Oil Price and Consumption Expenditure

Yi-Pei Chan*

Date: 2016.07.02

Abstract

This thesis studies the endogenous relation between consumption and oil prices in the United States form year 1980 to year 2016 on quarter basis, and mainly focuses on the change of consumption level in times of oil price declines. Fluctuations of stock market and housing market which are supposed to influence consumption are taken as explanatory variables in the empirical model.

With the Error Correction Model(ECM) under the Permanent Income Hypothesis, this thesis indicates how much of the positive effect of oil price declines on real GDP worked through the consumption channel were offset by the negative effect generated through allocative channels. Consumption behavior, and firm investment decision changes accordingly to oil price fluctuations are as well discussed.

Keywords: Oil Price, Consumption Expenditure, ECM, Error Correction Model

*Bachelor Thesis, National Taiwan University, Department of Economics
E-mail address: b01303133@ntu.edu.tw

1 Introduction

James Hamilton studied the relation between oil price and macro economy in 1983, strongly suggesting that sharp oil price increases might be the reason of recessions. Intuitively, on the contrary, oil price declines should be beneficial to the economy. However, empirical studies suggested that oil price declines do not have significant effects on real GDP in most oil importing countries; some even proposed that oil price declines leading to lower inflation rate may have negative effect on real GDP growth. While the negative correlation between oil price increases and economic activity has been widely studied, past researches have not yet reached a consensus on the degree to which the influences of oil prices declines have on an economy.

The West Texas Intermediate crude oil price has plummeted more than 50 percent since 2014, and increased supply has played a more dominant role than demand factors. In addition to production level higher than expected among OPEC countries, rising unconventional oil production, namely shale oil in the United States and bio-fuel in Brazil and Europe have contributed to greater output. Low oil price trend is likely to persist into the medium term, as OPEC nations have constantly failed to reach curtailment agreements and technologies in unconventional oil productions are expected to advance in reducing production costs. It is therefore of great importance to disentangle the channels oil price declines work through to influence the economy and to identify their relevant magnitudes.

After year 2000, personal consumption expenditures contributed more than 65 percent of the gross domestic product each year, and the share is still on the rise. To clarify the nonlinear relation between oil prices and macro economy, consumption—and hence aggregate demand—is an essential factor to be scrutinized carefully.

2 Literature Review

2.1 Theoretical mechanisms

Several theories and hypothesis have been proposed on illustrating how oil price changes affect macro economy. A thorough review of these mechanisms can be referred to Mork(1994). The real balance channel posits that oil price declines lower the production cost in energy-intensive production sectors, which indirectly reduce inflation, in other words, increasing real money balances of households and firms in the economy; thereby facilitates higher aggregate demand (Blanchard and Gali 2008). When oil price drops, however, people may rationally predict the oil price to rise again after a period, and choose to save rather spending. Consumption behavior in the US responding to oil price changes would be explained and concluded at the empirical result part later in the thesis.

Monetary policy has been acted as an important channel in modulating economic performance by governor. While tightened monetary policies were often implemented in fear of higher inflation rate induced by oil price increases, few monetary policy was launched against price plunges. Bernake, Gertler, and Watson (1997) suggested that compressing monetary policies may largely account for observed significant influences of oil price increases on macro economy. To discuss how otherwise price movements affect consumption level through monetary policy changes, the federal funds rate is adopted and its effect on consumption will be discussed incorporated with empirical model at full length in later sections.

Theory of income transfer posits that oil prices are regarded as costs for oil importing countries and as revenue for exporting countries; in times of oil price declines, incomes are transferred from the exporting nations to the importing nations, prompting higher consumption expenditure in the later. Rising production of shell oil in the US in recent years, which might to certain degree alter its previous role in international oil supply and demand market, will be taken into consideration in verifying the theory.

