Habits, Sentiment and Predictable Income in the Dynamics of Aggregate Consumption

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October 26, 2003

Abstract

This paper explores whether habit formation in the representative agent's preferences can explain two failures of the standard permanent income model: the sensitivity to lagged consumer sentiment, and to predictable changes in income. I show that in a habit formation model, the sensitivity of consumption to predicted income can be largely reinterpreted as a sluggish response to news. Moreover, the sensitivity of consumption to sentiment reflects the serial correlation in consumption growth generated by habits. The estimated model predicts an immediate (first-quarter) MPC out of a permanent tax cut of only about 30%.

Keywords: consumer sentiment, excess sensitivity, habit formation, consumption, marginal propensity to consume, tax cuts

JEL Classification: E10, E21, E62, H31

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1 Introduction

A standard version of the permanent income model predicts that the level of aggregate consumption is a random walk and consumption growth is unforecastable (Hall, 1978). Researchers have identified two circumstances when this prediction fails. First, Campbell and Mankiw (1989) demonstrated that consumption growth is correlated with predictable changes in current income.[1] Secondly, Carroll, Fuhrer and Wilcox (1994) have shown that a large fraction of consumption growth can be predicted by using measures of consumer sentiment.

In this paper, I explore whether a simple model of the representative consumer with habit formation in her preferences can explain these two failures. Under habit formation, consumers become addicted to the level of consumption they experienced in the past. By implication, they adjust their consumption levels to news about income and wealth only gradually. The reason is that the gradual adjustment keeps consumption well above habits for many periods, which is an optimal behavior for agents with these preferences. The slow response of consumption to shocks in this model implies that consumption growth is serially correlated.

The sensitivity of consumption to income has often been interpreted as evidence of liquidity constraints, or myopic consumption behavior of some consumers. Deaton (1992) has pointed out that habit formation might be an alternative explanation.[2] This is because the sensitivity of consumption to income instrumented by lags of various variables can be reinterpreted as a delayed response of consumption to news. A similar argument can also be made in the case of sensitivity to sentiment. The sentiment index carries information about

[1] Earlier studies documenting the relationship between consumption and past or predicted income include Flavin (1981), and Deaton (1987), among others.

[2] Other explanations include substitution between home and market consumption (Baxter and Jermann, 1999), precautionary saving motive (Ludvigson, Michaelides, 2001) and nonseparability between durables and nondurables (Deaton, 1987). It remains open question whether these channels can generate the effect of the size observed in the data, and whether they can explain the sensitivity of consumption to sentiment.

contemporaneous consumption growth. Therefore, the observed sensitivity of consumption to lagged sentiment can merely capture the autocorrelation in consumption growth caused by habits.

It may seem surprising that a model with serial correlation in consumption growth can explain these puzzles. It is well known that ordinary least squares estimates of autoregressive models for consumption growth yield significant but relatively small coefficients on lagged consumption growth. Indeed, one further element is necessary. Wilcox (1992) made evident that measurement error in the level of consumption often leads to incorrect inferences about the data. I document below that reported quarterly consumption data are subject to substantial measurement error. This measurement error leads OLS estimates of serial correlation in consumption growth to be biased downward.

In principle, serial correlation in aggregate consumption growth can be generated by different classes of models. Carroll and Sommer (2003) develop a rational expectations model with a slow diffusion of information among agents that implies similar aggregate dynamics as the representative-agent habit formation model. Serially correlated consumption can also be obtained in the learning model of Pischke (1995). However, the purpose of this paper is to test the implications of the habit formation model since it is a frequently used specification from the class of full-information rational-expectations models.

The rest of the paper is organized as follows. In Section 2, I present a simple model of habit formation and summarize its implications for the dynamics of consumption growth. In Section 3, I apply economic theory to the methodology of computing sentiment indexes. I show that the indexes should be closely related to current aggregate consumption growth. In Section 4, I examine correlations among sentiment, predictable income and habits in a simple two-stage least squares framework. For the purposes of the section, I ignore any distortions generated by the measurement error in the level of consumption. In line with the literature, predictable current income growth and past sentiment have forecasting power for current consumption growth. However, after I augment the consumption equation with lags of consumption growth to capture habits, sentiment becomes insignificant and the coefficient on predicted income falls.

In Section 5, I estimate the Euler equation derived from the habit formation model. The estimation takes account of the presence of measurement error in the level of consumption. Using the Kalman filter, I separate the measurement error from true consumption growth. The estimated habit formation coefficient is large and is highly statistically significant. The AR(1) process for true consumption growth is estimated with a coefficient of 0.73 (0.09) for nondurables and services consumption, and 0.64 (0.12) for nondurables consumption. In the second stage, I test the sensitivity of "true" consumption growth to predictable income growth and sentiment. After controlling for habits, the sentiment index has no predictive power for consumption growth. Moreover, the coefficient on predictable income is much smaller than previously estimated in the literature. These results are confirmed by instrumental variable estimates.

Finally in Section 6, I examine the likely effects of the recent tax cut on aggregate consumption. The permanent income hypothesis as well as the Campbell-Mankiw model predict that consumption immediately responds one-for-one to a permanent tax cut. However, results from Section 5 suggest that consumers form strong consumption habits. Consequently, they are likely to respond to the tax cut slowly. Under realistic assumptions, the immediate MPC out of the tax cut is only 30%. Such a modest first-round response of consumption to a permanent shock may seem surprising, but it is consistent with the recent work of Carroll (2000) and survey evidence in Shapiro and Slemrod (2001).

