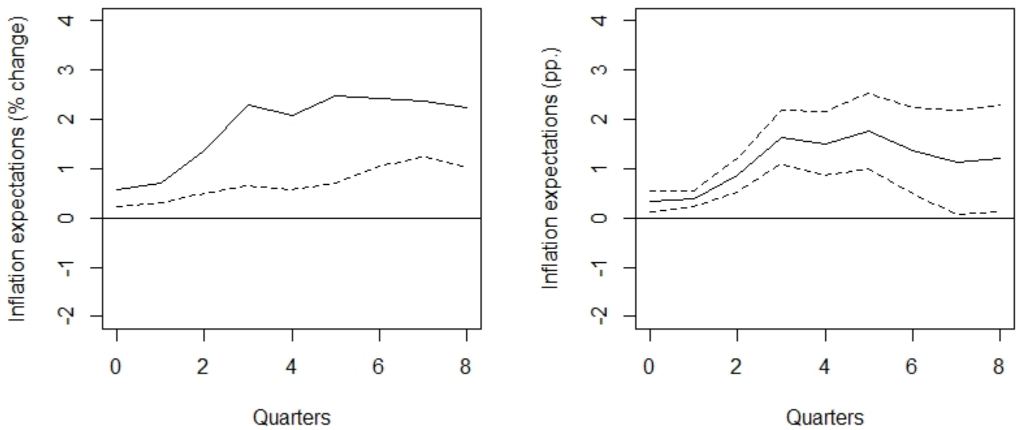


Table 5: Values of consumption in the buffer stock model

	m	$c(m)$
Point A	13.06	2.32
Point B	12.24	2.27
Change in consumption		-0.05
Point C	13.06	2.35
Point D	12.24	2.27
Change in consumption		-0.08
Point E	1.20	0.37
Point F	0.38	0.13
Change in consumption		-0.24

E to F is associated with a threefold increase in the response of consumption compared to the movement from C to D. This channel of transmission of gasoline expenditures to the economy is a fruitful area for future research.

Figure 12: Response of inflation expectations to 10% gasoline price shock in recessions and expansions



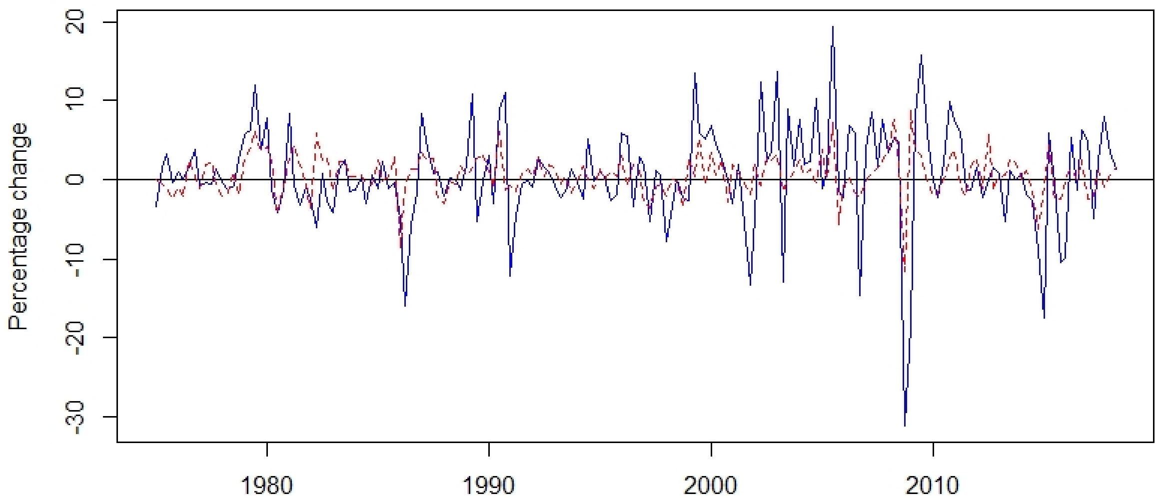
Notes: Solid line in the left column indicates the cumulative response to a 10% gasoline price shock during recessions while the corresponding dashed line is the cumulative response in expansions. Solid line in the right column indicates the difference in response across recessions and expansions, while the corresponding dashed lines are the 95% confidence intervals. A positive value implies a stronger response of inflation expectations to shocks that hit in recessions.

3.5 The Response of Inflation Expectations

An important channel by which changes in the price of gasoline affect the economy is the impact on inflation expectations (Binder and Makridis, 2022). Changing inflation expectations will then feed into consumption decisions (Binder and Brunet, 2022). This section compares the response of inflation expectations, as captured by the Michigan Consumer Survey, to gasoline price shocks that hit in recessions and expansions. The inflation expectations variable we use is the median expected price change over the next 12 months.

