Federal Reserve Bank of New York
Staff Reports

Subjective Intertemporal Substitution

Richard K. Crump
Stefano Eusepi
Andrea Tambalotti
Giorgio Topa

Staff Report No. 734
July 2015

Subjective Intertemporal Substitution

Richard K. Crump, Stefano Eusepi, Andrea Tambalotti, and Giorgio Topa

Federal Reserve Bank of New York Staff Reports, no. 734
July 2015
JEL classification: D12, D84, E21

Abstract

We estimate the elasticity of intertemporal substitution (EIS)—the elasticity of *expected* consumption growth with respect to variation in the real interest rate—using subjective expectations from the newly released FRBNY Survey of Consumer Expectations (SCE). This dataset is unique, since it includes consumers' expectations of both consumption growth and inflation, with the latter providing subjective variation in ex ante real interest rates. As a result, we can estimate a subjective version of the consumption Euler equation, without having to take a stand on the process of expectation formation. Our main finding is that this subjective EIS is precisely and robustly estimated to be around 0.8 in the general population, consistent with typical macroeconomic calibrations of the Euler equation. However, we find some evidence that the EIS rises to slightly above one for high-income individuals, consistent with the assumptions in asset pricing models featuring long-run risks or rare disasters.

Key words: subjective expectations, inflation expectations, Euler equation, elasticity of intertemporal substitution

---

Crump, Eusepi, Tambalotti, Topa: Federal Reserve Bank of New York (e-mail: richard.crump@ny.frb.org, stefano.eusepi@ny.frb.org, andrea.tambalotti@ny.frb.org, giorgio.topa@ny.frb.org). The authors would like to thank Stéphane Bonhomme, Andrea Ferrero, Andreas Fuster, Giacomo De Giorgi, and Jonathan Parker for helpful comments and suggestions. Zachary Bleemer and Matthew Yeaton provided excellent research assistance. The views expressed in this paper are those of the authors and do not necessarily reflect the position of the Federal Reserve Bank of New York or the Federal Reserve System.

1 Introduction

The elasticity of intertemporal substitution (EIS) is a fundamental parameter in economics. It measures the response of planned consumption growth to changes in expected intertemporal prices; the slope of the consumption Euler equation. As such, this parameter, and the intertemporal substitution mechanism that it regulates, are at the heart of virtually every modern dynamic model in both macroeconomics and finance.

Given the centrality of the EIS in theory, progress in its estimation has also accompanied the development of micro- and macro-econometrics over the last several decades, starting from the pioneering work of Hall (1978) and Hansen and Singleton (1982, 1983). The standard approach[1] in this vast empirical literature has been to exploit the moment restrictions embedded in the consumption Euler equation through a GMM procedure, both to estimate preference parameters, as well as to test the theory (see Attanasio and Weber (2010) for a recent survey). One of the challenges with this GMM approach is that it assumes that agents' expectations make rational use of the same conditioning information available to the econometrician, so as to produce forecast errors that are orthogonal to that information. Therefore, traditional tests of the Euler equation cannot be disentangled from auxiliary assumptions on the expectation formation process, resulting in estimates of the EIS that are quite sensitive to the instruments used to build the expectations, as well as to other details of the specification (see Havranek (2015) for a comprehensive meta study).

In this paper, we bypass this challenge entirely by estimating a first order approximation of the standard Euler equation directly on households' expectations of both their consumption growth and inflation, with the latter providing individual variation in ex-ante real rates of return. To our knowledge, this is the first study to provide direct evidence on subjective perceptions of the elasticity of intertemporal substitution, using quantitative survey measures of expectations. This advancement is made possible by a newly released dataset collected by the Federal Reserve Bank of New York, the Survey of Consumer Expectations (SCE). This representative monthly survey of about 1,300 U.S. households contains carefully crafted questions on spending plans and future inflation. The answers to these questions provide ideal measures of the moments of the perceived distributions of consumption and inflation that are relevant for estimating households' subjective assessment of their elasticity of intertemporal substitution. The availability of these direct measures of subjective expectations

[1] Of course, many different approaches and data sources have been employed to estimate the EIS. For example, Attanasio and Weber (1993, 1995) use cohort data formed from panels, Barsky et al. (1997) use survey responses to questions about specific hypothetical situations, Gruber (2013) exploit individual variation in capital income tax rates, Engelhardt and Kumar (2009) exploit differences in employer matching rates in 401(k) plans, Alan and Browning (2010) use synthetic residual estimation, Cashin and Unayama (2012) exploit an increase in the consumption tax rate in Japan, among others.

allows us to avoid taking a stand on the process by which these expectations are formed.

The main result of this estimation is that the subjective EIS is precisely and robustly estimated to be around 0.8 in the general population, with minimal variations depending on the controls included in the regression. This robustness of the estimates is remarkable, since the richness of our dataset allows us to control for many potential confounding factors in the regression, including second moments of the subjective distributions of future outcomes that would enter into a higher order approximation of the Euler equation.

Our baseline estimate is consistent with typical macroeconomic calibrations of the Euler equation, which often resort to log utility (i.e., EIS = 1) due to its balanced growth properties. In finance, values of the EIS higher than one are more common, especially in the literature on long-run risks (Bansal and Yaron (2004)) and rare disasters (Barro (2009)). We find some support for this choice when estimating the EIS for high-income individuals, defined as those with incomes higher than one hundred thousand dollars. Within this subset of the population, the EIS is estimated to be closer to 1.1 although it is not significantly different than 1. In fact, this is the only demographic group in our sample where there is evidence that the EIS is significantly different than the population average of 0.8.