2 The habit formation model

The assumption of habit formation in consumer preferences is becoming increasingly popular in many areas of economics. It has proven critical in explaining several important failures of standard optimizing models.[3] Here, I adopt the

[3] Most notably, it helps explain the relationship between saving and growth, the hump-shaped response of consumption to monetary policy shocks, the level of equity premium and the cyclical properties of asset prices. See Carroll, Overland, Weil (2000) for review.

simplest possible formalization of habits (Muellbauer, 1988). A representative consumer maximizes a stream of discounted utility subject to a budget constraint:

$$\max_{\{C_t\}} E_t \sum_{t=s}^{\infty} \beta^{t-s} u\left(C_t - \gamma C_{t-1}\right) \qquad s.t. \quad A_t = R(A_{t-1} + Y_{t-1} - C_{t-1}). \tag{1}$$

Here, C_t denotes the level of consumption, A_t is the stock of wealth, β is the time preference rate, and R is the gross real interest rate. C_{t-1} represents the "habit stock", i.e. the reference level to which the consumer compares her current consumption level. The parameter γ expresses how strong the habits are. When $\gamma = 0$, habits play no role and the consumer cares only about her consumption level. In the opposite extreme, when $\gamma = 1$, habits are most powerful and the consumer considers only her consumption growth. When $\gamma \in (0, 1)$, the consumer derives utility from both the level and the growth rate of consumption. This can be seen when the utility function is rewritten as $u\left(C_t - \gamma C_{t-1}\right) = u\left(\left(1-\gamma\right) C_t + \gamma \Delta C_t\right).$

The Bellman equation for the problem is:

$$V\left(A_t, C_{t-1}\right) = \max_{\{C_t\}} \left\{ u\left(C_t - \gamma C_{t-1}\right) + \beta E_t V\left(R(A_t + Y_t - C_t), C_t\right) \right\}.$$

Under the assumption of quadratic or CRRA outer utility, the equation for consumption growth can be approximated as:

$$\Delta \ln C_t \approx c_0 + \gamma \Delta \ln C_{t-1} + v_t, \tag{2}$$

where v_t is a white noise process reflecting innovations to lifetime resources (Muellbauer, 1988). Ignoring the constant, the equation (2) states that current consumption growth equals a fraction γ of last period's consumption growth plus a random element. Hence, in contrast to the standard utility specification, some of the period t consumption growth is predetermined at time $t-1$. Another implication of (2) is that current news about income and wealth captured by v_t influence consumption growth in both the present and the future. As suggested in the introduction, the serial correlation property will prove useful for explaining the sentiment puzzle, while the delayed response property helps reinterpret the predictable income effect.

In a more general model of habit formation such as in Abel (1990), or Carroll, Overland, and Weil (2000), the habit stock would equal a weighted average of past consumption levels. In this case, consumption growth in (2) would follow an AR process of order higher than one. Note also that without habit formation in preferences ($\gamma = 0$), the equation (2) would collapse to $\Delta \ln C_t = v_t$, which is the standard white noise implication of the PIH.

3 Surveys of consumer sentiment

In this section, I demonstrate that the sentiment indexes are closely related to contemporaneous consumption growth. This finding is important for two reasons. First, it helps to rationalize why the lags of consumption growth could control for the sensitivity of consumption to sentiment. Secondly, it implies that the sentiment index is a good instrument for "true" consumption growth. Sentiment is correlated with consumption growth, yet it is uncorrelated with measurement error in the consumption data. The reason is that the methodology of computing sentiment is completely different from the NIPA methodology of constructing personal consumption expenditures. This feature will be very valuable when one tries to control for measurement error.

Indexes of sentiment (or confidence) are computed from the survey responses of consumers and private sector executives about current and future values of important macroeconomic variables. The best known survey, the Index of Consumer Sentiment (prepared by the University of Michigan), is based on responses to five questions. These questions ask consumers about measures of aggregate economic activity, as well as about personal income and wealth. The answers of individual respondents are qualitative, e.g. consumers are asked whether they expect a given variable to rise, fall, or stay the same. Nevertheless, the construction of the indexes warrants that they carry quantitative information about the current growth rate of aggregate consumption.

Consider the following example. Question #2 of the Survey is: "Now looking ahead, do you think that a year from now you (and your family living there) will be better off financially, or worse off, or just about the same as now?". The sentiment index is computed as the difference between the fraction of people who answered that they would be better off and those who answered worse off. It is straightforward to show that such an index contains information about expected aggregate income growth. Suppose that all consumers have the same initial income $\ln Y_t$ in period t and that the distribution of expected income $\ln Y^e_{t+1,i}$ is uniform with mean $\ln Y^e_{t+1}$ and half-range a. The sentiment index can then be expressed as:

$$\begin{aligned} Sentiment_t^{Question\ \#2} &= P\left(\ln Y^e_{t+1,i} > \ln Y_t\right) - P\left(\ln Y^e_{t+1,i} < \ln Y_t\right) \\ Sentiment_t^{Question\ \#2} &= 1 - 2\int\limits_{\ln Y^e_{t+1}-a}^{\ln Y_t} \frac{1}{2a} d\ln Y^e_{t+1,i} = \frac{1}{a}\left(\ln Y^e_{t+1} - \ln Y_t\right), \end{aligned}$$

i.e. the sentiment index is proportional to expected aggregate income growth. A similar argument can be repeated for the other questions underlying the Index of Consumer Sentiment.[4] Questions #1-#4 are essentially questions about the wealth and income parts of the intertemporal budget constraint. Question #5 asks directly about one category of consumption (durables). Since the budget constraint makes (nondurables and services) consumption a function of all these variables, the Sentiment Index must carry information regarding contemporaneous movements in aggregate consumption. Figure 1 illustrates that this theoretical result holds strongly in the data. The correlation between (mea-

