The Excess Smoothness Puzzle, Habit Formation, and Forward-Looking Behavior in Aggregate Consumption

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Abstract: This paper addresses the excess smoothness puzzle, habit formation, and other trends in aggregate consumption data disaggregated into durable goods, services, and non-durable goods from 1959Q1-2006Q3. In addition, the degree of forward-looking behavior on the part of consumers is analyzed. From a consumer utility function we derive Euler equations for consumption and using GMM regression we estimate the parameters on these equations. Our results show consumers are primarily forward-looking in consumption of durables and services and backward-looking in aggregate and non-durables consumption. We then split our data into two sub-samples and find evidence that aggregate consumer behavior has changed significantly since the early 1980's. Specifically, consumers have become increasingly prone to backward-looking habits and less sensitive to interest rate conditions.

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1 Introduction

The ability of macroeconomists to accurately model real-world behavior is of utmost importance for achieving monetary policy objectives. The New Keynesian school of macroeconomics relies on microfounded models with frictions, such as sticky prices and sticky wages. Aggregate consumption data also feature a real friction, which is referred to as the "excess smoothness puzzle." The representative household may be slow to change consumption patterns in response to a shock to real income or other macroeconomic variables, such as inflation and interest rates. The purpose of this paper is to model consumer behavior in regards to this phenomenon. From the representative consumer's utility maximization problem one can derive a linearizeable equation to describe the behavior of aggregate consumption data. We derive Euler equations for consumption from a household utility function to determine the degree which consumers exhibit habits versus forward-looking behavior. Using GMM regression, we estimate the parameters on these equations for total consumption, durable goods, non-durable goods, and services for three separate time periods (1959Q1-2006Q3, 1959Q1-1979Q3, and 1982Q3-2006Q3). Our results show consumers are primarily forward-looking in consumption of durables and services and backward-looking in aggregate and non-durables consumption. We then analyze the two sub-samples and find evidence that aggregate consumer behavior has changed significantly over time. In particular, consumers have become increasingly backward-looking and less sensitive to interest rate conditions.

The excess smoothness puzzle is the empirical regularity that changes in aggregate income are associated with relatively small changes in aggregate consumption,

and variations in consumption about trend are smaller than variations in income about trend. This puzzle results in what is know as the "humped shaped" impulse response of consumption to aggregate income shocks. This phenomenon implies that consumers are not quick to re-optimize their consumption decisions in response to macroeconomic shocks. This fact could have implications for monetary policy makers hoping to combat these shocks and control business cycle fluctuations through monetary policy instruments.

A number of theories are proposed as solutions to the puzzle; there is a good amount of debate in the literature regarding the theory behind aggregate consumption as well as the specifications used to mathematically describe consumers' utility-maximization problem. The habit formation solution to the puzzle says that consumers make optimal, utility-maximizing choices that result in the slow response to an income shock. This solution has intuitive appeal, and allows for an introduction of human psychology into an economic model. While evidence in support of the theory is prevalent when examining aggregate consumption data, studies focused on microeconomic household data are less clear. The purpose of this paper is to investigate the validity of models that assume habit formation in consumption and analyze personal household consumption data disaggregated into durable goods, non-durable goods, and services consumption.

Section 2 surveys the existing literature and gives a broad overview of the evolution of economic thought in regard to consumption theory, the excess smoothness puzzle, and habit formation. Section 3 develops a model for consumption, describes the methodology used for our model's parameter estimates, and provides interpretation of our

results. Section 4 offers some concluding remarks including problems and suggestions for further empirical research on aggregate consumption.

2 Existing Literature Related to Aggregate Consumption

The pioneering work of Milton Friedman (1957) resulted in the permanent income hypothesis, which posits that consumers' optimal current consumption choices are not a function of current income but rather a discounted stream of expected future income. This theory offers a rather straightforward solution to the excess smoothness puzzle, as consumers will ignore business-cycle related income shocks (as well as short-run, traditional Keynesian government efforts to stimulate consumer activity, e.g. tax breaks and spending increases) and base their consumption decisions on real wealth—long term factors such as equity assets, health, expected retirement age, and education level. Therefore, as time progresses, consumption will be smooth, and only shocks to permanent income will result in changes in consumption spending patterns.

Evidence against the permanent income hypothesis explanation of smooth consumption patterns was first offered by Beveridge and Nelson (1981). They showed that the innovation variance of permanent income will exceed that of current income if the growth rate of current income is predominantly positively auto-correlated. Nelson and Plosser (1982) showed that the growth rates of many macroeconomic time series follow first-order moving average processes with a positive moving average coefficient. Deaton (1987) followed these earlier works and spelled out their implications for the consumption function. He argued that permanent income is "noisier" than current income; therefore, the permanent income hypothesis does not necessarily explain why

consumption is smoother than income. This finding was instrumental for those hoping to examine the behavior of aggregate consumption data.

Campbell and Deaton (1988) conclude that the permanent income hypothesis is an inadequate explanation of the excess smoothness puzzle. Rather, they offer evidence that consumption responds with a lag to changes in income. They begin their analysis with a bivarate vector autoregressive model of savings and labor income in an attempt to solve the puzzle. The key assumption in their analysis is that consumers are able to predict their permanent income better than an observer of the time series, and that the more information one possesses the smoother their consumption will be (and consumers reveal their expectations of future income in their consumption decisions). Therefore, they posit, a test for excess smoothness must be robust to possible "econometric misspecification" of the consumer's information set. Testing quarterly data from 1953 to 1984, they conclude that consumption is actually smoother than it should be if the permanent income hypothesis was correct.

Campbell and Deaton (1988) then attempt to find out why consumption is smooth if the smoothness of permanent income is not the explanation. In order to test this, they begin with the assumption that growth of labor income may have different long-run properties than its short-run characterization as an AR (1) process. Specifically, they believe that the labor income time series may be characterized by a deterministic trend. To diagnose this, they conduct a non-parametric test of the model. After further assumptions and VAR analysis, they find that there is a positive correlation between the change in consumption and the lagged change in income. If the permanent income model were true, the correlation would be zero. They offer this result as further evidence that

the permanent income theory is not the proper explanation for smooth consumption. They conclude their analysis by showing that excess sensitivity of changes in consumption to anticipated changes in income explains why consumption is excessively insensitive to unanticipated changes in income.

If the permanent income hypothesis is not a solution to the excess smoothness puzzle, then another theory must be proposed to explain the lagged response observed by Campbell and Deaton (1988). A common theoretical explanation is that consumers develop habits in their spending patterns, and that those habits can be specified in the consumer utility function. Therefore, the slow response of consumption to macroeconomic shocks is simply the result of optimizing behavior on the part of consumers.

The theory of habit formation can first be introduced using a consumption habit in its most extreme form, namely, a physical addiction to products such as alcohol or tobacco. Becker and Murphy (1988) offer the theory of "rational addiction" where rationality is defined as the desire to maximize utility over time. A strong addiction, they argue, requires a large effect of past consumption of a good on current consumption. While the fundamental ideas and assumptions presented in their paper differ from those underlying habit formation in aggregate consumer data, in both situations consumer preferences develop over time and within those sets of preferences is a desire to maintain a certain standard of living based on an expectation set in the past. A habit in consumption can therefore be seen intuitively as a less severe addiction to a certain standard of living that must be maintained through a predetermined consumption routine.

Kydland and Prescott's (1982) paper on time-to-build lags was instrumental in developing macroeconomic theory. The authors point out the theoretical implications of the amount of time it takes a large investment project undergone by a business to develop and reach the aggregate data. Specifically, they focus on the development of capital goods. Kydland and Prescott (1982) develop a non-time-separable household utility function in order to explain business cycle fluctuations in labor supply, employment, and consumption. Backing up their argument with previous empirical literature, they posit that a non-time-separable utility function that admits a greater intertemporal substitution of leisure by households is needed to explain aggregate movements in employment in a general equilibrium model. They justify this intuitively by citing that vacations and movements into and out of the labor force are not necessarily in response to movements in real wage levels. Furthermore, they offer the large variation in hours of market employment across seasons as evidence of a high rate of intertemporal substitution of leisure. The idea of a non-time-separable utility function is of utmost importance for models that include habits.

The general intuition behind a utility function with habit formation is that utility does not depend solely on contemporaneous consumption. Different types of habits, both exogenous and endogenous, can be introduced to different models, but all are essentially based on the assumption that consumers look backward to determine their current level of utility. One example of habit formation is a utility function that specifies current utility as a function of relative changes in consumption during subsequent time periods. The theory can be summed up with the idea that "the more I ate yesterday, the hungrier I am today." Once again this has a considerable amount of intuitive appeal. If consumers are

faced with a sudden negative shock to income, they may optimally continue their previous consumption behavior by borrowing against their future income or decreasing their propensity to save in order to maintain the same level of consumption they enjoyed in the time period before the shock. In addition, this type of habit allows for a steady growth of utility-maximizing consumption over time, which could also explain the phenomenon of continued consumption growth shown by modern, capitalistic societies. After all, the American dream is essentially the desire to enjoy a higher standard of living than your parents (e.g. consume more goods). Therefore, it makes sense that habit formation could be offered as a solution to the excess smoothness puzzle, as consumers' consumption patterns would respond with a lag to macroeconomic shocks if they in fact contained preference for a habit in their utility function.

Before analyzing the literature that relates habit formation to macroeconomics and the excess smoothness puzzle, it is worth briefly mentioning another important application of this theory; as it can theoretical justify the elements of human behavior used in these models. Campbell and Cochrane (1999) apply habit formation to explain a phenomenon observed in aggregate sock market behavior. Specifically, a puzzle exists in equity markets where the risk premia on assets seems to be higher during a downturn in the business cycle. This puzzle can be resolved when a habit is introduced into the investor utility function. Other researchers including Abel (1990) and Constantinides (1990) have looked at the equity premium puzzle using utility functions with habit formation. This research shows that there might be a human bias towards a habit preference. It can be related to our topic because people store units of consumption during different time periods using financial instruments (i.e. savings). Whether or not

investors or consumers consciously take their habits into consideration when making decisions is irrelevant; what matters is that these habits appear in the data, which suggests that investors and consumers behave in this manner. The difference between the two is that it might be easier to argue that an investor habit is completely irrational, while a consumption habit may in fact be rational behavior.