The results shown in the left panel of Figure 12 indicate a clear ratcheting up of inflation expectations following a gasoline price shock in either state of the economy. However, the response is much stronger when the shock hits during a recession (the solid line) rather than an expansion (the dashed line). The right panel shows that the difference is statistically significant. The difference in response is considerable at horizons longer than three quarters, with inflation expectations rising three times as much when the shock hits during a recession.

Figure 13: Gasoline expenditure changes and gasoline expenditure shock series



Notes: Solid blue line represents the percentage change in gasoline expenditures. The red dashed line is the identified gasoline expenditure shock series.
First-stage regression properties: R^2= 0.18, Adjusted R^2=0.17, F-stat = 38.11.

Households may pay greater attention to gasoline prices and gasoline expenditures during recessions, when liquidity constraints and concerns about future employment are strongest, leading to a greater adjustment of non-gasoline consumption when the shock hits during a recession.

3.6 Extensions

This section considers the effect of changes in several of our specification choices.

3.6.1 Alternative identification

We have used a recursive SVAR assumption (gasoline expenditures not responding to a shock to non-gasoline consumption in the same quarter) to identify the impulse response functions. This identifying restriction can be criticized for potentially contaminating the gasoline expenditure shock with other shocks.[20] In addition to the recursive SVAR model, we used a two-stage least squares method that, while inefficient, should be free of concerns related to inconsistency. Equation (2) is estimated using the oil supply news shock in Känzig (2021) as an instrument for the time t change in gasoline expenditures. If one accepts that Känzig's identified shock is free of information that would contaminate the gasoline expenditure shock in our recursive SVAR model, the estimates of d_i^{rec} and d_i^{exp} will be consistent. The identified gasoline expenditure shock and percentage change in gasoline spending are presented in Figure 13. The first-stage regression yields an adjusted R^2 of 0.17 and F-statistic of 38.11, highlighting the relevance of our instrument.

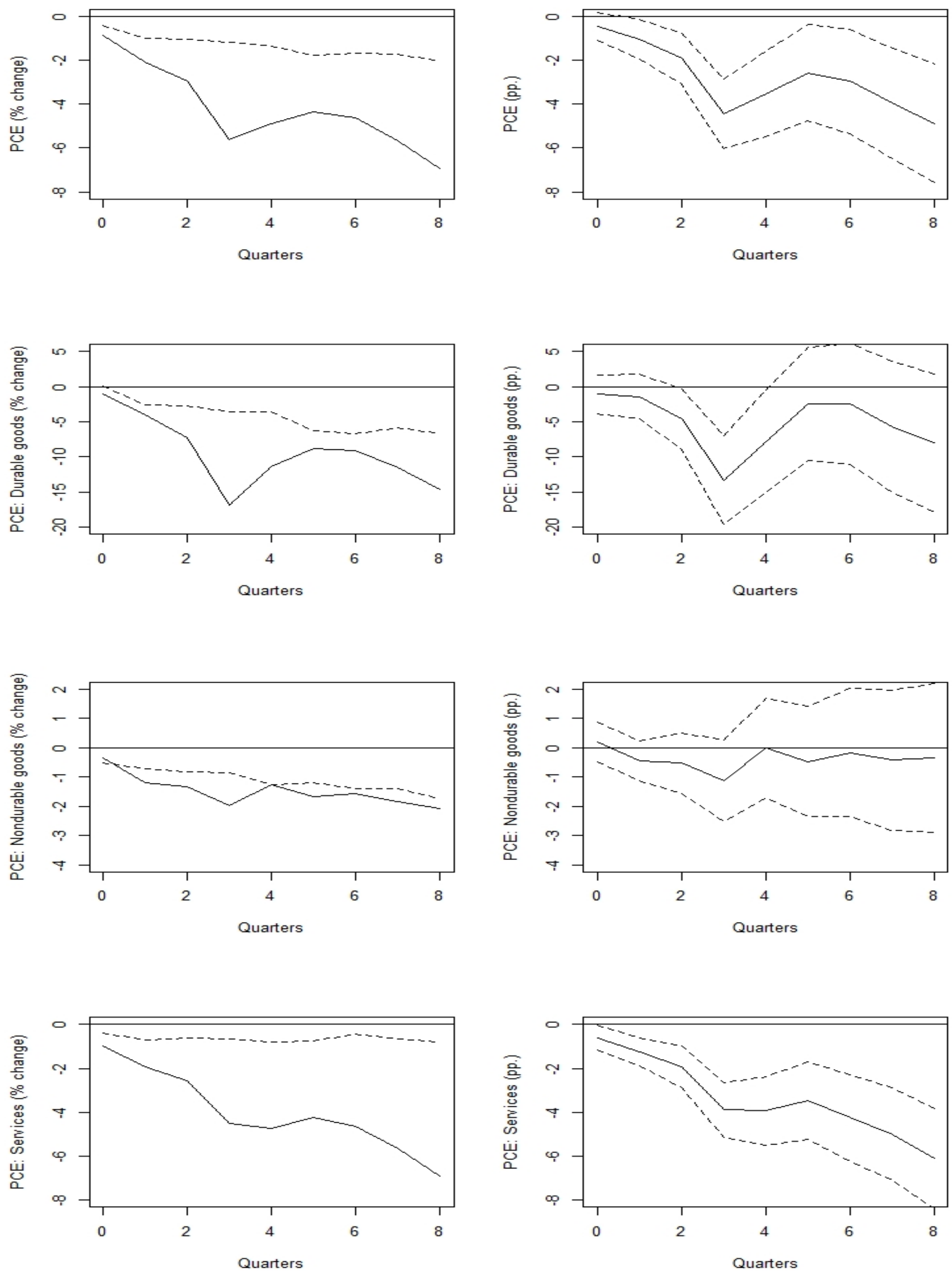
The cumulative impulse response functions along with the associated confidence bands are presented in Figure 14. The findings of asymmetry are in no way contingent on using a recursive identification scheme. A shock that increases gasoline expenditures by 10% generates a cumulative one-year decline in aggregate PCE of 4.9% in recessions as opposed to 1.4% in expansions. Similarly, other consumption categories including durables, nondurables, and services post a larger decline in recessions versus expansions.

