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Precautionary Saving and Consumption Fluctuations*

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Abstract

This paper uses the consumption Euler equation to derive a decomposition of consumption growth into four sources. These are new information and three sources of predictable consumption growth: intertemporal substitution, changes in the preferences for consumption, and incomplete markets for consumption insurance. Using data on the expenditures of households, we implement the decomposition for the average growth rate of consumption expenditures on nondurable goods in the U.S. from the beginning of 1982 to the end of 1997. Incomplete markets for trading consumption in future states lead to statistically significant and countercyclical movements in expected consumption growth: consumption growth is expected to be higher when the unemployment rate is high. The economic importance of precautionary saving rivals that of the real interest rate, but the relative importance of each source of movement in the volatility of consumption is not precisely measured.

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1. Introduction

According to canonical macroeconomic theory, aggregate consumption is the result of the optimal choices of a representative consumer. Consumption growth changes over time due to changes in the risk-free rate of return and changes in the information that the consumer has about current wealth, future income, and future rates of return. Consistent with this approach, aggregate consumption growth is largely unpredictable. But contrary to this theory, predictable movements in aggregate consumption growth are almost uncorrelated with the risk-free rate of return and are significantly correlated with predictable movements in income.[1]

What causes fluctuations in aggregate consumption growth? This paper uses household-level survey data to measure the relative importance of new information, the real interest rate, the preference for consumption, and precautionary saving for movements in average consumption growth. We are particularly interested in to what extent consumption fluctuations are due to precautionary saving. We develop a method that uses the consumption Euler equation and data on the consumption expenditures of households to decompose aggregated consumption growth into these four proximate causes, and factors outside the model. The measurement of precautionary saving is not straightforward due to measurement error in survey data on consumption expenditures and the possibility of model misspecification. The methodological contribution of this paper is the derivation of a robust measure of the predictable fluctuations in aggregate consumption that are due to consumption risk. Using both estimates and calibrations for a standard utility function, we implement this robust decomposition and find a significant role for precautionary saving in consumption fluctuations.

To carry out this decomposition, we begin with a standard consumption Euler equation, assuming expected utility theory and constant relative risk aversion utility, and estimate or calibrate the parameters of this function. Given survey data on households, it is then straightforward to calculate for each household the consumption growth that occurred due to the observed changes in the real interest rate and in preferences. Averaging across households tells us the role of these factors in average consumption growth. We construct consumption growth due to new information as the difference between observed average consumption growth and expected average consumption growth calculated using a set of lagged instruments. The last cause of consumption growth, predictable consumption growth due to precautionary saving, is measured as the predictable variation in the average of a nonlinear function of the constructed innovations to marginal utility.

These causes are proximate, rather than structural or exogenous, in the same way the causes of output growth in a Solow decomposition are proximate.[2] Our decomposition

[1] See Flavin (1981), Shiller (1982), Hall (1988), Campbell and Deaton (1989), and Campbell and Mankiw (1989).

[2] The methods are not in general analogous. We use an optimality condition, while a Solow decomposition uses a resource constraint; we require instruments to decompose movements in consumption into expected and unexpected components.

does not measure the contribution of primitive shocks like changes in technology or policies to consumption growth. Instead, our decomposition measures how important the real interest rate, preference nonseparabilities, and incomplete markets are for the propagation of such primitive shocks, and so for the dynamics of aggregate consumption.

We deal with three complications in measuring the role of precautionary saving. First, we derive a measure that is robust to some misspecification of the consumption Euler equation. That is, we omit some predictable movements in consumption growth from our decomposition so as to avoid allocating by definition all predictable consumption movements not explained by preference shifters and the real interest rate to precautionary saving. Second, measurement error in consumption data implies that mean consumption growth cannot be consistently decomposed, only movements around the mean. Finally, low-wealth households in the economy may face binding liquidity constraints. We measure consumption growth due to both precautionary saving and liquidity constraints for these households.

Implementing the decomposition using data from the Consumer Expenditure (CEX) Survey, we find that all proximate sources of consumption growth, including precautionary saving, make statistically significant contributions to fluctuations in expected consumption growth among households that are not likely to be liquidity constrained. For precautionary saving, this finding is a direct confirmation of the theoretical implications of incomplete markets. In simulated model economies with incomplete consumption insurance, precautionary saving can cause significant movements in aggregate consumption (when compared to movements in aggregate consumption in comparable model economies with complete markets).[3]

The dynamics of our precautionary saving series are also interesting. Caballero (1990) and Carroll (1997) argue that many of the existing puzzles of the consumption literature can in theory be explained by the omission of precautionary saving in the study of aggregate consumption data. While statistically weak, we find that consumption growth due to precautionary saving is countercyclical: expected consumption growth is greater when the unemployment rate is expected to increase. This is consistent with increased idiosyncratic consumption risk in recessions and the argument that incomplete markets amplify recessions. We also study policy variables and subsequent consumption growth. Expected increases in government spending are associated with faster consumption growth due to precautionary saving. But there is no discernible relationship between money shocks and subsequent consumption growth due to precautionary saving.

According to our findings the presence of precautionary saving is important for estimation and inference using consumption data. In a linearized aggregate consumption Euler equation, changes in precautionary saving fall into the residual and cause a violation of the orthogonality conditions upon which inference is based. We find that consumption growth due to precautionary saving covaries positively with consumption

[3]Nelson (1994) Cochrane (1991) and Attanasio and Davis (1996) reject complete consumption insurance in the U.S. and Rios-Rull (1994), Krusell and Smith (1998) and Gourinchas (2000) study precautionary saving in model economies.

growth due to the real interest rate, so that low estimates of the intertemporal elasticity of substitution in linearized or typically estimated aggregate models are not due to the fact that these models omit the precautionary saving term. Since consumption growth due to shifts in the preference for consumption covaries negatively with that due to preferences, low observed intertemporal substitution in response to the real interest rate is largely due to omitted preference shifters or misspecification of the consumption optimization problem more generally.[4]

Because of significant covariation among the sources of consumption growth, our decomposition does not precisely isolate the economic importance of each proximate cause of predictable variation in consumption growth. The share of variance of predictable consumption growth sourced to incomplete markets and that sourced to the real interest rate both vary over similarly wide ranges depending on the order in which the variance is decomposed. This highlights the proximate nature of the decomposition. The deeper sources of consumption growth – technology, policies and so forth– do not appear in the Euler equation.

Finally, the significant role of precautionary saving for aggregate consumption dynamics indirectly lends credence to the arguments of Caballero (1991), Constantinides and Duffie (1996) and Aiyagari (1995) that incomplete consumption insurance affects aggregate wealth accumulation, asset prices and the design of optimal policy. As an example, we note that expected consumption growth due to precautionary savings has declined during the time period of the sample, 1982 to 1997, so that decreased consumption risk contributed to the decline in the personal saving rate over this period.

Our research builds most directly on papers that exploit the variation and information in detailed household-level survey data on consumption expenditures to better understand consumer behavior and the dynamics of U.S. consumption (such as Hall and Mishkin (1982), Zeldes (1989a), Attanasio and Weber (1995), and Parker (1999a)). Our focus on precautionary saving owes much to Dynan (1993), which estimates the parameters of the utility function from a cross-sectional relationship between average consumption growth and the average volatility of consumption. Dynan (1993) also finds no significant relationship between average consumption risk and average consumption growth rates across industries and occupations. We find a significant relationship between the time-series movements in average consumption growth and the time-series movements in the average variance of consumption (actually all higher-order terms, but this is not the important difference). Our research is also related to previous methodologies for inferring the importance of precautionary saving, such as Skinner (1988), Carroll and Samwick (1997), Banks, Blundell and Brugiavini (2001), Lusardi (1998), Gourinchas and Parker (2002), and in particular, Storesletten, Telmer and Yaron (forthcoming) who, like us, find that consumption risk is countercyclical.

The paper proceeds as follows: section 2 shows how to decompose consumption

[4] See for example the models of Baxter and Jermann (1999), Basu and Kimball (2000), and Ogaki and Reinhart (1998). Carroll (1997) argues that incomplete markets are an important source of bias, Attanasio and Weber (1995) finds that labor supply is an important shifter of the preference for consumption.

growth using the consumption Euler equation and describes how we implement the decomposition. Section 3 discusses the main assumptions and implications of the decomposition. Section 4 considers a number of complications that affect how we implement the decomposition in practice. Specifically, in the basic decomposition, consumption fluctuations due to precautionary saving contains any consumption fluctuations due to binding liquidity constraints, to finite-sample predictability of expectation errors, or to some types of model misspecification. In practice, we implement adjustments to our basic decomposition that make it robust to these possibilities. Section 5 describes our use of the Consumer Expenditure Survey and the variables that we employ in our analysis. Sections 6 presents our results for households that are not liquidity constrained and Section 7 presents our results for all households. Section 8 demonstrates the robustness of the main results to the choice of instruments. A final section concludes. An appendix and an unpublisehd Technical Appendix contain additional details on the decomposition and estimation of parameters.

2. The causes of consumption growth

This section shows that, if the consumption Euler equation holds for each household in an economy, all movements in the average growth rate of consumption are directly due to one of four proximate causes.

We assume the economy consists of households that receive uncertain income over time and in each period make both a saving and a portfolio decision. Households have constant relative risk aversion utility and are expected utility maximizers and price takers. Equilibrium consumption for any household i ($C_{i,t}$) obeys a standard consumption Euler equation for the risk-free rate ($R^f_{i,t+1}$)[5]

$$C_{i,t}^{-\frac{1}{\sigma}} = E_t\left[R^f_{i,t+1}\exp\left(\mathbf{X}_{i,t+1}\boldsymbol{\delta}\right)C_{i,t+1}^{-\frac{1}{\sigma}}\right] \tag{2.1}$$

where σ is the elasticity of intertemporal substitution, E_t is the expectations operator conditional on the time t information set, and $\exp\left(\mathbf{X}_{i,t+1}\boldsymbol{\delta}\right)$ captures preference shifters that cause the marginal utility of consumption to be different over time and across households.[6] Equation (2.1) defines the expectation error for each household

$$\begin{aligned} \varepsilon_{i,t+1} &= R^f_{i,t+1}\exp\left(\mathbf{X}_{i,t+1}\boldsymbol{\delta}\right)\left(\frac{C_{i,t+1}}{C_{i,t}}\right)^{-\frac{1}{\sigma}} - 1 \\ E_t[\varepsilon_{i,t+1}] &= 0. \end{aligned} \tag{2.2}$$

[5] The subscript i anticipates our estimation strategy that makes use of household specific prices and inflation rates. The resulting real interest rate is therefore specific to each household.