The research applying habit formation to investor preferences has been extended by those interested in studying aggregate consumption. Lettau and Uhlig (1997) build on the model presented by Campbell and Cochrane (1999) and apply it to a situation where agents in the economy adjust consumption and labor in response to technology shocks. They show that adjustments of consumption levels can be channeled through the labor-leisure tradeoff. In other words, people adjust their willingness to supply labor in an effort to maintain a consistent level of consumption. This assumption implies that the introduction of a habit results in a risk-averse consumer, and therefore the elasticity of intertemporal substitution of consumption is very low. Following a positive technology shock that improves labor productivity, two competing effects emerge. First, the marginal product of labor increases; therefore, wages are higher. The wage increase gives workers an incentive to work more now to take advantage of the labor productivity increase. The competing effect is that as wages increase, consumers are induced to work less because their preference for smooth consumption implies that rapid increases in consumption levels are not necessarily optimal. The optimal level of labor chosen depends partly on the level of habit preference in consumption. If however, a habit is introduced into the consumer's preferences for leisure versus labor, the volatility of labor input decreases because labor has a preference to maintain a steady work schedule. Even

when adding habits to labor supply, Lettau and Uhlig (1997) find that consumption is still extremely smooth. They continue their analysis by introducing a model with two separate habits in consumption and leisure. They find that their new models result in a decrease in labor supply following a positive technology shock and a slightly positive increase in consumption following the shock.

In his paper, Fuhrer (2000) introduces a utility function where consumer utility in a specific time period depends not on consumption during that time period but on current consumption relative to lagged consumption, which he calls the "habit reference level." The function is of the form that follows:

$$U_t = \frac{1}{(1-\sigma)}\left[\frac{C_t}{C_{t-1}^{\gamma}}\right]^{(1-\sigma)} \tag{1}$$

Here, the γ parameter indexes the importance of the reference level relative to current consumption. Therefore, a smaller γ implies greater consumer utility from increases in relative consumption. This assumption has intuitive appeal as people may receive disutility from sudden changes in consumption patterns. Fuhrer's utility function attempts to explain the sluggish "gradual, hump-shaped" responses of consumer spending and inflation to various macroeconomic shocks. In an attempt to show that this phenomenon does not merely hold for the consumption of durable goods, (for which gradual responses to macroeconomic shocks could alternatively be explained by other theoretical factors such as "costs of adjustment, durability, and time-to-build lags") Fuhrer (2000) examines the response of non-durables and services consumption to shocks to test for evidence of consumer habits. First, he derives an equation to describe consumption from a utility function and inter-temporal budget constraint that directly links consumption, income and interest rates. Then, using vector autoregression and

quarterly macroeconomic aggregate data from 1966 to 1995, Fuhrer estimates the coefficients on the consumption function. He finds that a model that assumes habit formation among consumers can explain slow consumer responses to macroeconomic shocks. Specifically, the coefficient on the habit reference level is .80 and is based only on last period's consumption.

Fuhrer (2000) also allows for a certain amount of consumers to exhibit "rule-of-thumb" behavior, building off the evidence presented by Campbell and Mankiw (1989, 1990, 1991). Rule-of-thumb consumers are those whose current consumption equals current income (i.e. a predictable component of current income is correlated with current consumption). This, of course, is a violation of the permanent income hypothesis, but seems likely given the paycheck-to-paycheck lifestyle many American consumers live. Nevertheless, there seems to be evidence in the data that rule-of-thumb behavior does exist—Fuhrer finds that one-fourth of all consumers in his model exhibit this behavior. He then proceeds to insert his estimated consumption function into a Taylor Rule model in an attempt to develop a better monetary policy rule. After testing a model before and after introduction of habit formation into the consumption function, he concludes that the performance of the monetary policy models is significantly improved when habit formation is included in the consumer utility function.

Reis (2004) offers an interesting challenge to the habit formation hypothesis in his attempt to explain the excess smoothness puzzle. Rather than having consumers behave with habits, he introduces a theoretical model with sticky information. Specifically, he assumes there are significant costs for consumers to "acquire, absorb, and process" information that has an effect on their consumption decisions. Therefore, consumers

choose to rationally be inattentive because the costs of constantly updating their knowledge of the macroeconomic environment are too high relative to the benefits of continually re-optimizing their consumption bundle. He assumes news of events is slowly dispersed throughout the economy, and therefore consumption will respond with a lag to shocks. Specifically, it is "ordinary and unexpected" news that people are slow to respond to; consumption is not sensitive to extraordinary events such as hyperinflation and predictable events. Furthermore, Reis points to examples of extreme macroeconomic crisis and the reaction by economic agents as evidence in support of his theory. Reis (2004) offers another challenge to the permanent income hypothesis, concluding that only a fraction of agents are attentive when there is a shock to permanent income. Most interestingly, Reis' (2004) model finds that one-third of the U.S. population rationally chooses to never plan ahead when making consumption decisions. This again is similar to the rule-of-thumb behavior observed by Campbell and Mankiw (1989, 1990, 1991) and Fuhrer (2000). Reis (2004) also contrasts his model to those that attempt to explain smooth consumption using habit formation (although he states the two models are very similar). He critiques the assumption of habit formation as a preference, arguing that preferences are assumed not to change over time; therefore, sluggishness in consumption should be constant across all time periods.

While the literature covering habit formation has been extensive among macroeconomists, a number of economists have attempted to find evidence in support of this theory by looking at the micro-level data. After all, habit formation is introduced into macroeconomic models as being derived from s microeconomic consumer optimization problem. Therefore, it makes logical sense that if consumers do in fact

derive utility from habits that there will be evidence of habits in behavior at the individual household level for specific goods and services.

Heien and Durham (1991) search for evidence of habit formation at the micro level in their analysis. Using household level BLS Interview Panel data, they contrast the level of habits found in time series data to that found in cross-sectional data. Specifically, they noticed that all of the previous work on habit formation had used time series data, and were concerned that the habit effects could be overstated due to problems of autocorrelation in the data and the problems of aggregation specified in Wilcox (1992). Looking at 16 different household commodities such as clothing, entertainment, and medical care, they searched for evidence of habit formation using interrelated demand equations. Perhaps rather predictably, they find that habit effects are larger in time series data than cross-section data. In both cases, however, the effects are significant. While they conclude that the differences between time series data and cross-sectional data are statistically significant, they interpret their results as evidence in support of habit formation in consumption patterns.

Dynan (2000) takes a slightly different approach in her search for evidence of habit formation in consumer behavior. Using micro-data on food consumption from the Panel Study on Income Dynamics, she tests the data for habits and finds no evidence of habits at an annual frequency. Specifically, she derives an Euler equation from a utility function with habit formation, and uses GMM to make a point estimate of her habit parameter and concludes there is no significant evidence of consumer habits in food consumption. Although she finds no significant results at an annual frequency, it may be more likely that habits only persist at the quarterly or monthly level. Nevertheless,

Dynan's (2000) result contradicts the findings of much of the existing research and creates a potential puzzle: how can there be evidence of habit formation in consumption behavior at the aggregate level but not in the micro-data? The specification of the time period may be the answer. It is likely that a majority of non-durables are consumed within a year, and a habit may disappear over a long time period. Nevertheless, habits persisting for months or quarters at a time could be significant enough to affect macroeconomic conditions. Further empirical work on consumer habits using micro-data should compare parameter estimates using different time specifications.

While the habit formation hypothesis is based on consumers' engaging in backward-looking behavior, New-Keynesian models have commonly highlighted the importance of forward-looking expectations in determining current levels of macroeconomic variables. The significance of forward-looking behavior is important for the assumptions of microfoundations and rational expectations first presented in real business cycle models and later integrated with the New Keynesian assumptions of sticky prices and wages. The prevalence of this behavior is also important information for the monetary policy authority, who must anticipate the extent of rational reactions to its policy procedures. This presents an interesting and relevant question. What will the introduction of a forward looking term to a consumption equation do to the corresponding coefficients? The forward-looking component arises naturally from the consumer's intertemporal optimization problem, whereas the backward-looking term has to be introduced through habit formation or rule-of-thumb behavior. This paper includes a habit in the model to determine the extent of backward-looking behavior in consumers,

as well as its level relative to the forward-looking parameter estimate in the consumption equation.

Fuhrer and Rudebusch (2003) present a model characterizing aggregate output using a simple intertemporal Euler equation which is similar to that used in the empirical component of this paper:

$$y_t = E_t y_{t+1} - \sigma(i_t - E_t \pi_{t+1}) + \eta_t \tag{2}$$

Here, y_t is a measure of output gap, $E_t y_{t+1}$ is the expectation of next period's output gap formed during the current period, i_t is the current nominal interest rate, $E_t \pi_{t+1}$ is the expectation of next period's inflation formed in time t, and η_t is the aggregate demand shock term. The σ term is the parameter measuring sensitivity of output to changes in the expected real interest rate, and represents the intertemporal elasticity of substitution. For simplicity, this model assumes a closed economy without capital, durable goods investment, or government spending. It also assumes all output is consumed and that the path of output is the result of optimal consumption choices on the part of households (meaning the model is not explicitly derived from microfoundations). These assumptions, while bold, allow for some baseline analysis into the movements of aggregate macroeconomic variables.