3.6.2 Gasoline price shocks

Gasoline price shocks do not correspond exactly with gasoline expenditure shocks, since consumers can, to some extent, adjust the quantity of gasoline they purchase when the price of gasoline changes. On the other hand, it is easy to monitor the price of gasoline by observing the posted price at a gasoline station, and many consumers do. Consumers may be using gasoline prices as a proxy for their gasoline expenditures when they make consumption decisions. An example would be cutting back on non-gasoline purchases when they see an increase in the posted price of gasoline, even if they do not purchase any gasoline at that time. A higher gasoline price also means the gasoline currently in their vehicles has a higher replacement cost.

[20] While it is implausible that this can explain a finding of asymmetry across states of the business cycle, the magnitudes of the responses might be affected.

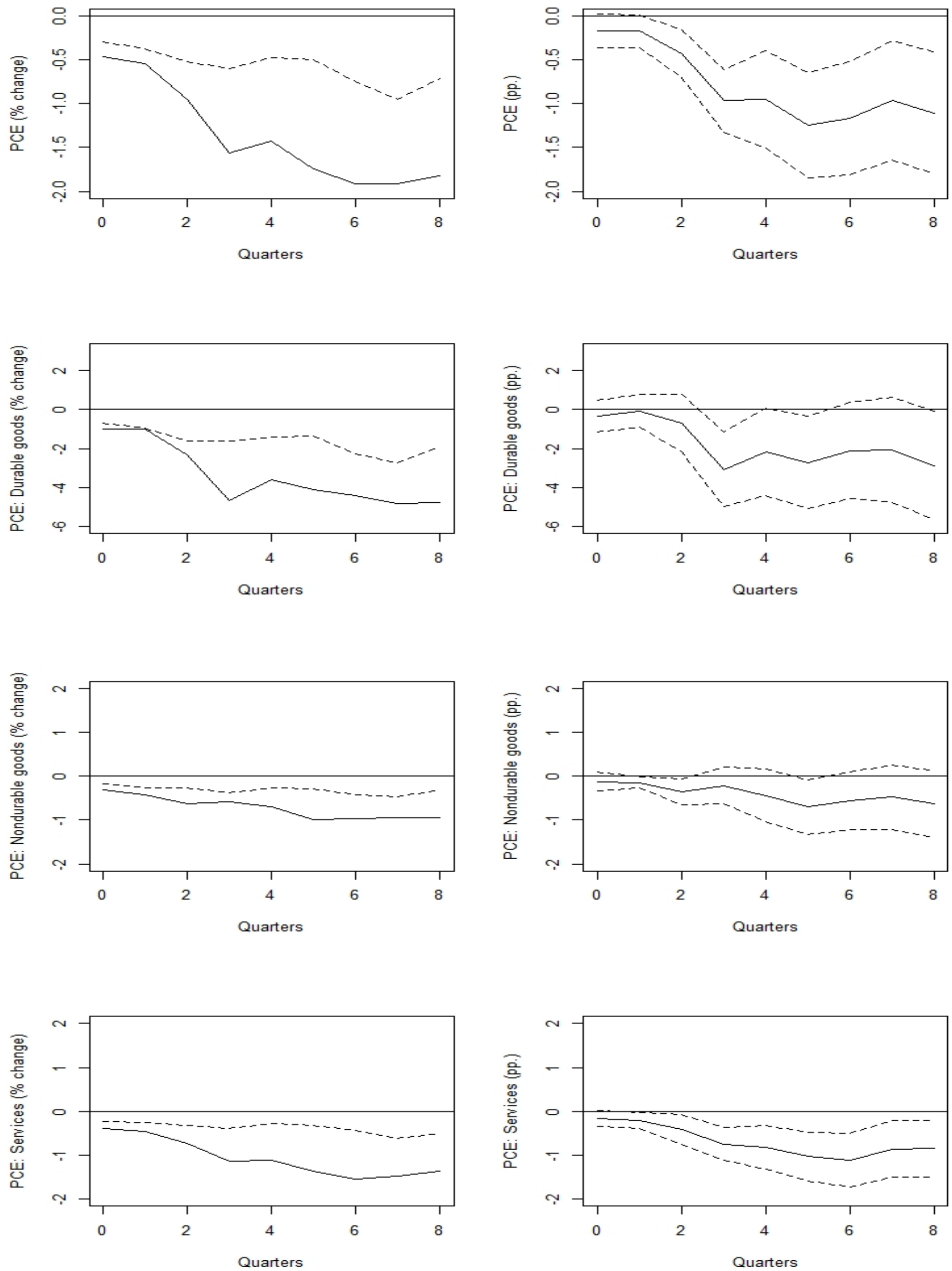
Figure 14: Cumulative response of consumption to a 10% gasoline expenditure shock in recessions and expansions



