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

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Objective

- What happens to non-gasoline consumption when there is a shock to gasoline expenditures?
- Does the response of non-gasoline consumption to gasoline expenditures depend on the state of the business cycle?
- Why is the response of non-gasoline consumption to gasoline expenditures different between recessions and expansions?

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What To Take Away

Using a structural VAR model for U.S. data covering the period 1973-2018, this paper shows that

- An increase in gasoline expenditures reduces aggregate consumption.
- The response to a gasoline expenditure shock is much stronger in a recession than in an expansion.
- The difference in response over the business cycle is due to the differences in household savings behaviour in recessions versus expansions.
- Our results are consistent with the literature showing large effects of fiscal policy in recessions.

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Contributions

- This is the first paper to suggest that the effect of a gasoline expenditure shock depends on the state of the economy.
- We present a novel forecasting model that accounts for this kind of asymmetry.
- This model would allow the Federal Reserve to precisely estimate the effect of a gasoline expenditure shock on consumption (or other macro variable) in recessions and expansions.

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Relationship between U.S. Consumption and Gasoline Expenditures (1973-2018)

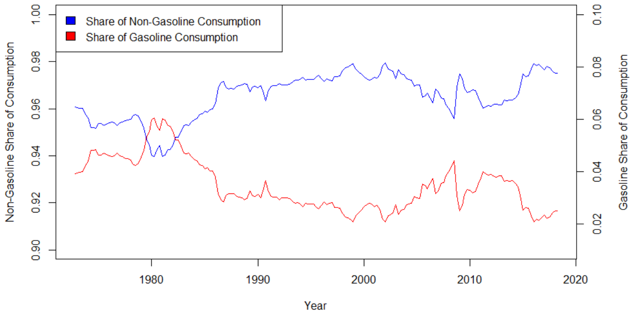

Figure 1: Gasoline and Non-Gasoline Shares of Consumption

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Relationship between U.S. Consumption and Gasoline Expenditures (1973-2018)

- Gasoline share of consumption peaked in the early 1980's.
- Low and stable global oil prices contributed to low shares during the 1990's.
- The more recent increase came in the early 2000's when oil prices increased due to high global oil demand.

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Relationship between U.S. Consumption and Gasoline Expenditures (1973-2018)

- A key question in macroeconomics is how aggregate consumption responds to a shock to gasoline expenditures?
- If gasoline consumption is inelastic in the short-run, a positive shock to gasoline price will lead to higher gasoline expenditures, reducing spending on non-gasoline goods and services.
  - Hamilton (2009): Less discretionary income available as gasoline expenditures rise.
  - Hamilton (1988): As gasoline expenditures increase, demand for energy-consuming goods falls.
  - Farrell and Greig (2015): The MPC for non-energy goods is 0.8 for every dollar saved on gasoline.
  - Gicheva et al. (2008): Higher gasoline expenditures affects consumers spending on food.

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U.S. Net Imports of Crude Oil (1973-2018)

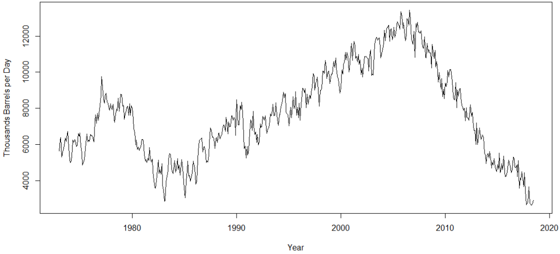

Figure 2: U.S. Net Imports of Crude Oil and Petroleum Products

- Increase in gasoline expenditures have caused a transfer of U.S. income to foreign oil producers.
- Higher gasoline expenditures have the same effect as a tax on the U.S. economy and should be expected to reduce aggregate consumption.

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U.S. Net Imports of Crude Oil

- Jannet Yellen (2011):

"A higher price of imported oil is the equivalent of a tax on consumers. It is a transfer from US consumers to foreign oil producers. The effect should be the same as a tax increase. This tends to have a dampening effect on consumer spending."

- S&P Global Economists Beth Bovino and Satyam Panday (2018):

"This would be tantamount to a tax increase for American households."