For their empirical analysis, Fuhrer and Rudebusch (2003) further expand their model so it will better match the aggregate data. There model is not explicitly micro-founded, however. Here, the output equation takes the form:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \mu E_{t-\tau} y_{t+1} - \beta E_{t-\tau}\left[\frac{1}{\kappa}\sum \frac{\kappa - 1}{j=0}\left(i_{t+j+m} - \pi_{t+j+m+1}\right)\right] + \eta_t \tag{3}$$

This equation adds two lags on output. The τ parameter controls the timing of expectation formation and the κ parameter measures the duration of the ex ante real interest rate. After testing their models using both GMM and maximum likelihood, they find little evidence supporting the theory that rational expectations of future output determine current output. They conclude that backward-looking behavior is more prevalent stating that their results imply a "sizable and robust weight on lagged output."

This finding has implications for our research. If Fuhrer and Rudebusch's (2003) estimates for output Euler equations show that people are primarily backward-looking, what will the results look like when estimating parameters for consumption? While there are some theoretical reasons to suspect that people should be forward-looking, utility from habits may make them more likely to be backward-looking.

3 Building a Model and Testing the Data

In order to offer insight into consumer behavior and work towards a solution to the excess smoothness puzzle, we analyze aggregate real consumption variables for durable goods, non-durable goods, and services consumption in the United States. Disaggregating the data into these components allows us to bridge the gap between the aggregate and micro-data, as well as compare the subtle differences in consumer decision-making regarding the three types of consumption. It is a relevant question whether or not consumers exhibit dissimilar behavior when dealing with different types of goods, as the production and distribution of each affects the economy in unique ways. Furthermore, comparison of the forward-looking and backward-looking parameters among the three types of goods could offer some insight into the nature of the consumer utility function. From three separable household utility functions (maximization of

durables, non-durables, and services consumption), we derive separate Euler equations to measure consumer habits, forward-looking behavior, and sensitivity to various interest rate measurements.

The data is taken from monthly observations published by Federal Reserve Bank of St. Louis and collected at the monthly frequency from Jan 1959 through October 2006 (a detailed description of the data set is in Appendix B: Data Appendix). From these monthly observations we construct quarterly values by taking the first observation of each quarter. This allows us to define a time period as three months. We believe that using quarterly data makes intuitive sense as firms and capital markets react to quarterly earnings reports (affecting aggregate production decisions) and household consumption decisions may not change from month to month, but likely change over two quarters. The choice of quarterly over monthly data also corrects for the large amount of autocorrelation that is likely to exist in preceding months of aggregate consumption data. In addition, most other empirical work on aggregate consumption analyzes data at the quarterly frequency; therefore, our results are easily comparable to similar studies.

Aggregate consumption grows along a deterministic trend; therefore, we remove the linear trend. First, we take the natural logs of the observed values, and then perform some manipulations (see Appendix B). Our consumption values are therefore the deviation of the natural logarithm of real consumption from its steady-state value. Figure 1 in Appendix A visualizes our constructed consumption time series over the entire sample.

Our goal is to determine the relative importance of a habit that persists for one-period versus forward-looking behavior one period ahead. This allows us to determine

whether or not consumers are primarily forward-looking or backward-looking agents in a simply economy. Our models also include a term measuring consumer sensitivity to various measures of the interest rate, which determines the intertemporal elasticity of substitution (how much consumers will forgo consumption today to consume tomorrow).

Three simple, separable utility functions where consumer utility is a function of consumption of durable goods, nondurable goods, and services (D, N, and S respectively in the functional form) provide a theoretical, microeconomically-derived foundation to our model. We assume that a consumer may choose to purchase a bundle of these goods or save their income for consumption in a later time period. Savings is a function of the interest rate, as consumers are assumed to adjust their spending habits in response to macroeconomic conditions. The representative household maximizes utility by taking the first order conditions with respect to consumption and bonds (which store units of income for future consumption) subject to the standard intertemporal budget constraint. The utility function is as follows.

$$\text{If } U(C) = E_0 \sum_{t=0}^{\infty} \beta^t \sum_i \frac{1}{1-\gamma^i} \left(C_t^i - h^i \overline{C}_{t-1}^i \right)^{1-\gamma^i}, \text{ where } i = \{D, N, S\}, \text{then}$$

$$C_t^i = \frac{1}{1+h^i} E_t C_{t+1}^i + \frac{h^i}{1+h^i} C_{t-1}^i - \lambda \left(i_t - E_t \pi_{t+1} \right), \text{ where } \lambda^i = \frac{1-h^i}{\gamma^i (1+h^i)}, h^i \text{ is the}$$

exogenously determined extent of habit formation, $\overline{C}_{t-1}^i$ is the average aggregate level of consumption that a household cannot individually optimize over, β^t is the discount factor, and γ^i is the coefficient of relative risk aversion. So if $\frac{1}{1+h^i} = \delta^i$, then

$$h^i = \frac{1}{\delta^i} - 1 = \frac{1-\delta^i}{\delta^i} \text{ and } \frac{h^i}{1+h^i} = \frac{1-\delta^i}{\delta^i} * \delta^i = (1-\delta^i).$$

Therefore, the (1-δ^i) is the extent of habit formation in our model, and δ^i is the extent of forward-looking behavior. Intuitively, this utility function says consumer utility is a function of an expectation formed during the current time period of a discounted stream of consumption given a certain risk preference level. The important assumption is consumers optimize separately with respect to the three goods, thus total consumer utility is determined by a summation of the three separate functions. We estimate the δ and λ parameters for all three Euler equations. Additionally, we estimate parameters on a single utility function for aggregate consumption. This equation takes the same form, although is derived from a function where consumer utility is not a summation of utility from durables, non-durables, and services, but is solely based on total consumption (i=total consumption).

From the above derivation, our baseline model of consumption in a simple economy gives the following:

$$c_t^i = (1-\delta^i)c_{t-1}^i + E_t\delta^i c_{t+1}^i - \lambda^i(i_t - E_t\pi_{t+1}) + \eta \qquad (4)$$

where c_t^i is current de-trended consumption and is determined by two parameters. The exogenously determined habit reference level, (1-δ^i), is the coefficient on the previous period's consumption, meaning consumers determine a certain amount of their current consumption based on a habit developed during the previous quarter. The coefficient δ^i is the expectation of next period's consumption formed in the current time period; this is the forward-looking term. The parameter λ^i measures consumers' sensitivity to the real interest rate based on the expectation of next period's inflation (consumption is negatively affected by the interest rate as consumers save). This is the intertemporal elasticity of substitution (how much consumers will forgo today to consume tomorrow).

We use three different interest rates measurements which are specified in Appendix B. From this, we look at the value of the coefficients to determine whether consumers tend to look forward or backward.

First, we estimate the parameters for the entire sample, 1959Q1-2006Q3, using the generalized method of moments (GMM). The instrumental variables used are four lags of the type of consumption being measured (c_t^i), four lags of the spread (the difference between the interest rate on a 10-year U.S. Treasury bond and a 3-month Treasury bill), four lags of inflation (π_t) as measured by the CPI, four lags of the interest rate on a 3-month Treasury Bill[1] (tbill), the intermediate average interest rate (irate), and the long-term average interest rate (lrate). Full descriptions of the construction of these variables are given in Appendix B.

Table 1 gives the GMM parameter estimates for aggregate consumption. Our results indicate that over the course of the sample consumers are more inclined to engage in backward-looking habits than forward-looking behavior in total consumption. Interestingly, none of the interest rate terms are negative (as theory would predict), although the λ term on the long rate is statistically significant at 10%.

Table 1: Aggregate Consumption 1959Q1-2006Q3 GMM Results

Coefficient	Short Rate	Inter Rate	Long Rate
(1- δ)	0.517056	0.530122	0.535041
δ	0.482944***	0.469878***	0.464959***
(S.E.)	(0.032754)	(0.031825)	(0.032050)
λ	0.001470	0.006841	0.016035*
(S.E.)	(0.006533)	(0.006690)	(0.009052)
Instruments: Four lags of c_t^a, spread, π_t, tbill, irate, and lrate.			
*** sig. at 1%, **sig. at 5%, * sig. at 10%			

[1] The short rate variable is the difference between the interest rate on a 3-month Treasury bill and the expectation of next period's inflation rate. Therefore, both variables are used as instruments.

These results give some support to the habit formation hypothesis, and are in line with the findings of Fuhrer and Rudebusch (2003) that agents in the economy are more backward-looking than forward-looking when estimating a similar equation (Equation 2) for output.

The parameter estimates for durables consumption from 1959 through 2006 (Table 2) seem to suggest that consumers are quite rational when purchasing durable goods. For both the short and intermediate interest rate measurements, consumer behavior is more forward-looking than backward-looking. Of course, as much of the previous empirical work has pointed out, the consumption of durable goods is quite different from non-durable goods and services. First, they are often purchases that represent a significant portion of a consumer's income during the relevant time period (i.e. computers, automobiles, lawnmowers, stereos, etc.). Second, they are usually purchased on credit payment plans. The interest rate on those plans is in part determined by the market rates available to lenders. This can explain the correct sign and statistical significance of the λ term on the short and intermediate rate; in both cases the parameter estimate relatively large and significant at 5%. This is a nice result supported by both microeconomic theory and intuition that says consumers will forgo durables consumption today if the cost of the interest payments results in a significant utility loss. The incorrect sign and insignificance of the λ term on the long rate could be offered as evidence that the long-term interest rate conditions are not important to household consumers (they do not optimize with respect to the long rate). In addition, the slight bias towards a habit when using the long-term interest rate measurement may mean consumers develop a habit in durables consumption over the long-run. Finally, the durability of these goods means

that they are not individually purchased at a relatively high frequency, making habits harder to develop over the relevant time period.