Notes: Solid line in the left column indicates the cumulative response to a 10% gasoline expenditure shock 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.

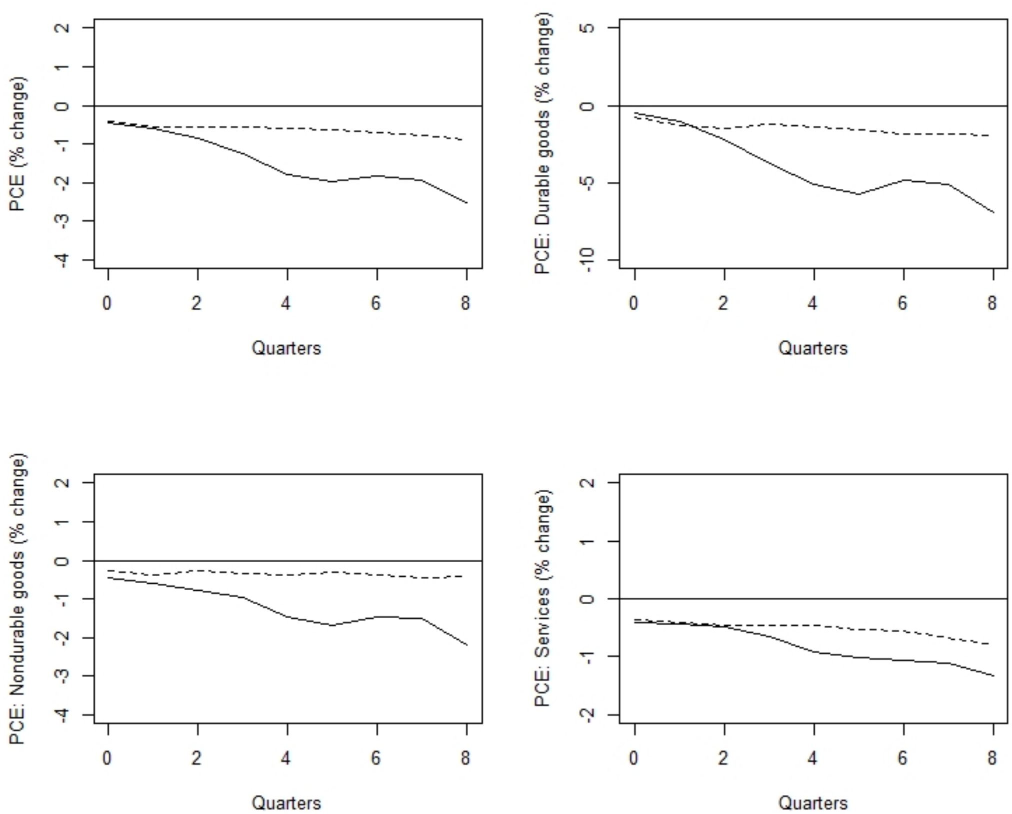
We have done the analysis using the real price of gasoline in place of gasoline expenditures. The results for aggregate consumption and its major components can be seen in Figure 15. A shock that increases the real price of gasoline by 10% leads to a decline in total consumption spending of 1.4% over the course of a year when the shock hits in a recession, with spending on durables, nondurables, and services declining by 3.6%, 0.7%, and 1.1%. When the same shock hits in an expansion, total consumption spending falls by 0.5%, and durables fall by 1.4%, nondurables by 0.3%, and services by 0.3%. Overall, we see a similar pattern for gasoline price shocks as for gasoline expenditure shocks, even though gasoline expenditure shocks are picking up other things such as changes in fuel efficiency. The difference in response along with the confidence bands are presented in the right panel of Figure 15.