Theory of oil as an input in the production function suggests that oil and capital are compliments in the production process, and oil price decrease leads to an increase in the economy's productive capacity as agents respond to lower oil price by increasing their utilization of both oil and capital, reaching their potential output. However, firms face capital limitation in the short run. Even when production costs are lower, because of oil price declines, firms may not have sufficient capital for greater output. The production sectors may thus undertake large-ticket consumption and purchase investment goods to reach higher production, increasing both output and aggregate demand through higher investment. Firms' decisions on whether to take on large-ticket consumption and investment goods depend on their expectations on if the low oil price is persistent or temporal. For how long- the length of time - firms perceived the price movement as temporal, i.e. not beneficial enough to alter their previous investment plans will be concluded in the empirical result.

All hypotheses above indicated that oil price declines have positive effects on the economy; however, Hamilton (1988) postulated a theoretical model, allocative channel, in which oil price increases and declines may adversely affect real economic activity. In this framework, an oil price decrease reduces demand for inputs used in energy-producing sectors and hence be contractionary if labor or capital could not be moved to favorably affected sectors. The high cost of reallocating labor or capital among sectors affected differently by oil price changes result in negative effects on the GDP growth.

Commodity prices may spike up in months after oil price increases in reflection of higher cost, but rarely drop down after oil price declines. While even the commodity prices remain the same, it still means that firms with high intensity use of oil earn higher profit than ever and thus can spend or invest more. For firms low in the use of oil are not affected by the oil price movement. For energy producing sectors, plunges in oil price might result in numerous problems, such as oil drill shutdowns, postponed large investments, labor redundancies, etc. As a whole, Hamilton (2003) asserted that the costly reallocation process may offset the sum of the positive effects of oil price drops on the GDP growth, leaving it unchanged in the short run. He posits that the relation between oil price changes and real GDP growth is nonlinear, namely, that oil price increases matter but oil price declines do not.

Oil prices have maintained at low level, compared to its historical values, for more than two years since 2014. Refer to the graphs at the appendix; the manufacturer's new order of durable goods actually rose after 2014 when the crude oil price dropped sharply. The obvious observation contradicts with the Hamilton's theory. This thesis will examine if the investment change was stimulated by lower oil price and further affected consumption level or whether it is a spurious relationship, as there may be a third factor to be included as explanation, since it might have happened to be an economic recovery during 2014, and the observation stated above happened simultaneously and accidentally.

2.2 Indirect oil price influence on consumption through stock market

Inflation often ensued after oil price soared; policy makers of oil-importing countries may hence increase the interest rate to stable the economy, which makes stock market less attractive, as expectation of increasing market interest rate reduces the value of stocks. In contrast, there is few monetary policy implemented in face of plummeting oil prices. When oil price veered sharply downward, the market may consider stock market more attractive; as companies faced with lower oil costs, their future cash flows are deemed to increase. Adopting oil price as an exogenous factor, the wealth of consumer- taking the stock return as wealth of households- rose when oil price dropped. This thesis will later examine if the claim is true in the consumption level determination process.

3 Methodology

Mechanisms working on consumption have traditionally been studied with the permanent income hypothesis or the life-cycle model, where wealth, current income and discounted expected future income stream are crucial determinants. This thesis follows the methodology used in the Hamilton (1996) and Mehra and Petersen (2005). A typical period budget constraint for two consecutive periods would be:

$$W_{t+1} = (1 + r_t)(W_t + Y_t - C_t) \tag{1}$$

where C_t is consumption spending at time t, r_t is prevalent interest rate, W_t the level of wealth, and Y_t is the household income. Imposing the Transversality condition and assume that household income is expected to grow at speed g every period, the lifetime budget constraint household sectors faced with can be written as:

$$\sum_{s=t}^{\infty}(\frac{1}{1+r})^{s-t}C_s = W_t + \sum_{s=t}^{\infty}(\frac{1+g}{1+r})^{s-t}Y_s \tag{2}$$

or

$$C_t^p = rW_t + r\sum_{s=t}^{\infty}(\frac{1+g}{1+r})^{s-t}Y_s \tag{3}$$

The long term relation between consumption, income, and wealth under the PIH hypothesis can thus be written as:

$$C_t^p = a_0 + a_1 W_t + a_2 Y_t^p \tag{4}$$

$$Y_t^p = Y_t + \sum_{s=t+1}^{\infty}(\frac{1}{1+r})^{s-t}Y_s^e \tag{5}$$

$$E(Y_{t+1}) = (1+g)Y_t \tag{6}$$

C_t^p is the planned consumption which is formulated by people based on current wealth, current income, and expected future income streams. In reality, it is rational to assume that actual consumption may differ from the planned consumption, because of habits or lag expenditures. The difference between actual and expected consumption level can be expressed in a dynamic equation as:

$$\Delta C_t = b_0 + b_1(C_{t-1}^p - C_{t-1}) + b_2\Delta C_t^p + \sum_{s=t}^{k} b_{3s}\Delta C_{t-s} + \mu_t \tag{7}$$

Substituting equation(4) into equation(7), and with some combinations of coefficients, the equation can be written as:

$$\Delta C_t = b_0 + b_1(C_{t-1}^p - C_{t-1}) + b_2(\Delta a_1 W_t + \Delta a_2 Y_t^p) + \sum_{s=t}^{k} b_{3s}\Delta C_{t-s} + \mu_t \tag{8}$$

Assumptions are to be made to formulate a feasible model that is applicable to real world data. Since the planned consumption, current household income and current consumption cannot be observed, it may be rational to assume that future income as well as wealth level are both proportional to their past values; hence the planned consumption level in equation(4) may also be proportional to its past values. As mention in the previous section, monetary policies were suggested to play a significant role in influencing macro economy in times of oil price fluctuations; hence lagged terms of federal funds rate are also adopted in the model. The wealth of household is seperated into two parts, first is stock market return, and second is the housing price change. The short-run dynamic consumption model can thus be written as:

$$\Delta C_t = \beta_0 + \beta_1(C_{t-1}^p - C_{t-1}) + \sum_{s=t}^{j} \beta_{2s}\Delta stockrt_{t-s} + \sum_{s=t}^{k} \beta_{3s}\Delta HPrt_{t-s}$$
$$+\beta_{4s}\Delta income_{t-1} + \sum_{s=t}^{l} \beta_{5s}\Delta C_{t-s} + \sum_{s=t}^{m} \beta_{6s}\Delta oilprice_{t-s} + \sum_{s=t}^{n} \beta_{7s}\Delta FFR_{t-s} \tag{9}$$

The measure of oil price changes in this thesis follows the idea similar to Hamilton (1996), using a variable called net oil price decrease to record the net amount by which oil prices have gone done over the past designated periods, namely quarters in this thesis. Net oil price decrease, $\Delta oilprice_{t-x}$, is defined as the amount by which oil prices in quarter t fell behind their trough value over the previous specified times, which is set to be a quarter, a year, two years, and three years. The fallen amount is recorded; if it does not fell behind the previous trough, then $\Delta oilprice_{t-x}$ is taken to be zero. The method records only the decline amount compared to minimum level within the designated period, in order to leave out the price increase and amendment processes after high oil prices. Excluding amendment processes after oil price shocks (increase) is based on the assumption that when oil prices went too high, the market may expect it to drop down in the near future, so that their investment decisions may be affected, which may lead to a biased outcome in the study if not excluded.

Figure 4 and figure 5 at the appendix indicate the differences in implementing varied methods to generate oil price changes. In figure 4, the quarterly oil price changes is generated by simply taking each quarter's oil price and subtract the oil prices from its previous quarter; while the negative decrease in oil price is derived by further recording the positive change to be zero. Figure 5 listed out the net oil price decreases with specified time periods of a year, two years, and three years. From the graph, it could be observed that oil price fluctuations in the history normally are increases, and declines were often happened to adjust previous spikes.