Table 2: Durables Consumption 1959Q1-2006Q3 GMM Results			
Coefficient	Short Rate	Inter Rate	Long Rate
(1- δ)	0.447884	0.452584	0.503399
δ	0.552116***	0.547416***	0.496601***
(S.E.)	(0.041332)	(0.041062)	(0.038443)
λ	-0.076564**	-0.072752**	0.011204
(S.E.)	(0.033154)	(0.034966)	(0.043453)
Instruments: Four lags of c_t^d , spread, π_t, tbill, irate, and lrate.			
*** sig. at 1%, **sig. at 5%, * sig. at 10%			

Our Equation 4 parameter estimates show that consumers appear to exhibit a strong preference towards habits in consumption of non-durable goods (Table 3). For all three interest rate measurements, the δ parameter estimate is close to .45, which indicates that habits are strongest in non-durables consumption relative to services and durables consumption. This makes sense intuitively; compared to durable goods, non-durables are purchased quite frequently. Every trip to the grocery store, discount retailer, or gas station convenience shop (where non-durables are typically purchased) represents a small percentage of household income. The frequency of these trips, however, means they still represent a significant portion of total consumer expenditures. There are a number of potential explanations for the persistence of a habit in non-durable consumption.

First, consumers may not be able to perceive their real income every time they go to the store and may not realize their budget constraint has changed due to inflation or other macroeconomic factors. In addition, many non-durable goods such as household cleaning products or personal care products are branded goods; consumers may not be willing to switch from familiar brands, even when facing income or price changes. The vast amount of non-durable goods in a household consumption bundle such as toothpicks, batteries, candles, light bulbs, soft drinks, and office supplies means the mental costs of

constantly re-optimizing the utility function subject to an ever-changing budget constraint may exceed the consumer's monetary benefits of re-adjustment. It might just be easier for a consumer to purchase a trusted brand name or a familiar product than risk disutility from dissatisfaction with an unfamiliar one. Marketers of non-durable goods attempt to exploit this through advertising campaigns designed to prevent brand switching. Additional factors such as social pressure to wear certain brands of clothing, for example, could also explain the bias towards a habit in non-durables consumption. Finally, the fact that both food and clothing are non-durable goods needed for survival could explain some degree of the preference towards a habit in non-durable consumption. Even when faced with macroeconomic fluctuations, consumers must always purchase a certain amount of food, clothing, and energy. While considerable volatility may exist within each non-durable category (i.e. normal vs. inferior goods) at the aggregate level, consumers will still purchase the same amount of food and clothes, and there is likely a lag time before a switch to an inferior good occurs.

All three λ estimates for non-durable goods are incorrectly signed and statistically insignificant. This suggests that consumers are not concerned with interest rates when determining their non-durable consumption level. The interest rate is not even relevant for goods whose durability wears out over a time period of less than one quarter. This result can also be justified intuitively if we assume most non-durable goods are not purchased on credit but rather are expenditures out of a household checking account. Therefore, the interest rate might not play into the consumers' optimization problem, as non-durable consumption may simply come out of a weekly or monthly family budget. Rule-of-thumb behavior may also play a significant role, and further empirical work

could build on this study using it. Additionally, the theory proposed by Reis (2004) of rationally inattentive consumers could also be at work and explain the backward-looking preference in non-durables consumption.

Table 3: Non-Durables Consumption 1959Q1-2006Q3 GMM Results			
Coefficient	Short Rate	Inter Rate	Long Rate
(1- δ)	0.552056	0.549842	0.545296
δ	0.447944***	0.450158***	0.454704***
(S.E.)	(0.036826)	(0.036919)	(0.038677)
λ	0.003234	0.005162	0.002873
(S.E.)	(0.005612)	(0.005724)	(0.009253)
Instruments: Four lags of c_t^n , spread, π_t, tbill, irate, and lrate. *** sig. at 1%, **sig. at 5%, * sig. at 10%			

Table 4 presents the Equation 4 parameter estimates for services consumption. Here, we find that consumers are slightly biased towards forward-looking behavior over the course of our sample. This preference is an indication that the consumption of services is not prone to the same degree of habit persistence as non-durable consumption. Once again, the frequency of purchases may be a factor. Unlike non-durable goods, many of the same services are not purchased at a relatively high frequency. A plumber or a lawyer is only called when something breaks or goes wrong. Households may only hire an accountant before tax season or after a large inheritance. In the case of services, there are many incentives for consumers to make informed and rational decisions. Few people want to hire a lousy accountant or spend the night in a dingy hotel room; the costs of a bad decision in these cases are relatively high. Therefore, consumers have an incentive to check facts on service providers and compare prices before making a consumption decision. Of course, a habit could develop in services consumption, especially if a consumer becomes very satisfied with a service or service provider, but this might not show up at the aggregate level. The fact that one's own labor can easily be substituted for many services, however, means switching costs are low relative to non-durable goods.

If real incomes are negatively shocked, for example, it would be prudent for a consumer to no longer employ a household cleaning service or eat out at casual dining establishments. Finally, compared to durables and non-durables, services are probably the first products to exit a household consumption bundle when real incomes are negatively shocked. Once again, many of the services available in a modern economy are simply not essential for survival, and one's labor acts as an inferior substitute.

None of the λ terms are statistically significant for services consumption, and two of the three are incorrectly signed. Once again this can be interpreted as evidence that interest rate conditions do not matter for consumption of services. Most services are not purchased on credit, and again this is a likely explanation. Also, most services have virtually no durability and cannot be stored for consumption in the next relevant time period.

Table 4: Services Consumption 1959Q1-2006Q3 GMM Results

Coefficient	Short Rate	Inter Rate	Long Rate
$(1-\delta)$	0.468889	0.481050	0.477378
δ	0.531111***	0.518950***	0.522622***
(S.E.)	(0.035049)	(0.034198)	(0.031726)
λ	-0.003196	0.000875	0.006950
(S.E.)	(0.004635)	(0.004864)	(0.006769)
Instruments: Four lags of c_t^s, spread, π_t, tbill, irate, and lrate.			
*** sig. at 1%, **sig. at 5%, * sig. at 10%			

We have shown that over the course of our sample consumers are somewhat split between consumption habits and forward-looking behavior. While consumption of durables and services is biased towards forward-looking behavior, non-durables, as well as aggregate consumption, are subject to habits. The over forty years of data covered in our sample presents another interesting question worth investigating. Has consumer behavior changed significantly over the second half of the 20th Century and into the 21st? In order to answer this question, we construct two new data series. The first covers the

period from the first quarter of 1959 through the third quarter of 1979. The second begins with the fourth quarter of 1982 through the third quarter of 2006. During the period from 1979 to 1982, the Fed was engaged in a policy of targeting money supply; we omit these observations. Figures 2 and 3 (Appendix A) show the time series graphs for the two sub-samples and can be compared to Figure 1 (the entire sample). Our GMM regression estimates present an interesting puzzle and suggest that habit formation in consumption has become more prevalent.

The methodology used in this section is identical to that used with the entire sample, although new separate data sets are constructed for the two time periods. We do not estimate the λ parameter on the long rate; however, as it does not make sense for the 1982Q3-2006Q3 sample given the way the variable is constructed. Nevertheless, the short and intermediate interest rate term offer some interesting points of comparison.

Table 5 presents Equation 4 parameter estimates for aggregate consumption during the two time periods. Notice how consumers have switched from primarily forward-looking agents sensitive to interest rate conditions to backward-looking agents not sensitive to the interest rate. The λ parameter estimate on the short rate is relatively large (-0.086167), significant at 1%, and correctly signed. For all purposes of this research, this result is beautiful, as it shows consumers acting quite rationally with respect to time. The λ estimate on the intermediate rate is also relatively large, statistically significant at 10%, and correctly signed. In addition, consumers during this era are heavily biased towards forward-looking behavior, with both δ estimates greater than .66. Compared to the low δ estimates for the 1982Q3-2006Q3 sub-sample, this is quite fascinating. Are consumers no longer as smart as they were during the 1960's and

1970's, or have some fundamental characteristics of the economy changed consumer behavior over time?[2]

The answer is likely yes and comparison of the macroeconomic conditions between these two eras might be able to explain this. The Paul Volcker-Alan Greenspan era of monetary policy has been characterized by a stabilization of inflation and historically low interest rates. As consumers have become accustomed to relative macroeconomic stability, a belief may have developed that tomorrow will always be better than today. The optimistic political rhetoric on the part of national leaders in regards to the economy as well as the unprecedented economic boom of the late 1990's may have further reinforced this belief. This may make consumers less likely to be forward-looking, as a constant increase in standard of living is assumed. Furthermore, the historical low interest rates observed during this period could explain less consumer responsiveness to the interest rate. When interest rates are high, consumers may be more inclined to forgo current consumption knowing that a high rate of return is possible. Lower interest rates, however, may be easier for consumers to ignore. Another possible explanation for the insignificant λ terms during the 1982Q3-2006Q3 sample is that consumers have moved towards different equity assets to store financial wealth for future consumption and hedge against the otherwise low rates of return. Our interest rate measurements are constructed from rates on U.S. Treasury Bills and Bonds, if consumers are more disposed towards holding riskier assets such as stocks or real estate during the latter time period, than this result might be predictable. This question could be answered with further empirical study.

[2] Of course economists tend to assume economic agents are rational utility-maximizers. Therefore, the latter explanation is likely at play.

The converse holds true for the former time period. Household consumers during the 1960's and 1970's were children of the Great Depression. Likely grounded in the importance of frugality, they might have been more apt to think through every household economic decision than their more fortunate offspring. Having witnessed worldwide depression during their lifetimes, an assumption of consistent increases in standards of living may not have been in place. The significant and large λ parameters in this sample suggest consumers during the 1960's and 1970's had a fundamental understanding of the time-value of money, or at least exhibited a preference towards holding wealth in U.S. Treasury securities.