[6] Note that our adoption of expected utility theory implies that the intertemporal elasticity of substitution equals the inverse of the coefficient of relative risk aversion, and our choice of constant elasticity of substitution utility function implies that the coefficient of relative prudence, that governs precautionary saving, is $1+\frac{1}{\sigma}$. Kimball and Weil (1992) demonstrate how precautionary saving depends separately on each parameter in the context of a two period model.

To move from marginal utility to consumption, first take logs and re-organize equation (2.2) to yield

$$\Delta \ln C_{i,t+1} = \sigma \ln R^f_{i,t+1} + \sigma \mathbf{X}_{i,t+1} \boldsymbol{\delta} - \sigma \ln (1 + \varepsilon_{i,t+1}). \tag{2.3}$$

This relation describes the dynamics of a household's consumption expenditures. To cleanly separate the role of new information in consumption growth and to measure the role of precautionary saving, take the conditional expectation of equation (2.3) and add the unexpected part of consumption growth to both sides, to yield

$$\Delta \ln C_{i,t+1} = \sigma \ln R^f_{i,t+1} + \sigma E_t [\mathbf{X}_{i,t+1}] \boldsymbol{\delta} - \sigma E_t [\ln (1 + \varepsilon_{i,t+1})] + \eta^C_{i,t+1} \tag{2.4}$$

where $\eta^C_{i,t+1} \equiv \Delta \ln C_{i,t+1} - E_t [\Delta \ln C_{i,t+1}]$. Finally, averaging across the set of households in the population alive at time t and and $t+1$, $H(t)$, we can write average consumption growth as driven by the four proximate causes:

$$\begin{aligned}
\underbrace{\frac{1}{H(t)} \sum_{i \in H_t} \Delta \ln C_{i,t+1}}_{\Delta \ln C^{Ag}_{t+1}} &= \underbrace{\sigma \frac{1}{H(t)} \sum_{i \in H_t} \ln R^f_{i,t+1}}_{\substack{\Delta \ln C^R_{t+1} \\ \text{Intertemporal} \\ \text{Substitution}}} + \underbrace{\sigma E_t \left[\frac{1}{H(t)} \sum_{i \in H_t} \mathbf{X}_{i,t+1} \boldsymbol{\delta} \right]}_{\substack{\Delta \ln C^{\delta}_{t+1} \\ \text{Preferences}}} + \\
& \underbrace{\frac{1}{H(t)} \textstyle\sum_{i \in H_t} \sigma E_t [- \ln (1 + \varepsilon_{i,t+1})]}_{\substack{\Delta \ln C^{IM}_{t+1} \\ \text{Precautionary} \\ \text{Saving}}} + \underbrace{\Delta \ln C^{Ag}_{t+1} - E_t \left[\Delta \ln C^{Ag}_{t+1} \right]}_{\substack{\eta^C_{t+1} \\ \text{Innovations to} \\ \text{Consumption Growth}}}.
\end{aligned} \tag{2.5}$$

The implementation of this decomposition seems straightforward: plug parameters and household-level data on consumption, preferences and interest rates into equation (2.5), and indeed this is the main idea. However, moving from these theoretical series to their empirical counterparts requires dealing with four important issues: consumption expenditures are measured with substantial error; preferences may be misspecified; the importance of precautionary saving may be upward biased due to the predictability of any variable in finite-samples; and some households may face binding borrowing constraints. We postpone presenting these issues to Section 4, and first discuss this theoretical decomposition.

3. Discussion

This decomposition is similar to the approximate nonlinear equation used by Dynan (1993) to estimate parameters. We use the exact relationship to decompose consumption growth given parameters.

Equation (2.5) decomposes consumption growth only into proximate causes. We decompose consumption growth into growth due to the listed factors rather than growth due to technology or policies. As an example, a primitive shock to the economy that alters risk typically changes not only precautionary saving but also wealth accumulation and real interest rates and therefore would appear in both consumption growth due to the real interest rate and that due to precautionary saving. Our decomposition is interesting because it measures how important nonseparabilities and incomplete markets are for the propagation of these primitive shocks, and so for the dynamics of aggregate consumption.

The mapping from structural shocks to consumption dynamics depends on the true structure of the economy. The advantage of our approach is that it is not dependent on the particular specification of the technology process, market completeness, the labor market, and so forth.

It is also worth noting that $\Delta \ln C_{t+1}^{IM}$ measures only the effect of consumption risk on predictable consumption growth. A primitive shock to the economy that increases future consumption volatility affects both predictable consumption growth and the innovation to consumption growth. Only the former appears in our proximate causes as precautionary saving, although unpredictable and predictable movements are linked through the budget constraint.

Along two dimensions, this decomposition is quite robust. We make no assumptions about the completeness of markets in the economy. Available assets may or may not span all possible future states of nature. Moreover, other than the risk-free rate, R_{t+1}^{f}, we do not assume that households have access to the same assets. For example, there might be fixed costs associated with entering the equity market and some households might choose not to participate in this market.

4. Measurement

An overview of our procedure is as follows. We first estimate or calibrate the parameters δ and σ, as described in section 6 and the Technical Appendix. Second, using CEX data and these parameters, we calculate the terms in equation (2.3) for each household observed in our survey and average across households in each period. In practice, we use an adjusted measure of the expectation error, as described in this section. Finally, we construct an empirical counterpart to each theoretical expectation using a small set of aggregate instruments. That is, we regress $\mathbf{Z}_t$, a $J \times 1$ vector of instruments, onto the sample analogues of $\frac{1}{H(t)} \sum_{i \in H_t} \mathbf{X}_{i,t+1}$, $-\frac{1}{H(t)} \sum_{i \in H_t} \sigma \ln(1+\varepsilon_{i,t+1})$, and $\Delta \ln C_{t+1}^{Ag}$ and use the fitted values in place of the theoretical expectations. Replacing the theoretical moments in equation (2.5) with these empirical constructs give us a time series for each proximate cause of consumption growth.

This section describes how we deal with four complications that arise in implementing this decomposition: the mismeasurement of consumption expenditures; the possibility of misspecification of preferences; an upward bias in the importance of precautionary saving due to the predictability of expectation errors in finite-samples; and the possibility of binding borrowing constraints. It is important to note that if there is in fact no need for the adjustments to the decomposition that we describe in this section, our estimates of the consumption growth due to incomplete markets remain consistent.

4.1. Measurement error in consumption

Consumption expenditures are measured with substantial error. We assume that the measurement error, $\mu_{i,t}$, is classical, additive in logs:

$$\left(\frac{C_{i,t+1}}{C_{i,t}}\right)^{-\frac{1}{\sigma}} = \left(\frac{C^*_{i,t+1}}{C^*_{i,t}}\right)^{-\frac{1}{\sigma}} \left(\frac{\mu_{it+1}}{\mu_{i,t}}\right)^{-\frac{1}{\sigma}}$$

where $C^*_{i,t}$ is the true level of consumption, $C_{i,t}$ is the observed level.

Measurement error of this form has two effects. First, the volatility of consumption growth appears larger than it is, and this leads to a bias in the mean of consumption growth due to precautionary saving. However, since the measurement error is classical, it is uncorrelated with lagged instruments, so that we can still consistently measure *fluctuations* in consumption growth due to precautionary saving. For this reason, we focus on changes in consumption growth and not mean consumption growth.

The second effect of measurement error is to bias upward the contribution of new information to consumption growth. Average consumption growth is mismeasured, to the extent that the cross-sectional average of measurement error is not zero in any finite sample. Since this measurement error is not predictable, it appears as if this movement in consumption growth were due to new information. Appendix A proves these claims.

4.2. Misspecification

The second complication regards the theoretical decomposition: all predictable movements in consumption not attributable to preferences and the real interest rate are assigned by construction to precautionary saving. To see this, substitute equation (2.2) into the precautionary saving term in equation (2.5):

$$\begin{aligned}
\Delta \ln C^{IM}_{t+1} &= -\sigma E_t \left[\tfrac{1}{H(t)} \sum_{i \in H_t} \ln \left(1 + R^f_{i,t+1} \exp\{\mathbf{X}_{i,t+1}\boldsymbol{\delta}\} \left(\frac{C_{i,t+1}}{C_{i,t}}\right)^{-\frac{1}{\sigma}} - 1 \right) \right] \\
&= -\sigma E_t \left[\tfrac{1}{H(t)} \sum_{i \in H_t} \left(\ln R^f_{i,t+1} + \mathbf{X}_{i,t+1}\boldsymbol{\delta} - \frac{1}{\sigma} \Delta \ln C_{i,t+1} \right) \right] \\
&= E_t \left[\Delta \ln C^{Ag}_{t+1} - \Delta \ln C^{R}_{t+1} - \Delta \ln C^{\delta}_{t+1} \right].
\end{aligned}$$

If the model were correct, then this feature would not be a concern. But in practice, the selection of factors influencing utility and the specification of parameters is not perfect, and assuming it is would label our ignorance or mismeasurement of precautionary saving.[7] Therefore, we modify our measure of precautionary saving so that it is robust to some types of model misspecification, and decompose consumption growth into each proximate cause and a time series of expected consumption growth that represents our ignorance.