[4] The index based on question #1 extracts information about the change in the aggregate wealth and question #3 (similarly to question #2) reflects beliefs about next year's aggregate income growth. Question #4 surveys expectations of long-term aggregate income growth and, finally, question #5 examines the level and growth of durables consumption.

sured) quarterly consumption growth and sentiment is 0.52.[5]

4 Preliminary regressions

In this section, I examine how habits, sentiment, and anticipated income interact. The question of interest is whether sentiment and anticipated income have any predictive power for consumption growth after controlling for serial correlation in consumption growth. In this section, I ignore any complications arising from the measurement error in aggregate consumption data. I stay as close as possible to the specifications and instrument sets previously used in the literature.

As a benchmark specification, I use the Campbell and Mankiw (1989) model reformulated by Carroll, Fuhrer and Wilcox (1994) as:

$$\Delta \ln C_t = c_0 + \lambda E_{t-1} \Delta \ln Y_t + \eta_t + \varphi \eta_{t-1}. \quad (3)$$

The model postulates that the fraction λ of aggregate disposable income accrues to consumers who do not optimize and spend all their income in every period. For this category of consumers, consumption growth equals income growth. The residual part of aggregate income $(1 - \lambda)$ accrues to consumers

[5] What is the exact nature of relationship between sentiment and consumption growth? The permanent income hypothesis predicts that consumption growth is unforecastable. Therefore it should only be the *innovation* to current sentiment that is correlated with current consumption growth. Past innovations to sentiment should have no predictive power. Under habits, however, current consumption growth is influenced by both current and past innovations. Since the actual sentiment series is serially correlated, the level of sentiment contains information about both current and past innovations to lifetime resources. We would therefore expect to observe a high correlation between the *level* of sentiment and current consumption growth especially if consumers form habits. Interestingly, the correlation between consumption growth and the level of sentiment is much higher than with the innovation to sentiment (0.52 versus 0.32). Similarly, consumption growth is significantly correlated with past levels of sentiment. Both features of the data may be interpreted as a violation of the permanent income hypothesis.

who make their consumption decisions optimally. For this group, consumption growth is white noise. Therefore, aggregate consumption evolves according to (3). For reasons summarized in Carroll, Fuhrer and Wilcox, it is necessary to instrument income growth, while allowing residuals to follow an MA(1) process.[6] My measure of consumption is real nondurables and services consumption per capita, or alternatively, nondurables consumption per capita only. $\Delta \ln Y_t$ is a change in the log of real disposable income per capita. The data sample covers 1966:1-2000:4. As a measure of sentiment, I use the University of Michigan Index of Consumer Sentiment. I report the regression results in the first two rows of Tables 1a and 1b. The estimated fraction of rule-of-thumb consumers is approximately 0.6 for nondurables and services consumption, which is statistically indistinguishable from the average estimate of Campbell and Mankiw of 0.5. For nondurables consumption, the fraction is higher, around 0.9.

In the next step, I replicate the regression of Carroll, Fuhrer and Wilcox, who found that sentiment helps predict consumption even after controlling for anticipated income growth. They estimate the following equation:

$$\Delta \ln C_t = c_0 + \lambda E_{t-1} \Delta \ln Y_t + \delta(L) Sentiment_{t-1} + \eta_t + \varphi \eta_{t-1}. \qquad (4)$$

I use three lags of sentiment when the instruments are timed t-1 up to t-3 and four lags of sentiment when the instruments are timed t-1 up to t-4 (for a description of the instrument sets, see Table 1a). The coefficients on sentiment are jointly statistically significant at the 10% level in all four cases

[6] Since the innovations to consumption and income are correlated, it is necessary to instrument income growth to avoid correlation between the regressor and the error term η_t. In regressions using quarterly data, it is highly likely that time averaging generates covariation even between $E_{t-1}\Delta \ln Y_t$ and η_t. There are two standard ways to deal with this problem under the null that the PIH is correct. Either one can lag the instruments twice, i.e. use $E_{t-2}\Delta \ln Y_t$ on the right-hand side (Campbell and Mankiw, 1989), or one can use $t-1$ instruments, while allowing the error η_t to follow an MA(1) process with coefficient φ (Carroll, Fuhrer and Wilcox, 1994). To increase the power of statistical tests, I use the methodology of Carroll, Fuhrer and Wilcox.

reported in the Tables (rows 3 and 4). As Carroll, Fuhrer and Wilcox point out, this finding cannot be reconciled with the framework of Campbell and Mankiw because sentiment should enter (4) only as a predictor of income growth.