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Fiscal Policy Literature

- 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): Tax cuts are more effective in boosting private consumption in recessions.
- Auerbach and Gorodnichenko (2012): Fiscal multipliers are larger in recessions than expansions.
- Jorda and Taylor (2016): Fiscal austerity depresses the economy more in a slump as opposed to a boom.

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Motivation

- Due to the oil-importing nature of the U.S. economy, shocks to gasoline expenditures have the same effect as a change in taxes.
- Fiscal policy has different effects in recessions and expansions.
- It follows that the effect of a gasoline expenditure shock should depend on the state of the business cycle.

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Why Should We Care?

- A finding of economically meaningful asymmetry of this type requires a change to empirical and theoretical macroeconomic models that include energy prices.
- Implications for consumption forecasting.
- A failure to find evidence would cast doubt on the following:
  - 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.
  - Both claims.

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Linear Model

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

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

- $z_t = (\Delta gas_t, \Delta c_t)'$
- Δgas_t is the percentage change in gasoline expenditures in quarter t
- Δc_t is a measure of consumption growth in quarter t
- $e_t = (e_{gas,t}, e_{c,t})'$ is a vector of reduced form residuals
- p represents the lag-length, whereas α and β_i are vectors of coefficients.

Linear Model

- Gasoline expenditures are defined as the real personal consumption expenditures on gasoline goods and services.
- The four measures of consumption growth we use are:
  - RPCE
  - RPCE: Durables
  - RPCE: Nondurables
  - RPCE: Services
- Estimation of the linear VAR model does not represent an original contribution.
- It provides a benchmark for comparison with results of the nonlinear model.

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Data Transformation

- Data on consumption was downloaded from National Income and Product Accounts (NIPA) tables.
- Nominal variables are deflated using the *Price Index for PCE* and transformed into real variables.
- We conduct stationarity tests like the Augmented DF, Phillips-Perron, and ERS modified DF test.
- Results suggest that the real consumption variables are non-stationery in levels but stationery in percentage differences.

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Data Transformation

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

Figure 3: All tests include an intercept and a linear trend. 5% critical values for the respective tests are: -3.42, -2.89, -3.42.

Data Transformation

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

Figure 4: All tests include an intercept and a linear trend. 5% critical values for the respective tests are: -3.42, -2.89, -3.42.

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Identification of the Linear Model

- Our ordering of the variables implies a recursive system with gasoline expenditures ordered first.
- Consumption responds contemporaneously to gasoline expenditures, and not vice versa.
- The Cholesky decomposition of the variance-covariance matrix of reduced form residuals suggests that,

$$e_t = \begin{pmatrix} e_{gas,t} \\ e_{c,t} \end{pmatrix} = \begin{bmatrix} 1 & 0 \\ a_{21} & 1 \end{bmatrix} \begin{pmatrix} \varepsilon_{gas,t} \\ \varepsilon_{c,t} \end{pmatrix}$$

$$e_{gas,t} = \varepsilon_{gas,t}$$

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

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Identification of the Linear Model

- Metric for judging the plausability of our assumption 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 correlations between residuals.
- On the other hand, if consumption expenditures are reacting to gasoline expenditures, the correlation will be negative.

Variables	Correlation ($e_{gas,t}$, $e_{c,t}$)
RPCE	-0.35
RPCE:Durables	-0.07
RPCE:Nondurables	-0.26
RPCE:Services	-0.45

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Interpretation of the Structural Shock

What is the structural shock ($\varepsilon_{gas,t}$) capturing?

- Unanticipated changes in the price of gasoline.
- Change in the preferences for larger or smaller vehicles.
- Change in travel patterns.
- Change in commuting behaviour due to fluctuations in house prices.

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Results: Linear Model

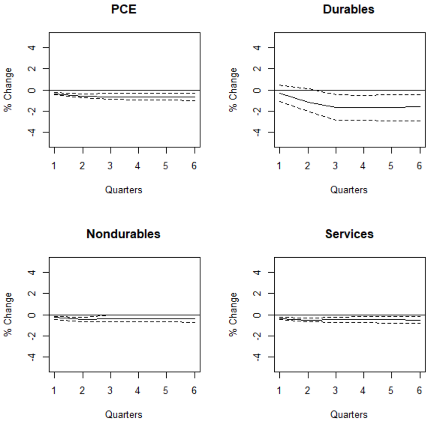

Figure 5: Response of consumption to a 10% increase in gasoline expenditures.