We consider the following type of misspecification. Suppose that the true model is given by

$$C_{i,t}^{-\frac{1}{\sigma}} = E_t \left[\exp\{\mathbf{X}_{i,t+1}\boldsymbol{\delta}\}\theta_{i,t} R_{i,t+1}^f C_{i,t+1}^{-\frac{1}{\sigma}} \right] \tag{4.1}$$

where $\theta_{i,t}$ is an omitted preference shifter, an incorrect choice of $\boldsymbol{\delta}$, or unobserved variation in the actual risk-free real interest rate faced by a given household such as from different marginal tax rates. Let $\epsilon_{i,t+1}$ denote the true innovation implied by equation (4.1). The innovation used in the decomposition, given by equation (2.2), is

$$\varepsilon_{i,t+1} = \frac{1+\epsilon_{i,t+1}}{\theta_{i,t}} - 1.$$

Equation (2.5) provides an inconsistent estimate of precautionary saving since

$$E_t \left[\varepsilon_{i,t+1}\right] = \frac{1}{\theta_{i,t}} - 1.$$

To estimate precautionary saving consistently, we replace $\varepsilon_{i,t+1}$ in equation (2.5) with $\tilde{\varepsilon}_{i,t+1}$ defined as

$$\tilde{\varepsilon}_{i,t+1} = \frac{\varepsilon_{i,t+1} - E_t\left[\varepsilon_{i,t+1}\right]}{1+E_t\left[\varepsilon_{i,t+1}\right]}. \tag{4.2}$$

Since $E_t\left[\tilde{\varepsilon}_{i,t+1}\right] = 0$, using $\tilde{\varepsilon}_{i,t+1}$ to construct $\Delta \ln C_{t+1}^{IM}$ yields

$$\begin{aligned} \Delta \ln C_{t+1}^{IM} &= -\sigma E_t \left[\tfrac{1}{H(t)} \sum_{i \in H_t} \ln \left(1 + \frac{\varepsilon_{i,t+1} - E_t\left[\varepsilon_{i,t+1}\right]}{1+E_t\left[\varepsilon_{i,t+1}\right]} \right) \right] \\ &= -\sigma E_t \left[\tfrac{1}{H(t)} \sum_{i \in H_t} \ln \left(1 + \frac{\frac{1+\epsilon_{i,t+1}}{\theta_{i,t}} - 1 - \frac{1-\theta_{i,t}}{\theta_{i,t}}}{1+\frac{1-\theta_{i,t}}{\theta_{i,t}}} \right) \right] \\ &= -\sigma E_t \left[\tfrac{1}{H(t)} \sum_{i \in H_t} \ln \left(1+\epsilon_{i,t+1}\right) \right] \end{aligned} \tag{4.3}$$

which is the concept of interest.

This technique leads to an additional source of movement in average consumption, which we call misspecification and denote $\Delta \ln C_{t+1}^{\theta}$. To be clear, this is not all possible misspecification. In particular, mismeasurement of σ or misspecification of stochastic preference shifters are not addressed by this correction. Finally, if the original Euler equation is not misspecified, that is if $\theta_{i,t} = 1$, then $E_t\left[\varepsilon_{i,t+1}\right] = 0$, and this correction does not bias any of our measures.

[7] The decomposition requires parameter values, which are chosen alternately by estimation and calibration. When estimating, we apply a generalized method of moments (GMM) procedure based on the nonlinear Euler equation to a synthetic panel. When calibrating, we choose parameters based upon the large previous literature studying consumer behavior. Particularly for the calibration results, some misspecification seems unavoidable and our adjustment therefore necessary.

4.3. Finite-sample bias

The third complication with which we deal is the possibility that, in a finite sample, the constructed expectation error may be predictable using the chosen instruments. That is, letting $\tilde{e}_{i,t+1}$ denote the sample analog to $\tilde{\varepsilon}_{i,t+1}$, even if the theory were true, in any finite sample

$$E_T\left[\frac{1}{I(t)}\sum_{i\in I_t}\tilde{e}_{i,t+1}|\mathbf{Z}_t\right]\neq 0 \tag{4.4}$$

with probability 1, where $I(t)$ denotes the number of households in the observed sample and we use the notation $E_T[\cdot|\mathbf{Z}_t]$ to denote our empirical expectation in a sample of size T. It is also straightforward to see that this condition is not guaranteed in finite samples by our correction in equation (4.2) for expectations calculated as linear projections.

We correct the measure of precautionary saving by subtracting this term, the left hand side of equation (4.4). The robust sample analog to $\Delta\ln C_{t+1}^{IM}$ in equation (2.5) is

$$\Delta\widehat{\ln C_{t+1}^{IM}}=-\sigma E_T\left[\frac{1}{I(t)}\sum_{i\in I_t}\ln\left(1+\tilde{e}_{i,t+1}\right)-\tilde{e}_{t+1}|\mathbf{Z}_t\right]$$

where "$\hat{}$" indicates the use of the use sample analogue adjusted for misspecification and small sample bias. The appendix proves that this adjustment removes the bias of concern and that each adjustment is necessary: removing sample correlation inside the logarithm leads to bias, and removing misspecification outside the logarithm leads to inconsistency.

4.4. Liquidity constraints

How does the presence of borrowing constraints alter the decomposition? Consider the world without misspecification or finite-sample bias. Let $\lambda'_{i,t}$ denote the multiplier on a constraint on wealth, then optimal behavior implies an Euler equation of the form

$$C_{i,t}^{-\frac{1}{\sigma}}=E_t\left[R_{i,t+1}^{f}\exp\left(\mathbf{X}_{i,t+1}\boldsymbol{\delta}\right)C_{i,t+1}^{-\frac{1}{\sigma}}\right]+\lambda'_{i,t} \tag{4.5}$$

where $\lambda'_{i,t}\geq 0$. Let $\epsilon_{i,t+1}$ be the true innovation to marginal utility implied by equation (4.5). Following the procedure to decompose consumption – without accounting for the presence of the unknown variable $\lambda'_{i,t}$ – consumption growth is given by the decomposition in equation (2.5) but with

$$\Delta\ln C_{t+1}^{IM}=\frac{1}{H(t)}\sum\nolimits_{i\in H_t}\sigma E_t\left[-\ln\left(1+\epsilon_{i,t+1}-\lambda_{i,t}\right)\right] \tag{4.6}$$

where $\lambda_{i,t}\equiv\lambda'_{i,t}C_{i,t}^{\frac{1}{\sigma}}$. Thus, if some households in the economy face binding liquidity constraints, the effect of these constraints appears as precautionary saving. We refer to equation (4.6) as consumption growth due to incomplete markets. For a set of unconstrained households, $\lambda_{i,t}=0$ for all i,t, and we measure only the effects of precautionary saving.

As in the world without constraints, equation (4.6) measures only the direct or proximate role of market incompleteness in consumption growth. Liquidity constraints can change consumption dynamics even if they never bind, which raises an important point. Little is lost by measuring the impact of liquidity constraints and precautionary saving together. Liquidity constraints are missing markets for transferring consumption over time; if precautionary saving is at all important, it comes from missing markets for trading goods across future states. These effects are substantively and technically closely related.[8]

The possibility of liquidity constraints also alters the implementation of the corrections for misspecification and finite-sample bias, as detailed in the appendix.

4.5. Summary

To summarize, the sample average of consumption growth ($\Delta \widehat{\ln C^{Ag}_{t+1}} = \frac{1}{I(t)} \sum_{i \in I_t} \Delta \ln C_{i,t+1}$) is the sum of four series, constructed as follows:

Consumption Growth due to:

Intertemporal Substitution
$$\Delta \widehat{\ln C^{R}_{t+1}} = \sigma E_T \left[\tfrac{1}{I(t)} \textstyle\sum_{i \in I_t} \ln R^f_{i,t+1} | \mathbf{Z}_t \right]$$

Changes in Utility Shifters
$$\Delta \widehat{\ln C^{\delta}_{t+1}} = \sigma E_T \left[\tfrac{1}{I(t)} \textstyle\sum_{i \in I_t} \mathbf{X}_{i,t+1} \boldsymbol{\delta} | \mathbf{Z}_t \right]$$

Changes in Consumption Risk
$$\Delta \widehat{\ln C^{IM}_{t+1}} = -\sigma E_T \left[\tfrac{1}{I(t)} \textstyle\sum_{i \in I_t} \ln\left(1 + \tilde{e}_{i,t+1}\right) - \tfrac{1}{I(t,\lambda=0)} \textstyle\sum_{i \in I_{t,\lambda=0}} \tilde{e}_{i,t+1} | \mathbf{Z}_t \right]$$

Changes in Information
$$\widehat{\eta}^{C}_{t+1} = \Delta \widehat{\ln C^{Ag}_{t+1}} - E_T \left[\Delta \widehat{\ln C^{Ag}_{t+1}} | \mathbf{Z}_t \right]$$

where

$$\tilde{e}_{i,t+1} = \frac{\varepsilon_{i,t+1} - E_{T,\lambda=0}\left[\varepsilon_{i,t+1} | \mathbf{Z}_{i,t}\right]}{1 + E_{T,\lambda=0}\left[\varepsilon_{i,t+1} | \mathbf{Z}_{i,t}\right]} \tag{4.7}$$

$$\varepsilon_{i,t+1} = R^f_{t+1} \exp\left(\mathbf{X}_{i,t+1} \boldsymbol{\delta}\right) \left(\frac{C_{i,t+1}}{C_{i,t}} \right)^{-\frac{1}{\sigma}} - 1 \tag{4.8}$$

The measures of consumption growth due to the risk-free real interest rate ($\Delta \widehat{\ln C^{R}_{t+1}}$), preferences ($\Delta \widehat{\ln C^{\delta}_{t+1}}$), and new information ($\widehat{\eta}^{C}_{t+1}$) all follow directly from equation (2.5). The measure of incomplete markets, ($\Delta \widehat{\ln C^{IM}_{t+1}}$), includes growth due to precautionary saving and liquidity constraints, is robust to a class of misspecification, and removes movements due to any in-sample covariation between the innovation to marginal utility and the instruments for unconstrained households. Finally, there is some additional consumption growth, $\sigma E_T [\frac{1}{I(t)} \sum_{i \in I_t} \ln\left(1 + \tilde{e}_{i,t+1}\right) - \ln\left(1 + \varepsilon_{i,t+1}\right) | \mathbf{Z}_t]$. When

[8] See Carroll and Kimball (2001), and the similarity in consumption behavior between Carroll (1997) on the one hand and Zeldes (1989b) and Deaton (1991) on the other.

reporting results based on estimation, for which it is reasonable to believe that this truly is misspecification, we omit this source of variation from the decomposition. When reporting results based on calibrations, we include this source of variation as variation due to preferences.