4 Empirical Result

To avoid spurious results in the time series data, Augmented Dickey-Fuller Test is implemented for every variable. The result of ADF t-statistic (p-value) is listed in table 2, and non-stationary variables are taken first differences before doing regression

Table 1: Data Description

Variable	Detail	Source
oilprice	WTI Crude Oil Price	Energy Information Administration
C	Personal Consumption Expenditure	Bureau of Economic Analysis
income	Disposable Personal Income	Bureau of Economic Analysis
$HPrt$	All-Transactions House Price Index Change	Federal Housing Finance Agency
stockrt	Russell 3000 Total Market Index return	FTSE Russell
FFR	Effective Federal Funds Rate	Federal Reserve

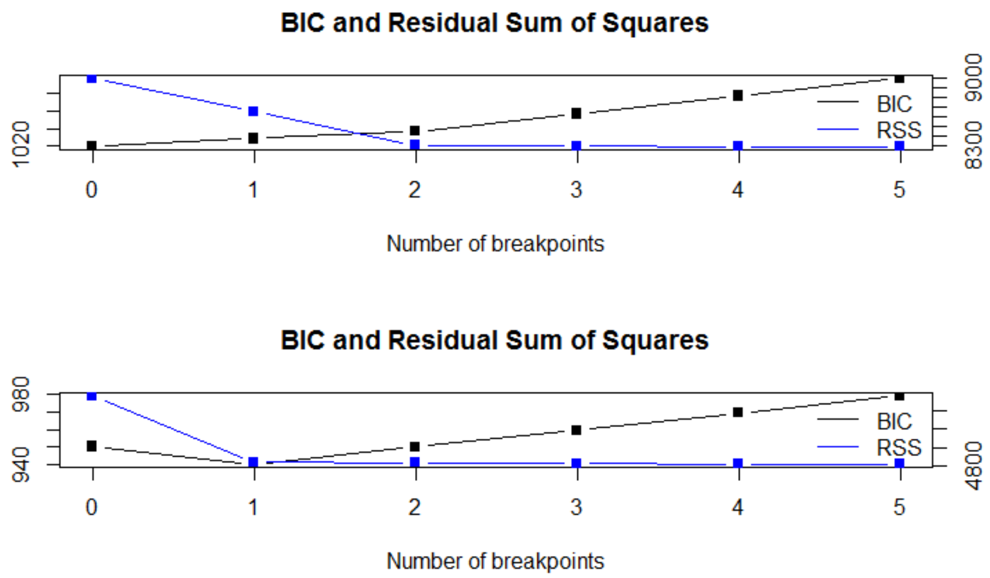
Table 2: Dickey-Fuller Test

Variable	ADF(original)	ADF(first difference)
$log(consumption)$	0.69286 (0.99)	-5.8188 (0.01)
income	0.51369 (0.99)	-5.9064(0.01)
$HPrt$	-2.9691 (0.172)	-14.097(0.01)
stockrt	-6.8087 (0.01)	
FFR	-2.332(0.4361)	-7.920(0.01)

model. The critical value for 1 percent level of significance, 5 percent and 10 percent is as follow: -3.46, -2.88 and -2.57. Lag lengths for the ADF test is determined by BIC. Stock return derived from Russell 3000 is an I(0)process, i.e it need not proceed with first difference; consumption, income, federal funds rate, and log housing price return have I(1) process, which require one term of log difference to reach stationary status. The lag lengths are determined by BIC for the model, as j is 1, k is 4, l is 6,m is 2, and n is 3.

It is likely that between 1980 and 2016 the U.S economy is marked with business cycles, which may reflect structural changes or structural breaks. For instance, the financial crisis in year 2008, ensued from mammoth defaults of prime mortgages, resulted in sluggish growth and recessions in the following years in real sectors. The shock affected economic behavior in both production and consumption perspectives.