A few other papers have used data on expectations from the U.S. and other countries to estimate the relationship between consumption growth and inflation or rates of return. Burke and Ozdagli (2013) use the NY Fed/RAND-American Life Panel households expectations survey, which served as a pilot for the SCE, to estimate the relationship between *realized* consumption growth, as reported by the survey respondents, and inflation expectations. The use of realized, rather than expected, expenditure growth makes their study much closer to the traditional literature that estimates Euler equations using microeconomic data, with all the econometric limitations discussed above. Bachmann et al. (2015) estimate a probit model to characterize the relationship between "readiness to spend" on durable goods and inflation expectations, using data from the University of Michigan Survey of Consumers. Their measure of readiness to spend can be thought of as an expectation, as in our dataset, although it refers to general conditions in the economy, rather than to an individual's assessment of her own spending plans. Moreover, the discrete and qualitative nature of the questions does not allow the authors to estimate an Euler equation, and hence to identify the EIS.[2] Finally, Jappelli and Pistaferri (2000) estimate a standard Euler equation on realized consumption with data from the panel section of the Bank of Italy Survey of Household Income and Wealth. This survey also includes observations on expectations of income and inflation, which the authors use to predict income growth, as a way to test

[2] D'Acunto et al. (2015) and Ichiue and Nishiguchi (2015) use a similar methodology on German and Japanese survey data, respectively.

for excess sensitivity of consumption. Given their focus on excess sensitivity, though, they do not include expected inflation in their Euler equation regressions, and therefore do not produce an estimate of the EIS.

Our paper is also linked to the burgeoning literature using actual expectations data to inform models of economics outcomes (see Manski (2004) or more recently, for example, Greenwood and Shleifer (2014), Barberis et al. (2015) and Gennaioli et al. (2015)). Further, as stressed in Manski (2004), different survey designs can have a substantial impact on the quality of the elicited expectations. In that vein, the SCE has several advantages over existing household surveys of expectations, such as the University of Michigan Survey of Consumers. The SCE has a relatively large sample size (1,300 household heads), and is based on a rotating panel where individual respondents participate for up to 12 months. These features imply a greater precision of our measures of subjective expectations. Further, the wording of its inflation expectations question has been carefully tested (Bruine de Bruin et al. (2012)), providing confidence that this question is uniformly interpreted by survey respondents. Related work shows that the SCE inflation expectations are informative, in the sense that they co-move in a meaningful way with investment choices in a financially incentivized field experiment (Armantier et al. (2015)). Moreover survey respondents update their inflation expectations sensibly, upon receiving relevant information (Armantier et al. (2013a)). A unique feature of the SCE relative to other surveys is that it elicits quantitative measures of *both* inflation *and* spending growth expectations at a well-specified time horizon. Finally, for several key questions the survey elicits density forecasts in addition to point predictions.

The paper is organized as follows. Section 2 provides the theoretical motivations for our empirical specification. Details of the data set are provided in Section 3. Section 4 provides our main results while robustness checks are reported in Section 5. Section 6 concludes and discusses further work.

2 Theory

The theoretical reference point for our estimation exercise is the standard intertemporal Euler equation, which encapsulates the optimal consumption and saving choice of a household that can freely borrow and lend in an asset with a given rate of return. In its most basic, and widely used, form, this equilibrium condition can be written as

$$1 = E_t^i \left[\left(\frac{R_t}{\Pi_{t+1}} \right) \beta \left(\frac{C_{t+1}^i}{C_t^i} \right)^{-\frac{1}{\sigma}} \right], \tag{2.1}$$

where R_t/Π_{t+1} is the (gross) real rate of return. We treat the (gross) nominal interest rate R_t and (gross) inflation Π_t as "aggregate" variables, which are common to all consumers. However, the expectation of inflation is allowed to be heterogeneous across households, as it is in our data.[3] This heterogeneity is captured by the i superscript on the expectation operator E_t.[4] Consumption C_t^i is also allowed to vary across individuals, and so is its expectation. On the contrary, the discount factor β and the elasticity of intertemporal substitution (EIS) σ are restricted to be the same for all individuals in our baseline specification. In principle, these parameters could vary in the cross-section. We will revisit this issue in Section 5.

A first order approximation of the Euler equation yields the familiar relationship

$$E_t^i \left[\Delta c_{t+1}^i\right] = \sigma \log \beta + \sigma r_t - \sigma E_t^i \left[\pi_{t+1}\right] + o_{i,t}, \tag{2.2}$$

where $o_{i,t}$ is a remainder collecting second and higher order terms in the approximation. This equation forms the basis for our regressions. However, in some of the robustness exercises, we will also attempt to measure the most relevant terms contained in the remainder, namely the variances and covariances of inflation and consumption growth as perceived by consumers. One may be concerned that some of these terms could be correlated with expected inflation and as such bias the inference on σ obtained from the first order approximation.

Equation (2.2) is ubiquitous in macroeconomics, starting from the pioneering work of Hall (1978). Most of this vast literature (see Attanasio and Weber (2010) and references therein) uses either aggregate time-series, or cross-sectional data on *realized* consumption and rates of return to estimate

$$\Delta c_{t+1}^i = c + \sigma r r_{t+1} + \varepsilon_{i,t+1},$$

where rr_{t+1} is a real interest rate, and the error term $\varepsilon_{i,t+1}$ now also includes agents' consumption forecast errors. In general, these forecast errors will be correlated with rr_{t+1}, requiring the use of instruments to estimate the EIS, and hence generating a host of econometric problems that the literature has not fully been able to address. Partly as a result of these problems, as well as of the limitations in the available consumption data, the available estimates of this important parameter range from close to 0 to well above 1, as nicely illustrated in the meta study of Havranek (2015).