One final point about this decomposition deserves note. The methodology delivers a lower bound on the proximate contribution of the interest rate, preferences, and incomplete markets to fluctuations in consumption growth. Unpredictable movements in marginal utility are estimates of the innovations to marginal utility. To the extent that the information set used to make these predictions is smaller than that available to the household, the role of innovations is overstated and the role of other factors understated.

5. Data and variables

We use data from the Family and Detailed Expenditure files from the interview survey of the CEX to make an unbalanced, overlapping panel of households that contains consumption data from December 1981 to February 1998, with some periods omitted due to changes in the survey. We define consumption as the sum of expenditures on food, alcoholic beverages, apparel and apparel services, gasoline and motor oil used in transportation, public transportation, entertainment, personal care, and reading. Data are deflated by the consumer price index for each category of consumption for the Census region in which the household resides. Further details are contained in the appendix. The final data set contains $148,117$ observations on consumption growth.

The real interest rate is the expected return on a three-month U.S. Treasury bill less the constructed, household-specific inflation rates based on the deflation method described above. Thus, estimation uses a household-specific real interest rate even though we consider the same asset for all households. We use monthly data, averaged to generate real interest rates covering three-month to three-month periods.[9]

Households are counted as unconstrained if they have more than $3,000$ $1982-84$ dollars in wealth in saving accounts, checking accounts, government bonds, stocks, and mutual funds, less debts, as of the start of their first report of expenditures. We also include any household reporting topcoded wealth in the final interview in this sample. Due to a large amount of missing wealth data, this split leads to only one quarter of the sample being clearly unconstrained – an implausibly small share of the population. Accordingly, we supplement this sample by using prior information about the characteristics of households in the economy that are likely to face binding liquidity constraints. Households are also counted as unconstrained if they have at least some college education and have age greater than 45.[10] These allocation rules impose that half the sample of households are unconstrained.

[9] As discussed in Hall (1988).

[10] Meghir and Weber (1996) and Japelli, Pischke and Souleles (1998) suggest that these characteristics are good indicators of lack of liquidity constraints.

The correction for misspecification requires estimation of expectations of household variables, $E_t[\varepsilon_{i,t+1}]$, which we do by predicting $e_{i,t+1}$ from linear regressions on instruments $\mathbf{Z}_{i,t}$ that the household might use to forecast future wealth, preferences, and risk, for a sample of households deemed unlikely to be constrained. All instruments are constructed so that they are in the household information set at the start of period t, allowing for time aggregation. $\mathbf{Z}_{i,t}$ contains: a quadratic function of age, month indicator variables, four education indicator variables, and four aggregate forecast variables – the expected unemployment rate at $t+1$, its change from t, and expected real and nominal interest rates at $t+1$, all interacted with five family types.[11] That is, $\tilde{e}_{i,t+1}$ is the fitted value from 5 separate regressions of $\varepsilon_{i,t+1}$ on age, age squared, month and education dummy variables, and the four aggregate variables. The aggregate instruments are forecasts constructed from rolling regressions.[12] In all of our analysis, we eliminate monthly seasonal variation.

$E_T[.|\mathbf{Z}_t]$ and $\tilde{e}_{t+1}$ are estimated by linear regression using the aggregate variables: a constant, the four forecasts of aggregate variables, month indicators, and twice lagged (un-instrumented) real interest rate series.

One important advantage of the data affects the decomposition. By using household data, we remove composition biases that are present in aggregate consumption data that lead to predictable movements in consumption growth.[13] We analyze average consumption growth across a subset of households,

$$\Delta \ln C_{t+1}^{Ag} = \tfrac{1}{I(t)} \sum_{i \in I_t} \Delta \ln C_{i,t+1},$$

while aggregate consumption data is,

$$\Delta \ln \bar{C}_{t+1} = \ln\left(\tfrac{1}{H(t+1)} \sum_{i \in H_{t+1}} C_{i,t+1}\right) - \ln\left(\tfrac{1}{H(t)} \sum_{i \in H_t} C_{i,t}\right).$$

Thus we omit households who are born or die, and do not incorrectly assign predictable movements in consumption due to births and deaths to precautionary saving or other sources, as could be mistakenly done using aggregate data.[14]

[11] The education groups are some high school, high school graduate, some college, college graduate. Edcucation is assigned on the basis of the male head if present, otherwise on the basis of the female head. The family types are single, single parent with children, married couple, married couple with children, unrelated individuals.

[12] The rolling regressions use the variable's own lags and monthly data for the post-war period to construct $E_T[x_{t+1}]$ for the three month period covered by $t+1$ given only information available at the start of period $t-1$.

[13] See Attanasio and Weber (1993).

[14] However, there is little evidence that population dynamics are important for fluctuations in consumption growth (Parker (1999b)).

6. The proximate causes of consumption growth for unconstrained households

This section studies the consumption growth of households that are not liquidity constrained, as determined by the criteria just described. The contribution of precautionary saving to consumption volatility is statistically significant, but the decomposition leaves a range of uncertainty as to the economic importance of precautionary saving. Our measure of expected consumption growth due to precautionary saving covaries positively with expected changes in government spending. Further, there is some evidence that precautionary saving is countercyclical, consistent with consumption risk being high in recessions.

In order to give a robust picture of the role of precautionary saving in consumption growth, we report results for several different utility functions. First, σ and $\boldsymbol{\delta}$ are estimated by GMM using grouped panel-data and the time-series moments implied by the consumption Euler equation. Variables that shift the preference for consumption ($\mathbf{X}_{i,t+1}$) include indicator variables for the month of the year to capture seasonal variations in demand. Since reported consumption declines slightly with each interview that a household participates in, preferences are allowed to vary by interview. We allow discount rates to differ by five-year birth cohorts. The number of family members and the number of children are both included because they shift the marginal utility of a given amount of expenditure. Finally, to control for the possibility that labor supply is non-separable from the marginal utility of consumption, the number of hours that the woman head of household works is included as a preference shifter. The intertemporal elasticity of substitution is estimated relatively precisely as 0.65 with standard error of 0.14, although there is also significant specification uncertainty. A Technical Appendix describes the GMM estimator and estimates in greater detail. Having estimated the utility function, it is possible that misspecification of preferences is minimal, so we present analyses of consumption growth with and without the correction for misspecification.

The second approach is calibration. We analyze three different intertemporal elasticities of substitution: 0.3, 0.65. and 1 (log utility). In each case we include no preference shifters, so that it is reasonable to believe that the misspecification adjustment is capturing preference variation. Therefore, as noted in section 4, the consumption growth due to misspecification is treated as consumption growth due to preference changes. In all cases, seasonal variation is removed.

Table 1 shows, for our sample of unconstrained households, the share of variation in consumption growth due to innovations to consumption growth and the share of predictable variation due to preferences, the real interest rate, and precautionary saving. Before turning to predictable consumption growth, note that 90 percent or more of the variance of average consumption growth in the CEX is due to news or measurement error, evidence that we are not over-fitting in predicting consumption growth. This is consistent with aggregate consumption growth being difficult to forecast with few instruments, and with measurement error in the CEX leading to unpredictable changes in average consumption growth.

Table 1 demonstrates that precautionary saving causes a statistically significant share of the volatility of expected consumption growth, and that there is a wide range of uncertainty concerning the economic importance of precautionary saving. Innovations to consumption growth are, by construction, orthogonal to the other components of consumption growth; however, the predictable series are not mutually uncorrelated. Therefore the share of variation due to any series depends on the ordering of the series in the variance decomposition. Table 1 presents two alternative orderings for each set of parameters. After the correction for misspecification, the GMM estimates of the percent of variation in predictable consumption growth due to precautionary saving range from 2.5 to 95 percent. For the results based on calibration – which treat misspecification as preference variation – estimates of the economic importance of precautionary saving range from irrelevantly small to 37 percent. In contrast, the first row of results, which omit the correction for possible misspecification suggest that precautionary saving is far more economically important, directly causing 70 to 80 percent of variation in expected consumption growth. But as emphasized in section 4, the presence of model misspecification inflates this measure by construction. The results with the correction for misspecification show that the importance of precautionary saving is significantly less, or at least more uncertain, when the predictable component of the error term is removed.[15]

Given this range of uncertainty, is there a statistically significant contribution of precautionary saving to the volatility of consumption growth? The last column of Table 1 reports the probability that there is no variation due to precautionary saving; that is the p-value for an F-test that the true coefficients in the regression used to construct the expectation in $\Delta \widehat{\ln C_{t+1}^{IM}}$ are all zero. Fluctuations in consumption due to precautionary saving are statistically significant in all cases except the raw residuals from GMM estimation.

The reason for the wide range of uncertainty over the economic importance of precautionary saving is itself informative. Expected consumption growth due to precautionary saving is negatively correlated with that due to preference variation and positively correlated with that due to movements in the real interest rate. These correlations are large, and this is what drives the uncertainty over relative importance. The positive covariance between consumption growth due to the real interest rate and that due to precautionary saving implies that omission of the precautionary term from a regression of consumption growth on the expected real interest rate would increase rather than decrease the estimated elasticity of intertemporal substitution. We also find that consumption growth due to shifts in the preference for consumption covaries negatively

[15] Also, comparing the second and fourth sets of results shows the effect of assuming that expected consumption growth due to misspecification is actually due to preference variation. The GMM estimates assume that estimated preferences capture all true preference variation and omit the misspecification series from the decomposition. The calibration assumes that misspecification captures omitted preference variation. When we include the misspecification as preference variation, the correlation of precautionary saving and preferences decreases and the role of precautionary saving is better pinned down.

with that due to the real interest rate. Thus low observed intertemporal substitution in response to the real interest rate, as observed by Hall (1988) for example, is largely due to omitted preference shifters or misspecification of the consumption optimization problem more generally.[16] Put differently, since precautionary saving leads to higher consumption growth when the interest rate is higher, precautionary saving cannot be the cause of low observed intertemporal substitution. This supports models in which expected changes in consumption growth are caused by nonseparabilities of nondurable consumption and home production, consumption of durable goods, or leisure.