Now consider the relationship between sentiment and habits. If the assumption of habit formation in preferences drives the dynamic correlations between consumption and sentiment, the lags of sentiment should become insignificant after lags of consumption growth are added to the equation (4):

$$\Delta \ln C_t = c_0 + \alpha(L)\Delta \ln C_{t-1} + \lambda E_{t-1}\Delta \ln Y_t + \delta(L) Sentiment_{t-1} + \eta_t + \varphi \eta_{t-1}. \quad (5)$$

As explained below, measured consumption is contaminated with substantial measurement error, so this prediction cannot be taken at a face value. The regression results in rows 7 and 8 of Tables 1a and 1b are indeed consistent with the hypothesis of habit formation *and* measurement error. In three cases out of four, the consumption terms dominate the sentiment terms. In the remaining case, sentiment dominates the consumption terms.[7]

As for the coefficient on anticipated income, it falls after lags of consumption are added: from 0.6 to 0.1-0.2 for nondurables and services, and from 0.9 to 0.2-0.5 for nondurables (in one case, the estimated coefficient λ is negative with a large standard error).

These preliminary regressions are very informative about the potential role of habit formation in rationalizing the effects of sentiment and predicted income. However, they do not fully control for the measurement error in consumption,[8] which creates biases in the estimated coefficients and leads to frequent rejections of overidentifying restrictions when measured consumption is used as an

[7] Carroll, Fuhrer and Wilcox considered habit formation as an explanation for the observed sensitivity of consumption to sentiment. They discarded the hypothesis based on the fact that the test of overidentifying restrictions did not reject the model (4). However, if sentiment and measured consumption are both imperfect proxies for the same variable - true consumption - than it is natural that one cannot often reject overidentifying restrictions in (4).

[8] In equations (3), (4) and (5), some of the measurement error is captured by allowing for the MA term in residuals series.

instrument. Therefore, one cannot make a definitive conclusion about the ability of habit formation model to explain both sensitivities of consumption data. These regressions also do not impose restrictions on coefficients of $\alpha(L)$ implied by standard habit formation models. In particular, I would like to verify how realistic the extremely simple model in Section 2 is, in which the habit stock is identified with last period's consumption and consumption growth is described as an AR(1) process.

5 Estimation of Euler equations

5A. Measurement error in consumption

The aggregate consumption data suffer from a large and possibly serially correlated measurement error. Since any habit formation model leads to specifications where consumption growth is a right-hand side regressor, and since consumption growth is often used as an instrument, it is necessary to specify an appropriate model for the measurement error before proceeding to an estimation. Wilcox (1992) has made it clear that failure to account for measurement error in consumption data may lead to misleading conclusions.

There are three main sources of measurement error in aggregate personal expenditure data. First of all, retail sales estimates, which account for approximately one half of aggregate consumption, are subject to two types of errors: sampling and nonsampling errors. The sampling error arises because the retail sales survey is conducted only on a limited number of firms. This error is relatively small. The BEA Retail Trade Report reports that the standard deviation of the forecast for retail sales is 0.5% for year-on-year growth rates. This is less than 5% of seasonally adjusted retail sales variability. The two other types of errors are likely to be quantitatively more important. The nonsampling error in retail data is generated by imputing missing data for non-respondents. Imputed sales routinely account for up to 25% of the total retail sales (Bureau of Economic Analysis, 2000a). Furthermore, a substantial fraction of quarterly services data (in particular, housing) is not directly measured but is estimated by using "judgmental trend" from annual data (Bureau of Economic Analysis, 1990 and 2000). Given the fact that a large fraction of quarterly consumption data (over 30%) is either imputed or interpolated, the measurement error must make up a non-trivial fraction of the total consumption variability.

The statistical properties of this measurement error have important implications for the estimation of the equation (2). It is not clear whether taking the classical approach (measurement error is white noise) is *a priori* justifiable. Bell and Hillmer (1990) have shown that the sampling error in the retail trade survey is highly serially correlated and follows a complicated pattern. The pattern is caused by the fact that the retail sales data are estimated from overlapping observations and firms are surveyed in rotating panels. This type of error is quantitatively small in aggregate PCE compared to the other two sources of mismeasurement. However, imputing of retail sales and interpolation of services data are also likely to generate serially correlated errors. If a consumer receives innovation to her lifetime resources, she will immediatelly (although not necessarily fully) respond, while the official statistics is likely to smooth the data. For simplicity, I assume that adding up all three error components (and potentially also the transitory components of consumption) leads to an MA(1) error structure in the log-level of consumption: $u_t + \theta u_{t-1}$. In economic terms, I allow measurement error to be serially correlated but I limit the impact of error on serial correlation properties of the data and introduce only one additional free parameter. Taking first differences leads to the model of measurement error for the growth rate of consumption: $u_t + (\theta - 1)u_{t-1} - \theta u_{t-2}$. As will become apparent below, many properties of the habit formation model can be established without taking this assumption.

5B. Structural coefficient estimates

The objective is to estimate the equation for the consumption growth (2) implied by the habit formation model, while allowing for the measurement error in the consumption data:

$$\Delta \ln C_t = \Delta \ln C_t^* + u_t + (\theta - 1)u_{t-1} - \theta u_{t-2}, \quad (6)$$

$$\Delta \ln C_t^* = \gamma \Delta \ln C_{t-1}^* + v_t + 0.4 v_{t-1}. \quad (7)$$

$\Delta \ln C_t$ denotes the observed consumption growth, u_t is the measurement error in the level of consumption and $\Delta \ln C_t^*$ denotes "true" consumption growth. "True" consumption growth is driven by habits and follows an ARMA(1,1) process.[9] Measured consumption growth is contaminated with an MA(2) measurement error, as specified above. As in Section 4, the data are quarterly and cover the 1966:1-2000:4 period. I use two alternative data series: real nondurables and services consumption per capita, or nondurables per capita only.