In contrast, our approach relies on direct measures of US households' expectations of both inflation and their consumption growth, which are available in the recently released

[3] In this formulation, the nominal interest rate is known by all agents at time t.

[4] As discussed in the introduction, we do not take a stand on the source of heterogeneity in expectations across households, or on the process of expectations formation, since we have direct measures of expectations.

NY Fed's Survery of Consumer Expectations. Thanks to this novel dataset, whose reliability has been amply documented by previous studies (e.g., Armantier et al. (2013a) and Armantier et al. (2015)), we can estimate equation (2.2) directly, hence bypassing many of the problems that have plagued the literature based on realizations of consumption and interest rates. To our knowledge, this is the first study to combine high quality survey data on both consumption growth and inflation expectations to estimate an Euler equation, and in particular the elasticity of intertemporal substitution.

3 Data

For our empirical analysis we use data from the NY Fed's Survey of Consumer Expectations (SCE). The SCE is a nationally representative, internet-based survey of a rotating panel of about 1,300 household heads. The survey has been conducted at a monthly frequency since June 2013. New respondents are drawn each month to match various demographic targets from the American Community Survey (ACS), and stay on the panel for up to twelve months.[5] The SCE has high response rates: first-time respondents have a participation rate of about 60%; For repeat respondents the participation rate is about 90%. In all our analyses we also employ survey weights to match population characteristics.

The survey contains a core monthly module on expectations about various macroeconomic and household level variables. Respondents are asked for their expectations of the "rate of inflation" "over the next 12 months". They are also asked for their expectations regarding total income growth (before taxes and deductions) and total spending growth for all members of their household (including themselves), "over the next 12 months". These questions form the basis of our baseline estimation. The survey also contains information about expected earnings growth (conditional on remaining in the same job at the same conditions) over the next 12 months; expectations about the likelihood of being laid off from their current job, and of leaving their job voluntarily; expectations about access to credit and about their household's financial situation; expectations about the state of the economy. In addition, the survey contains detailed demographic information about the respondents and their household.[6]

The SCE contains several important distinguishing features relative to existing house-

[5]The survey is conducted on behalf of the NY Fed by the Demand Institute, a non-profit organization jointly operated by The Conference Board and Nielsen. Nielsen also provides sampling weights to ensure that any small discrepancies between the realized sample and the demographic targets can be accommodated in empirical analysis. More details on the survey may be found in Armantier et al. (2013b), Armantier et al. (2013c), and Armantier et al. (2013d).

[6]The precise wording of the questions used in our analysis is reported in the Appendix.

hold surveys of inflation expectations. First, the rotating panel aspect enables us to observe changes in expectations (and behavior) of the same individuals over time. This is an important advantage over surveys that are based on repeated cross-sections with a different set of respondents in each wave. Second, the survey asks quantitative questions on *both* inflation *and* spending growth expectations. We believe this is a unique feature of our data. Third, for several key questions (including inflation expectations) the survey elicits density forecasts in addition to point predictions. This allows us to include measures of forecast uncertainty in our robustness exercises (see Section 5).

In order to elicit a density forecast for inflation, respondents are asked to assign probabilities to various possible inflation outcomes. Specifically, they are asked to state the percent chance that, over the next 12 months, the "rate of inflation" would fall within the following intervals: -12% or less, [-12%,-8%], [-8%,-4%], [-4%,-2%], [-2%,0%], [0%,2%], [2%,4%], [4%,8%], [8%,12%], 12% or more.[7] We then follow Engelberg et al. (2009) to fit a generalized beta distribution to each respondent's stated histogram.[8] This enables us to compute various statistics for each individual, including measures of central tendency (typically the density mean) and forecast uncertainty (the interquartile range or the variance).

We exploit the fact that we have two different measures of inflation expectations and drop survey responses where the point forecast of inflation and the density forecast are not consistent with each other in a weak sense. Specifically, we eliminate those responses where the point forecast lies outside the range between the 1st and 99th percentile of their fitted forecast density. We also drop observations where the density-implied variance is very high as in this case measures of central tendency are not very informative. In our main results we trim the top 5 percent of density-implied variances.[9] In our trimmed sample the correlation coefficient between point forecasts of inflation and the forecast-density-implied means is 0.8. We also investigated other variants of this rule and found that our results are highly robust to alternative approaches.

In addition to the core monthly module, the SCE also contains various "ad hoc" modules on specific topics, that are rotated every month. Our analysis will mostly focus on data from the monthly core modules, but will also use data from a special module fielded in April

[7] Respondents see the sum of their stated probabilities to make sure that they add up to 100. The item response rates to these density questions is close to 100%. Bruine de Bruin et al. (2011) show that respondents are willing and able to answer these questions, and like being able to express their uncertainty about future outcomes.

[8] As in Engelberg et al. (2009), in the case where a respondent assigns all probability to a single interval we fit a uniform distribution, and if the respondent assigns probabilities to only two intervals we fit a symmetric triangular distribution.

[9] In practice, we first trim the top 5% based on density-implied variance and then drop any additional observations based on the 1-99 consistency rule. This combination results in a loss of 7,516 observations out of the initial sample size of 30,489.

2015 on spending plans and expectations. In particular, the special module elicits spending growth expectations for specific spending categories, which match the broad categories used in the construction of the CPI.[10] It then poses the spending growth expectations question using a different wording than in the core module. Specifically, it asks respondents to think of "all spending categories combined" and to provide the expected change in "overall monthly household spending 12 months from now, compared to [their] current monthly spending". We use responses to this question in our robustness exercises, to ensure that respondents indeed report expected spending growth for a theoretical construct as close as possible to the one described in the theory, and with the correct time horizon.