Figure 15: Cumulative response of consumption to a 10% gasoline price shock in recessions and expansions



Notes: Solid line in the left column indicates the cumulative response to a 10% gasoline price shock 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: Alternative recession indicator: Chauvet and Hamilton (2006)



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

3.6.3 Alternative measures of recession

Different measures of recessions have been proposed in the literature. Owyang et. al (2013), and Ramey and Zubairy (2018) use a threshold unemployment rate of 6.5% to define the state of the economy. 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.[21] Since this proposed definition of recessions by Chauvet and

[21] See Chauvet and Hamilton (2006) 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.

Hamilton (2006) (hereafter, CH (2006)) is entirely mechanical, we rely on it as an alternative measure to the AG (2012) recession dates.

The recession measure proposed by CH (2006) corresponds to the probability that the underlying true economic regime is one of recession based on the available data. It is calculated in the following manner,

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

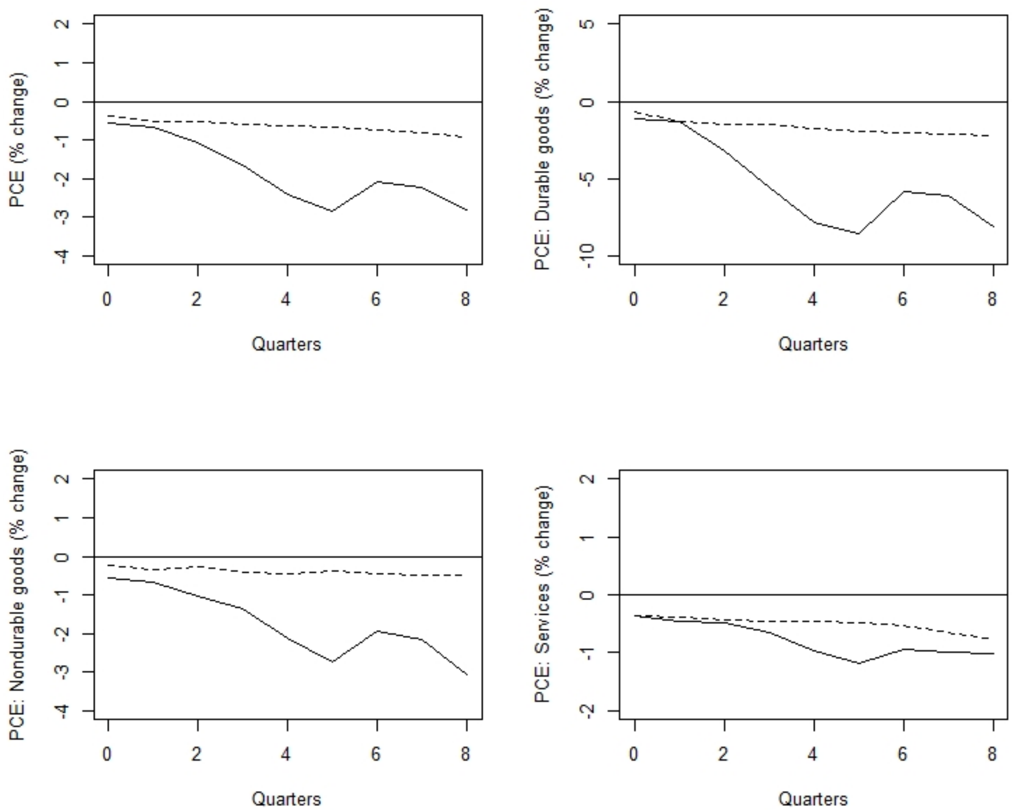
This equation gives us the conditional probability of the economy being in a recession given the value for GDP growth is observed. The numerator gives the joint probability of observing GDP growth and the occurrence of a recession, whereas the denominator measures the probability of observing the value of GDP growth.[22] Our results in Figure 16 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.