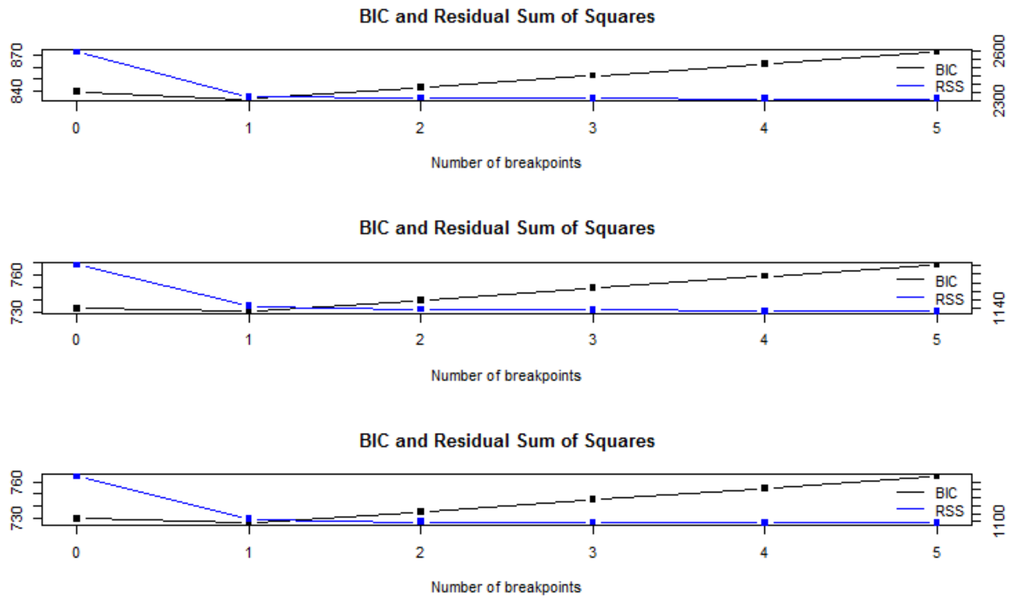
Figure 1: Structure Change Test (1980:Q1–2016:Q1)



Therefore, regressing consumption expenditure changes on oil price changes, the intercept, the slope, or both are likely to change in accordance with business cycles. This thesis implements the method of simultaneous estimation of multiple breakpoints proposed in Bai and Perron (2003). The number of breakpoints within the period is determined by choosing the minimum BIC estimator as listed in figure1 and figure2; figure1 examined the structural breaks in quarterly oil price change and negative oil price decrease, while figure2 investigates those of one to three years of net oil price decrease variables. The result indicates one structural change in year 2008 quarter three in common; thus the dummy variable year2008 is involved in the empirical model, which is set as zero before 2008 quarter three and as one otherwise.

Table 3 reported coefficients and t-values in parentheses of important parameters. Asterisks next to the number indicate the significance level of the parameter in the model; significance level are identified by p-values, with between 0 and 0.001 being marked with three asterisks ***, between 0.001 and 0.1 with two, between 0.01 and 0.05 with one, finally between 0.05 and 0.1 with a dot. The columns labeled

Figure 2: Structure Change Test (1980:Q1–2016:Q1)



(1) through (5) specify coefficients of models adopting different measures of oil price change. The first model uses quarterly oil price change, the second with negative decrease in oil price, and the third through fifth are measured with net oil price decrease as defined in the previous section. The variable negative decrease in oil price records the price difference compared to the last quarter; if negative, then the amount is recorded, otherwise recorded as zero.

The result restates the asymmetric relation between oil price changes and consumer spending, as the model with the parameter, quarterly oil price change, is significant, and all other new oil price decrease are not significant. Higher t value rejects the null hypothesis that the specified measure of oil changes has no effect on consumption expenditure changes. However, the asymmetric effect stating that oil price declines do not affect consumption is not accurate and may be partially wrong. From the first and second column of the table, oil price declines actually have almost equivalent amount of effect on consumption as that in times of oil price increase. Households change their behavior for higher consumption in a quarter when encountered with favorable oil price plunges, but they soon return back to their original consumption level in a year. Therefore, while using year data to explain that consumption did not change in times of oil price declines, and deduce that oil price have no effect on consumption may lead to misunderstanding, since it is in long term that oil price decline do not affect consumption, while in short run, like a quarter, oil price changes actually have symmetric effect on consumption. Variables measure in terms of net oil price decrease have relative lower t value, compared to that of the quarterly oil price change and negative decrease in oil price, implying that in the long run, for example more than an year, oil price declines do not affect consumption level.The dummy variable $year2008$ is significant in the five models, reaffirming the existence of structural change in the third quarter of year 2008.