4 Empirical Analyses

Our empirical strategy is motivated by equation (2.2). We estimate the following baseline regression model,

$$E_t^i \left[SG_{t,t+12}^i \right] = \alpha_i + \kappa_t + \zeta E_t^i \left[\pi_{t,t+12} \right] + \theta' x_{it} + \epsilon_{i,t} \tag{4.1}$$

where $\mathbb{E}_t^i \left[SG_{t,t+12}^i \right]$ is the 12-month ahead expected household spending growth (Question Q26 in Appendix) and $E_t^i \left[\pi_{t,t+12} \right]$ is the density-implied mean of 12-month ahead expected inflation (based on Question Q9 in Appendix). The theoretical relationship described in equation (2.2) is written in terms of real expected spending growth. On the other hand, the SCE queries respondents about their nominal spending growth expectations. Therefore, in order to recover the estimate of σ one need only apply the simple linear transformation $\sigma = 1 - \zeta$.

As our preferred measure of subjective inflation expectations we use the density-implied mean of 12-month ahead expected inflation as this measure is directly comparable across individuals in the sample. Later we show our results are robust to using point predictions. We include month dummies (κ_t) to proxy over time the changes in the interest rate faced by respondents since the interest rate is known at time t. All our regressions are estimated with individual fixed effects (α_i) to allow for the possibility of heterogeneity in individual discount rates (i.e., allowing for β_i in equation (2.2)). x_{it} represent additional control variables that vary both over time and across respondents (e.g., expected household income growth or labor

[10] The categories are: Housing (including mortgage, rent, maintenance and home owner/renter insurance); Utilities (including water, sewer, electricity, gas, heating oil); Food (including groceries, dining out, and beverages); Clothing, footwear and personal care; Transportation (including gasoline, public transportation fares, and car maintenance); Medical care (including health insurance, medical bills, prescription drugs); Recreation and entertainment; Education and child care.

force status of head of household). Our sample period includes monthly waves of the SCE from June 2013 through May 2015. Finally, all regression results are based on the sampling weights discussed in Section 3.

Table 1 presents our main results. Column (1) reports regression results where no additional controls, x_{it}, are included. The estimated EIS is 0.82 and we can strongly reject the null hypothesis that $\sigma = 0$ or $\sigma = 1$. Column (2) adds a host of individual control variables such as expected household income growth; variables that capture subjective expectations about both household level and economy-wide outcomes; and variables that control for local economic conditions. The full list of control variables is provided in the Appendix. Finally, Column (3) focuses on the subset of currently employed respondents and adds variables related to labor market expectations including expected wage growth of the household head and subjective job-finding and job-loss probabilities. The inclusion of these additional controls reduces the sample size to 22,341 and 13,010, respectively. Our estimate of the EIS is effectively unchanged by the inclusion of either set of controls with the estimated σ varying between 0.8 and 0.83.

Interestingly, the coefficient relating to expected household income growth is positive and significantly different from zero at the 10% level. This suggests that expected spending growth is associated in a systematic way to expected changes in household income and may be interpreted as evidence of excessive income sensitivity, or may be consistent with models of imperfect risk sharing.

Table 2 presents the results from the same specifications as in Table 1 where the point forecasts of inflation are used in place of the forecast-density-implied means. Our estimated EIS is slightly higher varying between 0.86 and 0.89 and we can again reject the null hypotheses of $\sigma = 0$ and $\sigma = 1$. Moreover, the key control variables of expected household income growth and expected wage growth have very similar coefficient estimates and associated confidence intervals.

5 Robustness

5.1 Higher-order Terms

In equation (2.2), the term $o_{i,t}$ represents the approximation error from the linearization of equation (2.1). One concern regarding our use of the linearized Euler equation is that the approximation errors may be correlated with our observed variables and consequently bias our estimates of the EIS. To provide some further intuition, if consumption growth and the real interest rate are assumed to be conditionally log-normal then the Euler equation may

be written as (Hansen and Singleton (1983))

$$\begin{aligned} E_t^i\left[\Delta c_{t+1}^i\right] &= \sigma \log \beta + \sigma r_t - \sigma E_t^i\left[\pi_{t+1}\right] \\ &\quad + \frac{1}{2}\sigma Var_t^i\left(\pi_{t+1}\right) + \frac{1}{2}\frac{1}{\sigma} Var_t^i\left(\Delta c_{t+1}^i\right) + Cov_t^i\left(\pi_{t+1}; \Delta c_{t+1}^i\right). \end{aligned} \tag{5.1}$$

More generally, the terms $o_{i,t}$ will represent conditional higher-order moments of the subjective joint distribution of consumption growth and inflation (e.g., Jappelli and Pistaferri (2000), Carroll (2001)). We address this issue in two distinct ways. First, respondents participate in our panel only for 12 months whereas these conditional moments are likely to shift only at lower frequencies. Consequently, the individual fixed effects included in equation (4.1) would absorb most of the variation generated by these approximation errors. Second, as discussed in the data section, the SCE provides rich detail on respondents' forecast distributions of inflation and earnings growth. We exploit this richness by including the variance of individual inflation expectations and earnings growth expectations in the "Economic controls" and "Employment controls" in all of our regression results (including Tables 1 and 2).