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Results: Linear Model

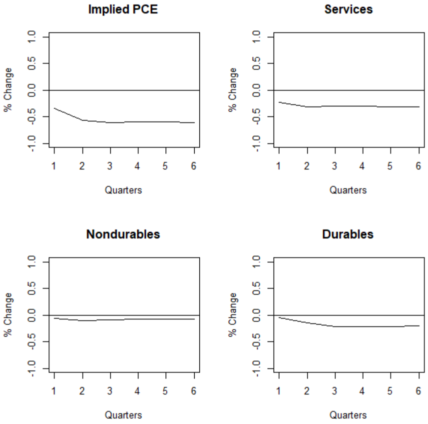

Figure 6: Contribution of each category in driving the response of consumption.

Interpretation of the Results

- The average household income before taxes for 2017 was \$73,572, of which \$60,060 was used by households for consumption.
- Based on our sample, consumers spend \$2,000 on gasoline and other energy goods.
- Following a \$200 increase in gasoline expenditures across the course of the year, an average household reduces spending by \$389 over the same time period.
- Services spending goes down by \$182, durables spending declines by \$123, and nondurables decreases by \$47.

Other Categories of Consumption

We also consider the following measures of consumption for our analysis:

- Durables
  - Furnishing Goods
  - Motor Vehicles
  - Recreational Goods
- Nondurables
  - Food and Beverages
  - Clothing
- Services
  - Housing and Utilities
  - Transportation
  - Other (Communication, Education, etc)

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Results: Other Categories of Consumption

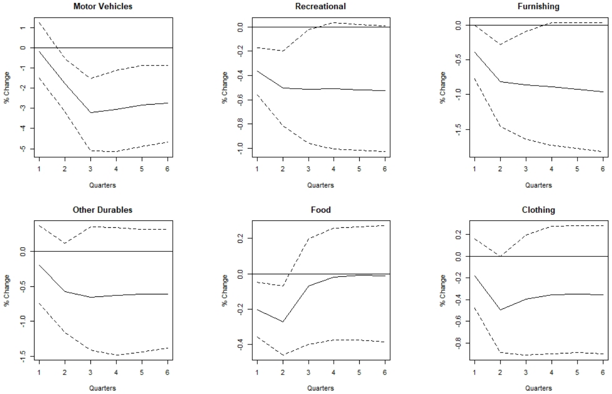

Figure 7: Response of consumption to a 10% increase in gasoline expenditures

Results: Other Categories of Consumption

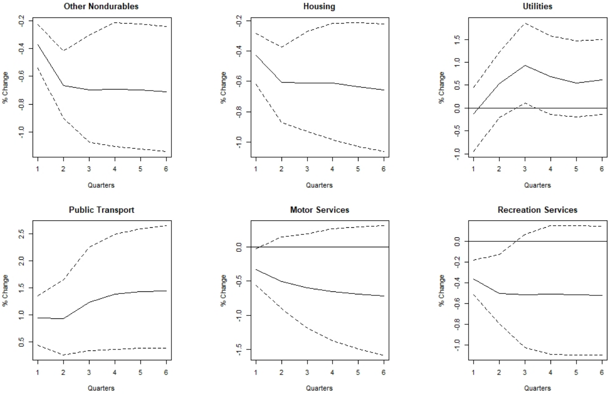

Figure 8: Response of consumption to a 10% increase in gasoline expenditures

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Other Categories of Consumption

- 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 furnishing and other durable household equipment, and clothing goes down by $16 and $10 respectively.
- Spending on food stays at its original level.
- Public transportation expenditures increase by $9.
- Expenditures on housing go down by $57, whereas utility bills increase by $11 over the course of a year.

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Crowding Out of Non-Gasoline Spending

- The bivariate VAR model results suggest that as gasoline expenditures increase, consumption falls.
- This decline in consumption is refered to as the ‘discretionary income effect’.
- Once consumers are done paying for gasoline and other gasoline goods, they have less money to spend on other goods and services.
- These results are evidence that an increase in gasoline expenditures has the same effect as an increase in tax on consumers.