Alloza (2022) shows that studies that estimate fiscal multipliers in recessions and expansions reach different conclusions depending on the manner in which the state of the economy is defined. They claim that the choice of a centered moving average to determine the state of the economy in AG (2012) drives the results. To address this concern, we re-estimate our main specification using the NBER recession dates to determine the state of the economy. The cumulative impulse response functions are presented in Figure 17. Consistent with our earlier findings, we observe that the response of consumption is stronger in recessions as opposed to expansions, with this effect seen throughout the durables, nondurables, and services sector. The difference in response along with the associated confidence bands using alternate indicators to determine the state of the economy are presented in Table 6.

Overall, we find that the estimated IRFs with the state of the economy determined following CH (2006) and NBER Business Cycle Dating Committee are qualitatively similar to

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

Figure 17: Alternative recession indicator: NBER recession dates



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

those generated when recessions and expansions are identified using the transition function in AG (2012). The similarity in results arises because, barring few instances, all three methods identify similar recession and expansion periods, as illustrated in Table 7. CH (2006), and AG (2012) identify a total of six recessionary periods across the time period between 1973 and 2018, which is also in line with assessment of NBER's Business Cycle Dating Committee. These include the recessions of 1973-74, 1979-80, 1980-82, 1990-91, 2001, and 2007-09. The key difference however lies in the starting and end points of these recessions. For example, CH (2006) and NBER dates suggests that 1973-74 recession started in Q4 of 1973 and ended in Q1 of 1975. In contrast, the findings of AG (2012) conclude that the recession started in Q1 of 1974 and ended in Q1 of 1975. Similar differences can be observed for other recessionary

Table 6: Cumulative difference in response

Recession Indicator	Consumption Category	Forecast horizon 0	4	8
CH (2006)	PCE	-0.05	**-1.19**	**-1.64**
	PCE: Durable goods	0.34	**-3.73**	**-4.96**
	PCE: Nondurable goods	-0.18	**-1.09**	**-1.79**
	PCE: Services	-0.04	-0.45	-0.51
NBER	PCE	-0.16	**-1.76**	**-1.87**
	PCE: Durable goods	-0.47	**-6.08**	**-5.97**
	PCE: Nondurable goods	-0.29	**-0.69**	**-1.30**
	PCE: Services	0.00	-0.49	-0.23

Notes: Cumulative difference in responses (expressed in pp.) to a 10% gasoline expenditure shock. **Bold** indicates statistical significance at the 5% level.

periods as well.

Other potential recession indicators include the unemployment rate and capacity utilization. The unemployment rate has undesirable properties as a tool for dividing the economy into expansions and recessions. Using a threshold unemployment rate of 6.5% as the indicator of a recession, the Great Recession did not start until late 2008 and did not end until early 2014. An unemployment rate of 8% implies a recession start date of February 2009 and recession end date of September 2012. From a different perspective, the unemployment rate identifies the peak of the recession as late 2009 through the end of 2010. Going back in time, the 6.5% unemployment rate threshold implies there was not a recession in the early 2000s, with the closest the US economy came to a recession being the middle of 2003.

These observations are wildly inconsistent with the profession's views on the timing of recent recessions, the news reporting at the time, and the response of policy. Capacity utilization has a similar problem, as it has never returned to its 2007 value, and it identifies another recession in 2016. Going back to the 1970s, capacity utilization has trended downward over time, and by definition this cannot be due to a recession. We do not view either of these variables as credible indicators of recession.