5.2 Group-Specific EIS

In our baseline specifications we have assumed that the EIS is common across households. Here we relax this assumption by letting ζ vary across demographic subgroups. In particular we focus on sub-groups by the following demographic attributes: age, income, education, and numeracy. As an additional robustness exercise we also allow κ_t to vary across the same demographic groups to accommodate different interest rates faced by different groups. In Table 3 we present the results from this additional specification. Columns (1) and (6) report the same ζ (and consequently σ) estimates as in Table 1. Columns (2)–(5) and (7)–(10) add interaction terms based on our selected demographic characteristics. Whether we focus on the whole sample or the sub-sample of employed respondents we find that the EIS may differ significantly only for high-income households, albeit only at the 10% level. The point estimate of the EIS for households with income above $100,000 is slightly above unity and significantly higher than for lower income households. This result is qualitatively consistent with the literature on limited asset market participation and intertemporal substitution (see, e.g., Attanasio et al. (2002), Vissing-Jorgensen (2002) or Guvenen (2006)).

5.3 Different Wording of Spending Question

As discussed in Section 3, the SCE fielded a different wording of the question on expected household spending growth in April of 2015 (see Appendix for the precise wording). This variant was introduced to assess whether responses are sensitive to different formats of the question. First, the alternative question is given to respondents immediately after a series of questions about each individual component of their monthly household spending, so respondents are more likely to consider all possible spending categories when expressing their spending growth expectations. Second, the description of the time horizon over which expected spending growth is expressed is worded differently. Table 4 displays the regression results with two alternative wordings of the spending question used as dependent variables. This regression uses data solely from the April 2015 survey and therefore individual fixed effects and time effects are not included. Consequently, the resulting estimate of σ is not directly comparable to those in Tables 1 and 2. Columns (1)–(3) contain results for the standard wording of the question used in all waves of the SCE whereas Columns (4)–(6) contain results for the special variant of the question used only in April 2015. The results show that the estimates of ζ are very similar across the two versions of the spending question.

5.4 Split Sample: Before and After Oil Shock

Starting in mid-June 2014 oil prices dropped precipitously throughout the rest of the year. To ensure our results have not been unduly influenced by this oil shock we re-run our baseline specifications splitting the sample as May 2013 through June 2014, and June 2014 through May 2015.[11] Table 5 presents the two sets of regression results with the earlier sub-sample in Columns (1)–(3) and the other sub-sample in Columns (4)–(6). The estimated EIS is quantitatively similar across both sub-samples and so is robust to possible spillovers to subjective expectations of inflation from the recent oil shock.

6 Conclusion

The elasticity of intertemporal substitution is the key parameter behind households' intertemporal consumption choices, regulating their responses to changes in real interest rates.

In this paper, we utilize a unique dataset of individual expectations of consumption and inflation to estimate a subjective version of the EIS, based on a first order approximation of the standard consumption Euler equation. These direct observations on expectations allow us to decouple the estimation of the Euler equation and the EIS from assumptions on the

[11] We split the sample in this way as the survey is conducted throughout the survey month.

expectations formation process. Despite remaining agnostic about how the expectations we observe are generated, we estimate a value of the EIS which is consistent with most of the macroeconomics literature.

We find a robust, significant relationship between expected consumption growth and expected inflation that implies an estimated subjective EIS of around 0.8 in the general population. This value is statistically different from both zero and one and it varies little across the many specifications we consider, as well as across different subsets of the population. However, we do find some evidence that the EIS may be above one for those households reporting higher income.

Aside from providing new evidence on the magnitude of a key parameter for intertemporal choice, our findings have important implications for monetary policy. For instance, Bachmann et al. (2015)) find a very weak relationship between expected inflation and "readiness to spend." This would suggest that "forward guidance," which is an important channel through which monetary policy can affect spending at the lower bound on nominal interest rates, might be less powerful than indicated by many macroeconomic studies (e.g., Del Negro et al. (2012)). In contrast, the robust, positive relationship between expected consumption growth and inflation we document is consistent with typical parameter choices in calibrations of macroeconomic models, providing supporting evidence for the "forward guidance" channel.

Appendix

Survey Questions

Question Q8 The next few questions are about inflation.

(a) **Over the next 12 months**, do you think that there will be inflation or deflation? (Note: deflation is the opposite of inflation)

- ○ Inflation
- ○ Deflation (the opposite of inflation)

What do you expect the rate of [inflation/deflation] to be over the next 12 months? Please give your best guess.

(b) **Over the next 12 months**, I expect the rate of [inflation/deflation] to be _____ %

Question Q9 Now we would like you to think about the different things that may happen to inflation **over the next 12 months**. We realize that this question may take a little more effort.

(a) In your view, what would you say is the percent chance that, **over the next 12 months** ...

the rate of inflation will be 12% or higher	____ percent chance
the rate of inflation will be between 8% and 12%	____ percent chance
the rate of inflation will be between 4% and 8%	____ percent chance
the rate of inflation will be between 2% and 4%	____ percent chance
the rate of inflation will be between 0% and 2%	____ percent chance
the rate of deflation (opposite of inflation) will be between 0% and 2%	____ percent chance
the rate of deflation (opposite of inflation) will be between 2% and 4%	____ percent chance
the rate of deflation (opposite of inflation) will be between 4% and 8%	____ percent chance
the rate of deflation (opposite of inflation) will be between 8% and 12%	____ percent chance
the rate of deflation (opposite of inflation) will be 12% or higher	____ percent chance

Question Q26 Now think about your total household spending, including groceries, clothing, personal care, housing (such as rent, mortgage payments, utilities, maintenance, home improvements), medical expenses (including health insurance), transportation, recreation

and entertainment, education, and any large items (such as home appliances, electronics, furniture, or car payments).