Table 1 also shows that the economic importance of precautionary saving is larger the larger the assumed level of household risk aversion and prudence. Lower values of σ, the elasticity of intertemporal substitution, imply a more important contribution of precautionary saving to predictable consumption growth. This occurs because σ also governs relative risk aversion $(\frac{1}{\sigma})$ and relative prudence $(1+\frac{1}{\sigma})$. A low elasticity of intertemporal substitution implies high risk aversion and high prudence.

Figure 1 displays the three time series of expected consumption growth for both the GMM estimates and the calibration with $\sigma = 0.65$. The data are quarterly averages converted to annual rates, and apart from the series for preferences, are visually similar across panels. The primary difference between the figures is due to the misspecification adjustment, which is included in the preference series in Figure 1b and omitted in Figure 1a. There is a significant amount of predictable variation in consumption growth "explained" by the nonstructural construction of $E_{T,\lambda=0}\left[\varepsilon_{i,t+1}|\mathbf{Z}_{i,t}\right]$, but unexplained by the more structural utility function used in the GMM estimation.

In both panels, we see some evidence that precautionary saving has become less important over the sample, contributing less to consumption growth. This is consistent with the increase in wealth and economic boom of the $1982-1997$ period and suggests that decreased risk has a role in the consumption boom (see Parker (1999b)). We also see that risk contributes substantially to consumption growth after the large 1982 recession, consistent with consumption dropping in recessions due to increased consumption risk in the future. There is no similarly dramatic pattern observed around the 1991 recession, though consumption growth due to precautionary saving rises before the recession, and falls during and after it, with somewhat more accentuated movements in Figure 1b.

These are visual impressions. To be more formal, Table 2 presents the results three regressions of expected consumption growth due to precautionary saving onto: the contemporaneous expected change in the unemployment rate, the contemporaneous expected growth in government spending, and lagged innovations to the federal funds rate.

The first column shows that precautionary saving leads to countercyclical expected consumption growth, although this is statistically insignificant. The point estimates imply that an expected one percent increase in the prime-age male unemployment rate is associated with 0.1 to 0.2 percent faster consumption growth due to consumption

[16] This supports one of the main findings of Attanasio and Weber (1995) and Attanasio and Weber (1993). These papers also argue that correct aggregation is an important part of the difference between linear models in micro and macro data.

risk. The sign of the effect supports our theoretical understanding of precautionary saving – when the unemployment rate is expected to increase there is greater risk and therefore precautionary saving should be high and expected consumption growth should be greater.

The second and third columns of Table 2 present some reduced form evidence on precautionary saving and macroeconomic policy. Theoretically, there are two channels through which economists have considered policy changing consumption risk and precautionary saving. First, expansionary policy can lead to less consumption risk, so that consumption increases when the policy is announced and then is expected to grow more slowly over time. This effect is not consistent with the observed impulse responses of consumption to monetary policy shocks, for example, which show faster consumption growth for a while after a reduction in the real interest rate (Bernanke and Gertler (1995)). If instead policy is going to cause precautionary saving to increase consumption growth, it must be that expansionary policy leads to increased consumption risk. For example, if policy improves expectations of future income, households increase consumption on announcement reducing their stocks of liquid wealth, and this leads to higher consumption risk and faster consumption growth.[17] To evaluate these theories, we ask how consumption growth due to precautionary saving responds to predictable movements in government spending and lagged monetary policy shocks.

An expected one percent higher growth rate of government spending is associated with a one-quarter to three-quarter of a percent faster consumption growth due to precautionary saving. This is consistent with pre-announced increases in government spending leading to faster consumption growth due to precautionary saving. As to monetary policy, we find no statistically significant relationship between consumption growth due to precautionary saving and 12 lags of monthly monetary policy shocks as constructed by Bernanke and Mihov (1998), although the sign of the effect is positive, consistent with the vector autoregression evidence on the impact of a monetary policy shock on aggregate consumption growth.

In sum, we find a statistically significant role for precautionary saving, some evidence that it has declined and is countercyclical, and conclude that its economic impact is both similar to that of the real interest rate and similarly uncertain in magnitude. We turn now from the sample of unconstrained households, in which we are studying the effects of precautionary saving, to the entire sample, in which our measure of consumption growth due to incomplete markets may include the impact of liquidity constraints.

7. The proximate causes of consumption growth

This section presents the results from a similar set of exercises as the previous section, but performed on the data for all households. We find that expected consumption growth due to incomplete markets is directly responsible for a slightly larger share of

[17]In models such as Carroll (1997), higher expected income growth leads to higher expected consumption growth through precautionary saving.

consumption growth in the entire population than in the sample containing only unconstrained households. There is evidence that incomplete markets were a more important determinant of consumption dynamics in the 1991 recession for all households than for unconstrained households alone. Furthermore, consumption growth due to incomplete markets is more countercyclical for all households than for unconstrained households alone, and has no significant co-movement with our policy variables. These results must be interpreted with care. There is a large negative correlation between expected consumption growth due to incomplete markets and that due to misspecification. The misspecification adjustment induces significant movement in the incomplete markets series. The economic interpretation of this finding is that, for all households, preference shifters (or misspecification) interact in important ways with incomplete markets. We give a concrete example below.

Table 3 presents the variance decomposition of consumption growth for all households. Similar to the findings in the smaller, unconstrained sample, expected consumption growth due to incomplete markets is highly statistically significant. Slightly more than 90 percent of consumption growth is unpredictable. Unlike for unconstrained households alone, the corrected estimates from the GMM estimation (second set of results) imply that precautionary saving and liquidity constraints together are directly responsible for a reasonably precise 52 to 69 percent of the predictable consumption growth. If however, one views all the predictable variation in the constructed expectation error as due to preferences then the measured effect of incomplete markets is smaller. The calibration results show a lower contribution of incomplete markets, and a greater level of uncertainty as to its role in fluctuations. As is the case for the unconstrained sample, expected consumption growth due to precautionary saving negatively covaries with that due to preference variation, and this covariance rises when "misspecification" is included as preferences changes. Across specifications, the percent of variation in predictable consumption growth due to incomplete markets ranges from 1.5 to 69 percent.

Figure 2 displays the three time series of expected consumption growth for the GMM estimates (Panel A) and the calibration with $\sigma = 0.65$ (Panel B). Again, incomplete markets and the real interest rate each lead to similar fluctuations in consumption growth in each panel. Adding the misspecification correction to preferences in Panel B leads to volatile consumption growth due to changing preferences that is more negatively correlated with consumption growth due to incomplete markets. Why is this? One answer is simply that $E_{T,\lambda=0}[\varepsilon_{i,t+1}|\mathbf{Z}_{i,t}]$ is estimated only using unconstrained households but used in the construction of $\Delta \widehat{\ln C_{t+1}^{IM}}$ for all households. Statistically, out of sample prediction creates this negative correlation. But a second answer is that there are good economic reasons for these predictions to be poor out of sample: constrained households are different. The presence of a binding liquidity constraint leads a household to adjust margins besides consumption and this can lead to exactly this type of negative covariance. For example, consider a young constrained household that increases labor supply in response to a binding constraint on borrowing. As the constraint relaxes, labor supply declines predictably, leading to slower desired consumption growth due to preference shifts, while consumption growth rises predictably due to the constraint relaxing. The large negative correlation suggests this is what is happening: preference shifters and liquidity constraints lead to offsetting movements in expected consumption growth. That said, given the magnitude of the correlation, the negative correlation may not be purely due to economic behavior alone, but may also be partly driven by imperfect prediction.

Like Figure 1, Figure 2 shows some evidence that precautionary saving and liquidity constraints have become less important over the time period covered by the data, contributing less to consumption growth. Comparing Figures 1 and 2, this decline appears slightly larger for all households than for only liquid households. Also, liquidity constraints or precautionary saving of low wealth households seem to have played a role in maintaining consumption growth in the 1991 recession. Again, these are visual impressions. Table 4 reports the results of regressing consumption growth due to incomplete markets onto the same set of variables as Table 2.

First, incomplete markets lead to countercyclical expected consumption growth. The point estimates imply that an expected one percent increase in the prime-age male unemployment rate is associated with just over a one percent higher rate of expected consumption growth rate. This effect is larger than that estimated for unconstrained households alone, implying that precautionary saving is more important for low wealth households. Larger increases in consumption risk for low wealth households could be due to the fact that unemployment falls more heavily on lower income households or that credit constraints are tighter when unemployment is expected to rise, so that borrowing to smooth consumption becomes more difficult. Either way, the estimates imply that incomplete markets amplify business cycle movements in consumption. Consumption risk increases and/or borrowing constraints tighten upon news of a coming recession and therefore incomplete markets for transferring consumption across time and states amplify the decline in consumption that occurs on this news.

The remaining columns of Table 4 show that both of our measures of policy have insignificant correlations with expected consumption growth due to incomplete markets. Unlike for unconstrained households, the impact is not consistently of one sign. There is no evidence that the combination of liquidity constraints and precautionary saving amplify or damp the impact of government spending or monetary policy on total consumption growth.

8. Robustness

Our main conclusions are robust both to using a larger instrument set that adds five additional instruments, and to using a smaller instrument set that uses only our four forecast aggregate variables. The first five columns of Table 5 report the variance decomposition of the series, and the last two columns report the relationship between our series and the business cycle and government spending. Panels A and C show that the larger instrument set typically tightens the bounds on the variance of consumption growth due to each series, and does not change what we infer about the relationship of precautionary saving to either the business cycle or predictable movements in government spending. Panels B and D show that the smaller instrument set typically widens the bounds on the variance of consumption growth due to each series, and again leaves our other conclusions largely unchanged.

9. Conclusion

This paper finds that incomplete markets for trading future consumption cause statistically significant movements in expected consumption growth and that the economic importance of precautionary saving rivals that of the interest rate.

For households that are unlikely to be liquidity constrained, there is some evidence, although imprecise, that precautionary saving is countercyclical, leading to higher consumption growth when unemployment rates are increasing. And there is some evidence that high expected growth in government spending is associated with greater consumption growth due to precautionary saving.

Incomplete markets are more important for fluctuations in expected consumption growth for all households. Precautionary saving and liquidity constraints together are highly statistically significant, and cause movements in consumption growth that are positively correlated with movements due to the real interest rate and negatively correlated with movements due to preferences or misspecification more generally. Consumption growth due to incomplete markets is countercyclical, and so amplifies recessions, but we find no evidence that it is correlated with past policy.