Table 3: Empirical Aggregate Consumption Equation

$$\Delta C_t = \beta_0 + \beta_1 (C^p_{t-1} - C_{t-1}) + \sum_{s=t}^{1} \beta_{2s} \Delta stockrt_{t-s} + \sum_{s=t}^{4} \beta_{3s} \Delta HPrt_{t-s} + \beta_{4s} \Delta income_{t-1}$$
$$+ \sum_{s=t}^{6} \beta_{5s} \Delta C_{t-s} + \sum_{s=t}^{2} \beta_{6s} \Delta oilprice_{t-s} + \sum_{s=t}^{3} \beta_{7s} \Delta FFR_{t-s} + year2008$$

Variable	(1)	(2)	(3)	(4)	(5)
C_{t-1}	0.05539 (1.060)	0.20028 (-0.90)	-0.05 (-0.82)	-0.04 (-0.75)	-0.04(-0.61)
$\Delta income_{t-1}$	0.20028 (4.039)***	0.15 (2.93)**	0.15 (3.04)**	0.16 (3.12)**	0.165 (3.26)**
ΔC_{t-s}	-0.23352 (-1.954) .	-0.29 (0.03)*	-0.22 (-2.31)*	-0.23 (-2.63)*	-0.24 (-2.73)**
$\Delta HPrt_{t-s}$	51.15345 (1.831) .	59.76 (2.06)*	54.31 (1.86)*	57.50 (2.09)*	61.97 (2.24)*
$stockrt_{t-1}$	1.47738 (1.588)	1.74 (1.94) .	2.02 (2.22)*	2.03 (2.23)*	1.91(2.08)*
ΔFFR_{t-s}	12.25517 (2.092)*	10.65 (1.91) .	8.38 (0.14)	8.97 (1.60)	8.90 (1.59)
$year2008$	-64.23 (-3.56)***	-64.96 (-3.60)***	-63.58(-3.44)***	-63.08(-3.42)***	-61.46(-3.33)**
$\Delta oilprice_{t-s}$	-1.13 (-2.16)*				
$N\Delta oilprice_{t-s}$		-1.51 (-2.15)*			
$Net\Delta oilprice_{t-s}$					
$1year$			0.71 (0.72)		
$2year$				-0.70 (-0.43)	
$3year$					1.43 (0.82) .
$Adj.R^2$	0.48	0.48	0.46	0.46	0.46
Residual SD error	35.69	35.73	36.48	36.52	36.45

5 Reference

1. Hmilton, J. D. (2003), What is an oil shock?, Journal of Econometrics, 363-398

2. Mehra, Y.P. and J.D. Petersen (2005), Oil Prices and Consumer Spending, Federal Reserve Bank of Richmond Economic Quarterly Volume 91(3), 53-72

3. Hamilton, J. D. (1983), Oil and the Macroeconomy Since World War II, Journal of Political Economy 91(2), 228-248

4. Bernanke, B.S., M. Gertler and M. Watson (1997), Systematic Monetary Policy and the Effects of Oil Price Shocks, Brookings Papers on Economic Activity vol. 28, 91-157

5. Mehra, Y.P. (2001), The Wealth Effect in Empirical Life-Cycle Aggregate Consumption Equations, Federal Reserve Bank of Richmond Economic Quarterly 87(2), 45-68

6. Mork, K. A. (1989), Oil and the Macroeconomy When Prices Go Up and Down: An Extension of Hamilton's Results, Journal of Political Economy 97(3)

7. Boone, L. and N. Girouard (2002),The Stock Market, the Housing Market and Consumer Behavior, OECD Economic Studies No. 35

8. Park, J., and R.A. Ratti (2008), Oil Price Shocks and Stock Markets in the U.S. and 13 European Countries, Energy Economics No. 30

9. Perron, P. (1989), The Great Cash, the Oil Price Shock and the Unit Root Hypothesis, Econometrica, vol.57, 1361-1401

6 Appendix

Figure 3: Oil Price and Durable Goods Consumption (1980:Q1–2016:Q1)