I utilize two different estimation techniques. First, I estimate γ using the two-stage least squares estimator. The major advantage of this approach is that with appropriate instruments, the estimated habit formation parameter γ does not hinge on validity of the particular structure of measurement error in (6). As a more efficient alternative, I use the Kalman filter to jointly estimate the habit formation coefficient γ and the measurement error coefficient θ. At the same time, I separate true consumption growth from the measurement error.

(i) Two-stage least squares estimator

Substituting equation (6) into equation (7) yields:

$$\Delta \ln C_t = \gamma \Delta \ln C_{t-1} + v_t + 0.4 v_{t-1} + u_t + (\theta - 1 - \gamma) u_{t-1} - [\theta + \gamma(\theta - 1)] u_{t-2} + \gamma \theta u_{t-3}. \quad (8)$$

The residual series follows a complicated process. It is the sum of a white noise and an MA(3) process. To obtain a consistent estimate of γ, it is necessary

[9] Due to time aggregation, the innovation to "true" consumption growth v_t follows an MA(1) process (Christiano, Eichenbaum, Marshall, 1991). As follows from Muellbauer (1988) and as shown explicitly in Carroll, Sommer (2002), the MA(1) coefficient is about 0.4 when consumers form habits.

to find variables which are correlated with consumption growth, but uncorrelated with measurement error u_t. As explained in Section 3, the primary candidate is the sentiment index. Is is highly correlated with the consumption growth, yet should be orthogonal to the measurement error in the consumption growth. I also include the customary variables such as T-bill rate, unemployment rate and S&P 500 return in the instrument sets. I do not use past consumption growth and income growth as instruments, because it would be necessary to lag them for four quarters. Tables 2a and 2b report the regression results.[10] The estimated autoregressive coefficients are in the range of 0.64-0.96 and are all statistically significant.

The OLS estimates of γ are one-half or one-third of the intrumental variables estimates: 0.41 for nondurables and services and only 0.27 for nondurables. This comparison demonstrates the danger of estimating habit formation coefficients without accounting for the measurement error in consumption.

I also augment the equation (8) with predicted current income and measures of sentiment. The coefficient on predicted income is insignificant in all eight analyzed cases reported in the Tables. Moreover, estimates of the coefficient are much smaller than in the case when the habits term $\Delta \ln C_{t-1}$ is excluded. This suggests that habits can indeed account for the sensitivity of consumption to income. Adding sentiment destabilizes the estimated coefficients including the coefficient on lagged consumption. This is natural because sentiment and reported consumption data are noisy measures of true consumption growth and are collinear. At the same time, the instruments are not sufficiently strong to help determine which term is the primary source of variation in consumption growth. The results are nevertheless broadly consistent with the hypothesis of habit formation and measurement error.

(ii) Kalman filter estimation

Kalman filter is more efficient than the two stage least squares because it ex-

[10] I use the Newey-West standard errors to control for serial correlation in residuals generated by the measurement error.

plicitly models the correlation structure in the measurement error. My strategy is to impose the model on the data and then test whether it generates sufficient sensitivity of consumption to sentiment and predicted income. I rewrite (6) and (7) in a state-space form and I estimate the model using the Kalman filter. Table 3 shows the summary statistics from the estimation. The habit formation coefficient γ is large and highly statistically significant. Its value is 0.73 (0.09) for nondurables and services, and 0.64 (0.12) for nondurables data (the PIH would imply $\gamma = 0$). The coefficient estimates are comparable to those estimated by other authors (Ferson and Constantinides, 1991, Fuhrer, 2000, Gruber, 2000). They are also close to the theoretical values required to explain various puzzles (e.g. Constantinides, 1990, Jermann, 1998, Carroll, 2000).

The Kalman filter attributes approximately 50% of the variation in consumption growth to the sum of measurement error in consumption growth and transitory consumption. The implied signal to noise ratio of 1:1 is consistent with the gap between the OLS and IV estimates found in the previous subsection. This estimation also confirms that the measurement error in the level of consumption is serially correlated. The estimate of θ is 0.55 (0.10) for nondurables and services, and 0.34 (0.13) for nondurables data.

(iii) Second stage regressions.

The Kalman filter extracted the true consumption growth $\Delta \ln C_t^*$ and consumption "momentum" from the data, i.e. the fraction of consumption growth that reflects habits ($\gamma \Delta \ln C_{t-1}^*$). An interesting question is whether sentiment and predictable income contain any information about true consumption growth beyond the information contained in consumption momentum. To test this, I estimate regressions of the following form:

$$\begin{aligned} \Delta \ln C_t^* &= \beta Momentum_t + \lambda \Delta \ln Y_t + \delta(L) Sentiment_{t-1} + \mu_t, \quad (9) \\ Momentum_t &\equiv \gamma \Delta \ln C_{t-1}^*. \end{aligned}$$

Tables 4a and 4b present regression results for both datasets. The lags of sentiment are jointly statistically insignificant in all specifications. This result confirms the conjecture based on preliminary regressions in Section 4 which established that the habit formation channel can explain the forecasting power of sentiment for future consumption. In fact, just one lag of consumption growth is sufficient to eliminate the sensitivity of consumption to sentiment. The fall of coefficient on *Momentum* after adding sentiment is relatively small, which confirms that Kalman filter did a good job in extracting true consumption from the noisy data.