Asymmetric Effects Over Business Cycle

- We model the asymmetric response of consumption variables to gasoline expenditure shocks in recessions and expansions using local projections.
- Local projections have the ability to accomodate nonlinear specification.
- Estimating a linear model for each regime separately will make our estimates imprecise due to insufficient degrees of freedom for recessions.
- On the other hand, a nonlinear model allows us to utilize the entire dataset for our analysis.

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Asymmetric Effects Over Business Cycle

Assuming that consumption growth responds contemporaneously to an increase in gasoline expenditures, the immediate response of consumption growth, Δc_t, to a gasoline expenditure shock can be estimated with the following regressions.

$$\Delta c_t = \alpha + \sum_{i=0}^{k} \phi_i I_{t-i} + \sum_{i=0}^{k} \theta_i \triangle y_{t-i} + \sum_{i=1}^{k} \beta_i \Delta c_{t-i} + \sum_{i=0}^{k} \gamma_i \triangle gas_{t-i}$$

$$+ \sum_{i=0}^{k} \delta_i inter_{t-i} + \varepsilon_t$$

Where,

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

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Asymmetric Effects Over Business Cycle

We follow AG (2012) and define a recession in the following manner,

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

The transition function that indicates the state of the economy takes the following functional form,

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

Where 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,

$$Pr(F(z_t) > 0.8) = 0.2$$

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Asymmetric Effects Over Business Cycle

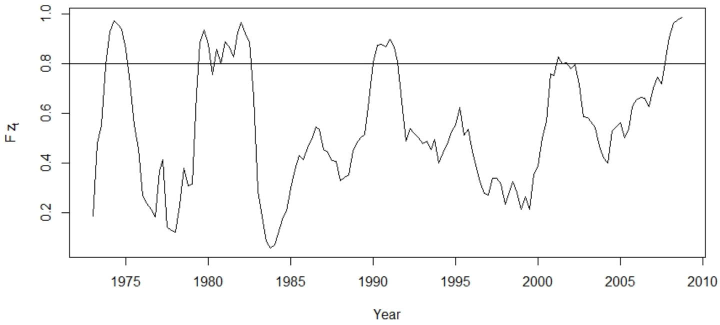

Figure 9: Estimated values of the AG (2012) transition function

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Asymmetric Effects Over Business Cycle

Defining Δgas_0 as the change in gasoline expenditures in recessions and expansions, and $inter_0$ as the change in gasoline expenditures in recessions, the contemporaneous response of Δc_t, Δc_0 is defined as

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

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

$$\Delta c_0^{exp} = \hat{\gamma}_0 \triangle gas_0$$

Since the shock under study is a 10% increase in gasoline expenditures $\triangle gas_0 = 0.1$. For a 10% shock in recessions, $inter_0 = 0.1$. For expansions, on the other hand, $inter_0 = 0$ since $I_t = 0$.

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Asymmetric Effects Over Business Cycle

We then define the initial response vector for each regime,

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

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

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

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

$$+ \sum_{i=1}^{k} \delta_i inter_{t-i} + \varepsilon_t$$

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Asymmetric Effects Over Business Cycle

The response for both regimes is calculated using the following,

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

and

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

where

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

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Asymmetric Effects Over Business Cycle

- 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.

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

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

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Asymmetric Effects Over Business Cycle

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.

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Results: Asymmetric Effects Over Business Cycle

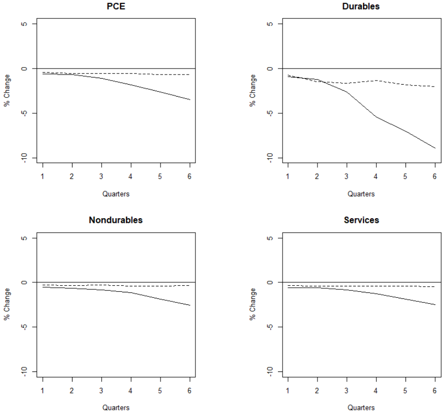

Figure 10: Response of consumption to a 10% increase in gasoline expenditures. Solid line is the response in a recession, whereas the corresponding dashed line is the response in an expansion.