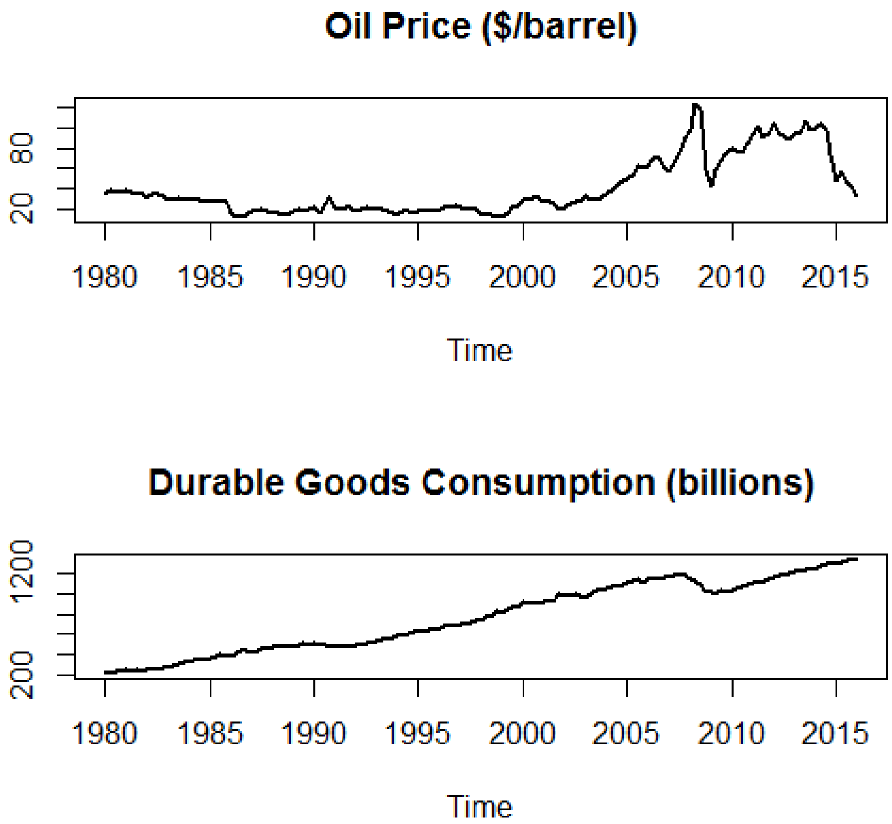


Figure 4: Oil Price Change (1980:Q1–2016:Q1)

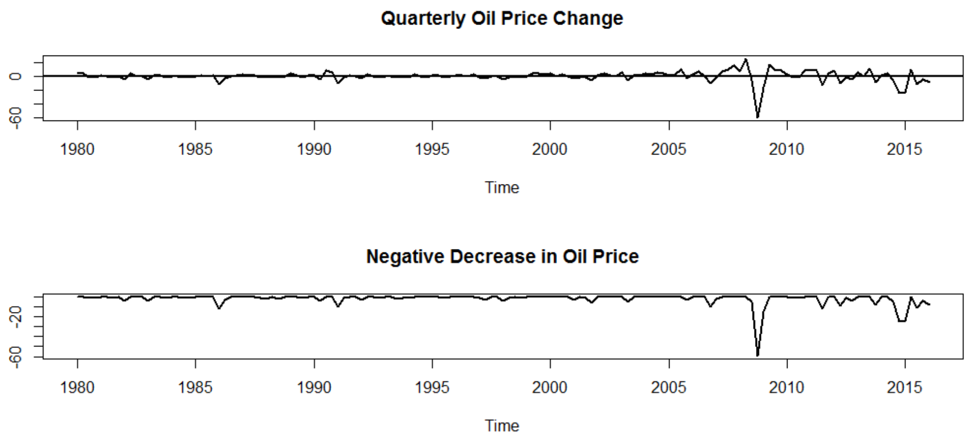


Figure 5: Net Oil Price Decrease (1980:Q1–2016:Q1)