After accounting for the measurement error, a large fraction of the predictable income effect disappears as well. However, the evidence is not clear cut in this case. The λ coefficient is statistically significant in half of the analyzed specifications. At the same time, all the coefficients are clustered in a narrow range around 0.1-0.2 for nondurables and services. This suggests that habits control for most of the predicted income effect in the data, although it may not be the only channel which generates the sensitivity. In any case, almost all point estimates of λ are much smaller than 0.5 estimated by Campbell, Mankiw and other authors. The tables reveal that results are robust to various changes in the instrument sets.

6 Effects of a permanent tax cut

Carroll (2000) has pointed out that the immediate marginal propensity to consume out of permanent shocks is very small for a habit-forming consumer. With habits, consumers want to enjoy a period of higher consumption growth and they adjust their consumption to the new level of permanent income slowly (see Figure 3). The recent campaign of President Bush that favors a large personal tax cut has been motivated by the belief that the tax cut would quickly revive a slowing economy:

"Over the past several months, the economy has slowed dramatically. President Bush's tax cut will give the economy a timely second wind by placing more money in the hands of consumers and entrepreneurs." (The White House, 2001)

Indeed, both the PIH and the Campbell-Mankiw model predict that a permanent tax cut must have an immediate, one-for-one effect on the level of aggregate consumption. However, results from the previous section suggest that consumers form strong consumption habits. In this section, I examine the dynamic response of aggregate consumption to the tax cut given the habit parameters estimated in the previous section.

In the habit formation model presented in Section 2, the consumption growth equaled (under CRRA utility and perfect certainty):

$$\Delta \ln C_t = (1-\gamma)\frac{1}{\sigma}\ln R\beta + \gamma \Delta \ln C_{t-1}, \tag{2'}$$

where is σ the CRRA coefficient of relative risk aversion. I calibrate the parameters σ, R and β such that the steady-state growth of quarterly consumption $\frac{1}{\sigma}\ln R\beta$ equals the sample mean of 0.6%. The baseline parameter values are $\sigma = 3$, $\beta = 0.995$ and $R = 1.023$. The value of habit formation parameter γ is assumed to be 0.731. This is the Kalman filter estimate of the parameter for nondurables and services consumption. Both instrumental variables point estimates were higher for this category of consumption and thus this value of γ is a conservative assumption. I simulate the path of consumption following an unanticipated permanent cut in marginal tax rates, assuming that the economy starts from a steady state. The estimated immediate MPC out of the tax cut is 28.0% for the baseline parameter values.[11] Of course, consumers eventually fully reflect the tax cut in their consumption level. But it would take approximately 3 quarters for consumers to start consuming at least 75% of the additional income provided by the tax cut in every period. Table 5 shows that the estimated MPCs are robust to alternative assumptions about parameter values.

Some of the regressions results in Section 5 could be interpreted in the sense that a small fraction of consumption dynamics (of around 20%) is attributable to rule-of-thumb consumers or consumers with a strong precautionary savings

[11] The MPC is defined here as the percentage increase in current-quarter consumption over the percentage reduction in the marginal tax rate.

motive.[12] Since the consumption of these consumers would react immediately to the tax cut, I also compute the MPC under the assumption that 20% of income accrues to the rule-of-thumb consumers. As reported in the last column of Table 5, the immediate MPC is typically between 40-45% in this case.

These propensities are close to the results of Carroll (2000), who calibrated the version of habit formation model that allows for the precautionary savings motive, and found the MPC to be in the range of 20-35%. The low propensity to consume is also consistent with the recent survey evidence of Shapiro and Slemrod (2001), who found that only 22% of households would spend their tax rebate checks.

7 Conclusion

This paper shows that a simple model of consumer with habits is capable of explaining the sensitivity of aggregate consumption fluctuations to sentiment and most of the sensitivity to predicted income. A small part of the income effect is present even after controlling for the habits. It is an open question whether this is because some fraction of consumers is myopic, is subject to liquidity constraints, or has a strong precautionary saving motive. As follows from the work of Carroll (1997) and as shown in detail by Ludvigson and Michaelides (2001), the precautionary motive slows consumer's reaction to anticipated events. Combined with habit formation, the precautionary saving channel could rationalize the remainder of the income sensitivity puzzle. Analyzing sensitivity properties of this category of models (Carroll, 2000) is an important area of future research.

[12] These consumers would be unwilling to set their consumption far away from their income because they want to stay at or close to their target savings/income ratio (Carroll, 1997). This could further diminish reaction of consumers to future expected changes in income and generate additional sensitivity to predicted income growth.