Table 5: Aggregate Consumption GMM Results		
1959Q1-1979Q3		
Coefficient	Short Rate	Intermediate Rate
$(1-\delta)$	0.308439	0.33638
δ	0.691561***	0.663620***
(S.E.)	(0.041462)	(0.037276)
λ	-0.086167***	-0.054185*
(S.E.)	(0.028346)	(0.029535)
1982Q3-2006Q3		
$(1-\delta)$	0.576083	0.614744
δ	0.423917***	0.385256***
	(0.049566)	(0.047528)
λ	-0.000533	0.002026
	(0.007418)	(0.008173)
Instruments: Four lags of c_t^a , spread, π_t, tbill, and irate.		
*** sig. at 1%, **sig. at 5%, * sig. at 10%		

The consumption of durable goods is biased towards forward-looking behavior in both samples, although a δ value of slightly less than .5 is observed for the 1982Q3-2006Q3 sub-sample when the intermediate interest rate is used. All four λ terms are negative, although none are statistically significant. Once again, the proper sign of the λ term in Equation 4 for durable goods is to be expected considering the fact that expensive durables are usually purchased on credit. The λ term is significantly smaller in absolute

value for the second sub-sample, suggesting that the interest rate is of less importance today than it was 40 years ago.

The degree of forward-looking behavior in durable goods consumption appears to be eroding over time, as the 1982Q3-2006Q3 sub-sample shows a smaller δ parameter estimate for the short rate and a value of less than .5 on the intermediate rate. Perhaps durables such as video game consoles, televisions, stereos, and household appliances such as dishwashers and clothes dryers have become "necessities" in the minds of the American public. If this is true, than a persistent habit in durable goods consumption could develop. Another potential factor could be what some economists and others refer to as "catching up with the Joneses." What this model says intuitively is that people derive utility from keeping their consumption levels equal with their proximate neighbors. In a game of one-upmanship, neighbors compete to buy the newest and best durable goods so they can show off their relative economic prosperity. The idea of durable goods such as luxury SUVs being used as social status symbols is not much of a stretch. This, of course, could result in sub-optimal long-run consumer behavior, as consumers would be more likely to look backward than forward.

Table 6: Durables Consumption GMM Results

1959Q1-1979Q3		
Coefficient	Short Rate	Intermediate Rate
(1- δ)	0.445935	0.429257
δ	0.554065*** (0.044119)	0.570743*** (0.043325)
λ	-0.064325 (0.093476)	-0.1483311 (0.099250)
1982Q3-2006Q3		
(1- δ)		
δ	0.528566*** (0.058146)	0.491777*** (0.058480)
λ	-0.029374 (0.031598)	-0.036429 (0.033917)
Instruments: Four lags of c_t^d , spread, π_t, tbill, and irate. *** sig. at 1%, **sig. at 5%, * sig. at 10%		

The GMM parameter estimates for non-durables consumption (Table 7) are interesting. From the 1959Q1-1979Q3, consumers were primarily forward-looking. The λ estimates, while statistically insignificant, are correctly negatively signed, although quite small in absolute value. The δ parameter estimates, however, suggest that consumers were not prone to habitual behavior during the earlier sub-sample. An intuitive explanation for this once again could be that the nature of consumption has changed. Those who grew up during the Great Depression were especially thrifty, and perhaps that carried into their later life. They may, for example, have been more likely to elongate the durability of non-durables. Today, a torn article of clothing is often thrown out. During the 1960's and 1970's, however, consumers may have been less inclined to prematurely dispose of non-durables. In the case of a torn article of clothing, years ago a sewing kit might have been preferred over a trip to the retail shop. This is hard to prove, but makes sense intuitively.

The changes observed in the latter sub-sample are to be expected given the nature of non-durable consumption in today's economy. These results verify much of the previous empirical literature on non-durable consumption. The λ estimates for the 1982Q3-2006Q3 are once again insignificant and incorrectly signed. What is interesting, however, is that while most previous studies have discovered habits in non-durables consumption, none reviewed by this author found evidence of forward-looking behavior over any time period. The separation of the data allowed this interesting result to appear, and should be analyzed with further empirical work.

Table 7: Non-Durables Consumption GMM Results		
1959Q1-1979Q3		
Coefficient	Short Rate	Inter Rate
$(1-\delta)$	0.405974	0.412967
δ	0.594026*** (0.034097)	0.587033*** (0.031215)
λ	-0.033633 (0.022314)	-0.022577 (0.026034)
1982Q3-2006Q3		
$(1-\delta)$	0.526454	0.522114
δ	0.473546*** (0.055627)	0.477886*** (0.055173)
λ	0.002740 (0.007357)	0.005850 (0.008991)
Instruments: Four lags of c_t^n, spread, π_t, tbill, and irate. *** sig. at 1%, **sig. at 5%, * sig. at 10%		

Table 8: Services Consumption GMM Results		
1959Q1-1979Q3		
Coefficient	Short Rate	Inter Rate
$(1-\delta)$	0.50036	0.488713
δ	0.499964*** (0.047723)	0.511287*** (0.046311)
λ	-0.005474 (0.011132)	-0.009882 (0.012615)
1982Q3-2006Q3		
$(1-\delta)$	0.41255	0.415025
δ	0.587450*** (0.042550)	0.584975*** (0.042767)
λ	0.002700 (0.005147)	0.005352 (0.006405)
Instruments: Four lags of c_t^s, spread, π_t, tbill, and irate. *** sig. at 1%, **sig. at 5%, * sig. at 10%		

The Equation 4 parameter estimates for services consumption in the two sub-samples show a bucking of the trend observed for total consumption, durables and non-durables consumption. Consumers have become quite forward-looking during the 1982Q3-2006Q3 sub-sample. Perhaps the increase of services as a percentage of total GDP observed during this period has affected consumer behavior. As essential non-durables such as food and clothes become a smaller relative percentage of consumer expenditures, habits could develop in non-durables while consumption of services could

be subject to forward-looking behavior for reasons mentioned earlier. The lack of a strong forward-looking behavior in the 1959Q1-1979Q3 sub-sample suggests other forces were at play during this time period. Once again, none of the λ parameter estimates are significant or correctly signed, and their lack of durability may be the reason.

4 Concluding Remarks and Suggestions for Further Study

This paper has built a micro-founded model of aggregate consumption applied to durable goods, non-durable goods, and services to determine the relative importance of an exogenous consumption habit versus forward-looking behavior. The GMM parameter estimates for the entire sample (1959Q1-2006Q3) suggest that consumers are more backward-looking in terms of aggregate consumption and non-durables consumption while more forward-looking in terms of durables and services consumption. When the data was split into two sub-samples, a considerable difference in consumer behavior was observed. Consumers have become more backward-looking during the latter time period. We offered some potential explanations for these empirical observations, although any number of other factors could explain these results, as the data is the aggregated result of millions of individuals optimizing utility.

Our first suggestion for further study involves searching for variables that will result in more statistically significant λ terms. The ability of consumers to store current wealth for future consumption is very important when a non-time-separable utility function is assumed. Our study only allowed consumers to store wealth in Treasury bonds and Treasury bills. Of course, consumers have many other resources for storing wealth at their disposal. Other variables such as average returns on the S&P 500,

corporate bonds, mutual funds, real estate, or other equity assets could be included in the Euler equation. The degree of proliferation of consumer purchases of equity assets through financial services firms over the last 20 years should be analyzed in order to gain a full understanding of aggregate consumer behavior when a non-time-separable utility function is assumed.

Expanding the data set to include other developed countries could present an interesting extension. Cross-country comparisons of consumer behavior could offer explanations for differing economic conditions observed all over the developed world.

Another extension of this research could develop more complicated Euler equations by building different types of habits into the consumer utility function. An endogenous habit, for example, should be the first extension of this project. Other habits such as the geometric form presented in Equation 1 could also be used. Comparing monetary policy models derived from habit formation, rule-of-thumb, inattentive, and catching up with the Joneses consumer models could help work towards a better Taylor Rule for monetary policy-makers as well as a solution to the excess smoothness puzzle.