Over the next 12 months, what do you expect will happen to the total spending of all members of your household (including you)?

(a) **Over the next 12 months**, I expect my total household spending to ...

- ○ increase by 0% or more
- ○ decrease by 0% or more

By about what percent do you expect your total household spending to [increase/decrease]? Please give your best guess.

(b) **Over the next 12 months**, I expect my total household spending to [increase/decrease] by _____ %

Question Q26 (April variant)† And now thinking of all spending categories combined, what do you think will happen to your overall monthly household spending **12 months from now, compared to your current monthly spending?**

(a) **12 months from now**, I expect my overall monthly household spending to ...

- ○ have increased by 0% or more
- ○ have decreased by 0% or more

By about what percent do you expect your total household spending to [increase/decrease]? Please give your best guess.

(b) **12 months from now**, I expect my overall monthly household spending to have [increased/decreased] by _____ %

Conditioning Variables

Here we list the conditioning variables used as controls in our regression specifications. For the exact wording of each question see http://www.newyorkfed.org/microeconomics/sce/.

†This question comes immediately after a question about expenditure shares for various spending categories and a question about the expected change in monthly household spending in each category 12 months from now compared to current monthly spending.

Economic Controls

Expected Income Growth The expected percent change in household income over the next year

Situation Year Ago Scale from 1 (much worse off) to 5 (much better off) of financial health compared to one year ago

Situation Year From Now Scale from 1 (much worse off) to 5 (much better off) of financial health one year from now compared to present

Expected Unemployment The expected percent chance that the US unemployment rate will be higher 12 months from now

Expected Interest Rate The expected percent change that the average interest rate on savings accounts will be higher 12 months from now

Expected Equity Values The expected percent chance that average US stock prices will be higher 12 months from now

Full Time Employee Indicator for working full time

Household Size Total number of individuals in household

Past Credit Availability Scale from 1 (much harder) to 5 (much easier) in difficulty of obtaining credit compared to one year ago

Future Credit Availability Scale from 1 (much harder) to 5 (much easier) in difficulty of obtaining credit one year from now compared to present

Default Likelihood The expected percent change with which the respondent will be unable to make a debt payment within three months.

Inflation Variance The variance of the fitted density distribution of each respondent's inflation expectations

Unemployment[‡]: The actual county-level unemployment rate (LAUS)

House Prices[‡]: The actual zip-code-level house price index, fixed at 100 in 2000 (CoreLogic)

‡ In our regression specifications including the "Economic Controls" we include a dummy variable for those respondents who cannot be assigned a local unemployment rate or local house price index. This occurs either because the respondent's zip code was misreported or, in the case of the CoreLogic house price index, that the respondent resides in an area not covered by the data. All regression results are robust to omitting the local unemployment and house price series.

Employment Controls

Quit Likelihood The expected percent chance that the respondent will quit her job in the next year

Termination Likelihood The expected percent chance that the respondent will lose her job in the next year

Expected Wage Growth The mean of the fitted density distribution of each respondent's wage growth expectations

Wage Variance The variance of the fitted density distribution of each respondent's wage growth expectations

	Exp. Spending		
	(1)	(2)	(3)
Exp. Inflation	0.182***	0.168***	0.195***
	(.059)	(.06)	(.071)
Exp. HH Inc. Growth		0.00768*	0.0159*
		(.0043)	(.0084)
Mean Earnings Growth			0.133
			(.082)
Constant	5.271***	3.778	8.633**
	(.75)	(2.8)	(3.9)
Economic Controls	No	Yes	Yes
Employment Controls	No	No	Yes
Indiv. Effects	Yes	Yes	Yes
Month Effects	Yes	Yes	Yes
Number of Obs.	22973	22341	13010

Standard errors in parentheses

* p<.1, ** p<.05, *** p<.01

Table 1: Baseline Specification using Forecast-Density-Implied Mean

This table presents regression results from our baseline specification in equation (4.1) using the respondent's forecast-density implied mean as the measure of subjective inflation expectations. All panel regressions include individual fixed effects and time effects. Column (1) reports results with no conditioning variables. Column (2) report results including Economic controls whereas Column (3) reports including both Economic controls and Employment controls. A list of control variables is provided in the Appendix. Robust standard errors are reported in parentheses. The sample period is 2013:06–2015:05.

	Exp. Spending		
	(1)	(2)	(3)
Exp. Inflation, PE	0.140***	0.114**	0.145***
	(.052)	(.051)	(.05)
Exp. HH Inc. Growth		0.00768*	0.0159*
		(.0043)	(.0084)
Mean Earnings Growth			0.134
			(.082)
Constant	5.464***	4.074	8.839**
	(.72)	(2.8)	(3.9)
Economic Controls	No	Yes	Yes
Employment Controls	No	No	Yes
Indiv. Effects	Yes	Yes	Yes
Month Effects	Yes	Yes	Yes
Number of Obs.	22973	22341	13010

Standard errors in parentheses
* p<.1, ** p<.05, *** p<.01

Table 2: Baseline Specification using Point Forecast

This table presents regression results from our baseline specification in equation (4.1) using the respondent's point forecast as the measure of subjective inflation expectations. All panel regressions include individual fixed effects and time effects. Column (1) reports results with no conditioning variables. Column (2) report results including Economic controls whereas Column (3) reports including both Economic controls and Employment controls. A list of control variables is provided in the Appendix. Robust standard errors are reported in parentheses. The sample period is 2013:06–2015:05.