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Figure 1
Measured consumption growth and the Index of Consumer Sentiment

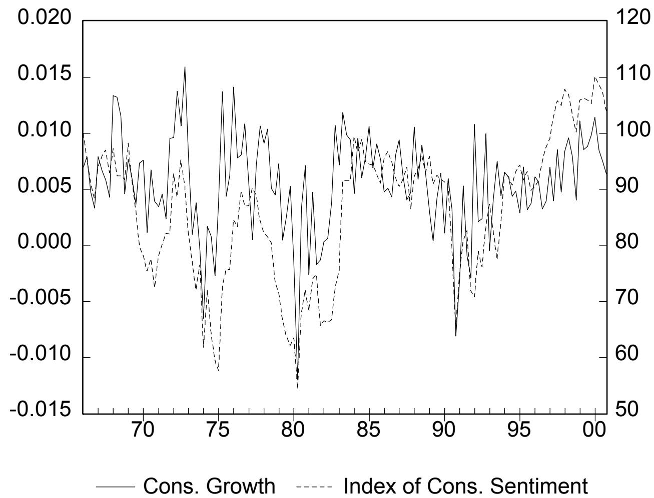

Figure 2
Measured consumption growth (demeaned) and Kalman-filtered growth

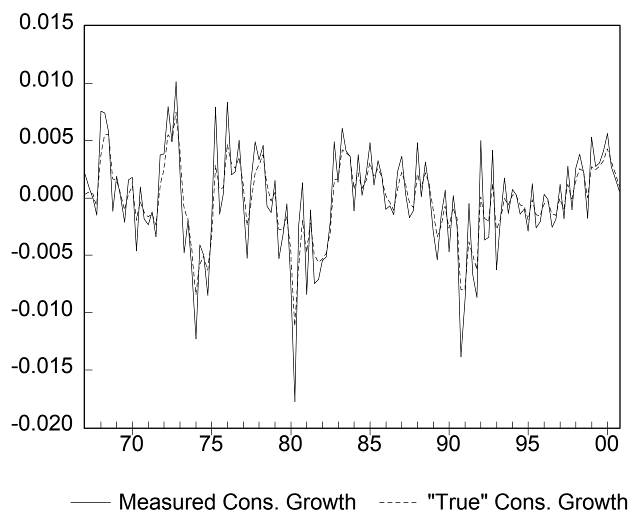

Figure 3
Response of consumption to a positive permanent shock

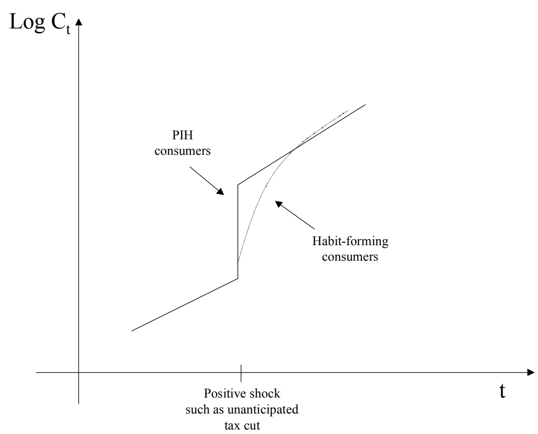

Table 1a
Preliminary regressions: nondurables and services consumption

	Instr. set	p-value sentim.	p-value cons.	λ	φ	p-value overid.
Campbell-Mankiw model	1			0.560^{**} (0.131)	-0.100 (0.115)	0.083
	2			0.627^{**} (0.127)	-0.140 (0.109)	0.280
Model with sentiment	1	0.037		0.322^{*} (0.133)	0.028 (0.129)	0.009
	2	0.100		0.480^{**} (0.128)	-0.099 (0.116)	0.064
Model with consumption lags	1		0.000	0.190 (0.138)	-0.190 (0.210)	0.330
	2		0.009	0.141 (0.131)	0.196 (0.201)	0.003
Model with sentiment and consumption lags	1	0.258	0.002	0.148 (0.196)	-0.239 (0.282)	0.567
	2	0.282	0.067	0.090 (0.133)	0.254 (0.217)	0.004

Notes: 2SLS estimates of equations (3), (4) and (5). Quarterly data, sample 1966:1-2000:4. Sentiment = Index of Consumer Sentiment. Two sets of instruments. Set 1: constant, real-disposable income growth, consumption growth, sentiment; timing of instruments from t-1 up to t-4. Set 2: Set 1 and changes in three-month T-bill rate, unemployment rate, and S&P 500 average return; timing of instruments from t-1 up to t-3. Columns 3 and 4 report p-values of F-tests that coefficients on sentiment and/or consumption lags are equal to zero. The last column reports p-values of the test of overidentifying restrictions.

Table 1b
Preliminary regressions: nondurables consumption

	Instr. set	p-value sentim.	p-value cons.	λ	φ	p-value overid.
Campbell-Mankiw model	1			0.917^{**} (0.249)	-0.148 (0.108)	0.369
	2			0.847^{**} (0.211)	-0.137 (0.105)	0.345
Model with sentiment	1	0.013		0.349 (0.269)	-0.036 (0.124)	0.111
	2	0.010		0.506^{*} (0.202)	-0.098 (0.109)	0.178
Model with consumption lags	1		0.019	0.444 (0.263)	-0.240 (0.156)	0.038
	2		0.086	0.534^{*} (0.223)	-0.173 (0.136)	0.076
Model with sentiment and consumption lags	1	0.154	0.074	-0.559 (0.548)	-0.368^{*} (0.171)	0.226
	2	0.042	0.318	0.188 (0.215)	0.018 (0.259)	0.100

Notes: For explanations, see Table 1a.