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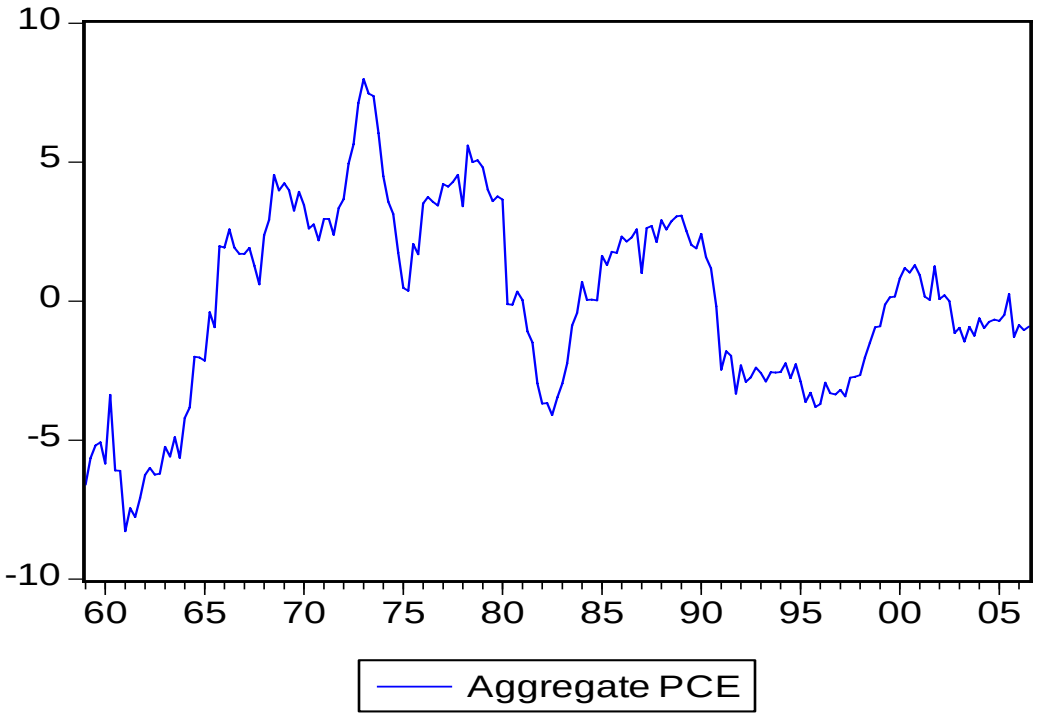
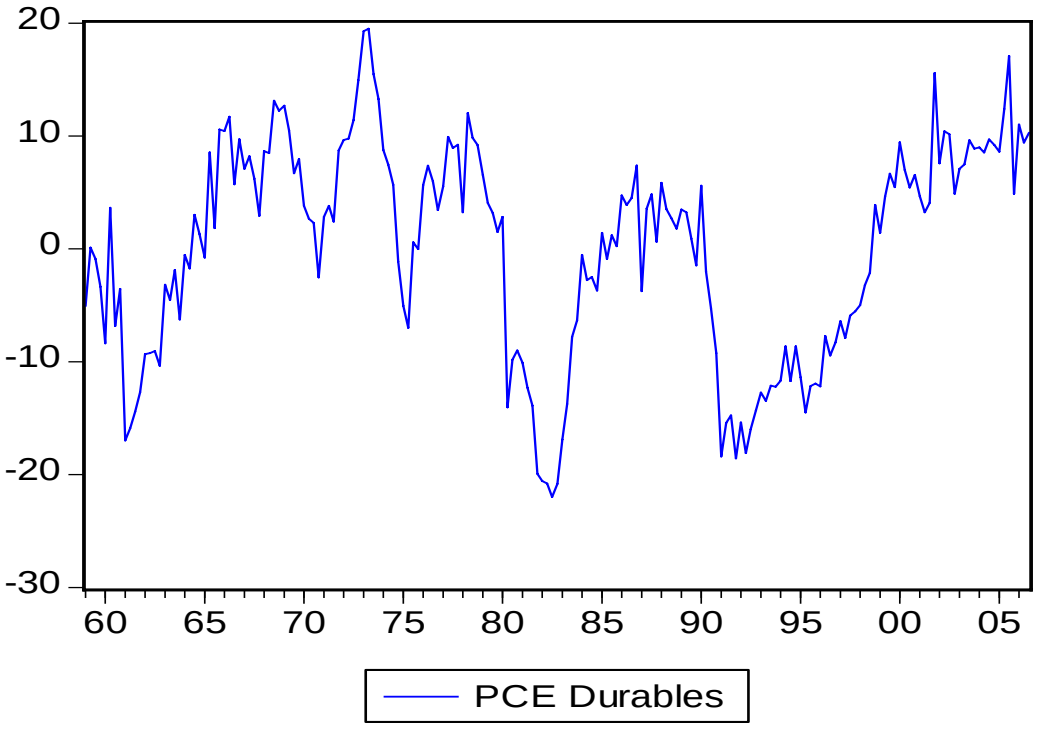
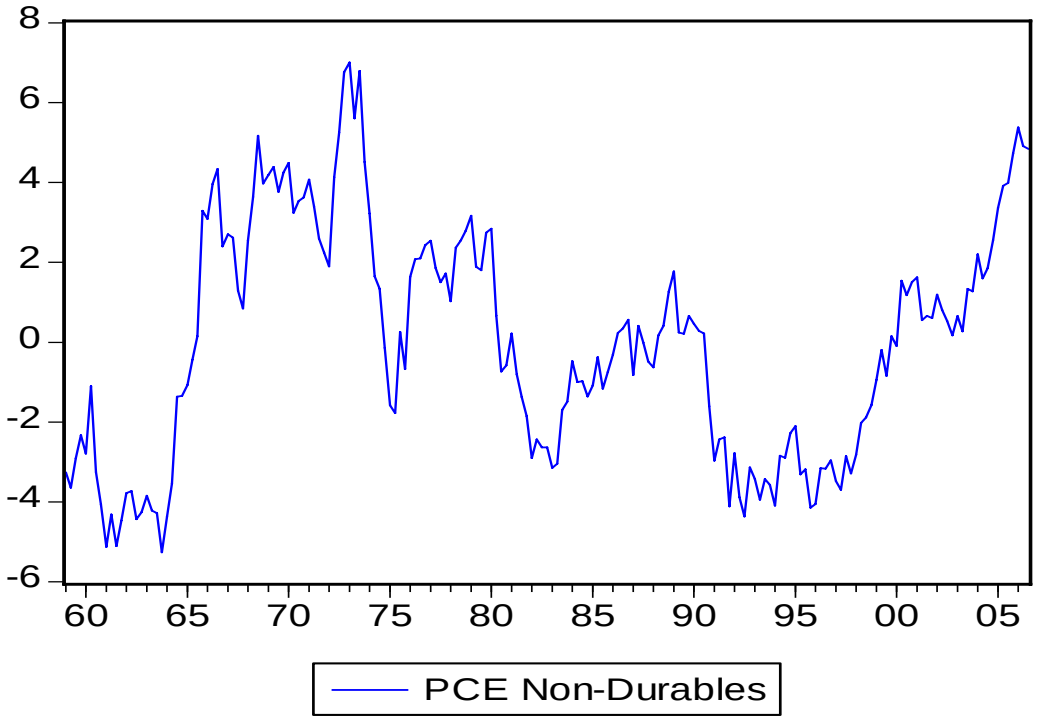
Appendix A: Time Series Graphs