Table 7: Comparison of identified recession dates

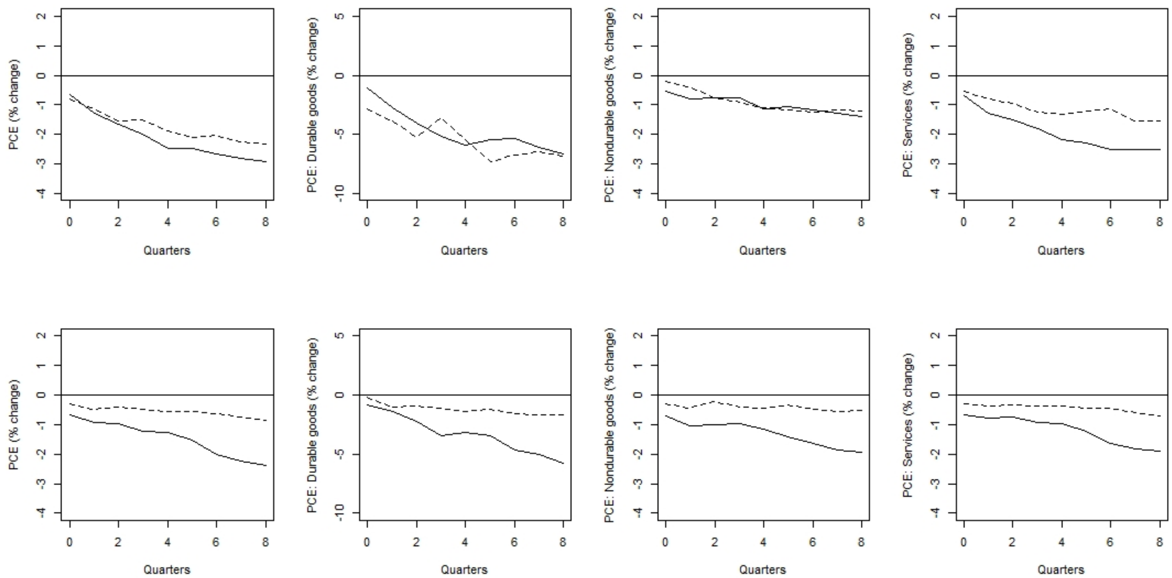
Recession	Identification		
	AG (2012)	CH (2006)	NBER
1973-74	1974:Q1-1975:Q1	1973:Q4-1975:Q1	1973:Q4-1975:Q1
1979-80	1979:Q3-1980:Q4	1979:Q2-1980:Q2	1980:Q1-1980:Q3
1980-82	1981:Q1-1982:Q3	1981:Q2-1982:Q2	1981:Q3-1982:Q4
1990-91	1990:Q1-1991:Q2	1989:Q4-1991:Q1	1990:Q3-1991:Q1
2001	2001:Q2-2001:Q4	2001:Q1-2001:Q3	2001:Q2-2001:Q4
2007-09	2007:Q4-2009:Q2	2007:Q4-2009:Q2	2008:Q1-2009:Q2

3.6.4 Time Variation in the Consumption Response

It is widely believed that the relationship between gasoline expenditures and consumption has weakened (Melek and Vigfusson, 2021). One reason is that the US has become less dependent on imported oil. To see if this has meant the asymmetry we identified earlier is driven by the start of our sample, we did the analysis on the first half and second half of our dataset separately. Figure 18 shows responses for the first half of the sample (upper panel) versus the second half (lower panel).

We find that the response to shocks that hit during an expansion is close to zero in the recent data, consistent with the conventional view. Importantly, that is not true for gasoline expenditure shocks that hit during a recession. If anything, the response of consumption to those shocks appears to be stronger in the more recent data. This can be explained by the different mechanisms at play during recessions and expansions. For example, if the greater response of consumption during recessions is due to liquidity constrained consumers, there is no reason to expect the response during recessions to decline in the later subsample. The Great Recession was more severe than initial recessions in our sample, and the associated financial crisis may have resulted in more severe liquidity constraints. The asymmetry we have identified is a feature of the recent data, and it should be accounted for when forecasting consumption expenditures.

Figure 18: Response of consumption series in recessions & expansions across subsamples



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. The upper panel represents the response in the first half of the sample (1973:Q1 to 1995:Q3), whereas the lower panel indicates the response in the latter half of the sample (1995:Q4 to 2018:Q2).

Table 8: Cumulative difference in response

Sample Period	Consumption Category	Forecast horizon 0	4	8
1973:Q1-1995:Q3	PCE	0.14	-0.57	-0.60
	PCE: Durable goods	1.72	-0.44	0.24
	PCE: Nondurable goods	-0.35	-0.02	-0.22
	PCE: Services	-0.15	-0.85	-0.96
1995:Q4-2018:Q2	PCE	**-0.39**	**-0.70**	**-1.55**
	PCE: Durable goods	-0.70	-1.73	**-4.18**
	PCE: Nondurable goods	**-0.40**	**-0.70**	**-1.42**
	PCE: Services	**-0.36**	**-0.59**	**-1.16**

Notes: Cumulative difference in responses (expressed in pp.) to a 10% gasoline expenditure shock. **Bold** indicates statistical significance at the 5% level.

4 Concluding remarks

Motivated by the literature on the effects of fiscal policy shocks over the business cycle, this paper has estimated of the degree of asymmetry in the response of non-gasoline consumption to gasoline expenditure shocks across expansions and recessions. A shock that causes gasoline expenditures to rise by 10% over the course of a year is followed by a decrease in spending on non-gasoline goods and services of 0.8%. Most of this response is attributable to services and durables consumption. When we allow the response to differ for shocks that hit during expansions and recessions, we find a much larger response during recessions, with the asymmetry being present in all of the components of consumption. The finding of asymmetry is robust to changes in identification and model specification.