	Exp. Spending									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Exp. Inflation	0.168***	0.245**	0.204**	0.188*	0.237**	0.195***	0.261*	0.313***	0.264**	0.257***
	(.06)	(.12)	(.087)	(.1)	(.094)	(.071)	(.14)	(.1)	(.12)	(.096)
College Ed.		-0.157					-0.125			
		(.14)					(.16)			
S. College Ed.		-0.129					-0.119			
		(.13)					(.16)			
Inc. Over 100k			-0.294*					-0.485***		
			(.16)					(.18)		
Inc. 50k-100k			0.0318					-0.0257		
			(.12)					(.15)		
Age Over 60				-0.0670					0.00863	
				(.11)					(.15)	
Age 40 and 60				0.00685					-0.136	
				(.16)					(.16)	
Low Numeracy					-0.147					-0.153
					(.12)					(.14)
Constant	3.778	3.755	3.694	4.867*	3.477	8.633**	8.661**	7.695*	7.417*	6.033*
	(2.8)	(3.1)	(2.7)	(2.9)	(2.8)	(3.9)	(4.2)	(4.2)	(4)	(3.6)
Economic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Employment Controls	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Indiv. and Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Demo. Month Effects	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Number of Obs.	22341	22341	22341	22341	22341	13010	13010	13010	13010	13010

Standard errors in parentheses

* p<.1, ** p<.05, *** p<.01

Table 3: Variation in EIS Based on Demographic Group

This table presents regression results from our baseline specification in equation (4.1) using the respondent's forecast-density implied mean as the measure of subjective inflation expectations. All panel regressions include individual fixed effects and time effects. Columns (1) and (6) replicate the results in Table 1. All other columns report results based on interactions between both inflation expectations and time effects and demographic characteristics. Columns (1)–(5) include Economic controls whereas Columns (6)–(10) include both Economic controls and Employment controls. A list of control variables is provided in the Appendix. Columns (2) and (7) are based on education; (3) and (8) are based on income; (4) and (9) are based on age; (5) and (10) are based on numeracy. Robust standard errors are reported in parentheses. The sample period is 2013:06–2015:05.

	Exp. April Spending			Exp. April Spending, Alt.		
	(1)	(2)	(3)	(4)	(5)	(6)
Exp. Inflation	0.463***	0.440***	0.741***	0.357**	0.359***	0.780***
	(.12)	(.13)	(.22)	(.14)	(.13)	(.17)
Exp. HH Inc. Growth		0.137***	0.226***		0.119***	0.216***
		(.029)	(.04)		(.02)	(.043)
Mean Earnings Growth			-0.593			-0.536
			(.42)			(.42)
Constant	2.719***	-2.123	0.336	4.464***	1.453	-0.0695
	(.65)	(3.2)	(4.4)	(.77)	(3.7)	(4.9)
Economic Controls	No	Yes	Yes	No	Yes	Yes
Employment Controls	No	No	Yes	No	No	Yes
Number of Obs.	836	833	472	836	833	472

Standard errors in parentheses

* p<.1, ** p<.05, *** p<.01

Table 4: Sensitivity to Wording of Survey Questions

This table presents regression results from our baseline specification in equation (4.1) using the respondent's forecast-density implied mean as the measure of subjective inflation expectations. Columns (1)–(3) are based on the standard spending question used in each monthly survey whereas Columns (4)–(6) are based on the special spending question used in the April 2015 survey only. Columns (1) and (4) reports results with no conditioning variables. Columns (2) and (5) report results including Economic controls whereas Columns (3) and (6) report results including both Economic controls and Employment controls. A list of control variables is provided in the Appendix. Robust standard errors are reported in parentheses.

	Exp. Spending					
	(1)	(2)	(3)	(4)	(5)	(6)
Exp. Inflation	0.196**	0.181**	0.265***	0.161***	0.146**	0.183**
	(.098)	(.085)	(.1)	(.057)	(.057)	(.085)
Exp. HH Inc. Growth		0.0405**	0.0291***		0.00420	0.00489
		(.017)	(.0094)		(.0028)	(.0054)
Mean Earnings Growth			0.189			0.122
			(.12)			(.1)
Constant	2.514***	4.439	3.169	4.212***	4.388	8.317*
	(.78)	(6.9)	(16)	(.53)	(3)	(4.2)
Economic Controls	No	Yes	Yes	No	Yes	Yes
Employment Controls	No	No	Yes	No	No	Yes
Indiv. Effects	Yes	Yes	Yes	Yes	Yes	Yes
Month Effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of Obs.	12334	11760	6939	11614	11549	6615

Standard errors in parentheses

* p<.1, ** p<.05, *** p<.01

Table 5: Split Sample Before and After Oil Shock

This table presents regression results from our baseline specification in equation (4.1) using the respondent's forecast-density implied mean as the measure of subjective inflation expectations. All panel regressions include individual fixed effects and time effects. Columns (1)–(3) are for the sample period 2013:06–2014:06 whereas Columns (4)–(6) are based on the sample period 2014:06–2015:05. Columns (1) and (4) reports results with no conditioning variables. Columns (2) and (5) report results including Economic controls whereas Columns (3) and (6) report results including both Economic controls and Employment controls. A list of control variables is provided in the Appendix. Robust standard errors are reported in parentheses.

References

Alan, S., Browning, M., 2010. Estimating intertemporal allocation parameters using synthetic residual estimation. Review of Economic Studies 77, pp. 1231–1261.

Armantier, O., Bruine de Bruin, W., Topa, G., van der Klaauw, W., Zafar, B., 2015. Inflation expectations and behavior: do survey respondents act on their beliefs? International Economic Review 56, 505–536.

Armantier, O., Nelson, S., Topa, G., van der Klaauw, W., Zafar, B., 2013a. The price is right: Updating inflation expectations in a randomized price information experiment. Review of Economics and Statistics (forthcoming).