Figure 1: Consumption Time Series 1959Q1-2006Q3



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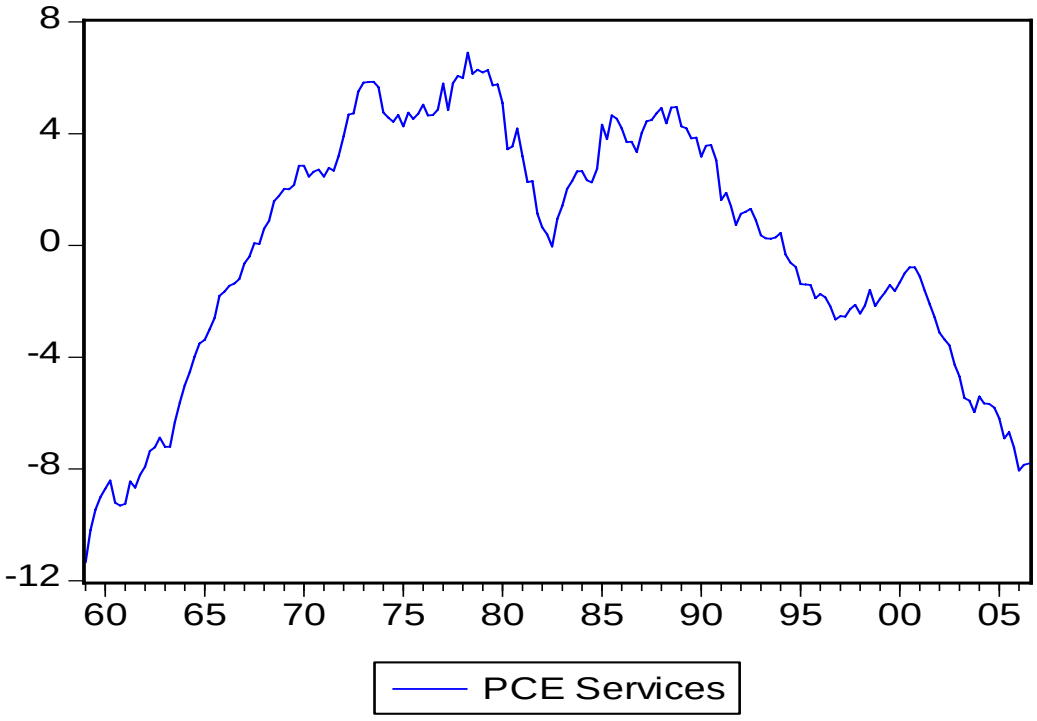
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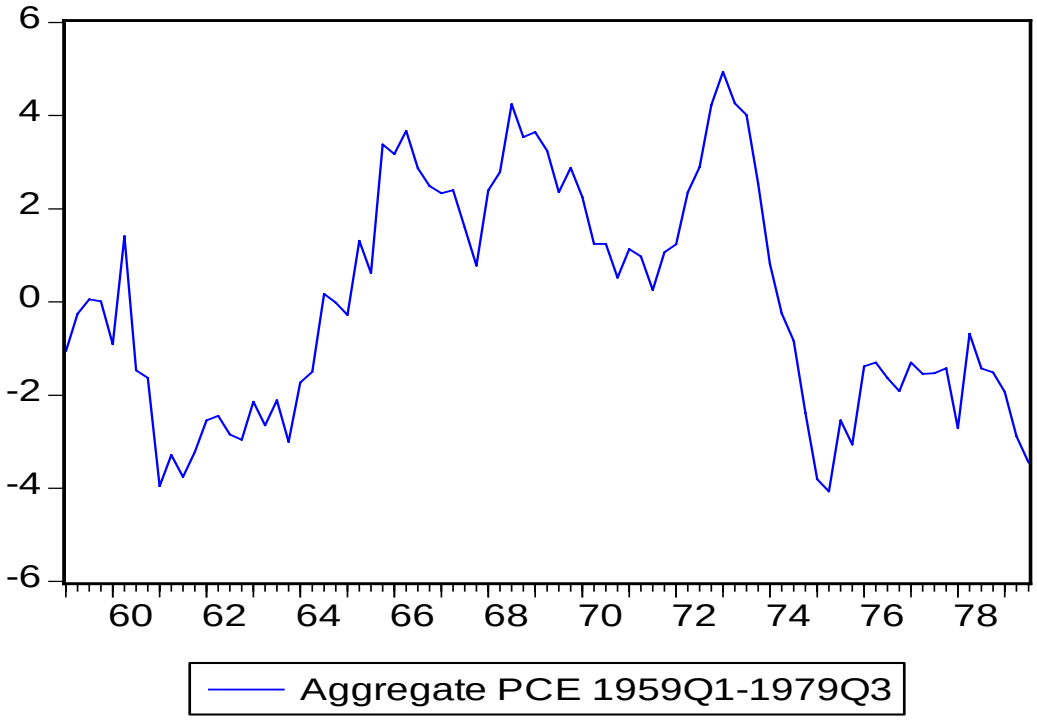
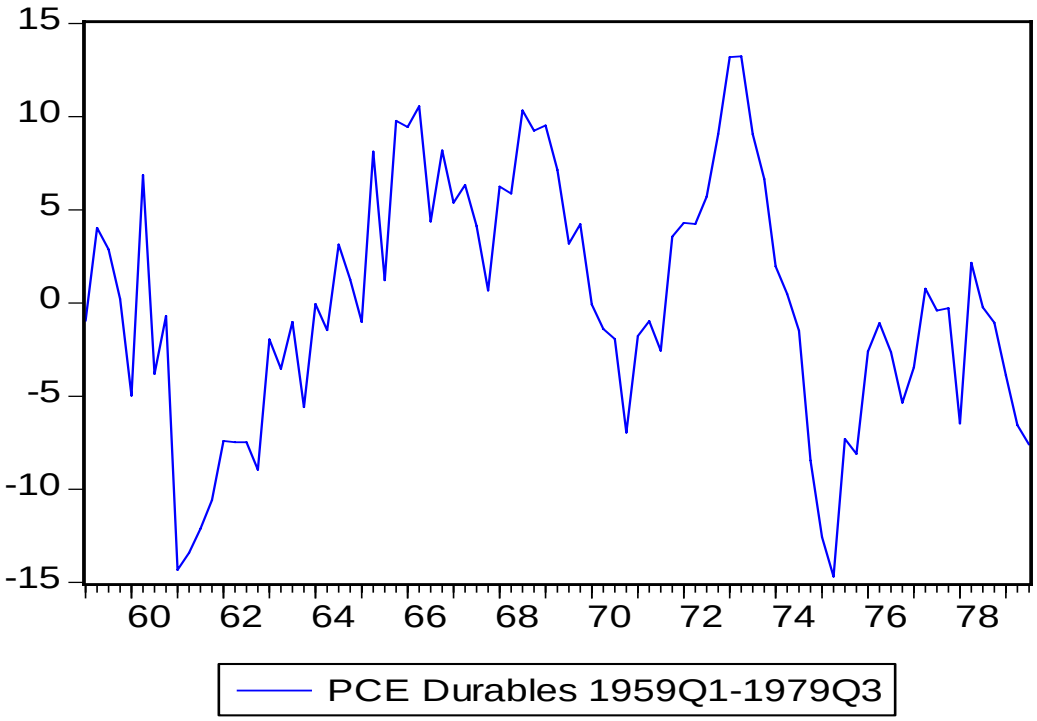
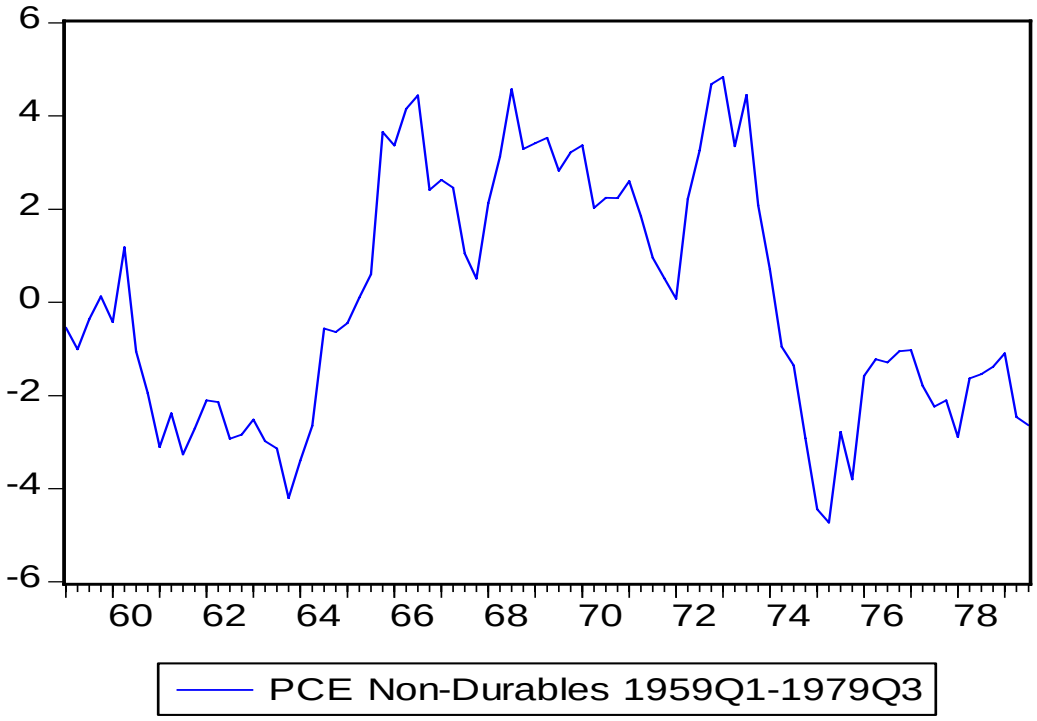
Figure 2: Consumption Time Series 1959Q1-1979Q3



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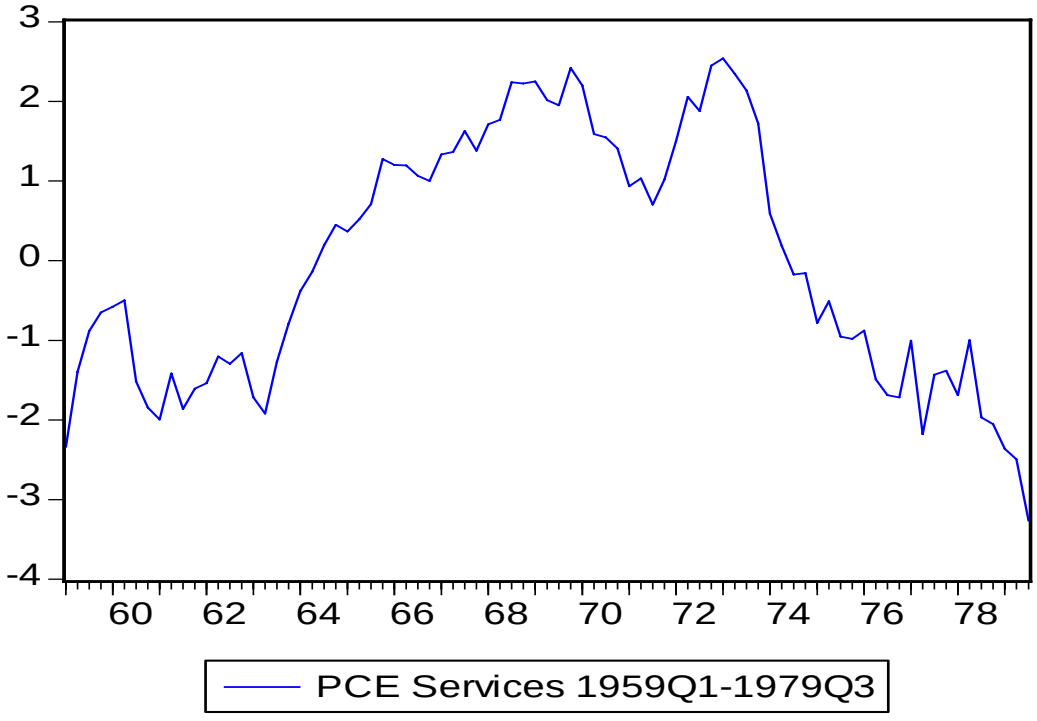
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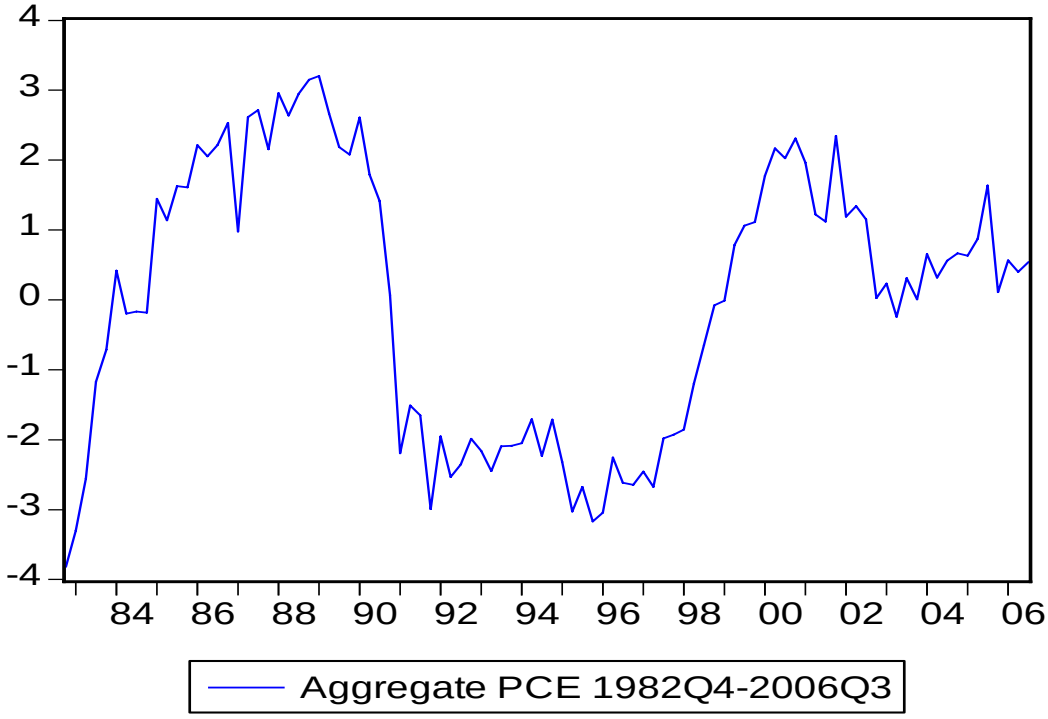
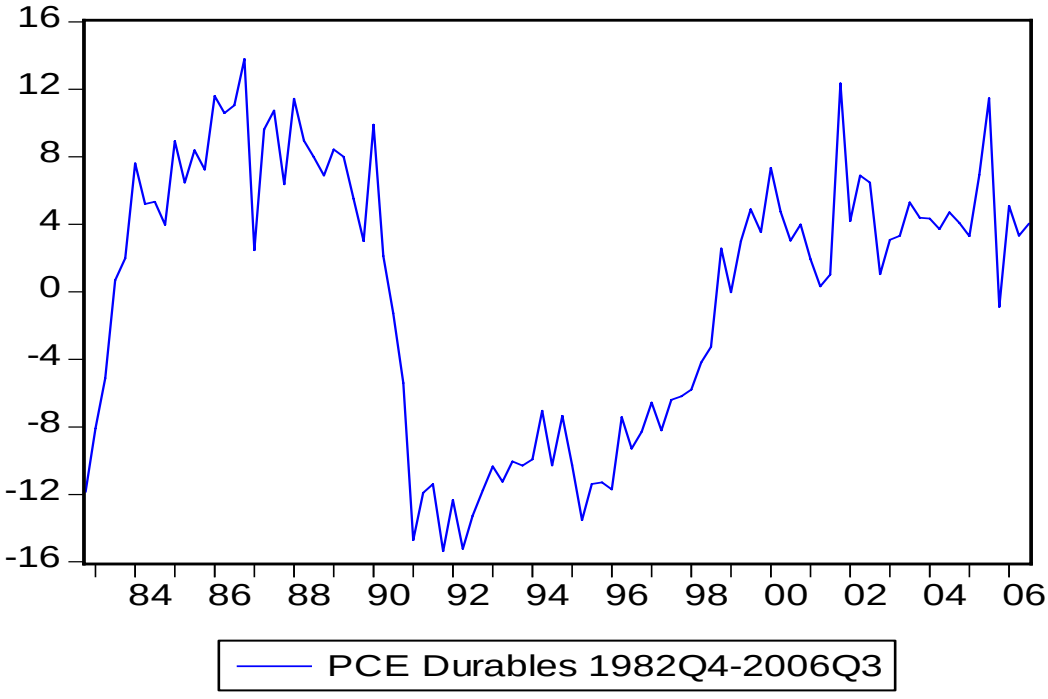
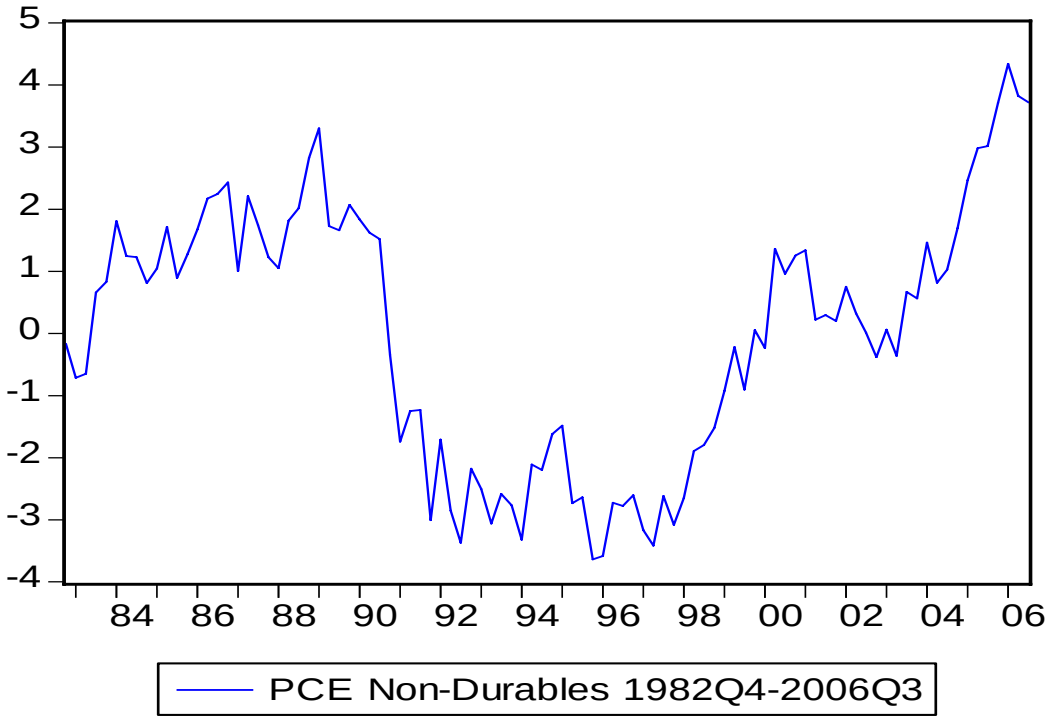
PCE Services 1959Q1-1979Q3