We suspect that measurement error in consumption growth limits our ability to infer the characteristics of consumption growth. Better measurement (or data in which with longer growth rates can be studied) would allow a tighter decomposition and a more accurate mapping from primitive shocks to subsequent movements in precautionary saving. Better measurement may also allow analysis of trend growth rates. Of specific interest is the variation across countries in consumption growth rates, which are largely unexplained by variations in real interest rates. Our decomposition provides a way to use microeconomic data to map the differences in consumption risk across countries into implied differences in expected growth rates of consumption.

A. The effect of measurement error in consumption

To see that measurement error biases the mean and only the mean of consumption growth due to precautionary saving, plug observed consumption growth into the theoretical measure for a household

$$\begin{aligned}
\Delta \ln C_{i,t+1}^{IM} &= -\sigma E_t \left[\ln \left(1 + e^{\mathbf{X}_{i,t+1}\boldsymbol{\delta}} \left(\frac{C_{i,t+1}^*}{C_{i,t}^*} \right)^{-\frac{1}{\sigma}} \left(\frac{\mu_{i,t+1}}{\mu_{i,t}} \right)^{\frac{-1}{\sigma}} R_{i,t+1}^f \; - 1 \right) \right] \\
&= -\sigma E_t \left[\mathbf{X}_{i,t+1}\boldsymbol{\delta} - \frac{1}{\sigma} \ln \left(\frac{C_{i,t+1}^*}{C_{i,t}^*} \right) - \frac{1}{\sigma} \ln \left(\frac{\mu_{i,t+1}}{\mu_{i,t}} \right) + \ln R_{i,t+1}^f \right] \\
&= E_t \left[\ln \left(\frac{\mu_{i,t+1}}{\mu_{i,t}} \right) \right] - \sigma E_t \left[\ln \left(1 + e^{\mathbf{X}_{i,t+1}\boldsymbol{\delta}} \left(\frac{C_{i,t+1}^*}{C_{i,t}^*} \right)^{-\frac{1}{\sigma}} R_{i,t+1}^f - 1 \right) \right] \\
&= \phi - \sigma E_t \left[\ln \left(1 + \varepsilon_{i,t+1} \right) \right] \\
&= \phi + \Delta \ln C_{i,t+1}^{IM*}.
\end{aligned}$$

where $\Delta \ln C_{i,t+1}^{IM*}$ denotes the true (correctly measured) consumption growth due to incomplete markets and where $\phi \equiv E_t \left[\Delta \ln \mu_{i,t+1} \right]$, constant since the measurement error is independent of conditioning information.

To see that the volatility of consumption growth and innovations to consumption are overstated,

$$\begin{aligned}
\eta_{t+1}^C &= \tfrac{1}{H(t)} \sum_{i \in H_t} \Delta \ln C_{i,t+1} - E_t \left[\tfrac{1}{H(t)} \sum_{i \in H_t} \Delta \ln C_{i,t+1} \right] \\
&= \tfrac{1}{H(t)} \sum_{i \in H_t} \Delta \ln C_{i,t+1}^* + \tfrac{1}{H(t)} \sum_{i \in H_t} \Delta \ln \mu_{i,t+1} - E_t \left[\tfrac{1}{H(t)} \sum_{i \in H_t} \Delta \ln C_{i,t+1}^* \right] - \phi \\
&= \eta_{t+1}^{C*} + \tilde{\mu}_{t+1}
\end{aligned}$$

where η_{t+1}^{C*} denotes the correctly measured variance of consumption growth and $\tilde{\mu}_{t+1} \equiv \frac{1}{H(t)} \sum_{i \in H_t} \Delta \ln \mu_{i,t+1} - \phi$ which is an MA(1) variable independent of all lagged instruments. Both arguments also hold in our robust measures. In sum, the measures overstate mean consumption growth and mean consumption growth due to precautionary saving by a factor ϕ, and overstate the volatility of consumption growth and innovations to consumption by $Var_t \left(\tilde{\mu}_{t+1} \right)$.

B. The corrections to precautionary saving

To see that the finite-sample adjustment to the consumption growth due to precautionary saving eliminates the finite-sample bias, take a second-order expansion of the logarithm around

$\tilde{e}_{t+1} = 0$:

$$-E_t\left[E_T[\tfrac{1}{I(t)}\sum_{i\in I_t}\tilde{e}_{i,t+1} - \frac{\tilde{e}^2_{i,t+1}}{2} - \tilde{e}_{t+1}|\mathbf{Z}_t]\right] = \frac{1}{2}E_t\left[\tfrac{1}{I(t)}\sum_{i\in I_t}\tilde{e}^2_{i,t+1}\right]$$

which is the cross-sectional variance of interest. Note that if $E_T\left[\frac{1}{I(t)}\sum_{i\in I_t}\tilde{e}_{i,t+1}|\mathbf{Z}_t\right] = 0$, then corrected and uncorrected measures of precautionary saving are numerically identical.

We now show that the specification of the corrections described in section 4 are not interchangeable. Consider first applying the correction for misspecification in the manner of the second correction. Assuming parameter estimates are correct apart from the misspecification term θ, the household-level measure of precautionary saving would be

$$-\sigma\tfrac{1}{I(t)}\sum_{i\in I_t}E_T\left[\ln\left(1+\varepsilon_{i,t+1}\right) - \varepsilon_{i,t+1}|\mathbf{Z}_t\right].$$

Since

$$\varepsilon_{i,t+1} = \frac{1+\epsilon_{i,t+1}}{\theta_{i,t}} - 1$$

the expectation of this measure is equal to

$$\begin{aligned}
& -\sigma E\left[\ln\left(\frac{1+\epsilon_{i,t+1}}{\theta_{i,t}}\right) - \frac{1+\epsilon_{i,t+1}}{\theta_{i,t}} + 1\right] \\
= \quad & -\sigma E\left[\ln\left(1+\epsilon_{i,t+1}\right)\right] - \sigma(-\ln\theta_{i,t} + \frac{1}{\theta_{i,t}} + 1).
\end{aligned}$$

Expanding the second logarithm around $\theta_{i,t} = 1$, one can see that this measure is correct to the first order but not higher. Under this alternative, $\theta_{i,t}$ raised to powers would show up in our measure of precautionary saving.

Turning to the correction for small-sample bias, suppose that we were to subtract $\hat{e}_{t+1} \equiv E_T\left[\frac{1}{I(t)}\sum_{i\in I_t}\tilde{e}_{i,t+1}|\mathbf{Z}_t\right]$ from the residual in the manner of the adjustment for misspecification, so that the measure of consumption growth due to precautionary saving is

$$-\sigma E_T\left[\tfrac{1}{I(t)}\sum_{i\in I_t}\ln\left(1+\tilde{e}_{i,t+1}-\hat{e}_{i,t+1}\right)|\mathbf{Z}_t\right].$$

Taking the expectation of a second-order expansion of the expectation around $\tilde{e}_{i,t+1} - \hat{e}_{i,t+1} = 0$ yields

$$\begin{aligned}
= \quad & -E_t\left[\tfrac{1}{I(t)}\sum_{i\in I_t}\tilde{e}_{i,t+1} - \hat{e}_{t+1} - \frac{\left(\tilde{e}_{i,t+1}-\hat{e}_{t+1}\right)^2}{2}\right] \\
= \quad & -E_t\left[\tfrac{1}{I(t)}\sum_{i\in I_t}\tilde{e}_{i,t+1}\right] + \tfrac{1}{I(t)}\sum_{i\in I_t}E_t\left[\hat{e}_{t+1}\right] + E_t\left[\tfrac{1}{I(t)}\sum_{i\in I_t}\frac{\tilde{e}^2_{i,t+1} - 2\hat{e}_{t+1}\tilde{e}_{i,t+1} + \hat{e}^2_{t+1}}{2}\right] \\
= \quad & \frac{1}{2}E_t\left[\tfrac{1}{I(t)}\sum_{i\in I_t}\tilde{e}^2_{i,t+1}\right] - \frac{1}{2}\tfrac{1}{I(t)}\sum_{i\in I_t}E_t\left[\hat{e}^2_{t+1}\right] \\
= \quad & \frac{1}{2}\overline{Var}_t\left[\tilde{e}_{i,t+1}\right] - \frac{1}{2}\tfrac{1}{I(t)}\sum_{i\in I_t}E_t\left[\hat{e}^2_{t+1}\right]
\end{aligned}$$

which is the object of interest less a term that is always positive and possibly quite large. Taking the true conditional expectation of this measure yields the quantity of interest less a positive term.

C. Liquidity constraints and the decomposition

First consider the effect of liquidity constraints on the adjustments to the expectation errors and the precautionary saving series. For the misspecification adjustment, we estimate $E_t\left[\varepsilon_{i,t+1}\right] = \frac{1}{\theta_{i,t}} - 1$ as a function of characteristics of household i using the sample of households that are not constrained. We denote the sample function as $E_{T,\lambda=0}\left[\varepsilon_{i,t+1}|\mathbf{Z}_{i,t}\right]$ and use this as the sample analog to $E_t\left[\varepsilon_{i,t+1}\right]$ in constructing $\tilde{e}_{i,t+1}$. For the finite-sample bias, since $\varepsilon_{i,t+1}$ measures $\epsilon_{i,t+1} - \lambda_{i,t}$ for a constrained household, $E_t\left[\varepsilon_{i,t+1}\right]$ should not equal zero for constrained households. Therefore, we omit the small-sample correction for possibly constrained households.