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Results: Asymmetric Effects Over Business Cycle

- Non-gasoline consumption decreases by around 2% more in recessions as opposed to in expansions.
- Durables PCE decreases by almost 5.20% more following the shock in recessions.
- The difference in response among nondurables and services is -1.45% and -1.43% respectively.
- The highly elastic nature of durable goods explains the big drop.

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Results: Asymmetric Effects Over Business Cycle

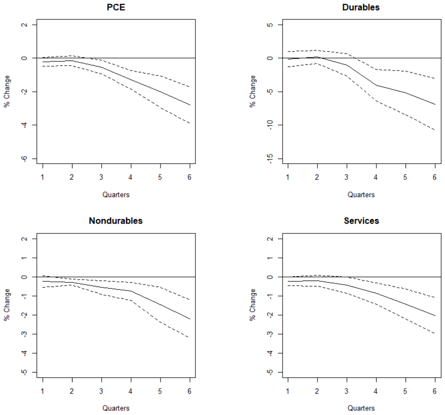

Figure 11: Solid line represents the difference in response, whereas the corresponding dashed line is the 95% confidence interval.

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Results: Asymmetric Effects Over Business Cycle

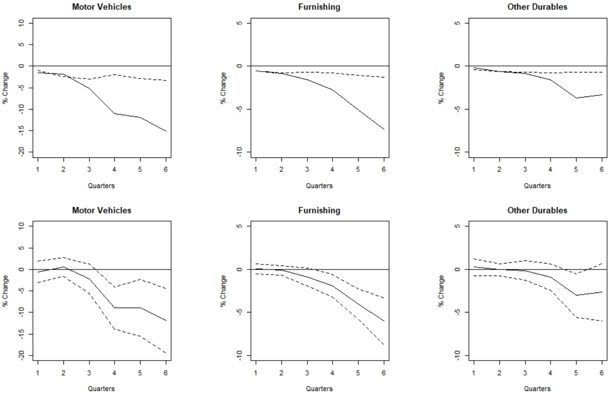

Figure 12: The top row indicates the response of consumption to a 10% increase in gasoline expenditures, whereas the lower row represents the difference in response across regimes with the corresponding dashed lines are the 95% confidence interval.

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Results: Asymmetric Effects Over Business Cycle

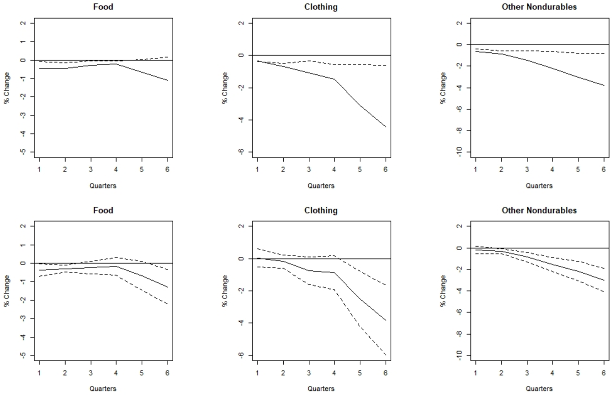

Figure 13: The top row indicates the response of consumption to a 10% increase in gasoline expenditures, whereas the lower row represents the difference in response across regimes with the corresponding dashed lines are the 95% confidence interval.

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Results: Asymmetric Effects Over Business Cycle

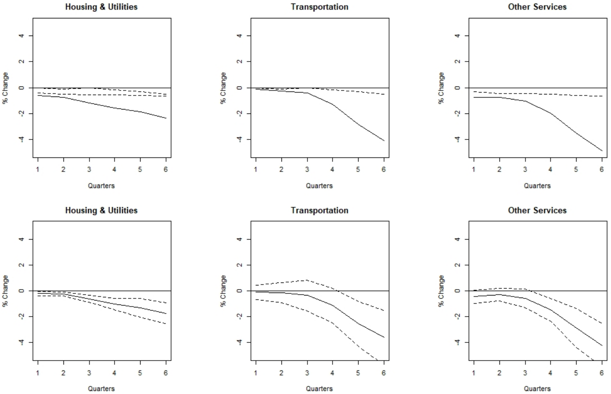

Figure 14: The top row indicates the response of consumption to a 10% increase in gasoline expenditures, whereas the lower row represents the difference in response across regimes with the corresponding dashed lines are the 95% confidence interval.