Figure 3: Consumption Time Series 1982Q4-2006Q3



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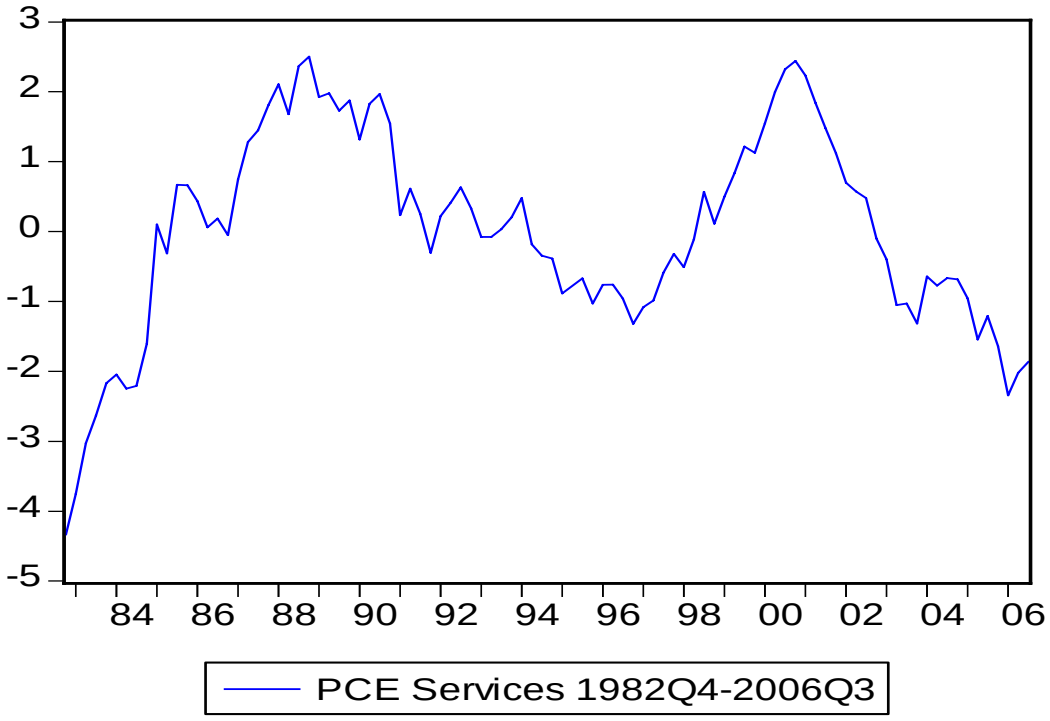
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PCE Services 1982Q4-2006Q3

Appendix B: Data Appendix

Our data is available upon request. The data was taken from United States monthly observations from January 1959 through November 2006. To construct the quarterly variables, the first monthly observation of every quarter was used. The data is published by the Federal Reserve Bank of St. Louis and is available online at: http://research.stlouisfed.org/fred2/

Data Series Downloaded from Federal Reserve Economic Database		
Series Title	**Units**	**Series ID**
Real Personal Consumption Expenditures	Billions of chained 2000 U.S. dollars	PCEC96
Real Personal Consumption Expenditures: Durable Goods	Billions of chained 2000 U.S. dollars	PCEDGC96
Real Personal Consumption Expenditures: Nondurable Goods	Billions of chained 2000 U.S. dollars	PCENDC96
Real Personal Consumption Expenditures: Services	Billions of chained 2000 U.S. dollars	PCESC96
Consumer Price Index For All Urban Consumers: All Items	Index 1982-1984=100	CPIAUCSL
3-Month Treasury Bill: Secondary Market Rate	Percent	TB3MS
10-Year Treasury Constant Maturity Rate	Percent	GS10

Constructed Data Series

- The series for total consumption, durables, non-durables, and services consumption were constructed by first collecting real personal consumption expenditures for each, taking the natural logarithms of those values (lrpce), and then regressing these values on time using OLS (Equation 1). The de-trended data set was then constructed by subtracting the first coefficient and the second coefficient multiplied by time (the steady-state value) from the observed value (Equation 2).

$$lrpce = \alpha_1 + \alpha_2 * time \tag{1}$$

$$c_t^i = lrpce - \alpha_1 - \alpha_2 * time \tag{2}$$

- The inflation variable, π_t, was constructed by subtracting the natural log of the previous period's CPI from the current period's CPI and multiplying by 400 to give a quarterly value.

$$\pi_t = (\log cpi_t - \log cpi_{t-1}) * 400 \tag{3}$$

- The spread variable was constructed by taking the difference between the interest rate on a 10-year Treasury bond and a 3-month Treasury bill.

$$spread = bond - tbill \tag{4}$$

- The short rate variable was constructed by subtracting next period's inflation (π_{t+1}) from the interest rate on a 3-month Treasury bill during the current period.

$$shortrate = tbill - \pi_{t+1} \tag{5}$$

- The intermediate rate variable is the average of the short rate in a given time period over the following four quarters.

- The long rate variable is the average of the short rate in a given time period over the following 40 quarters.

- For the two sub-samples, all data was reconstructed in the same manner over the defined time period.