Armantier, O., Topa, G., van der Klaauw, W., Zafar, B., 2013b. Introducing the FRBNY survey of consumer expectations: Household finance expectations. Liberty Street Economics Blog, December.

Armantier, O., Topa, G., van der Klaauw, W., Zafar, B., 2013c. Introducing the FRBNY survey of consumer expectations: Labor market expectations. Liberty Street Economics Blog, December.

Armantier, O., Topa, G., van der Klaauw, W., Zafar, B., 2013d. Introducing the FRBNY survey of consumer expectations: Measuring price inflation expectations. Liberty Street Economics Blog, December.

Attanasio, O. P., Banks, J., Tanner, S., 2002. Asset holding and consumption volatility. Journal of Political Economy 110, 771–792.

Attanasio, O. P., Weber, G., 1993. Consumption growth, the interest rate and aggregation. Review of Economic Studies 60, pp. 631–649.

Attanasio, O. P., Weber, G., 1995. Is consumption growth consistent with intertemporal optimization? evidence from the consumer expenditure survey. Journal of Political Economy 103, 1121–57.

Attanasio, O. P., Weber, G., 2010. Consumption and saving: Models of intertemporal allocation and their implications for public policy. Journal of Economic Literature 48, 693–751.

Bachmann, R., Berg, T. O., Sims, E. R., 2015. Inflation expectations and readiness to spend: Cross-sectional evidence. American Economic Journal: Economic Policy 7, 1–35.

Bansal, R., Yaron, A., 2004. Risks for the long run: A potential resolution of asset pricing puzzles. Journal of Finance 59, 1481–1509.

Barberis, N., Greenwood, R., Jin, L., Shleifer, A., 2015. X-CAPM: An extrapolative capital asset pricing model. Journal of Financial Economics 115.

Barro, R. J., 2009. Rare disasters, asset prices, and welfare costs. American Economic Review 99, 243–64.

Barsky, R. B., Juster, F. T., Kimball, M. S., Shapiro, M. D., 1997. Preference parameters and behavioral heterogeneity: An experimental approach in the health and retirement study. Quarterly Journal of Economics 112, 537–579.

Bruine de Bruin, W., Manski, C. F., Topa, G., van der Klaauw, W., 2011. Measuring consumer uncertainty about future inflation. Journal of Applied Econometrics 26, 454–478.

Bruine de Bruin, W., van der Klaauw, W., Downs, J. S., Fischhoff, B., Topa, G., Armantier, O., 2012. The effect of question wording on consumersÕ reported inflation expectations. Journal of Economic Psychology 33, 749–757.

Burke, M. A., Ozdagli, A. K., 2013. Household inflation expectations and consumer spending: evidence from panel data. Working Papers 13-25, Federal Reserve Bank of Boston.

Carroll, C. D., 2001. Death to the log-linearized consumption euler equation! (and very poor health to the second-order approximation). B.E. Journal of Macroeconomics 1, 1–38.

Cashin, D., Unayama, T., 2012. Measuring intertemporal substitution in consumption: Evidence from a VAT increase in Japan. Review of Economics and Statistics (forthcoming).

D'Acunto, F., Hoang, D., Weber, M., 2015. Inflation expectations and consumption expenditure, working paper.

Del Negro, M., Giannoni, M., Patterson, C., 2012. The forward guidance puzzle. Staff Reports 574, Federal Reserve Bank of New York.

Engelberg, J., Manski, C. F., Williams, J., 2009. Comparing the point predictions and subjective probability distributions of professional forecasters. Journal of Business & Economic Statistics 27, 30–41.

Engelhardt, G. V., Kumar, A., 2009. The elasticity of intertemporal substitution: New evidence from 401(k) participation. Economics Letters 103, 15–17.

Gennaioli, N., Ma, Y., Shleifer, A., 2015. Expectations and investment. NBER Macroeconomics Annual 30.

Greenwood, R., Shleifer, A., 2014. Expectations of returns and expected returns. Review of Financial Studies 27, 714–746.

Gruber, J., 2013. A tax-based estimate of the elasticity of intertemporal substitution. Quarterly Journal of Finance 3.

Guvenen, F., 2006. Reconciling conflicting evidence on the elasticity of intertemporal substitution: A macroeconomic perspective. Journal of Monetary Economics 53, 1451–1472.

Hall, R. E., 1978. Stochastic implications of the life cycle-permanent income hypothesis: Theory and evidence. Journal of Political Economy 86, 971–87.

Hansen, L. P., Singleton, K. J., 1982. Generalized instrumental variables estimation of nonlinear rational expectations models. Econometrica 50, 1269–86.

Hansen, L. P., Singleton, K. J., 1983. Stochastic consumption, risk aversion, and the temporal behavior of asset returns. Journal of Political Economy 91, 249–65.

Havranek, T., 2015. Measuring intertemporal substitution: The importance of method choices and selective reporting. Journal of the European Economic Association pp. 1–25.

Ichiue, H., Nishiguchi, S., 2015. Inflation expectations and consumer spending at the zero bound: Micro evidence. Economic Inquiry 53, 1086–1107.

Jappelli, T., Pistaferri, L., 2000. Using subjective income expectations to test for excess sensitivity of consumption to predicted income growth. European Economic Review 44, 337–358.

Manski, C. F., 2004. Measuring expectations. Econometrica 72, 1329–1376.

Vissing-Jorgensen, A., 2002. Limited asset market participation and the elasticity of intertemporal substitution. Journal of Political Economy 110, pp. 825–853.