As long as $E_t\left[E_{T,\lambda=0}[\varepsilon_{i,t+1}|\mathbf{Z}_{i,t}]\right] = \frac{1}{\theta_{i,t}} - 1$, the presence of liquidity constraints does not alter the interpretation of our decomposition.[18] Suppose that for a constrained household, omitted preference shifters are predicted by variables in $Z_{i,t}$ with the same coefficients as for an unconstrained household. That is, assume that the true model is given by equation (4.1) and that the function of $\mathbf{Z}_{i,t}$, $E_{\lambda=0}[\varepsilon_{i,t+1}|\mathbf{Z}_{i,t}] = \frac{1}{\theta_{i,t}} - 1$, independent of λ. For constrained households the (theoretical) robust measure of consumption growth due to incomplete markets is

$$\begin{aligned}
\Delta \ln C_{i,t+1}^{IM} &= -\sigma E_t\left[\ln\left(1 + \frac{\varepsilon_{i,t+1} - E_{\lambda=0}\left[\varepsilon_{i,t+1}|\mathbf{Z}_{i,t}\right]}{1 + E_{\lambda=0}\left[\varepsilon_{i,t+1}|\mathbf{Z}_{i,t}\right]}\right)\right] \\
&= -\sigma E_t\left[\ln\left(1 + \frac{\frac{1+\epsilon_{i,t+1}-\lambda_{i,t}}{\theta_{i,t}} - \frac{1}{\theta_{i,t}}}{\frac{1}{\theta_{i,t}}}\right)\right] \\
&= -\sigma E_t\left[\ln\left(1 + \epsilon_{i,t+1} - \lambda_{i,t}\right)\right].
\end{aligned}$$

which is the quantity of interest.

Is it plausible that $E_{T,\lambda=0}[\varepsilon_{i,t+1}|\cdot]$ is not a function of λ? Suppose that a binding liquidity constraint causes an increase in labor supply. Suppose further that hours worked is omitted from $X_{i,t}$ and that hours worked do not otherwise vary with $Z_{i,t}$. Then, this condition fails: the change in the expected growth rate of consumption due to the change in hours is allocated to liquidity constraints. To see this more formally, let $\theta^{-1}(\lambda, Z_{i,t})$ be the predicted value of

[18] If this assumption fails, the interpretation changes: expected changes in preferences that occur for constrained households and that are not predicted by $\mathbf{Z}_{i,t}$ for unconstrained households are allocated to the series on liquidity constraints rather than preferences. Both this appendix and the results section contain examples of interpretation.

$\theta_{i,t}^{-1}$ for a household as a function of liquidity constraint and other characteristics.

$$\begin{aligned}
\Delta \ln C_{i,t+1}^{IM} &= -\sigma E_t \left[\ln \left(1 + \frac{\varepsilon_{i,t+1} - E_{t,\lambda=0}\left[\varepsilon_{i,t+1}\right]}{1 + E_{t,\lambda=0}\left[\varepsilon_{i,t+1}\right]} \right) \right] \\
&= -\sigma E_t \left[\ln \left(1 + \frac{\frac{1+\epsilon_{i,t+1}-\lambda_{i,t}}{\theta(\lambda,\mathbf{Z}_{i,t})} - \frac{1}{\theta(0,\mathbf{Z}_{i,t})}}{\frac{1}{\theta(0,\mathbf{Z}_{i,t})}} \right) \right] \\
&= -\sigma E_t \left[\ln \left(\frac{\theta(0,\mathbf{Z}_{i,t})}{\theta(\lambda,\mathbf{Z}_{i,t})} \left(1 + \epsilon_{i,t+1} - \lambda_{i,t}\right) \right) \right]
\end{aligned}$$

The effect of a binding liquidity constraint on preferences appears in the incomplete markets series since movements in θ caused by λ (unpredictable by $Z_{i,t}$ and unmodelled in $X_{i,t}$) move $\frac{\theta(0,\mathbf{Z}_{i,t})}{\theta(\lambda,\mathbf{Z}_{i,t})}$ away from unity.

D. The CEX sample

The 1997 files include data on household expenditures for all three-month interview periods starting in 1997, so that the data we use cover up to and including February of 1998. We use both the raw data files and SAS files available from Lorna Greening at: ftp://elsa.berkeley.edu/pub/ices/. We omit 1980 and 1981 data because it is of significantly worse quality. Due to decennial survey changes, we cannot match consumption growth to the first three months of 1986 or 1996. When decomposing consumption growth we also drop the three observations on consumption growth across 1987 to 1988 and the three across 1995 to 1996 due to large increases in the variance of consumption growth in these periods due to changes in the survey instrument. Finally, when decomposing consumption growth, we drop the observation in which $t+1$ ends in July 1996 due to several strange factors. It has a variance of consumption growth similar to a survey change, and it has the largest mean movement in several preference categories. This inclusion of this single observation does not substantively alter our inference. This leaves 16 years and three months less two months of observations in levels, for a time dimension of 177 three-month to three-month growth rates and a pre-sample of 6 months.

We are forced to drop any observations missing the required consumption data, variables that shift marginal utility, or instruments used to proxy expectations. Rural households are dropped, as are households living in student housing. We drop observations in which the gender of the head of the household remains the same and the head or spouse changes age by more than a year or less than no years in between interviews. Only households for which the age of the head and spouse are less than 85 and greater than 21 are included. We drop observations reporting family size changes greater than 3. Finally, to limit the effects of measurement error in consumption, we drop the bottom one percent of households in the distribution of real consumption per effective householder.[19] In addition, we drop the top and bottom 2.5 percent of households in the distribution of consumption growth, on the grounds

[19]For this exercise only, effective household size is defined as one, plus one if there is a spouse present, plus 0.4 times each additional family member. The first percentile in the

that these observations are more likely to represent mismeasurement than actual movements in marginal utility.[20]

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distribution is predicted by a constant and a time trend and observations below this fitted value are dropped. The fitted values range from 190 to 230 real 1982-1984 dollars per effective household member per three months.

[20]This represents a decision about the trade-off between consistency and robustness in finite samples. SeeVissing-Jorgensen (1998) and Brav, Constantinides and Geczy (2002) for example.

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Table 1: Variance Decomposition of Average Consumption Growth for Unconstrained Households

	Percent of variation that is not predictable	Percent of predictable variation due to			p-value for precautionary saving series
		Real Interest Rate	Changing Preferences	Precautionary Saving	
GMM Estimates (Raw)					
In Order Listed:	96.4	5.3	14.8	79.9	0.167
Order Reversed:		22.9	7.0	70.1	
GMM Estimates					
In Order Listed:	95.4	81.3	16.3	2.5	0.027
Order Reversed:		4.6	0.2	95.2	
Calibration σ=0.3					
In Order Listed:	90.5	50.5	40.3	9.2	0.000
Order Reversed:		6.4	50.1	43.5	
Calibration σ=0.65					
In Order Listed:	93.8	14.9	81.5	3.6	0.000
Order Reversed:		8.9	80.3	10.7	
Calibration σ=1					
In Order Listed:	94.4	0.0	98.3	1.7	0.000
Order Reversed:		9.5	90.4	0.0	

Note: The GMM (raw) series is constructed without applying the either correction for misspecification or for small-sample bias; the remaining rows do apply this correction. The decompositions for the GMM estimates do not include the movement in consumption due to predictable variation in the innovation to marginal utility -- the misspecification correction described in the main text; the remaining decompositions include this movement in the preferences series. See text for further details.

Table 2: Properties of Consumption Growth Due to Precautionary Saving

Dependent variable:	Expected change in unemployment rate	Expected change in real government spending	Lagged monetary policy shocks
Standard deviation of variable:	0.0017	0.0041	0.0032
GMM Estimates			
Coefficient:	0.21	0.32	
Standard error:	(0.19)	(0.05)	
Sum of Coefficients:			0.15
P-value:			0.80
Calibration σ=0.3			
Coefficient:	0.20	0.78	
Standard error:	(0.39)	(0.08)	
Sum of Coefficients:			0.10
P-value:			0.88
Calibration σ=0.65			
Coefficient:	0.14	0.39	
Standard error:	(0.21)	(0.04)	
Sum of Coefficients:			0.08
P-value:			0.88
Calibration σ=1			
Coefficient:	0.10	0.26	
Standard error:	(0.14)	(0.02)	
Sum of Coefficients:			0.06
P-value:			0.88

Note: The decompositions for the GMM estimates do not include the movement in consumption due to these misspecification adjustments; the remaining decompositions include this movement in the preferences series. See text for further details. For monetary policy shocks the table reports the sum of the estimated coefficients. The p-value refers to the f-test that all lags are zero. For the remaining series point estimates and associated p-values from a t-test are reported. Newey-West standard errors are reported, correcting for up to 12 months serial correlation.

Table 3: Variance Decomposition of Average Consumption Growth for All Households

	Percent of variation that is not predictable	Percent of predictable variation due to			p-value for precautionary saving series
		Real Interest Rate	Changing Preferences	Incomplete Markets	
GMM Estimates (Raw)					
In Order Listed:	95.6	0.2	92.1	7.7	0.028
Order Reversed:		1.6	20.2	78.2	
GMM Estimates					
In Order Listed:	92.9	47.1	0.4	52.5	0.013
Order Reversed:		25.2	5.7	69.1	
Calibration σ=0.3					
In Order Listed:	93.1	47.5	30.2	22.3	0.000
Order Reversed:		41.0	50.8	8.2	
Calibration σ=0.65					
In Order Listed:	96.1	4.5	53.0	42.4	0.000
Order Reversed:		65.6	32.9	1.5	
Calibration σ=1					
In Order Listed:	95.5	13.9	46.1	40.0	0.001
Order Reversed:		32.3	62.1	5.6	

Note: The GMM (raw) series is constructed without applying the either correction for misspecification or for small-sample bias; the remaining rows do apply these corrections. The decompositions for the GMM estimates do not include the movement in consumption due to predictable variation in the innovation to marginal utility -- the misspecification correction described in the main text; the remaining decompositions include this movement in the preferences series. See text for further details.