Table 2a
Instrumental variables estimates of the model: nondurables and services

Instrument set	OLS	A	B	A	B	A	B	A	B
γ	0.407**	0.957**	0.736**			0.805*	0.567*	2.885	−0.895
	(0.071)	(0.149)	(0.156)			(0.376)	(0.228)	(2.769)	(1.133)
λ				0.751**	0.569**	0.154	0.186	−0.490	0.234
				(0.153)	(0.144)	(0.360)	(0.213)	(1.392)	(0.343)
p-value sentim.								0.905	0.587
Overid. test	N.A.	0.496	0.179	0.392	0.161	0.558	0.056	N.A.	0.879

Notes: 2SLS estimates of equation (8). Newey-West standard errors, the lag truncation parameter is set equal to 4. Row 3 reports p-values of the exclusion test on the lags of sentiment. Row 4 reports p-values of overidentification test. Instrument set A: constant, sentiment, change in the three-month T-bill rate, timing from t-2 up to t-4. Instrument set B: set A plus change in unemployment and S&P 500 return, timing from t-2 to t-3.

Table 2b
Instrumental variables estimates of the model: nondurables

Instrument set	OLS	A	B	A	B	A	B	A	B
γ	0.271**	0.847**	0.638**			0.701*	0.324	0.591	−0.704
	(0.085)	(0.186)	(0.193)			(0.350)	(0.290)	(0.728)	(0.704)
λ				0.873**	0.807**	0.217	0.549	−0.180	0.191
				(0.235)	(0.208)	(0.399)	(0.287)	(0.530)	(0.455)
p-value sentim.								0.473	0.313
Overid. test	N.A.	0.659	0.133	0.432	0.346	0.471	0.195	N.A.	0.669

Notes: For explanations, see Table 2a.

Table 3
Kalman filter estimates of the habit formation model

	Nondurables and services	**Nondurables**
γ	0.731^{**}	0.637^{**}
	(0.086)	(0.119)
θ	0.548^{**}	0.340^{**}
	(0.098)	(0.129)
$\ln\sigma_u^2$	-12.185^{**}	-11.154^{**}
	(0.180)	(0.209)
$\ln\sigma_v^2$	-12.701^{**}	-11.658^{**}
	(0.329)	(0.378)
$\frac{var\Delta\ln C^*}{var\Delta\ln C}$	0.448	0.362
R^2	0.546	0.423

Notes: Kalman filter estimate of system (6) and (7). Consumption growth was demeaned before estimation. The R^2 refers to the explanatory power of equation for "true" consumption $\Delta\ln C^*$.

Table 4a
Second stage regressions: nondurables and services consumption

Instr. Set	A	B	C	D	A	B	C	D
β	0.996**	0.970**	0.891**	0.866**	0.831**	0.816**	0.733**	0.727**
	(0.104)	(0.103)	(0.143)	(0.131)	(0.172)	(0.133)	(0.168)	(0.147)
λ	0.084	0.097	0.189*	0.201**	0.015	0.052	0.129	0.182**
	(0.073)	(0.067)	(0.073)	(0.062)	(0.096)	(0.073)	(0.097)	(0.064)
p-value sentim.					0.082	0.178	0.181	0.467
Overid. test	0.089	0.087	0.060	0.254	0.994	0.676	0.708	0.536

Notes: 2SLS estimates of equation (9). Newey-West standard errors, the lag truncation parameter is set equal to 4. Four sets of instruments. Sets A and C: constant, true consumption growth, sentiment, change in the three-month T-bill rate. Sets B and D: Set A plus change in unemployment rate and S&P 500 return. Timing of instruments: Sets A and B: from t-2 to t-3, Sets C and D: from t-2 to t-4. Row 4 reports p-values of F-tests that coefficients on sentiment are equal to zero.

Table 4b
Second stage regressions: nondurables consumption

Instr. set	A	B	C	D	A	B	C	D
β	0.992**	0.958**	0.936**	0.915**	0.656**	0.655**	0.773**	0.784**
	(0.128)	(0.129)	(0.155)	(0.150)	(0.228)	(0.180)	(0.196)	(0.192)
λ	0.226*	0.240*	0.322**	0.327**	−0.042	0.061	0.290	0.312**
	(0.109)	(0.101)	(0.101)	(0.093)	(0.227)	(0.129)	(0.171)	(0.112)
p-value sentim.					0.069	0.041	0.325	0.375
Overid. test	0.093	0.170	0.266	0.550	0.995	0.877	0.444	0.672

Notes: For explanations, see Table 5.

Table 5
Marginal propensity to consume out of a permanent tax cut

	σ	β	R	γ	$MPC^{Habits\ Only}$	$MPC^{20\%\ Rule-of-thumb}$
Baseline specification	3	0.995	1.023	0.71	28.0%	42.4%
Sensitivity to σ	1	0.995	1.011	0.71	27.2%	41.7%
	2	0.995	1.017	0.71	27.6%	42.1%
	4	0.995	1.028	0.71	28.4%	42.7%
Sensitivity to R	3	0.980	1.038	0.71	29.1%	43.2%
	3	0.985	1.033	0.71	28.7%	43.0%
	3	0.990	1.028	0.71	28.3%	42.7%
	3	0.999	1.018	0.71	27.7%	42.2%
Sensitivity to γ	3	0.995	1.023	0.65	35.9%	48.7%
	3	0.995	1.023	0.70	31.0%	44.8%
	3	0.995	1.023	0.75	26.1%	40.9%
	3	0.995	1.023	0.80	21.2%	37.0%

Notes: Parameters are calibrated such that the steady state consumption growth $\frac{1}{\sigma}\ln R\beta$ matches the sample mean of 0.6% per quarter.