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Interpretation of the Results

- 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.
- Durables lose out by \$530 in recessions as opposed to \$137 in expansions.
- Spending on nondurables decreases by \$249 in recessions and \$55 in expansions.
- On the other hand, services spending goes down by \$689 in recessions as opposed to \$156 in expansions.

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Source of Asymmetry

- Precautionary Savings Effect: Edelstein and Kilian (2009)
- We reestimate the nonlinear model using personal savings as the dependent variable,

$$Personal\ Savings = Disposable\ Income - Personal\ Outlays.$$

- The estimates from our model suggest that a 10% increase in gasoline expenditures over the course of a year increases savings by 3.57% in recessions as opposed to 0.92% in expansions.

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Source of Asymmetry

- The difference in response of savings indicates that the precautionary savings channel is amplified in recessions.
- A $200 increase in gasoline expenditures increases private savings by $398 in recessions and $60 in expansions.
- As gasoline expenditures increase in recessions, consumers become skeptical about the future path of the economy.
- Consumers increase their savings by more because they perceive a higher likelihood of unemployment during recessions.

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Why Should We Care? (Change)

- A finding of economically meaningful asymmetry of requires a change to empirical and theoretical macroeconomic models that include energy prices.
- This suggests that the Federal Reserve's consumption forecasting models need to account for this asymmetric behaviour.
- Forecasts with the linear model might underestimate the effects of gasoline expenditure shocks. (Add details about models being forecasted.)

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Forecasting Implications

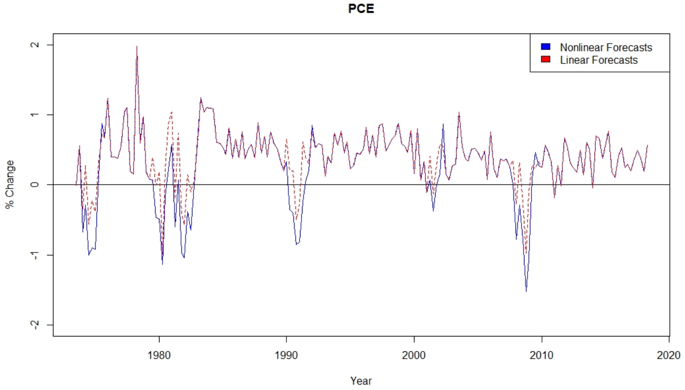

Figure 15: Consumption forecasts following a 10% increase in gasoline expenditures.

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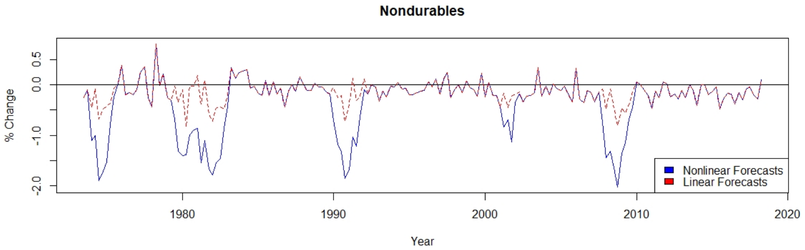
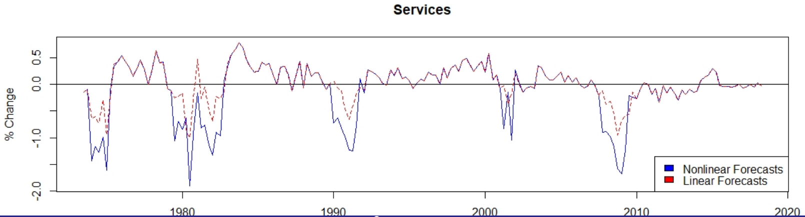
Forecasting Implications





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Alternative Recession Dates

- Different measures of recessions have been proposed in the literature, i.e. unemployment rate, capacity utilization, and output gap.
- We reestimate our model using an alternative recession date proposed by Hamilton.
- Hamilton like AG (2012), also estimates recession dates,