Table 4: Properties of Consumption Growth Due to Precautionary Saving and Liquidity Constraints

Dependent variable:	Expected change in unemployment rate	Expected change in real government spending	Lagged monetary policy shocks
Standard deviation of variable:	0.0017	0.0041	0.0032
GMM Estimates			
Coefficient:	1.03	0.00	
Standard error:	(0.16)	(0.13)	
Sum of Coefficients:			-0.27
P-value:			0.78
Calibration σ=0.3			
Coefficient:	1.19	0.29	
Standard error:	(0.36)	(0.17)	
Sum of Coefficients:			0.03
P-value:			0.32
Calibration σ=0.65			
Coefficient:	1.09	-0.07	
Standard error:	(0.26)	(0.15)	
Sum of Coefficients:			0.05
P-value:			0.67
Calibration σ=1			
Coefficient:	1.04	-0.21	
Standard error:	(0.23)	(0.14)	
Sum of Coefficients:			0.05
P-value:			0.71

Note: The decompositions for the GMM estimates do not include the movement in consumption due to the misspecification adjustment; the remaining decompositions include this movement in the preferences series. See text for further details. For monetary policy shocks, the sum of the estimated coefficients is reported. The p-value refers to the f-test that all lags are zero. For the remaining series point estimates and associated p-values from a t-test are reported. Newey-West standard errors are reported, correcting for up to 12 months serial correlation.

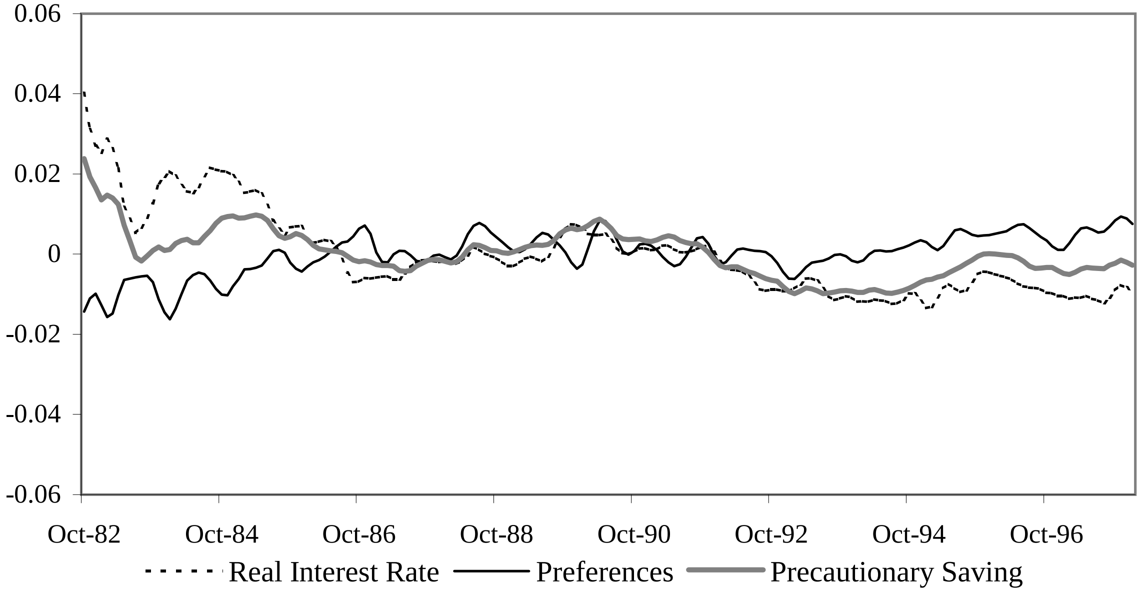
Table 5: Robustness to Alternative Instrument Sets

	Percent of variation that is not predictable	Percent of predictable variation due to: Real Interest Rate	Changing Preferences	Precautionary Saving	p-value for precautionary saving series	Expected Change in Unemployment Rate	Expected Change in Government Spending
			Panel A: Unconstrained Households Large Instrument Set				
GMM Estimates							
In Order Listed:	0.91	64.0	29.0	7.0	0.007	0.23	0.29
Order Reversed:		10.2	5.3	84.5		(0.18)	(0.06)
Calibration σ=0.65							
In Order Listed:	0.92	16.3	67.7	16.0	0.000	0.14	0.35
Order Reversed:		22.3	55.9	21.8		(0.18)	(0.05)
			Panel B: Unconstrained Households Small Instrument Set				
GMM Estimates							
In Order Listed:	0.96	84.0	15.1	0.9	0.125	0.21	0.24
Order Reversed:		1.1	0.5	98.4		(0.13)	(0.06)
Calibration σ=0.65							
In Order Listed:	0.94	15.0	81.6	3.4	0.000	0.13	0.29
Order Reversed:		8.6	80.8	10.6		(0.14)	(0.06)
			Panel C: All Households Large Instrument Set				
GMM Estimates							
In Order Listed:	0.92	47.4	0.9	51.7	0.000	1.03	0.06
Order Reversed:		38.4	0.1	61.4		(0.17)	(0.07)
Calibration σ=0.65							
In Order Listed:	0.93	7.8	43.8	48.4	0.000	1.08	-0.05
Order Reversed:		45.1	50.8	4.1		(0.25)	(0.10)
			Panel D: All Households Small Instrument Set				
GMM Estimates							
In Order Listed:	0.94	52.6	15.1	32.3	0.031	1.06	0.13
Order Reversed:		15.1	11.3	73.6		(0.13)	(0.06)
Calibration σ=0.65							
In Order Listed:	0.97	7.0	75.0	18.0	0.001	1.11	0.05
Order Reversed:		73.2	2.8	23.9		(0.23)	(0.08)

Note: See text and notes to previous Tables. The large instrument set adds the twice-lagged, uninstrumented preference series, twice-lagged employment growth, average age, average age-squared, and share of households over 45 to our baseline instrument set; the small instrument set includes only the four aggregate instruments. Both sets continue to contain monthly seasonal indicator variables, but all seasonal variation is removed from the analysis.

Figure 1: Predictable Consumption Growth for Unconstrained Households

a) Based on GMM estimates



b) Based on calibration with σ=0.65

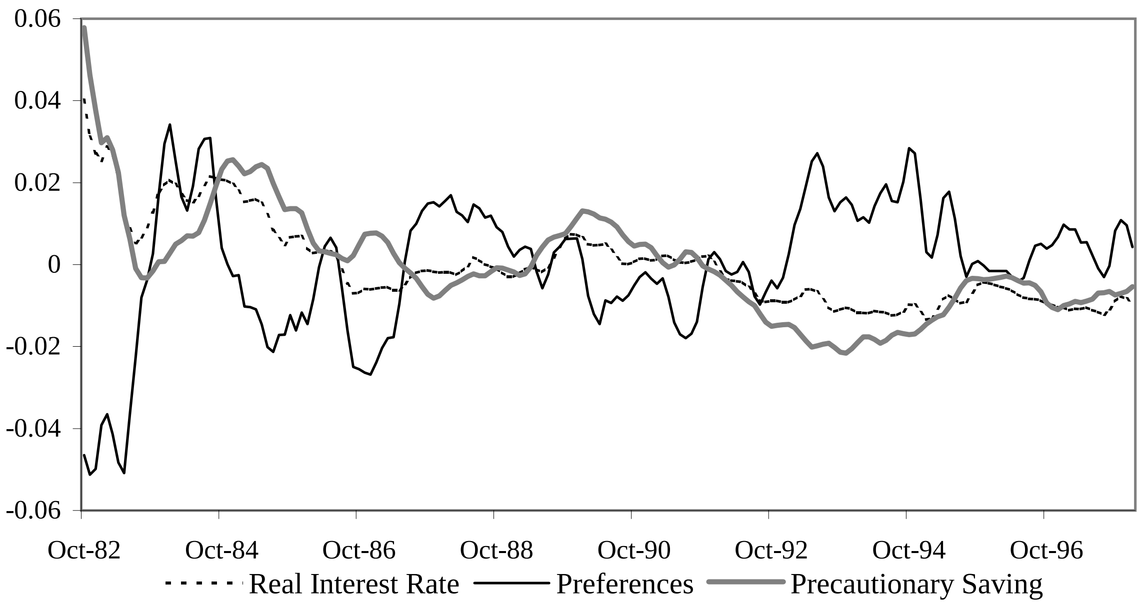
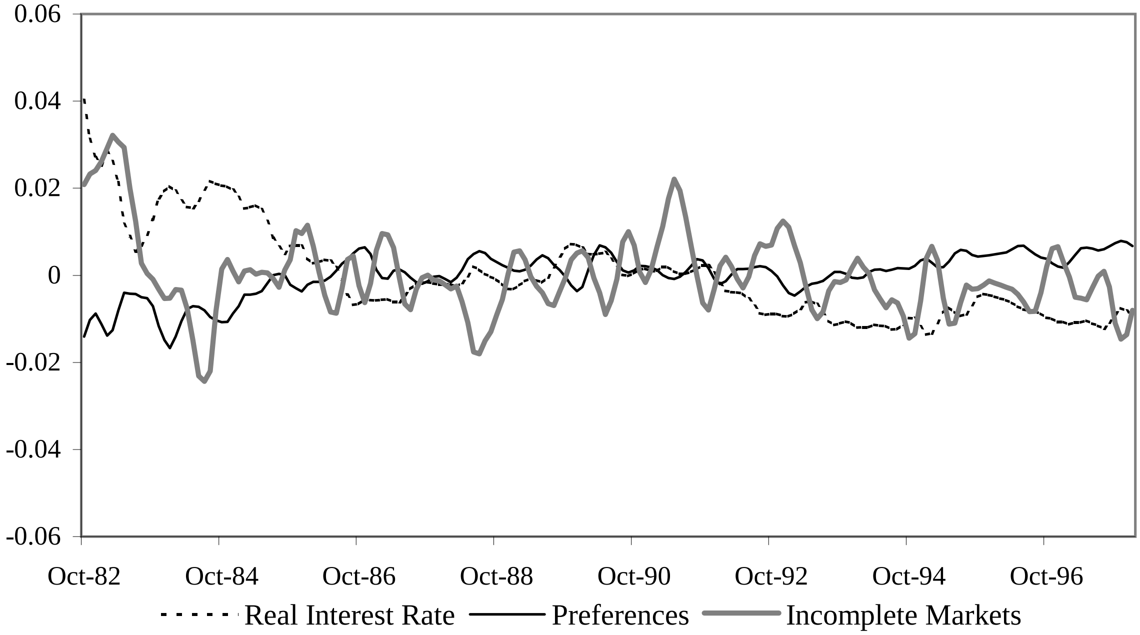


Figure 2: Predictable Consumption Growth for All Households

a) Based on GMM estimates



b) Based on calibration with σ=0.65