Savings exhibits different responses to these shocks in recessions and expansions. There are several potential explanations. It is consistent with increased liquidity constraints and precautionary saving behavior during recessions. Consumers facing credit and other constraints will have no choice but to cut expenditures one-for-one with gasoline expenditures and as they prepare for higher future gasoline expenditures. Lower discretionary income causes households to value savings more during a recession. Future research should be aimed at providing a better understanding of these channels.

References

[1] Alloza, Mario (2022), Is Fiscal Policy More Effective during Recessions? *International Economic Review.*

[2] Alsalman, Zeina, and Mohamad Karaki. (2018). Oil Prices and Personal Consumption Expenditures: Does the Source of the Shock Matter? *Oxford Bulletin of Economics and Statistics*, 81(2), 250-270.

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

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

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

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

[7] Binder, Carola, and Gillian Brunet (2022). Inflation expectations and consumption: Evidence from 1951. *Economic Inquiry,* 60(2), 954-974.

[8] Binder, Carola, and Christos Makridis (2022). Stuck in the seventies: Gas prices and consumer sentiment. *Review of Economics and Statistics,* 104(2), 293-305.

[9] Carroll, Christopher, and Miles S. Kimball (2008). Precautionary Saving and Precautionary Wealth. *The New Palgrave Dictionary of Economics*, 1-9.

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

[11] De Michelis, Andrea, Matteo Iacoviello, and Thiago Ferreira (2020). Oil Prices and Consumption across Countries and U.S. States. *International Journal of Central Banking*, 16(2), 3-43.

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

[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.

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

[14] Gelman, Michael, Yuriy Gorodnichenko, Shachar Kariv, Dmitri Koustas, Matthew Shapiro, Dan Silverman, and Steven Tadelis (2022). The Response of Consumer Spending to Changes in Gasoline Prices. *American Economic Journal: Macroeconomics.*

[15] 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.

[16] Gonçalves, Sílvia, Ana María Herrera, Lutz Kilian, and Elena Pesavento (2022). When do state-dependent local projections work? Working Paper.

[17] Gonçalves Sílvia, and Lutz Kilian (2004). Bootstrapping Autoregressions with Conditional Heteroskedasticity of Unknown Form. *Journal of Econometrics*, 123(1), 89–120.

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

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

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

[21] Herrera, Ana María, Mohamad Karaki, and Sandeep Kumar Rangaraju (2019). Oil Price Shocks and U.S. Economic Activity. *Energy Policy,* 129, 89-99.

[22] Jorda, Oscar, and Alan Taylor (2016). The Time for Austerity: Estimating the Average Treatment Effect of Fiscal Policy. *The Economic Journal,* 126(2), 219-55.

[23] Känzig, Diego (2021). The macroeconomic effects of oil supply news: Evidence from OPEC announcements. *American Economic Review*, 111(4): 1092-1125.

[24] 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.

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

[26] Knotek, Edward, and Saeed Zaman (2021). Asymmetric Responses of Consumer Spending to Energy Prices: A Threshold VAR approach. *Energy Economics*, 95, 105127.

[27] Mehra, Yash, and Jon Petersen (2005). Oil Prices and Consumer Spending. *Economic Quarterly*, 91(3), 53-72.

[28] Melek, Nida, and Robert Vigfusson (2021). The Evolving Link between Oil Prices and U.S. Consumer Spending. *Federal Reserve Bank of Kansas City Economic Review*, 106(1), 5-16.

[29] Mertens, Karel and Morten Ravn (2013). The Dynamic Effects of Personal and Corporate Income Tax Changes in the United States. *American Economic Review*, 103(4), 1212–47.

[30] Montiel-Olea, Jose Luis, James Stock, and Mark Watson (2016). Uniform Inference in SVARS Identified with External Instruments. New York University.

[31] Owyang, Michael, Valerie Ramey, and Sarah Zubairy (2013). Are Government Spending Multipliers Greater during Periods of Slack? Evidence from Twentieth-Century Historical Data. *American Economic Review*, 103(3), 129-134.

[32] Pindyck, Robert (1991). Irreversibility, Uncertainty and Investment. *Journal of Economic Literature,* 29, 1110–1148.

[33] Ramey, Valerie, 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.

[34] Stock, James, and Mark Watson (2012). Disentangling the Channels of the 2007-09 Recession. *Brookings Papers on Economic Activity*, 44(1), 81–156.

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

[36] Wang, Yu Shan (2013). Oil Price Effects on Personal Consumption Expenditures. *Energy Economics*, 36, 198-204.