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

Alternative Recession Dates (Change)

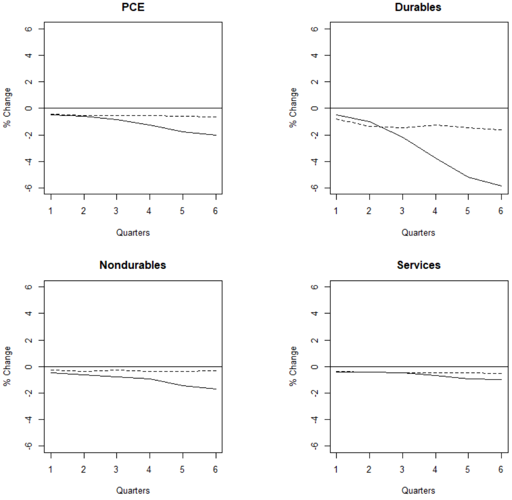

Figure 17: Responses and Difference in Response

Alternative Measure of Shock

- We also redo the analysis using real price of gasoline.

$$\Delta c_t = \alpha + \sum_{i=0}^{k} \phi_i I_{t-i} + \sum_{i=0}^{k} \theta_i \triangle y_{t-i} + \sum_{i=1}^{k} \beta_i \Delta c_{t-i} + \sum_{i=0}^{k} \gamma_i \triangle rpg_{t-i}$$

$$+ \sum_{i=0}^{k} \delta_i inter_{t-i} + \varepsilon_t$$

Where,

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

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Alternative Measure of Shock (Change)

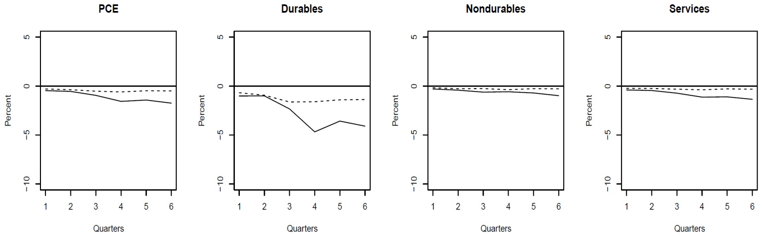

Figure 18: Response of consumption to a 10% increase in real price of gasoline.

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Positive versus Negative Shocks

- We also consider the response of consumption to negative gasoline expenditure shocks.
- Oil price decreases cause a transfer of wealth from oil-exporting to oil-importing countries.
- A decrease in gasoline expenditures frees up a portion of income, consequently, increasing spending on non-gasoline goods and services.

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Positive versus Negative Shocks

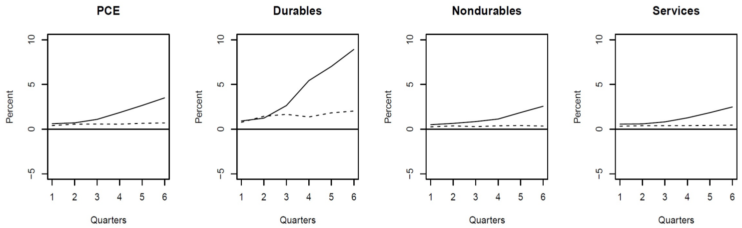

Figure 19: Response of consumption to a 10% decrease in gasoline expenditures.

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Conclusion

- An increase in gasoline expenditures has the same effect as a tax on U.S. consumers, because it transfers a portion of theirincome to foreign oil producers and depresses non-gasoline consumption.
- We find evidence that the effect of a gasoline expenditure shock depends on the state of the business cycle.
- The response to a gasoline expenditure shock is much stronger in a recession than in an expansion.
- We present a forecasting model that accounts for the asymmetric behaviour of consumption to a gasoline expenditure shock across recessions and expansions.

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Conclusion

- The difference in response over the business cycle is due to the differences in household savings behaviour in recessions versus expansions.
- Our central estimates are robust to alternative measure of recession and shock as well.
- The extra income generated following a decrease in gasoline expenditures is more effective in boosting consumption during recessions.

Thank You.

Questions?

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